MANAGEMENT, QUALITY and ECONOMICS in BUILDING

EDITED BY

Artur Bezelga
and
Peter Brandon

Taylor & Francis
Taylor & Francis Group

Management, Quality and Economics in Building

EUROPEAN SYMPOSIUM ON MANAGEMENT, QUALITY AND ECONOMICS IN HOUSING AND OTHER BUILDING SECTORS

The organizers gratefully acknowledge the special support of the following organizations and firms in the sponsoring of the Symposium.

Instituto Nacional de Habitação

European Commission
'SPRINT' Programme

SECIL
Cimento de Qualidade
Produtos de Prestígio

Fundação
Calouste Gulbenkian

CAIXA GERAL
DE DEPOSITOS

EPUL
EMPRESA PÚBLICA
DE URBANIZAÇÃO
DE LISBOA

JNICT

junta nacional de investigação científica e tecnológica

IGAPHE

INSTITUTO DE GESTÃO
E ALIENAÇÃO DO PATRIMÓNIO
HABITACIONAL DO ESTADO

Management, Quality and Economics in Building

EDITED BY

Artur Bezelga

Professor of Civil Engineering

Instituto Superior Técnico

Lisbon

Peter Brandon

Professor of Quantity and Building Surveying

University of Salford

Manchester

TRANSACTIONS OF THE EUROPEAN SYMPOSIUM ON MANAGEMENT, QUALITY AND ECONOMICS IN HOUSING AND OTHER BUILDING SECTORS HELD IN LISBON, 30 SEPTEMBER—4 OCTOBER 1991

The Symposium was organized by:

Technical University of Lisbon
(Instituto Superior Técnico)
Civil Engineering Department
Lisbon, Portugal
University of Salford
Department of Surveying
Salford
UK

The Symposium was held under the auspices of, and endorsed by:
CIB—Conseil International du Bâtiment
pour la Recherche, l'Etude et la Documentation
and CIB Commissions
W65—Organization and Management of Construction
W88—Quality Assurance
W55—Building Economics
W70—Property Asset Management
ENHR—European Network for Housing Research
EOQC—European Organization for Quality, Construction Section

E & FN SPON
An Imprint of Chapman & Hall
London · New York · Tokyo · Melbourne · Madras

Published by E & FN Spon, an imprint of Chapman & Hall, 2–6 Boundary Row, London SE1 8HN
This edition published in the Taylor & Francis e-Library, 2006.

" To purchase your own copy of this or any of Taylor & Francis or Routledge's collection of thousands of eBooks please go to http://www.ebookstore.tandf.co.uk/."

Chapman & Hall, 2–6 Boundary Row, London SE1 8HN, UK
Van Nostrand Reinhold Inc., 115 5th Avenue, New York NY10003, USA
Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 7F, 1–7–11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan
Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205, Australia
Chapman & Hall India, R.Seshadri, 32 Second Main Road, CIT East, Madras 600 035, India

First edition 1991

ISBN 0-203-97348-8 Master e-book ISBN

ISBN 0 419 17470 2 (Print Edition) 0 442 31520 1 (Print Edition) (USA)

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication data available

Contents

Preface

This book presents the proceedings of the European Symposium on Management, Quality and Economics in Housing and other Building Sectors held in Lisbon, from 30 September to 4 October, 1991. The Symposium was organized by the Civil Engineering Department of the Technical University of Lisbon (Instituto Superior Técnico), Portugal and the University of Salford, Surveying Department, United Kingdom.

The purpose of this book and the Symposium is to establish the state-of-the-art and new trends in research and practice in four important scientific and technical themes for residential and other buildings. The themes are:

- building policy,
- building quality,
- building economics,
- construction management.

In the structuring of this work two strategic objectives were pursued:

- to establish, in a comprehensive and rigorous way, the situation and trends in the above areas within the European Community and, to establish a more general picture in the rest of the world;
- to cover all types of buildings, but with particular emphasis on housing, which is so important in all countries of the world.

These objectives were broadly achieved. The authors hope that the book contributes to a detailed analysis of the domains of management, quality and economics in building and also looks across the boundaries between the main themes. The development and integration of these three domains addresses a real need felt by numerous experts in the practice of construction, and in research and education.

The book has 189 invited papers, 60 per cent of which are from European Community countries. The remaining 40 per cent were provided by Northern and Eastern Europe, Asia, Africa, North and South America and Australia—with more than 20 countries represented, including USA, Australia, Brazil, Turkey, Canada, Sweden, Singapore, Finland, Japan, Yugoslavia and others.

Knowledge transfer

Over the last decade there has been an acceleration in knowledge transfer in construction, both in EC countries and worldwide. The role of CIB (International Council for Building

Research, Studies and Documentation), has been most valuable, for building in general and for this book in particular.

There are many CIB Commissions that are, in a direct or indirect way, related to the areas of management, quality and economics in building. The ones that are closest are:

W65—Organization and Management of Construction
W88—Quality Assurance
W55—Building Economics
W70—Property Asset Management.
W92—Procurement Systems.

The Commission W87—Post Construction Liability and Insurance, W86—Building Pathology, W91. A—Housing Research Latin America, and several others, are also, to various degrees, related to the management, quality and economics subject areas.

In the quality domain, the valuable work of EOQC (European Organization for Quality, Construction Section) should be recognized. The results of the EOQC Construction Quality Seminars have been very significant in introducing and developing quality in building.

Recently, the work of ENHR (European Network for Housing Research) has played an important part with regard to housing.

Many other bodies are also beginning to work in related areas and it would be difficult to point to them all. The role of the European Community in research and technology transfer in building is now increasing. It is hoped that in the near future it will be of even greater importance.

The EEC SPRINT Programme was the first sponsor of the European Symposium on Management, Quality and Economics in Housing and Other Building Sectors which ultimately gave rise to this book.

Programmes such as SPRINT, ESPRIT, COMETT, TEMPUS, ERASMUS, BRITE, SCIENCE and others, could be very valuable in the future to develop research and technology transfer in building.

It is hoped that this book will contribute effectively to creating an international European community of research and practice in management, quality and economics in housing and building and, at the same time, promote a worldwide exchange of knowledge across different continents.

Objective matrix framework

The objectives of this work, already referred to above can be classified as follows:

- Housing/Building Policies, Management, Quality, Economics, Information Technologies, in general.
- Project Life Phase—Inception, Briefing, Design, Construction, Use, Global Process.

- Type of Works—New Construction, Rehabilitation, Maintenance.
- Project/Firm Focus—Project Focus, Firm Focus, Other Focus.

Under these headings the invited experts could present one of the three types of contributions, a state-of-the art review, a specialized contribution, or a case study. In general terms, contributions in this book fit into this framework, which is presented in the table opposite.

Book structure

It was decided to divide the book into five parts following the concepts defined above.

Part One	Management
Part Two	Quality
Part Three	Economics
Part Four	Information Technology
Part Five	Policy

The most important themes are management, quality and economics, but the other two provide a contextual framework.

Part Four, Information Technology, includes the information technology contributions that could be separated out although these are, of course, related to the other important themes of the book. It should be stressed that nearly all the invited papers in this part belong to the management area.

In Part Five, Policy, the idea is to present a framework embracing general issues including the market, financing, legal, policy and other matters.

The classification made and the designation of contributions in a particular part can certainly be the object of debate. For instance:

- a few invited papers included in Part Five such as legal or other frameworks could also belong to Parts One, Two or Three;
- maintenance or facilities management could be included in Part One, considering that is a management domain: however, it was decided to put all the contributions in this area inside Part Three since the majority of them are of a conceptual nature and can be related to economics and maintenance;
- some of the invited papers dealing with information technology could obviously be included in Part Four, or in Parts One, Two or Three. The editors had to make a personal judgement as to which was most relevant.

European Symposium on Management, Quality and Economics in Housing and other Building Sectors

Basic themes	Project life cycle
	Inception Briefing Design Construction Use Global process
0. Housing Building Policies	
0.1 Market—Supply/Demand	
0.2 Financing	
0.3 Policies	
1. Management	I STATE OF THE ART REVIEW (in all themes)
1.1 Management of Projects-Time, Cost, Quality, Risk, Human Resources, Procurement….	II SPECIALIZED CONTRIBUTIONS (in all themes)
1.2 Management of Housing, Building Firms—Organization, Investment, Production, Financing, Marketing, Subcontracting,…	III CASE STUDIES (in all themes)
2. **Quality**	
2.1 Housing/Building and Product Liability ● Certification ● Assurance ● Control	A NEW CONSTRUCTION (in all themes)
2.2 Quality Management of Housing/Building Projects and Firms ● Quality Management ● Quality Assurance ● Quality Control ● Quality Evaluation	B REHABILITATION (in all themes) C MAINTENANCE (in all themes)
3. Economics	
3.1 Cost Modelling	
3.2 Economic Evaluation-Deterministic, Risk,…	

3.3 Economic Optimization	
4. Information Technology (DB, IDB, CAD/CAM, KBS, DSS, RS, VT)	
5. General (Management/Quality/ Economics, Building Technology)	

It is difficult to summarize the principal subjects treated in the different chapters. In fact, the great number of papers included ensures that the majority of the subjects in management, quality and economics are dealt with, in more or less detail, depending on the contributions.

Part One—Management
The subjects covered include the management of projects and the building firm with particular emphasis on the following:

- Strategic management studies.
- Management information systems.
- Construction site management.
- Integrated management in the building firm.
- Contracting and subcontracting.
- Human resources management.
- Procurement methodologies.
- Safety and health management.
- Bidding systems and contract strategy.
- Management of design.
- Time/cost management of projects.
- Expert systems in management.
- Risk management and building failures.
- Industrial planning and control methods applied to building.
- Work time modelling.
- Cash-flow planning and control.

Part Two—Quality
The majority of contributions in this part belong to the fields of quality management and quality assurance, both for building projects and firms. The European standards EN 29000 are beginning to be the object of great interest.

Building quality evaluation, both in design and in construction, the relationship of quality to other fields (e.g. technology, economics, pathology, insurance, human resources, research, education and others), the certification of products and housing quality profiles are also covered.

The following subjects are addressed:

- Quality evaluation and control in design and construction-methodologies and case studies.
- Quality in rehabilitation works.
- Overall approach to quality.
- Quality assurance for clients.
- Quality management and assurance of building projects.
- Quality management and assurance in the building firms.
- The use of EN 29000 in construction.
- Implementation of quality assurance programmes.
- Inspection and testing plans and procedures.
- Quality and the consumers.
- Quality and education.
- Quality and technology.
- Quality, pathology and insurance.
- Certification of construction products, building projects and firms.

Part Three—Economics

The subjects included in this part cover a wide range; real estate appraisal, cost modelling, design economics, economic evaluation methods, economics of maintenance and facilities management, economics of rehabilitation and many others.

The following subjects are addressed:

- Real estate appraisal methods.
- Cost estimating methods.
- Economic evaluation of building projects.
- Economics of residential areas.
- Economic evaluation of public buildings.
- Asset management.
- Property portfolio management.
- Systematic evaluation on site for rehabilitating buildings.
- Cost estimation in rehabilitation.
- Renewal theory and strategic maintenance management.
- Economics of maintenance and facilities management.
- Case studies in maintenance and rehabilitation.
- Asset management manuals.
- Quality evaluation and control in design and construction-methodologies and case studies.

Part Four—Information Technology

In this part are included contributions belonging principally to the following areas: information technology systems, integrated data bases, knowledge-based systems and CAD systems.

The following areas are covered:

- Project databases.
- Expert systems in design, construction and housing administration.
- Design review and IT.

- CAD in structural design.
- Presentation of CAD systems in building design.
- Expert systems in rehabilitation.
- IT in housebuilding management.

Part Five—Policy

The subjects included in this part cover the present situation of the construction/housing sector in several countries, the presentation and analysis of some alternative building policies and the influence of some policy frameworks, such as regulations, codes and others.

The following subjects are emphasized:

- The market for the building industry in countries or regions (United Kingdom, Germany, Nordic, Turkey and others).
- Housing in Latin America and in the Portuguese speaking countries.
- Regulations, codes, standards and affordable housing.
- Development of a European housebuilding industry.

Conclusion

The areas of building construction management, economics and quality are becoming more and more the object of international research, practice analysis and application. The need to create a consistent body of knowledge for building project management and building firm management which attempts to address rigorously the areas of management, quality and economics seems to be a goal to aim at in the near future, at both a European and an international level.

This aim will only be successful if it puts together the industrial, educational and research systems and creates networks of technology development and transfer, i.e., linking and strengthening theory and practice.

This book and the Symposium on which it was based are a first step on the road to reaching this goal.

A.A.Bezelga
P.S.Brandon

PART ONE
MANAGEMENT

1
The client's brief: a holistic view

P.BARRETT

Abstract
This paper considers the construction briefing process starting with the traditional perspective. Consideration is then extended by viewing briefing, respectively, as communication, leadership and teamwork. The issue of the "worldview" taken of the client is then treated.

A holistic view of the briefing process is then presented and, within this context, a contingency approach suggested with the client's level of knowledge as a major independent variable.

Keywords: Briefing, Construction, Holistic View, Project Management, Facilities Management

1 Introduction

Establishing the client's brief is, of course, a critical step in any construction project. By this means the client's requirements are set down: time, quality and cost parameters are defined around the central issue of the physical artefact desired by the client. Although this sounds straightforward the process is, of course, complex and the result uncertain. This paper reviews the traditional approach to briefing and then moves on to more complex views.

2 Traditional Views

The Banwell Report stated strongly that clients:

> *…seldom spend enough time at the outset on making clear in their minds exactly what they want or the programme of events required in order to achieve their objective… (MPEW, 1964)*

It recommended that greater effort should be made to establish the brief and further criticised professional advisers for not emphasising that this is 'time well spent'. It is clear from this that the ideal brief was seen as a well defined input at the start of the construction project.

The way in which the client's brief links into the construction process is very clearly defined in the RIBA Plan of Work (RIBA, 1967). Here the brief is developed from Stage

A (Inception) through to Stage D (Sketch Design) via feasibility studies and outline proposals. It is then stated that the *"brief should not be modified after this point"*. That is, no change should occur as the scheme is designed in detail, production information prepared, or while the Works are tendered or executed. At the *end* of the process Stage M allows for 'Feedback'.

The Plan of Work was criticised in a study by the Tavistock Institute for the *"sequential finality"* (Tavistock, 1966, p 45) implied by the step-by-step process. The need to adapt to the client's changing needs and to new information as it comes to light are both stressed (p 47).

A further area of concern raised revolves around the oversimplified use of the term "client" which is often, in reality, an organisation with competing factions. Thus Tavistock use the term "client system" and suggest that there is a need:

> *…to be very much more aware and responsible in developing the brief through a more conscious understanding of the whole field of social forces they must work with. (p 40)*

One reaction to this problem is provided in the Wood Report (NEDO, 1975) which focussed on public sector clients and suggested that:

(a) a senior officer of the user department should be appointed as the client's representative for each project to coordinate requirements;
(b) for large or complex developments, a project manager should be appointed to assume overall responsibility;

Thus, a mechanism to orchestrate the requirements within the client organisation is proposed and the integrating role of the project manager is suggested, typically focussed on the construction team. An erosion of the traditional "linking pin" (Likert, 1967) role of the architect is implicit in the above developments and the need for clear communication between the principal parties is thereby made explicit.

The above reports generally put forward a view that the "traditional" approach to construction in the UK requires a full brief at the start and that this should not be changed thereafter. A dissenting view is provided by the work of the Tavistock Institute. From whichever angle it is viewed successful briefing relies critically on good communication.

3 Briefing as Communication

Bejder (1991) insightfully suggests the application of the Johari Window concept (Luft, 1970) to the briefing process. This assists in the analysis of the process of communication involved and highlights possible problem areas. The framework provided by the Johari Window (adapted to the subject analysis) is given in Fig. 1, below:

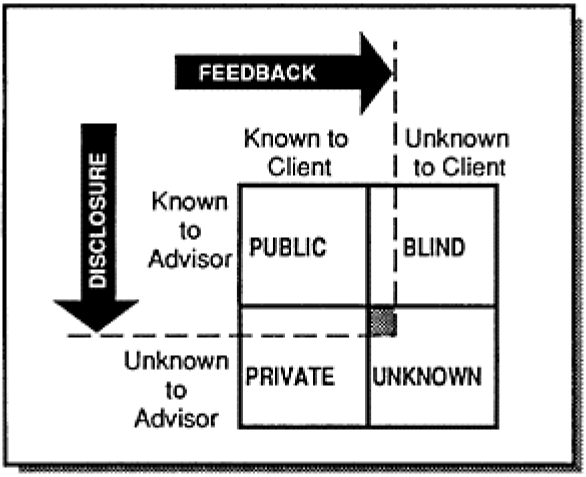


Fig. 1. Johari Window View of Briefing

From the diagram it is clear that there are four main situations to consider. The "public" area represents the client communicating without difficulty his requirements to the professional advisers. The "blind" area can be seen to be the needs of the client that are identified by the adviser through two-way discussion *(feedback)* even though the client cannot initially articulate these needs himself. The "private" area relates to the information that the client does not *disclose,* whether purposefully or not. The "unknown" area is not known to the adviser or the client, but through the twin processes of feedback and disclosure this last area can be revealed, at least in part.

If the brief is to accurately and fully represent the client's requirements then the importance of advisers encouraging clear disclosure and providing feedback information to the client is apparent. This argues for close and freeflowing discussion possibly over a considerable period. This need not of necessity be limited to the early stages of the project.

The communication process is that much more complicated if the "client" is in fact a group of people or an organisation. In this case the communications must be multi-stranded both in terms of disclosure and feedback.

In the above briefing is viewed in global terms. Recent work by Gameson (1991) has analysed, at a detailed level, the process of communication between clients and professionals in the initial stages of brief formation. This was achieved by recording the discussions and breaking down the content into categories. The predominant types of interaction were: "giving orientation" (information) and "giving opinions" with, to a lesser extent, "agreeing". Thus, *disclosure* and *feedback* are key areas as anticipated.

A very interesting finding was that the inputs from the parties varied considerably from one case to another depending on the client's prior experience of construction. For instance, with an experienced client the architect only spoke for 36% of the time, whilst the client made a 64% input. In contrast, taking a case where the client had no previous experience of construction, the comparable percentages were 76% and 24%. A complete reversal.

It is clear from this work that the briefing process will be quite different depending on the experience the client brings with him. This argues strongly for a *contingency approach* to briefing. The objective is to identify the appropriate approach to briefing in particular circumstances. One independent variable is clearly the project relevant knowledge-base of the client. Are there others?

4 Briefing As Leadership

A fuller view of clients can be obtained by viewing the briefing situation in terms of situational leadership theory. In this literature the distinction is made between the task-related needs of the follower and the sociometric dimension (Hersey and Blanchard, 1982).

Clients want their professional advisers to do something they cannot, or do not want to, do themselves. The relationship is founded on the adviser giving the client something he lacks. In all commissions the client will expect the professional to “get the job done”, but the actual contribution made may differ considerably, especially at the early briefing stage as shown in Gameson’s work, described above. This work did not however distinguish the two dimensions drawn from leadership theory. Taking these dimensions together a matrix can be formed as shown in Fig. 2, below.

	SUPPORT NEEDED	
	A LOT	VERY LITTLE
KNOWLEDGE NEEDED: A LOT	*"Help me through it"*	*"Give me the extra space"*
KNOWLEDGE NEEDED: VERY LITTLE	*"Do it so I can check it"*	*"Get on with it"*

Fig. 2. Typology of Clients Based on Their Needs

The professional is generally leading, providing varying degrees of knowledge and support to the client depending on the client’s particular needs, however, in the case of a very knowledgable, confident client the roles may be reversed with the client taking the lead (influencing). The client types given in the grid can be typified as follows:

Table 1: Suggested Typical Client Types

Description	Explanation
"Help me…	Often the naive private individual involved in construction for the first and possibly only time in relation to a very personal project. A lot of knowledge and support required from the adviser.
"Do it…	This client is often a representative in a large organisation which has a lot of its own procedures and requirements, for example many local authorities. The representative has to "cover his back" and demands support for this despite a high level of relevant knowledge.
"Give me…	Clients in this category have little interest in construction per se. It is a means to an end, for example a factory extension required for increased production. Little support is needed, but a lot of knowledge must be supplied.
"Get on…	This client is knowledgable and confident, say a developer client. He does not need support and can articulate his requirements clearly. That done the onus is on the "adviser".

Although the above model is crude, the message is clear: advisers must diagnose their client's individual needs if the appropriate input is to be provided to the briefing process.

5 Briefing As Teamwork

The briefing process can be viewed as a *team* effort between the various parties. There are many categorisations of the various types of team members to be found in a team, however, to be effective such groupings should ideally have *complementary* abilities, but *compatible* underlying norms (eg Handy, 1985).

Based on his work in this area Powell (1991) argues that clients should:

(a) *"…understand their own needs first and then… secure a design/build team who will reflect their own view of the world."*

(b) choose a design team which displays a full range of *functional* roles and *team* roles by bringing together a group of complementary individuals thus releasing latent synergy. The functional skills has been discussed above in terms of the knowledge requirements of the project. At an individual level psychosocial factors have also been considered in terms of leadership. Powell's perspective extends consideration to include the group dynamics necessary for the team to achieve its objectives.

A central point in Powell's analysis is that:

> *"the skills required to produce truly user responsive buildings can no longer exist in any one designer/builder"*

Thus, the issue of effective groups is inescapable. This is very sweeping and, although undoubtly resonant with a strong trend, it is possible to imagine a private individual with straightforward needs who would be manageable for a single designer.

The principal generator of the overload on the traditional designer is the need to accommodate a wide variety of perspectives within the client system if buildings are to be created that satisfy the wide range of demands. Thus, it can be seen that a fuller appreciation of the client’s requirements leads to the need for a more elaborated construction team. And it is inevitable that the issues of communication and leadership discussed above will be of critical importance *within* the design team as well as between the client and the “team”.

There is also the question of the contractor’s early involvement which seldom occurs in the traditional approach to construction in the UK. This has long been criticised and various newer approaches are allowing the beneficial inputs possible, such as Design and Build. This radically changes the roles of those involved in construction and other forms such as Design Led and Build are emerging where architects are acting as lead consultants *and* contractors (Nicholson, 1991). There is not space here to pursue this area, but the issue is clear—the range of factors and involvement is variable on the building team side in just the same way as within the client system.

The above considerations are inextricably linked to the issue of a project management role drawing together the participants within the *construction system* and focussing them towards the client’s objectives (eg Walker, 1984).

A key factor implicit in all steps of the discussion so far is that the starting point for any analysis should be the choice of view taken of the “client” and the level of complexity thus admitted.

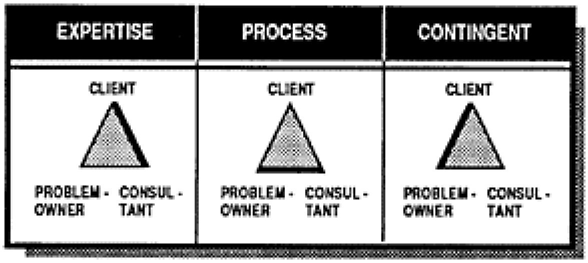
6 Views of the Client

The Lancaster School of Management (eg Wilson, 1984) stresses the importance of the “worldview” (“W” for Weltanschuung) taken of any problem that is being analysed. Solutions found will be inextricably bound up in the orientation of the decision-maker. Ask an architect and you will get a design-biased answer, ask a quantity surveyor and you will get a financially-biased answer, ask an engineer and you will get a technology-biased answer and so on. Over simplified, yes, but broadly true.

Apply this to the question of briefing and it is clear that if an adviser’s “W” of his “client” is of someone who has funds and is looking for a quick return then the briefing process will be quite different in substance and style from an adviser whose “W” includes, say, longer-term issues, the user and society at large.

Obviously the “W” adopted will be conditioned by the client to a great extent, but there are many other forces at work such as education and professional conditioning and simply an awareness of the possibilities.

Drawing from his observation of trends in management consultancy (Garrett, 1981) suggests that the consultant will often have to deal with the client and the “problem-owner” (who is often not the client, for example tenants) and that this has led to three different styles of consulting becoming evident. These are shown in Fig. 3, below.



Fig, 3. Garrett's Alternative Consulting Styles

Expertise consulting is the traditional approach. Process consulting is where the consultant works predominantly with the problem-owner, but this can unsettle the client. Garrett favours contingency consulting which is where the consultant draws out a solution from the client system including both client and problem-owner. This assumes that *"…most of the experiences needed to solve a client's problems are already in the organisation."*

Research by Bejder (1991) in Denmark focussed on University buildings confirms the importance of involving in the briefing process all parties whose needs should ultimately be satisfied. In the study cited the views of students, administrative staff, cleaners, maintenance workers, funders, designers and others were included. Comparing two building phases of the same University it was found that the appropriateness of the involvement in each phase did correlate with the differences found in the quality of the buildings against a range of criteria.

This broadening of perspective when viewing the client system is consonant with recent developments in the field of facilities management (eg Becker, 1990, pp 123–151).

7 Summary

The question of the client's brief has been approached from a variety of directions. In mapping out the range of factors, and therefore actors, who should be involved it has become clear that the formal, or traditional, view of the process is greatly over-simplified and excludes many factors that can be crucial. This coarsening of the analysis occurs both in the worldview ("W") taken of the client system and the "W" of the building team. Generally the architect and the particular part of the client system that has the need (the "instigator") are the focus for the analysis. Fig. 4 shows the parallel trends (Bertalanffy, 1971) within the two systems towards a broader view, symbolised by the *project manager* in the construction system and the *facilities manager* within the client system.

Taken together these trends suggest a more holistic view developing which is bound to influence the briefing process, also depicted in Fig. 4., below.

When the project manager talks to the facility manager sparks should fly!

Having said that, in addition to the range of factors involved, the *nature* of the interaction and the outcomes of different scenarios has been considered. A *contingency* *approach* has been suggested depending on the client's knowledge and confidence and also driven by the range of functional and team management skills required which itself will depend on the breadth of view taken of the 'client'. Tentative evidence has been adduced to support the proposition that those whose needs you are trying to satisfy should be involved in the briefing process.

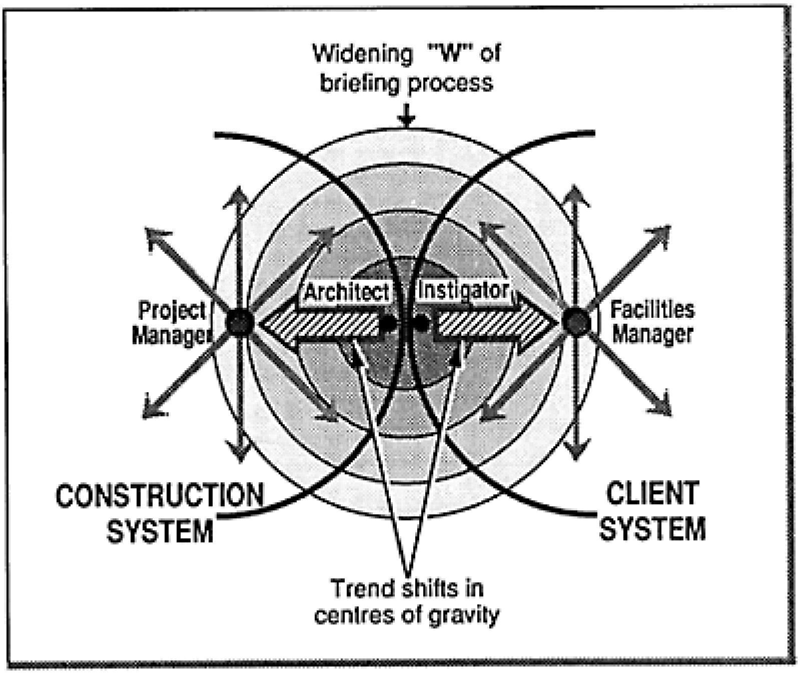


Fig. 4. A Holistic View of the Briefing Process

8 Conclusion

When those in construction approach the briefing process with a client it seems reasonable to suggest that they should initially consider:

(a) how extensive a view to take of the client and construction systems;
(b) the location of pertinent knowledge and experience; be it with the client, the designer, the contractor, etc.;
(c) contingent on the outcomes of (a) and (b), how to satisfy the client's needs through consideration of alternative structural and technological responses (Galbraith, 1973).

In any particular instance it is quite possible that the traditional approach will be appropriate, however, it is also entirely conceivable that a broader view may be required.

9 References

Barrett, P.S. and A.R.Males (Editors), 1991, *Practice Management: New Perspectives for the Construction Professional,* E and F.N.Spon, London

Becker, F., 1990, *The Total Workplace: Facilities Management and the Elastic Organisation,* Van Nostrand Reinhold, New York.

Bejder, E., 1991, "From Client's Brief to End Use: The Pursuit of Quality" in Barrett and Males (1991), pp 193–203.

Bertalanffy, L.Von, 1971, *General Systems Theory: Foundations, Development and Applications,* Allen Lane, The Penguin Press.

Galbraith, J.R., 1973, *Designing Complex Organisations,* Addison-Wesley, Mass., USA.

Gameson, R., 1991, "Clients and Professionals: The Interface" in Barrett and Males (1991), pp 165–174.

Garrett, R., 1981, "Facing Up to Change" in *Architects Journal,* 28/10/81, pp 838–42.

Handy, C.B., 1985, *Understanding Organisations,* Penguin, Harmondsworth.

Hersey, P. and K.H.Blanchard, 1977, *Management of Organisational Behaviour: Utilising Human Resources,* Prentice-Hall, New Jersey, USA.

Likert, R., 1967, The Human Organisation, McGraw-Hill, New York.

Luft, J., 1970, *Group Processes,* Second Edition, Mayfield Publishing Co., Palo Alto, USA.

MPBW, 1964, *The Placing and Management of Contracts for Building and Civil Engineering Work* (Banwell Report), HMSO, London.

NEDO, 1975, The Public Client and the Construction Industries (Wood Report), HMSO, London.

Nicholson, M.P., 1991, "The Procurement of Architectural Design Services, Particularly Regarding Design and Build Contracts" in Barrett and Males (1991), pp 50–58.

Powell, J., 1991, "Clients, Designers and Contractors: The Harmony of Able Design Teams" in Barrett and Males (1991), pp 137–148.

RIBA, 1967, *Plan of Work,* RIBA, London.

Tavistock, 1966, *Interdependence and Uncertainty,* Tavistock Institute, London.

Walker, A., 1984, *Project Management in Construction,* Collins, London.

Wilson, B., 1984, *Systems: Concepts, Methodologies and Applications,* John Wiley, Chichester.

2
Management information systems: the use of work breakdown structure in the integration of time and cost

A.T.BAXENDALE

Abstract
A systematic way of defining and identifying the division of production activity is considered. The work package is analysed to classify the varying resource requirements of construction programme activities. Criteria for a work breakdown structure for production control models are reviewed. Problems in integrating time and cost control are considered based on a case study of an integrated reporting system. Finally criteria for a project control model are given.
Keywords: Management Information, Work Breakdown Structure, Integrated Production Control.

1 Introduction

The incompatibilty of estimating with the production process and any relevance to resource control was noted by Blyth and Skoyles (1984). In competitive tendering the completed building should reflect the information provided at tender stage but rarely does so. Any calculation of resources at the start of a contract will therefore remain fluid for much of the duration of the building process. Resource control is seen to involve labour, plant and materials; but information is also a resource. It is in the form of drawings, specifications and instructions and required control. A limited proportion of resources are in the direct control of the site manager when there is a high element of subcontracting.

The direct cost of production (labour, plant and materials) plus the indirect costs (site staff, accommodation and the like) can be readily derived, but the detail is in different forms from that in which resources are developed or consumed. It is impossible to provide any degree of control without the provision of good budgetary information and the problem is one of quantifying needs. Those reflected in the documentation of the contract are often in the wrong terms. The principal skill in production control will lie in procedures that enable site managers to apply their resources flexibly in a changing environment.

2. Activity based schedules

The existing standard methods of measurement were not designed to produce bills of quantities that relate to work items or cost centres. The organisation of construction in the UK reflects traditional practice and there is inherent resistance to change.

McCaffer and Tyler (1986) recognised that, given forms of contract where contractors are required to produce their own data, it is possible to study aspects of contract control unconfined by bills of quantity. The effectiveness of computer based control and information transfer in contracts where the contractor originates basic data on measurement, time and cost can be evaluated. The use of activity schedules as a control and information source is then worthy of research. Such systems should:

> Create a greater awareness of progress. Ease the task of interim measurement and valuation. Assist in assessing the impact of variations on time and cost.
>
> Facilitate in the valuation of variations.

If data drawn from activity schedules is appropriately coded then the computer can sort by operation sequence, trade, phase or element. Having sorted items they can then be listed. The system can respond to the manner in which a demand for information occurs.

3 Work breakdown structure

A systematic way of defining and identifying the division of production activity is required. The need is for a Project Breakdown Structure or Work Breakdown Structure (WBS). This involves an elemental dominance in definition such as foundations, frame or external cladding. WBS is a hierarchical method of breaking down a large project into the services and work items required to produce the end product (Lavold 1983). The result is a hierarchy of portfolios of smaller projects, each with their responsibility defined and allocated. WBS descriptions which are synonomus with network activities in a master or overall programme (produced at pre-tender or pre-contract stage) create the link between elements and their progress. By allocating resources we can then proceed to cost.

3.1 Work package

The work package classifies the varying resource requirements of network activities. The dominating influence on classification will be work section, trade, construction form or material and location. A clearer statement of construction logic is produced for short-term or stage planning. It should aid measurement for progress reporting. The work package breaks down the WBS for example: a suspended concrete floor slab could appear under formwork, reinforcement and concrete work packages; an electrical installation subcontractors work into location by floors. It is important, of course, that work packages are defined in a standard form for transfer to a data base. Retrieval for future planning or estimating is important for the full economic utilisation of such a system.

In detailed terms there are three dimensions to be recorded in a work package:

Physical characteristics (quality, specification and location).
Resourcing (personnel, plant, materials, work space and time).
Relationship to priced items of work.

A standard system of WBS will be required that has to be constantly applied to a firm's work to reconcile accounts with and between jobs. It will be necessary for the level to lie between summarised general information (too crude for meaningful comparison from job to job) and too detailed a collection of information (requiring too much administration). A problem is that some work packages are critical while others are incidental to contract sucess. A small negative value in one may be considerably more damaging than a large one in another. Warning and danger limits should be identified if control is to be exercised properly.

3.2 Integration

A uniform and consistent system of communication is required where data input or information produced by the various control functions can be sorted and reported on a common basis. Sharing data electronically is not enough for effective integration. For example, the value of work for an item and its cost must be allocated to the same work package if comparison is to produce accurate and meaningful information. The WBS will form the basis of communication between all control functions involved with a contract and therefore the use of a common WBS is required for the effective integration of a management information system. Integration is not the collection of data but the correlation of data so that variences can be calculated in relation to a standard.

The WBS is at a summary level for reporting time and cost in relation to master programme activities. The work package is at a detailed level for allocating labour and plant or labour only subcontract use of resources. An example of a coding application for an insitu reinforced concrete internal wall is shown in Table 1. The coding system relates to that devised by Baxendale (1987). Additional coding digits will be required for location and subcontract identification that are contract specific.

Table 1. Work breakdown structure and work package coding.

ALL superstructure	2	0		
Superstructure internal walls	2	2		
ALL concrete work			E	0
Insitu concrete			E	1
Formwork			E	2
Reinforcement			E	3
WBS code	2	2	E	0
Work package code: Concrete	2	2	E	1
Formwork	2	2	E	2

Reinforcement	2	2	E	3

4 Work breakdown structure criteria

The criteria devised for production control models based on a WBS are as follows:

(a) Each work package is to be identified as a network programme activity (each activity will also have to be a work package).

(b) The definition of each work package for each contract will have to be identified and agreed by all who use the system (estimator, planner, contracts surveyor and site manager).

(c) Data will have to be collected in relation to the work contained in each activity.

(d) Activity data will have to include resources that are to be the subject of control (labour, plant, site overheads and materials in order of priority).

(e) The input of data will be site based and the output of information reported for both contract and company.

(f) Updating of work package content will be necessary for any variations in quantity or value.

(g) The coding of work packages in a standard form that is transferable from contract to contract for comparison.

(h) A statistical data collection facility in relation to an historical input to a data base (mean, range and distribution).

(i) Recognition that different criteria will apply to subcontractors who are controlled on site by performance and quality only.

(j) Easily understood by all those who use the system.

5 Integration of time and cost

The integration of a planning (time control) system and a budgeting (cost control) system gives rise to a number of problems. However cost information cannot be meaningful unless it is related to a time frame (Sancho 1982). The major functions of a planning system are to:

Establish a work programme (or schedule of objectives).

Report progress of the work.

Identify deviations from plan.

Show a projected schedule for the remaining work.

Show the effect of contract changes.

The primary functions of a budgeting system are to:

Establish cost objectives.
Report historical costs to date.
Show estimated costs to date.
Compare estimated with actual costs.
Show the effect of changes.

The functions of control systems are:

To set standards (performance objectives).
To measure output and compare it with standards.
To react to unacceptable deviations by signalling them.
To repond to signals by providing a basis for decision making in respect of any corrective action.
To facilitate that action.
To review standards.

5.1 Alternative methods of integration

An information system that integrates time and cost has two important requirements:

Integrated data collection based on consistent cut-off dates and single data sources.
Reporting that reflects both cost and time effects on project performance trends.

Two alternative approaches considered by Hermes (1982) are now reviewed.

The direct alternative:

Project costs can be broken down to agree with scheduled activities and will directly eliminate the structure mismatch problem. At the planning stage costs must be budgeted by activities and during project execution, budget accounts are opened and closed as activities are started and finished. Thus performance problems are detected early as each activity reports progress or is completed. This approach of work packaging is considered to have serious limitations.

(a) The practical problem of collecting actual cost by activity.

Scheduled activity breakdown often changes during project life and is more volatile than cost codes. Scheduling can require activities to be defined at levels of detail where cost data collection can be cumbersome. The reverse also being possible, for example tracking bulk material costs by activity.

(b) The factors that drive costs and schedules are not all same.

A material may not be purchased for only one activity. Operative and plant resources may be used across more than one activity.

The indirect alternative:

Cost and schedule breakdown remain different but both the structure and processing of data are interfaced where appropriate. There will be a common dependency on resource links for both cost and schedule. Reporting costs in the same format as schedules can be an artificial way of suggesting that integration exists. Progress is reported from the scheduling system which in turn integrates with a resource control system. Finally the resource control system is integrated with cost reporting, financial and accounting systems in which data is summarised into information. The indirect approach can be attractive to contractors who manage construction resources in the field. Implementing this approach requires a careful use of coding structures and information systems interfaces. The emphasis is on achieving cost/schedule integration without compromising the individaul objectives of each control function.

5.2 Level of detail for integration

Cook (1982) states that it is impossible to integrate cost and schedule systems effectively at summary level. Measurement of the criticality of the work being performed is required in order to give proper weighting to reports. To be successful, cost/schedule integration must be performed at the detailed level. The interrelating of the systems needs to:

Develop the cost system and the schedule system at the level of detail each independently requires.

Determine which cost items and which schedule items can be correlated.

Transmit meaningful and required data between the systems.

Realise that it is not possible to determine a direct correspondance for transmitting all information.

Analyse the information being generated by direct contact with the personnel involved.

Cost and schedule systems are compatible but not identical, every item cannot be integrated. Correlating data and analysing the resulting reports will improve the ability to develop, monitor and control both cost and schedule.

6 Case study of an integrated system

The application of an integrated time and cost control system is considered that was in use on a project. An integrated reporting system (IRS) is developed, with the emphasis on cost, to enhance an adequate existing short-term programming system. The reporting system is based on work packages which are broken down in relation to resource usage and location. A variance report is also calculated for each work package as a basis of forecasting for the total project. The problems found with data collection and presentation together with the implications for site mangement found are now reviewed.

The project ran without any major problems as regards progress, however, the failure of the programme to define distinct work package activities created problems. This was highlighted in the case of the edge strip and floor slab, but is of more importance in other areas, where whole sections of work were missing. On this project no builder’s work appeared in the budgets or on the programme and labour was released from the site too soon; this led to daywork bills for 2 men for 2 months. A simple mistake in grouping builder’s work with service sub-contract work could easily have been avoided had the IRS system been used.

With the traditional system the invoicing of materials provides the cost control point, however, this can lead to problems when assessing the cost of individual activities. This becomes more pronounced at the project level. At one stage of the project the profit to date was shown as £20,000 less than it should be. This was due to profits made on materials which did not come to light until after all the invoices had been collected.

To overcome this problem fully is difficult due to the historical nature of invoicing, however considerable improvment is made by the introduction of the IRS system. Each work package has its own budget, including materials and also has its own reporting sheet. Therefore full information on materials for each area can be applied, providing a good guide to the material costs in relation to budgets. In this way the future costs of materials can also be judged leading to a correct statement of profit and clear understanding of the contract status. The IRS reporting system would be weekly. This provides site management with a more up to date view of activity and resource needs at a time before problems occur and the project falls behind schedule.

The decisions that site management make will depend on two major factors, namely previous experience and the information provided by their control system. The IRS system provides a wide range of co-ordinated information on both costs and progress relevant to each clearly defined area for the contract, or work package. This should lead to more accurate and relevant decisions. Variance from the control plan can be accurately assessed and located at the root cause for correction. The availability of historical data adds to the previous experience of the management. The ability to forecast specific events, from data specific to those events, allows genuine control of cost and time, not merely historical confirmation of events.

In terms of data processing the administrative workload is increased. The effect of such a system on resource allocation on site and therefore for the company and industry must, if properly used, be advantageous. With increased accuracy in making decisions, resources will be more fully utilised, leading in turn to greater efficiency for all parties.

The case study has shown that there are many common elements between a cost system and a time system: the programme develops dates which are required for calculating cash flow forecasts; the budget estimate provides data for resource outputs required for determining activity durations and resource levels; the cost reporting generates information on work completed and payments made which relate to schedule progress; the remaining activities can be extrapolated to give cost at completion forecasts. The primary aims of integration are to transmit information between the systems, provide better utilisation of data and provide consistency of information between the systems. The advantages of integration shown agree with those reviewed by Shiring (1982). There is a natural dependency between when the work is scheduled and the spending of the budget and the budget can be phased over the time of the project. The effect of contract changes can be more easily found when both the budget and the schedule are involved, as well as improving the accuracy of estimates on completion.

7 Criteria for project control

Control of time and cost can be integrated through work packages. These can be defined in a standard form for continuity of feedback. The objectives and functions of each contributing resource data system should remain unaffected. A work package will relate to a programme activity and to an estimate of cost for that activity. It is the presentation of processed data in the form of variances in time and cost that should assist managers in controlling projects. The control system should also afford strategic aims against which the satisfying of user needs by the system can be measured.

A model to represent the practice of project planning, monitoring and control will have the following objectives:

(a) Model the projected work in terms of planned progress and cost using a common data base.

(b) Permit a comparison of actual progress and cost against planned.

(c) Identify the sources of variance and quantify them in terms of time and cost.

(d) Provide a means to explore operational decision making by allowing independent access at varying levels of detail.

(e) Record data on resource usage in relation to performance and cost to facilitate future planning and estimating (historical records).

(f) Relate the flow of funds for the project to the policy and performance of the organisation as a whole (accounting records).

(g) Recognise that user requirements are of paramount importance and that information from the system must be capable of influencing the decision maker.

The possibility of integrating time and cost data for site based control, at both the overall and detailed level, has been established. An integrated system has been devised in a case study that overcomes the practical problems of producing control variance and forecasting reports.

There is a need to integrate time and cost control systems, but for such information to be effective it must also be practical. Automated computer project control systems are available, but their success is more a function of how they are used rather than what the software can do.

Indirect integration can be achieved by using a common coding system which allows all existing systems to interface information. Careful use of work breakdown structure for programme activities at project level, particularly in relation to subcontracting, will overcome the problems of direct integration, provided that cost data is prepared in relation to activity format.

References

Baxendale, A.T. (1987) A Coding System for New Building Work, **Technical Information Service,** Chartered Institute of Building, No 86.

Blyth, D. and Skoyles, E.R. (1984) A Critique of Resource Control, **Building Technology and Management,** Journal of the CIOB, February.

Cook, R.R. (1982) Cost/Schedule Integration—Panacea or Poison, **American Association of Cost Engineers,** Transactions E-l.

Hermes, R.H. (1982) Cost Schedule Integration Alternatives, **American Association of Cost Engineers,** Transactions E-5.

Lavold, G.D. (1983) **Project Management Handbook,** Developing and Using Work Breakdown Structure, Van Nostrand Reinhold.

McCaffer, R. and Tyler, A. (1986) Managing Contracts without Bills of Quantities—with and without Computers, **Building Technology and Management,** Journal of the CIOB, January.

Sancho, W.M. (1982) A Critique of Integrated Cost/ Schedule Systems, **American Association of Cost Engineers,** Transactions A-3.

Shiring, P.B. (1982) Integration of Cost and Scheduling Systems, **American Association of Cost Engineers,** Transactions H-3.

3
Choosing between building procurement approaches-concepts and decision factors

G.S.BIRRELL

Abstract

The situation of the choice between various building procurement approaches is considered as' an early decision of the building client. Such decision will be in the context of his opportunity costs among the available procurement processes because each has a different effect on the execution of the various phases of the generic building procurement process as well as on the overall benefits and costs of the client from the building. Each procurement approach will be outlined in relation to phases of the generic process of building procurement. Decision/choice factors drawn from research projects on building procurement will be presented. The effect of each factor will be related to the procurement process with which it is most and least compatible.

Key Words: Buildings, Procurement, Client, Decision, Factors, Approaches, Traditional, Design/Build, Construction Management, Vendor/Provider, Program Manager, Cost/Benefit Analysis, Opportunity Costs.

Introduction

The choice of procurement approach for every future building project should be made as a specific choice to match primarily, the needs of the building's client. That choice should be made objectively, carefully and at its latest, prior to beginning designing of the building.

This paper discusses the concept of building procurement and a feasibility study approach including opportunity costs in each of the array of procurement approaches as a means of choosing the most appropriate procurement process for each future building project.

It goes on to outline each procurement approach and then presents four groups of factors which could lead to a more appropriate choice of procurement approach for a future building project by a more rational choice process than is generally used currently.

The stimulation for writing this paper came after carrying out and re-reading the results of two research projects on building procurement. During these it became very clear that numerous role experts in the building industry saw that the rational choice of one procurement approach came more from (a) the building clients' desire's from the procurement process, (b) the nature and current status of the client, (c) the nature and current status of the local construction industry as well as to a lesser extent, (d) the expected nature of the physical building.

The generic process of procuring most building's comprises the phases of Building Idea or Need, Feasibility Study, Design Process, Construction Contracting, Construction Process and Commissioning. In each phase consideration should be made of the effects of the management processes and decisions which guide this generic process as well as considering the materials of the building and its construction and erection work.

There are five alternative approaches to procuring buildings i.e. Vendor/Provider, Traditional, Design/Build, Construction Management, and Program Management. The choosing of one of them for each building project should be seen as managerial decision which, currently, is often made by default or ignored. This important decision should be made rationally and objectively and no later than before the design process begins. Furthermore, as this choice of one approach from an array of approaches can affect the processes of design, contracting and construction which in turn affects the quality, cost and duration of the building project for the client, it follows that the Feasibility Study for the building project should have variables based on the use of each of the alternative approaches to building procurement. Thus, there is a complementary relationship between the timing of the feasibility study for the building and the choosing of one building procurement approach from those available in the marketplace.

Research Process

All of the above and what follows was derived mostly from the results of two research projects examining building procurement approaches (1), (2). The balance of sources comes from reading, practicing and discussing building procurement over many years.

One of the sets of research results from which this paper was produced was a research report from face to face interviews with many building client/owners on the comparison between and strengths and weaknesses of various of procurement approaches. The other set of more specific research results from which the paper was produced was a series of six round table discussions at each of which there were usually two representatives of building clients, architects, general contractors, construction managers and sub contractors responding to a single questionnaire/discussion guide on construction management. These groups of exponents were chosen to represent top quality practitioners in their role in each urban area in which the meetings were held.

Subsequent to completing both of these studies this topic of why and how to objectively choose the most appropriate procurement approach for a particular project was considered, contemplated, the results reexamined and the paper written.

Building Procurement as a Concept

Building procurement implies the client receiving a physical building but also implies that the client has to pay for the building he receives. It is insufficient to consider that there is only the process of delivering a building from which there are flows of benefits-social and pecuniary- to the building client over its economic life. The form of payment is as a capital investment cost (including the cost of materials put in place plus human and machine construction resources used to do so) and functioning costs (maintenance and operating) of the building over its economic life. Furthermore, from these, the client can use the concept of value of the building, meaning that the maximum value is derived from the maximum difference between the life cycle sums of both the flows of benefits (social and pecuniary) and of the flows of costs (social and pecuniary) from the building.

The abstract opportunity costs derived from making the choice to use one building procurement approach over other available approaches should be built into this benefit/cost Feasibility Study phase of the generic procurement process for buildings. These opportunity costs of each procurement approach should be considered because they relate to the potentials to change both the degree of satisfaction of the needs of the building users and client and hence change the flow of benefits and change the flow of costs by affecting construction costs and its duration of negative cash flow as well as affecting the maintenance and operating costs of the designed building.

Choosing the Most Appropriate Procurement Approach

Making a rational, objective choice of one procurement approach from those available should be a major managerial decision for the building client because it will have widespread long term and short term effects on the client and his future buildings and the fortunes of both. Too often this choice is made by default or only made after the design phase is nearing completion or is made by choosing the current fashionable process which is being lauded in journals and publicity vehicles.

At the very latest this major decision or choice should be made before design begins. It should be made by choosing the one approach which is most compatible with (a) the needs of the client from the procurement process, (b) the nature and current status of the client, (c) the state of the current local building marketplace and (d) the resulting nature of the future building. As a result of careful thinking in making this decision/choice the project can be put in place with better “goodness of fit” to the needs, benefits, and costs of the client and building users than would be the case if the generic procurement process was always carried out by one procurement approach as a given rather than as a choice from alternatives. By objectively making the choice between these procurement alternatives, considerable latent value potential could be harvested by the client in the form of less cost in money and time and greater goodness of fit to the building users and client needs etc. The decisions and choices which create and crystallize most of the benefits and costs of any building occur mainly in the design and contracting phases.

Alternative approaches to building procurement are now sufficiently common that it is possible to see each as a separate alternative management technology for building procurement.

The Alternative Procurement Approaches

The array of alternative building procurement approaches available in the marketplace are Vendor/Provider, Traditional, Design/Build, Construction Management, and Program Management. Each has characteristics to best suit different clients, under different procurement situations and different marketplace characteristics. Each of these alternative procurement approaches has different characteristics and effects on the potential activities in the design, contracting, and construction phases of the generic building process.

Vendor/Provider and Program Management Approaches. In both of these approaches a building procurement expert agent is hired by the client to operate as the knowledgeable surrogate of the real client. This surrogate makes the choice of most appropriate procurement approach for each building project from among the three other basic approaches.

In the Vendor/Provider approach the agent will buy land, design, construct, and rent the building to the client based on how best to procure each building.

In the Program Management approach the agent will be an advisor or executant for the client on how best to procure each building in that program of buildings.

Traditional Approach. The client will hire the architect as his only principal agent advisor. The architect will be in charge of the whole design and all contract documents and contracting for construction. He will advise on the choice of contracting process and be an inspector of the building during construction but will not manage the construction process. The construction process will be carried out by and be the responsibility of a general contractor usually for a fixed sum of money.

The client has the advice of the architect throughout all phases of the procurement process but the architect’s capabilities are mainly in design and constituents of the building rather than in management of complex contracting processes and settlement of contractual matters before, during, and after construction.

Design/Build Approach. The client will seek from a single source, or say from each of three competing sources, a single contractual offer for a proposed building. Each design/build bid is based on either an outline building program or a proposed conceptual design, a set of contract conditions, outline specifications, a building delivery date and the lump sum of money bid for carrying out all the work of remaining design, contracting and construction.

Usually the contract conditions, delivery date and the lump sum for the building are fixed and the remaining design content and specifications are variables to be controlled by the design/builder which is usually dominated by the “build” side of the company or joint venture. Such control is to produce a building within the contracted lump sum by adjusting the design, its constructabi1ity, and specifications etc. by the design/builder who will hire local sub contractors to work under his own “build” staff operating as an internal quasi general contractor.

The client may not have the expertise to evaluate the constituents of the design proposals from each bidding design/build organization and may not even be able to write a feasible design program. The client will have no influence on what is designed, contracted or constructed after he has accepted the design/build bid, based on the above outline design and specification and all such decisions and work are carried out by the design/builder.

Construction Management Approach. The client hires both the architect and the construction manager before design begins. Then, the triumvirate of client, architect, and construction manager carry out and manage each sub phase of the procurement process as a core team with different but appropriate inputs and periods of participative leadership of that team. The architect will have the capabilities of a professional architect, he will be responsible for all design work required for the building and will manage all work of the array of design consultants. The construction manager should bring considerable abilities in providing construction related advice in costing, scheduling, constructability to the building as its design evolves as well as provide advice on appropriate structuring of contracting subtrade packages to match the current local construction marketplace as well as having capabilities to manage the construction process.

Decisions Factors by Which to Choose the Most Appropriate Procurement Approach

The format of use of these decision factors is to pose them as questions regarding the anticipated building project. For example, the first factor in Group A is-Clear or Unclear Objectives. Put as a question it would be "Does the client have clear objectives of what he wants as a result of the procurement process?" That he can state these clearly in writing is one response, if he is unclear of what he wants then such objectives remain to be established in the procurement process by his agents and a procurement approach which accommodates that should be sought.

Alternately, each factor can be seen as an "if" statement. If that state exists points to one procurement approach and if it does not, it points to another procurement approach to be best for the client.

After having evaluated the situation of the proposed building project by these factors there will be sets of votes from zero upwards for each or the alternative procurement approaches for that building project. The approach which gains the most votes is the procurement approach most likely to best satisfy that proposed building project. Furthermore, by spotting the factors which go against that most desirable approach can warn the procurement participants to carefully handle features under these factors as they carry out their work.

A client should be aware that the choice/decision of one procurement alternative may come from the permutation of factors rather than the individual factors. Thus, care should be exercised in moving from the apparent choice based on the sum of votes from individual factors to a final decision of which procurement approach is best for the whole project.

These factors are presented in four groups: Group A, Client's Objectives from the Procurement Approach; Group B, Nature of the Client; Group C, Marketplace Prevailing

Conditions for Procurement; and Group D, Client's Objective from the Physical Building.

Below, each decision factor is outlined within its group. Mostly, these factors were distilled from the results of the two research projects on procurement approaches for buildings. Also, suggested against each factor is its most favorable and unfavorable procurement approach. The examples of procurement approaches chosen for each factor resulted from thinking about the implications of each factor in relation to the nature of each alternative building procurement approach.

Group A: Client's Objective From the Procurement Process

1. Client's Clear or Unclear Objectives. Where the client is clear (with validity) on what he wants from the procurement process etc. he can benefit by inputting his clear objectives to the design/build approach but the more unclear he is about his objectives means he can benefit more from the construction management approach, unless the clear objectives dictate otherwise.
2. Client's Maximum Value. To achieve a building of best fit to his space and aesthetic needs along with minimum cost and minimum procurement duration is most likely to be achieved by the interactive multiple advice of construction management approach and least likely with the design/build approach.
3. Client's Desire for Maximum Control. Desire for maximum client control of details in the procurement process will come from construction management or traditional approaches. Least client control of procurement comes from the design/build approach.
4. Client's Minimum Construction Cost. Minimum construction cost to the client requires easy constructabi1ity from the design and competitive bidding for construction trade which could be achieved by the construction management or traditional approaches.
5. Minimum Calendar Duration of Procurement. Most likely to be achieved by the design/build or by construction management approaches whereas the traditional approach usually will consume most calendar duration.

Group B: Nature of the Client

1. Client's Knowledge of Building Procurement. A client whose knowledge of building procurement is considerable creates greater potential to reap the full benefits of construction management or design/build approaches. A client whose knowledge of building procurement is small could be best served by the traditional or construction management approaches.
2. Client's Willingness to Participate in Procurement. Greater client willingness to participate in procurement phases leads towards construction management and least willingness to participate leads to design/build.
3. Client's Entrepreneurial Risk Carrying Capability. The client who can mentally and emotionally tolerate knowingly being involved in entrepreneurial risks in the procurement process can benefit most from construction management and the opposite type of client would be best served by the design/build approach.

4. Client’s Operational Constraints. An organizational client which has bureaucratic rules by which to carry out most of his procurement is most likely to benefit from the traditional approach and has least potential to benefit from using the construction management approach.
5. Size of Client’s Organization. A large organization as client tends to have complexity in design programming and information handling which is best handled by the construction management or to a lesser extent, the traditional approach. A very small client would tend to benefit from the traditional or design/build approaches.

Group C: Marketplace Prevailing Conditions for Procurement

1. Status of the Money Markets. When interest rates and/or inflation rate is high then the approximately good design with high speed procurement of the design/build approach provides the best results where as the traditional approach probably provides the most benefit under the opposite circumstances.
2. Local Building Regulations. Very complex, multi agency or stringent building regulations can require special handling by the client’s agents during procurement which can best be done under construction management or design/build.
3. Ensuring High Quality Construction Skills. Ensuring high skill quality in construction work can be achieved best by the traditional or construction management approaches.
4. Ensuring Availability of Trade Contractors and Workers. Most achievable under the construction management and design/build approaches. The former is set up to benefit the client and the latter to benefit the design/builder.
5. Matching the Building Needs with the Local Construction Industry. This match can be best achieved by the construction management approach for the benefit of the client. Design/build can do the same but the benefits flow to the design/builder.

Group D: Client’s Objectives from the Physical Building

1. Unusual/Unique/Complex Building. The more extreme is the nature of the building the more likely it will be best procured by the construction management approach and least likely under the design/build approach. Simple buildings can be best procured by design/build or the traditional approaches
2. Quality of Functional Use of Building. High functional quality in design is best achieved with the traditional approach or construction management approach.
3. Quality of Materials in Building. Ensuring specified quality of materials in the finished building is best achieved with the traditional approach or construction management approach.
4. Requirements of Building Alteration Work. Complex integration of new to exisiting buildings and to enable the client’s organization activities to continue during construction may require uncommon building construction sequencing. Construction management approach can best satisfy this whereas design/build has the least potential to provide this satisfaction.
5. Neighborhood Surrounding the Site. The simplicity of procuring a building on a clear, open site would be best satisfied by the design/build and traditional approaches

whereas a central business district site tends to provide benefits from the construction management approach.

Conclusion

Making the choice of which procurement approach is most appropriate to the project should be by considering factors grouped under the client's objectives from the procurement process, the nature of the client, the nature of the current, local construction marketplace and prevailing conditions as well as features of the physical building. This choice/decision is very important for the client to achieve highest value from the building and should be made as rationally as possible prior to design and perhaps as early as the feasibility study for the project. Currently, this major choice/decision is usually made by subjective habit or default which precludes the client from benefitting from carefully considering the opportunity costs of each alternative procurement approach in the cost/benefit analysis feasibility of the proposed building project.

This paper suggests a research based outline of an improved way of selecting the procurement process for a building project.

References

(1) "So You Need a New Building?" A Guide to Clients on Procurement Approaches", by Dr. George S.Birrell, 1989, (copies available from the Executive Secretary, Florida Building Construction Industry Advisory Committee, c/o School of Building Construction, University of Florida, 32611, U.S.A.).

(2) "The Construction Management Approach-An Industry Executive Consensus", by Dr. George S.Birrell, 1991, (copies available from the Executive Secretary, Florida Building Construction, University of Florida, Gainesville, Florida, 32611, U.S.A.).

4
Factors and variables to induce effective construction schedules and efficient construction

G.S.BIRRELL

Abstract
The paper will present an array of factors deemed most important and variables stated as appropriate for inclusion in construction schedules. The sources of the underlying data were senior executives of general contractors and the research methodology was by a carefully structured and executed research process. The use of these factors and variables will be in creating effective construction schedules as guides to future efficient building construction work. Also presented will be the effect of these factors in the form of savings and losses on the costs and durations of building work from their inclusion in construction schedules.

Keywords: Building, Construction, Schedules, Factors, Variables, General Contractors, Effectiveness, Efficiency, Expertise, Cost Saving, Duration Savings.

Introduction

Implementation of buildings' designs means different things to different people. However, for the building to stand ready for use requires that it be built and presumably built as presented in the plans, specifications and contract documents.

The building process is complex and in it there can be considerable variances in efficiency of the building process from the different uses and choices of permutation of construction resources over the duration for construction. Also, the nature of the building, its design features, the specifications and contract conditions can cause increases and decreases in efficiency of the construction process from variances in resource consumption and/or durations of construction of parts of the building or of the whole building.

The result of considering all of the above variables for construction of a particular building is the schedule of the future construction process which is prepared as a guide to the execution of its actual construction process.

This paper addresses the topic of the factors and variables which provide the emphases and biases in construction schedules which lead to maximizing efficiency in the actual construction process.

The contents of this paper may seem strange and unusual to people who only design buildings. However, these contents summarize the views of general contractor experts in the construction process regarding effective scheduling and efficient actual construction of buildings. If the contents of this paper are unusual to designers of buildings that indicates a potential to learn about efficient construction of buildings. In turn these can be used to adjust designs, specifications and contract documents to facilitate efficient construction.

Alternatively, the contents of this paper may appear to lack uniqueness to people who are seeking the latest “way out potential solution” to all construction problems in the future. Seeking such a single solution tends to have failings which have yet to be perceived by such an uninitiated person. Rather, the comparatively simple suggestions to maximizing effectiveness in construction schedules and efficiency in the actual construction process presented in this paper comprise the consensus of the thinking of many top quality general contractor construction experts. It will be by appropriately applying them to each and every construction process that tending towards maximum construction efficiency can be achieved.

Source of Research Results in Scheduling of Construction

This paper is derived from the results of a research project which sought the views of senior construction executives on factors and variances in building construction schedules (1). Fifty senior executives were drawn equally from office based and site based executives of top quality general contractors companies which operated in major urban areas in a major growth state in the U.S.A. Each was questioned face to face on the topic of construction scheduling using a carefully prepared questionnaire prepared according to the tenets of social science research.

The Cost and Duration Effect of Including These Factors in Construction Management

It was the consensus of the views of these experts in construction of buildings that using their normally experienced construction schedule as their datum, if the factors mentioned in this research were included in a construction schedule that there would be a 10% saving in cost and 15% saving in duration in the actual construction process, These experts considered that If these scheduling factors were not included in the construction schedule that construction costs would be 17% higher than normal and durations would be increased by 30% from the achieved by a normal construction schedule. Thus, there is a cost range of saving 10% to losing 17% and a duration range of saving 15% to losing 30% from the datum of a normally experienced construction schedule based on the degree of inclusion or exclusion of these factors from the construction schedule. Thus, the client’s team of advisors wishing minimum duration and cost of construction i.e. a major part of the implementation of the building, should pay attention to the following factors in creating the schedule which will guide the actual construction process. Also, the contents of the bid package produced by the design team should pay attention to the following factors and variables in the creation of the design and its documentation as input to the construction process.

Most Important Factors in Construction Schedules

From a pilot research project among equivalent construction executives, forty-five factors were produced which affected the efficiency of the actual construction process and which were seen to be valid for expression in the construction schedule by whatever scheduling technique was to be used. In the subsequent main research project each of the fifty experts was asked to state the degree to which he used each of these factors. From the summation of the results, fifteen factors of the forty-five factors were categorized as most important. In order of their importance and only very briefly described these were:

1. Realistic Construction Duration. The overall duration for a construction process should be compatible with and usually derived from a realistic construction process and its duration. Too short or too long a duration leads to inefficiency and to arrive at an overall duration calls for study and creation of a realistic construction process.
2. Lead Time for Materials Delivery. The position of work tasks in the schedule should be set after establishing the realistic require delivery durations for its materials from their source and including shop drawing and contracting for supply as well as the logic of the on site construction process.
3. Required Types of Construction. By having to create a schedule forces an examination of the types of materials and construction processes as the schedule. Such thinking causes facing up to construction issues before they occur on the site so that surprises during the actual construction process are at a minimum.
4. Critical Pieces of Work. Work tasks which are critical to the overall duration or to the logic of construction or because of their geographic location in the building having the potential to cause construction complexities should be highlighted in the schedule as such. The thinking creating the schedule should dissolve as many of these bottlenecks as possible.
5. Work or Materials by Others. The construction schedule should be for all required construction work for the building including that of non contractors such as utility companies, work by the client’s workers and staff as well as inspections of work done by local government officials.
6. Previous Experience of the Contractor. The scope of the basic construction knowledge of the general contractor and his scheduling knowledge are both very important in producing or precluding a high quality schedule and construction process.
7. Complexity of the Project. A major function of the schedule is to dissolve the complexity of the construction process arising from the required design and express it in the simplest, best process for efficient construction.
8. Previous Experience of the Scheduler. The person making up the schedule or responsible for its creation must have high quality knowledge of construction

processes as well as scheduling capability and have the ability to blend together these two bodies of knowledge.

9. Subcontractor Input. The construction schedule should receive input from at least major subcontractors before or during its creation to solve their trade work problems and the conflicts from interactions among the work of most trades as efficiently as possible.
10. Contract Documents. The contract package of conditions of contract, specifications and drawings etc. should be carefully examined in order to focus on features which aid or inhibit efficient construction work.
11. Restraining Items. Required work items which restrain, block, or compound the start of other work items should be identified and a construction process should be selected to minimize their restraining influence.
12. Expected Productivity. The duration of work tasks and hence the whole construction process is dependent on the quality and numbers of resources used and the duration of use. The quality and duration of work is dependent on the productivity capacity of local workers. These expected productivity rates should be sought and used as input to scheduling.
13. Size of Project. To create its schedule, a large project can be analyzed to be an array of adjacent small projects. However, the results of such analyses should be to create one schedule meshed together as a whole schedule with the best overall construction strategy as well as containing or representing the required details. Once created it can be cut into sub sets relevant to the configuration of the local construction marketplace.
14. Communication with Others. The schedule once completed, has to be in a form, complex or simple, which can be communicated, understood and used by the people in contractors' offices, on construction sites and in the clients' offices. Thus, it must take into consideration their level of understanding and communication capabilities.
15. Conditions Which Affect Productivity. The local construction marketplace in which construction will take place should be examined and analyzed to establish major existing variables which will affect construction productivity at the time when this building will be under construction for inclusion in the schedule.

Types of Buildings and Their Variables in Construction Processes for their Effective Scheduling

In the main research project the views of the construction experts were sought on the constituents of the variables to be incorporated into the construction of different types of buildings to maximize efficiency of construction. These are presented below individually.

For each future construction process to be efficiently carried out, its input should be drawn not from only one of the following set of variables but from the permutation of variables expressed below appropriate to the type and nature of the future building. For example, an hospital could be high rise, of normal materials, of few repeatable work process etc. or it could be low rise of high quality materials and with many repeatable work processes. Thus, to effectively schedule construction work requires its creation to include these variances as well as the above factors.

The variables and sub variables are in the following groups: A-Quality of Materials, B-Height of Building, C-Degree of Repeatability of Construction Activities, D-Location of the Building, and E-Nature of Major Use of the Building.

A1 Building of High Quality Materials. These will require special scheduling attention to the delivery processes of such materials and the flow of materials and high skilled craftsmen to and across the site (as well scheduling of their construction processes). In the construction work schedule greater attention should be put on the greater volume of preceding support/work usually required to receive the high quality material finishes in the building.

A2 Buildings of Normal Quality Materials. Efficient construction and effective scheduling will require realistic appraisal of the availability and supply of highly productive workers to the site so that the flow of materials to the site will be scheduled and controlled to match the requirements of an efficient construction process.

B1 High Rise Buildings. The construction of high rise buildings requires scheduling of vertical movement of materials for all trades as well as their cross site movement. Construction work in the schedule should be expressed with maximum parallelism of the different required work flows. Establishing the sequence of parallel work flows should be derived from “cycle analysis” of the design of repeatable elements of the buildings. This should be preceded by expediting foundations and structural framework. The early enclosure of the building and bringing elevators into early operation require attention in the schedule.

B2 Low Rise Buildings. To achieve efficient construction, the schedule should focus on maximizing continuous harmonious work flows with minimum of interferences. This calls for high quality strategic common sequencing of all work flows around the building as input to the detail scheduling. Such strategic scheduling should include considering the layout of site support services and their movement on the site to support the changing locus of direct construction work. Enclosure of the building, structural framework, foundations, and installations of major pieces of equipment should be both executed quickly and carefully positioned in the schedule within the strategic sequencing of work around the building.

C1 Buildings with Many Repeatable Work Processes. The schedule should try to harness as fully as possible the learning curve benefits on as many resource flows as possible as they progress through each repeatable work item. This requires maximizing parallelism in the schedule and allocating resources to each flow so that the work on all flows are changes in resource allocations and inspections of work delaying the specific flows of work which then delay other flows of work. The design should be “cycle analyzed” to produce the best start sequence of work flows through the most repeatable location in the building.

C2 Buildings with Few Repeatable Work Processes. Efficient construction requires premium thinking on the logic of the interactions between the diverse array of work items so that down time between them is minimized. Complementary to the above is establishing a realistic duration for each work task. In this type of construction work a greater volume of information has to be handled expeditiously. Also, the use of work people with a broad array of skills is advantageous and all the above has to be expedited by management to achieve the most expeditious flow dynamics.

D1 Buildings in City Center Locations. Here careful scheduling is needed of the deliveries of materials to the site, their movement on site combined with carefully considered storage locations on site. The security interface between the site and the public must be maintained for safety of people as well as for security of materials on site. If materials are lost, considerable construction holdups can occur because their loss is not realized until the work is about to start. Scheduling of work expediting site utilities, subsurface work and providing appropriate lead times to bring subcontractors on to the site can also lead to efficient construction process.

D2 Buildings in Rural Locations, Here efficient construction work calls for focussing on ensuring that materials will be on site when needed and that there is security for the materials already delivered to the site. If the matters are not attended to, there will be holdups in direct construction work. Lack of required skill labor, in total or in calendar time, can impede the construction process as can the usually slow and awkward travel for materials to such sites. Early scheduling of on site utilities work and early availability of temporary power lead to more efficient construction.

D3 Buildings in Suburban Locations. Efficient scheduling of construction work in such locations should reflect compatabi1ity to local government ordinances, controlling working hours, material delivery times of the day and load capacities of streets. Carefully selecting and maintaining accesses to the site for all types of resources traffic and for security of adjacent properties should be built into construction work and its schedule. Also, work should be directed at maintaining separation of the site from the neighborhood for both the safety of children etc. and security of materials and equipment delivered to the site.

E1 Office Buildings. These tend to require sequential waves of work in the construction of (1) the shell and (2) tenant finishes. The shell work tends towards many repetitive work processes and the tenant finishes tends towards few repetitive work processes with high quality materials.

E2 Apartment Buildings. These tend to require waves of work processes which may be constrained by a strategic work flow to achieve completion dates for specific parts of the project and a balancing between maintaining stable sized work crews and minimizing time friction between work crews.

E3 Schools. These have their desired finish date as a major priority and tend to require careful scheduling of work particularly to dates of government inspections. Kitchens and heavy machines appear to be potential restraining work in construction.

E4 Factories. Critical types of work tend to be the foundations and bases and power supplies for machines as an early wave of work to be followed by the installation of the completed machines prior to their encasing by the fabric of the building. Thus, these two major waves of work should bracket the scheduling of installation of the machines.

E5 Hospitals. These tend to be unique buildings which require many stringent inspection clearances and quality considerations along with a critical mass of complex logical interactions among building parts and construction resources. Also, the temporary openings for the building in of special equipment has to be included in the construction process schedule usually after long delivery durations. Hospital construction which includes alterations to existing buildings should be scheduled interactively with new construction. Both should be scheduled around maintaining ongoing hospital services if the construction is adding a building to an existing hospital.

Conclusion

The factors, variables, emphases and biases outlined above can increase the efficiency of construction processes and increase the effectiveness of schedules created to guide construction processes. These elements can reduce cost and durations by 10% and 15% respectively by their inclusion in a construction schedule. Their omission from a schedule can add to cost and duration of construction 17% to 30% respectively.

As these factors and variables could provide such benefits to the participants in the construction of buildings it follows that for the client to also gain from such advantages requires every bid package (conditions of contract, specifications and drawings, etc.) should be examined for compatabi1ity to the above factors and variables to maximize the building features which are in harmony with them to lead to efficient construction of the buildings.

Reference

(1) “Construction Scheduling Factors, Emphases, Impediments and Problems as Seen by Construction Experts”, by Dr. George S. Birrell, 1988, (Florida Construction Industry Advisory Committee, c/o School of Building Construction, University of Florida, Gainesville, Florida 32611, U.S.A.)

5
The building procurement roles—their professional personalities and communications issues among them

G.S.BIRRELL and R.G.McGARRY

Abstract
This paper presents the hypotheses and results of a pilot research project into the professional personalities of role representatives in the building procurement core team of roles. This research was set up to seek and initiate the improvement of communication quality among members of the procurement team. While the hypothesis of different personalities for each role was found invalid, there is value in establishing the common professional personality which exists across all team roles. That personality type is the extrovert, sensing, thinking, judging (ESTJ) type. Knowing this, the vital topic of communication among them can begin to be handled more effectively to benefit the output of the whole team and other roles around it.

Keywords: Building, Roles, Communications, Personality, Temperament, Human, Professional, Testing, Management, Theory, Research

Introduction: Background and Common Notions

Organisational Theories and Managerial Communications

The concept is well founded in managerial literature that information is very important to the work of managers. Moreover, the closer the organisational structures reflect the needed lines of communication among managers the more efficient it will be. Some theorise that Information is considered as "the stuff" by which managers do their work (1) (2) and that information is the major input into the managerial major function of decision making (3) as well as being a major component of the managers others functions (4). Other theorists argue that about 80% of a manager's time is spent in communicating with others (5) and that a manager can expect only a maximum of half and hour without interruption from having to communicate others (6). It follows that the flow of information between managers is a fundamental component of the structure of an organisation (7), (8). Most of the above theories about communications in organisations were derived from whole, single entrepreneurial organisations. However, the principles derived therein apply equally to the ad hoc organisation described below for managing the procurement of a building. In fact, that the procurement organisation team is ad hoc and derived from the members of different entrepreneurial companies should increase the need for quality communications and information to promote team efficiency.

Information and Communication in the Bui lding d ing Project Team

For the effective execution of the entire procurement processes many different roles (identified below) are involved. A vast amount of information is necessary for completion of all work. Much of that information has to be processed and coordinated in an interactive and sometimes iterative manner among the participants. Thus, in order to maximise the performance of the whole team as a communication network there is great need for high quality communication.

The Building Project Team and Core Roles

Many roles are involved in the process of procuring a new building. The core set of roles are (a) the client for whom the building is to be designed and constructed, (b) the architect who is an agent of the client and who carries out the design process, and (c) the many specialist subcontractors who carry out most of the actual construction work. The work of the numerous subcontractors is coordinated on each building project by either (d) a general contractor or (e) a construction manager.

Usually, the client will seek the advice of many other disciplines such as real estate advisors, bankers, urban planners, and specialists within the client's organisation whose space needs etc. have to satisfied in the future building. The architect will direct and coordinate the required array of specialist design consultants whose expertise has to be coordinated to produce the design of the building. Each of the subcontractors has a trade speciality which requires the service of specific material suppliers and fabricators and specially skilled labour to perform that trade on the building project.

The two alternate coordinating roles between (i) the client, his agent, the architect and (ii) the subcontractors are the general contractor or the construction manager. The general contractor is an entrepreneurial role usually under contract to the client to coordinate the construction of the whole building as designed and specified by the architect. Alternatively, the construction manager is an agent of the client who provides advice on construction and contracting during design and contracting. This role may also be used to guide the execution of the actual construction process by subcontractors.

Thus, each major role in the core team has a subsidiary set of roles with which it generally interacts. Moreover, it is these core roles which, by communicating with each other, carry the building project through the building procurement process to fruition. Core role participants tend to operate within the context of two team formats and two time phases. For the two types of core teams, (1) general contractor and (2) construction manager, each major communications pattern is shown in Figure 1 below for (a) the design and contracting phases and (b) the construction phase. (9)

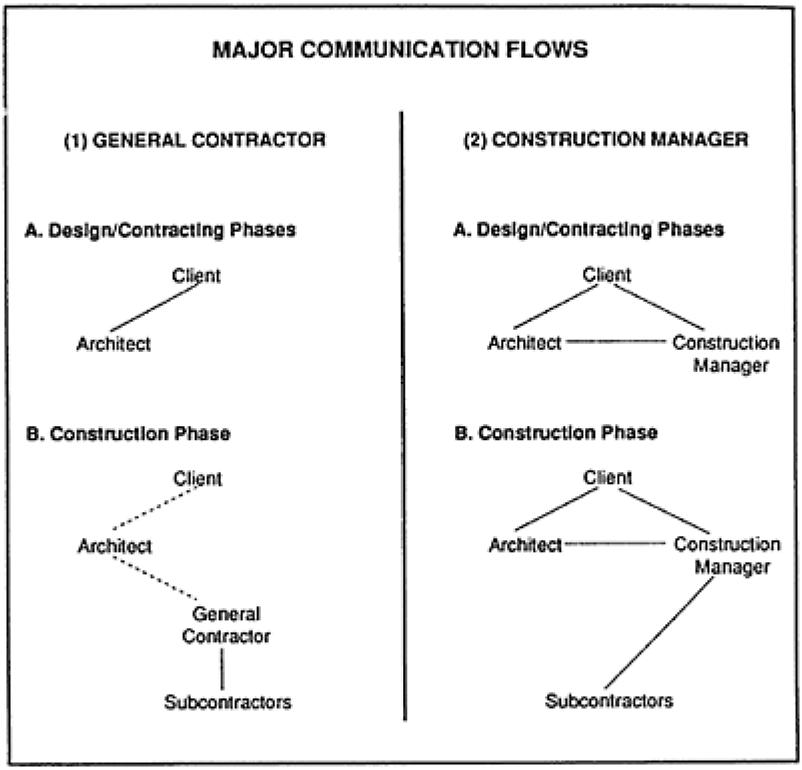


FIGURE 1

Establishing Role Characteristics in the Building Project Team

A major step in improving the quality of communications in the building project team would be to establish the professional personality of each member of the core team. Having done so, guidance could be provided to participants regarding how best to communicate with each professional role. This was the original objective of this pilot research project.

Underlying this assumption is the basic premise that each professional role would have its own individual or unique personality. Each of the core roles of the procurement team, client, architect, general contractor, construction manager, and subcontractor would tend to come from different, professional and perhaps even social positions. Certainly, the educational processes, formal and informal, through which each passes prior to entering their roles would be different. Moreover, it is possible that the perceived characteristics of each role would attract people with certain characteristics or the roles are known about by different types of human beings prior to their entering that role.

From the above, it was hypothesised: that communication quality is a major and probably essential feature in achieving the fullest effectiveness and efficiency of the building procurement core team of roles; that because of the professional interests, responsibilities and background of each core role were different, the professional personality of each core role would be different; that by discovering the professional personality of each different role, that communication to and from that role can be improved for the whole team during the whole procurement process.

Moreover, by so improving communication among the core roles there would be more effective and efficient management of the building procurement process.

People, Roles and Personalities

Characteristics of Individual People

Every individual possesses a predisposition toward certain beliefs and modes of actions (10). These researchers state that,

> people are different in fundamental ways. They want different things; they have different motives, purposes, aims, values, needs, drives, impulses, and urges. Nothing is more fundamental than fact. They believe differently: they think, recognise, conceptualise, perceive, understand, comprehend, and cogitate differently. And, of course, manners of acting and emoting, governed as they are by wants and beliefs, follow suit and differ radically among people. (10)

It is this fundamental notion as it affects communication

between the roles in the alternative patterns of teams managing the design and construction of building that forms the basis for this study.

Noted research psychologists Myers and Briggs present a way in which personality/temperament of individuals can be established and quantified in some measure (11). Historically, this Myers-Briggs Type Indicator Test has served as a valuable tool for measuring factors within individual personalities. This measurement of human personality is carried out by establishing the individual predispositions from among the overall array of tendencies in human personalities. It is possible to measure these tendencies by considering them in dyads and establishing patterns of temperaments. A simpler but close adaptation of the Myers-Briggs Type Inventory test is the Keirsey Temperament Sorter (10). It utilises four major personality dyads, the compilation of which is a measure of an individuals personality or temperament.

A caveat must be offered before presenting these dyads. The personality typologies discussed below are tendencies only. They are not to be taken as strict opposites. For example, a person who is termed a “sensing-thinker” is so labelled because he/she tends to be most comfortable in environments wherein objectivity, facts, and rules are prevalent. This is not to suggest that these individuals have no feelings nor do they, from time to time, creatively envision future possibilities.

The Four Personality Dyads

The first such dyad consists of extroversion vs. introversion. Extroverts tend toward "sociability" while introverts are inclined to "territoriality". In other words, extroverts prefer engaging in human contact/interaction and work well as members of a larger collegial team. Introverts, by contrast, perform best when given a task involving few other people, wherein they have an opportunity to analyse and elucidate a problem with little interference from others.

The second dyad consist of intuition vs. sensation. An intuitive type person is one which suggests descriptors such as "visionary", "speculator", "daydreamer". These persons are most comfortable performing tasks which demand that they look at possibilities for the future. Sensing types of people are those who are seen as "realists", relying mainly on experience and facts and who "notice the actual and want to deal with that. They focus on what actually happened rather than worrying about what might have been or what will be in the future" (10).

The third dyad of human personalities comprise a thinking vs. feeling axis. This opposition is somewhat self-explanatory. Thinking types tend to be most comfortable in environments wherein rules, norms, and overtly expressed objectives are observed, where as feeling types tend toward cooperative environments wherein people take precedence over the task itself. In other words, for the thinker, task resolution is of primary importance whereas, for the feeler, the communal process leading to a solution provides the individuals with satisfaction.

The fourth and final dyad is that of judging vs. perceiving. These terms are somewhat misnamed in that all persons maintain the capacity to both perceive and make judgements about their environments despite their temperament. However, a judging personality is a planner, a decision maker. The judging type does not like to leave unfinished business, but rather opts for reaching closure on a particular item. By contrast, perceivers tend toward fluidity of interactions. That is, they tend to postpone decisions in order to accommodate as much data as possible. Judging types of people tend to be satisfied once a decision has been reached, in stark contract to people who are perceivers who tend to possess disquietude over their decisions.

The application of the Kiersey Temperament Sorter can establish which of four elements are predominant in a subject's personality makeup. There can be sixteen permutations of results or sixteen personality makeups which can be described.

Research Hypotheses

As indicated above, the objective of this pilot research project was to state which of the sixteen personality types was attributable to each major role in the building project core team and then provide insight into how best to communicate with each.

Research Process

The Research Tool

The chosen means of establishing the professional personality of each role was the Kiersey Temperament Sorter (10). The more detailed Myers-Briggs personality type indicator test requires a trained professional to apply and score the test. Neither of the authors of this paper have that skill and as the Keirsey Termperament Sorter is a seventy personal choice questionnaire tool which can be administered by untrained personnel it was used in this pilot study. Furthermore, it assumed that the Kiersey Bates Personality Test could establish the personality of a professional group of people as well as for individuals.

Situation of the Research Work

An ongoing research project was funded to establish the essential features of the building procurement approach known as Construction Management. (12). The chosen research process was to hold six round table discussions in major urban areas of Florida, USA on this subject. The locations of these meetings were Gainesville, Orlando, Tampa, Jacksonville, Tallahassee, and Miami. The participants comprised two representatives of each of the core team roles i.e. building clients, architects, construction managers, general contractors and subcontractors. A crucial feature in selecting all participants was that they were seasoned professionals in their role.

Selection of Role Representatives for Research

The process of selecting the subjects consisted of contacting professional and business representative organisations in each locality such as the American Institute of Architects, the Associated General Contractors of America as well as Local Builders Exchanges. Additional information was obtained from locally knowledgeable acquaintances. During the initial contract, the nature of the construction management research project was explained and a request was made for names of top quality role representatives in the local design and building industry. From these contact sources, the seasoned professionals names were sought and compiled. The choices of participants represented the nature of the building procurement industry in that locality for public and private, commercial and services buildings. (Housing subdivisions participants were not included in the work type universe.) Role representatives were chosen as follows: building clients from public agencies and private real estate developers, architects from both large and small practices dealing with public and private projects, construction managers from national and local firms, general contractors from large and small firms and sub contractors from the electrical and mechanical trades who do a large percentage of the work constructing a building, but a few other sub trades were represented in one or two of the meetings.

The key ingredients sought in all the role representatives were that each had considerable experience in their role, had worked on many projects and would be willing to speak their mind on the subject of the construction management approach.

We did not gather specific information about each discussion participant but we know that all had at least ten years experience, most had twenty to forty years experience and some had experience greater than forty years.

At a couple of the meetings, one or two role representatives did not attend or show up due to sudden business emergencies. Proxies were sent on other occasions by their organisation for the same reason. In total, fifty five subjects, out of a potential complement of sixty subjects, participated (two representatives of each of five roles at six meetings).

Research Findings

Overall Findings

First and most significant finding was that all role representatives in the research universe exhibit approximately the same temperament type. That is, across the different roles in the core building team there were only minor variances in their professional personality. This finding invalidates a part of the original research hypotheses because there was not a separate professional personality for each major role.

Findings on Each Dyad

Considering this common professional vis-a-vis the four dyads it was found that most participants across all roles tend to be extroverted. Of the fifty five respondents surveyed, 80% showed strong indications toward extroversion. A mere 11% of respondents were scored as introverted types. The remaining 9% of participants were borderline, i.e. having an equal number of extroversion and introversion responses. Interestingly, the location of these minor introversion features is indicated on both ends of the building project management team. Among project owners (3 clear introversion scores, 2 borderlines) and architect/design engineers (2 clear introversion scores) on one end of the team and among subcontractors (3 borderline scores) on the other end. Apart from a single general contractor who was scored “introverted”, the remainder of the construction managers and general contractors display clear extroversion scores.

Considering the combination of the second and third dyad (intuition vs. sensation and thinking vs. feeling)) as a single temperament unit the majority of role representatives (73%) were “sensing thinkers”. This is indicative of a person who is a skilled organiser who prefers orderly processes and rule governed behaviour.

On the individual dyad of intuition vs. sensation, 82% of the participants were sensing types and about 15% were intuitive types with the balance being on the borderline. The feeling vs. thinking dyad results were that 89% of the participants were thinking types and 5 1/2% were feeling types with the balance being on the borderline.

The fourth dyad of judging vs. perceiving shows that the very large percentage of 94.5% of the participants were judging types. Only one project owner registered a positive “perceiving” score and two subcontractors were borderline. With a strong judgement component, it could be assumed that these role representatives are “comfortable judging others in terms of standard operating procedures”. (10)

The Common Personality in the Building Core Team

These results suggest that professionals in the building procurement process are sensing-thinking-judging (STJ) types with tendencies towards extroversion (E). This type of personality would likely have planned each stage in the process well in advance of actual negotiations with others. Moreover, this STJ type would likely have predicted and planned for most unforeseen circumstances which can (and normally do) occur in the building procurement process. However, the down side for the STJ personality would be his/her tendency to be more comfortable carrying out the planning process individually rather than as a member of a team. Moreover, because STJs tend to be fact-oriented, problems in communication can occur when the same facts are interpreted differently by different members of the team. Effective resolution of such conflicts is often facilitated by individuals in the team or added to the team who, according to Kiersey & Bates, are "capable of tracking the processes and ideas of others", and are sensitive to harmonious relations among team members (10). A team comprised solely of STJs may have trouble resolving communication conflicts due to the insistence of each member on "keeping on their own track". Thus, to gain more effectiveness from the expertise and professional capabilities of the normal role representatives in the team, their communication network could benefit by adding participants or communication skills of the type mentioned above.

Conclusions

The patterns discussed above and derived from this small pilot study lead to two fundamental conclusions. First, contrary to one of the initial hypotheses, there is a common professional personality among seasoned practitioners in the building process. Second, communications among the role representatives could be enhanced by each knowing that common personality type and by adding to that team participants who have some capability in sensing what other role representatives are saying and meaning in group or individual communications

Subsequently, two interesting hypotheses can be derived from these conclusions, meriting further research in this area. First, the findings may indicate that despite an individuals personality temperament upon entering the field of building procurement, over time, he/she develops an STJ temperament given the actualities of their work in building procurement process. Alternatively, the results may indicate that persons of similar personality temperaments may tend to cluster into the construction field.

In order to offer firm conclusions on these resulting hypotheses, diachronic tests, using the Keirsey Temperament Sorter, should be performed on a larger survey universe.

The second conclusion reached by this study is that communication among team members of this common type in the building procurement process can be enhanced by either the addition of personalities who are aware of and sensitive to the personality temperaments of their colleagues while furthering their own contributions to the team's objectives or each member of the core team could enhance the communications among the group by deliberately being more considerate of the thoughts and ideas of other team members.

The adjustment in communication role behaviour suggested above increases the potential effectiveness of the communication networks shown in Figure 1 of this paper.

References

(1) Burns, T. and Stalker G.M., "Management of Innovation", 2nd edition, (Tavistock Publications, London, 1961).
(2) Barnard, C.I., "The Function of the Executive", (Harvard University Press, Cambridge, Mass., 1938)
(3) Simon, H.A., "The New Science of Management Decision", (Harper & Rowe, New York, 1960)
(4) Mintzberg, H., "The Managers' Job: Folklore and Fact", (Harvard Business Review, July-August, Cambridge, Mass., 1975)
(5) Mintzberg, H., "The Nature of Managerial Work", (Harper & Rowe, New York, 1973)
(6) Stewart, R., "Managers and Their Jobs", (MacMillan, London, 1967)
(7) Leavitt, H.J., "Managerial Psychology", 4th edition, (University of Chicago Press, Chicago, 1978)
(8) Simpson, R.L., "Vertical and Horizontal Communication in Formal Organizations", (Administrative Science Quarterly, 1959, number 2)
(9) Birrell, G.S., "So You Need a New Building? A Guide to Clients on Procurement Approaches", (Florida Building Construction Industry Advisory Committee, School of Building Construction, University of Florida, Gainesville, Fl, 1989)
(10) Kiersey, D., and Bates, M., "Please Understand Me-Character and Temperament Types", 5th edition, (Prometheus Nemes is Book Company, DelMar, CA., 1984)
(11) Myers, I., "Manual: The Myers-Briggs Type Indicators", (Consulting Psychologists Press, Palo Alto, CA., 1962)
(12) Birrell, G.S., "The Construction Management Approach-An Industry Executive Consensus", (Florida Building Construction Industry Advisory Committee, School of Building Construction, Gainesville, FL, 1991)

APPENDIX

RAW RESULTS FROM KIERSEY-BATES TEST

	GVLL	ORLD	TAMP	TALL	JVLL	MIAM
BOWN1	XNTJ	ESTJ	XSTJ	ISTJ	ISTJ	ISTJ
BOWN2	ENFP	ESTJ	ESTJ	ESTJ	ESTJ	–
A/E1	ENTJ	ESTJ	ISTJ	ESXJ	ISTJ	ESTJ
A/E2	ESXJ	ESTJ	ESTJ	ENTJ	ENTJ	ENXJ
CM1	ESTJ	EXTJ	ESTJ	ESTJ	ESTJ	ESTJ
CM2	ESTJ	ESTJ	ESXJ	ESTJ	–	ESTJ
GC1	ESFJ	ISTJ	EXTJ	ESTJ	ESTJ	ESXJ
GC2	ESTJ	ESTJ	–	ESFJ	ESTJ	ESTJ
SC1	ESTX	ESTJ	XSTJ	ENFJ	ESTJ	XSTJ
SC2	XXTJ	–	ESTJ	ENTX	–	ESTJ

6
Towards automation of design, construction, maintenance and management for residential buildings

T.BOCK

Abstract
Techniques involved in building activities are related either to industrial processes -e.g. prefabrication-to onsite production or to building maintenance. Problems of robotization differs according to their application in the factory or at the site. Development of robots in factories can be executed in the framework of industrial robotics and factory automation. Some prototypes of on-site robots have been tested different construction works, and the successful types are already marketed. The building site of the future will look very different from now, uti1izing advanced robotic technology to decrease high accident rate and to humanize working place and increase quality and productivity of construction.

Keywords: Construction Automation and Robotics, Design, Construction, Construction and Building Management, Construction Quality, Building Operation and Maintenance.

Introduction

Today the building and construction industry is considered as one of the least efficient and technologically stagnating industries.

This can be attributed to the complexity of the building projects, their geographical dispersion, heterogeneous nature and sensitivity to various economical and environmental factors, lack of skilled workers, aging workers, high accident rate, occupational disease and death This can also be explained by the general decline in the quality of the construction labor, and the reluctance of architects and engineers to experiment with new solutions and technologies already implemented in other branches of engineering and industries.

The main difference between the industrial robots which are applied to the prefabrication of buildings and their subsystems and the construction robots which are mostly needed for on-site construction, is requiring ability of the later movement from one location to another with interaction of environment through sensors and built-in intelligence, and cope with hard work conditions. The specific technology needed for this purpose already largely exists, and can be modified for the particular building tasks. The problem is not with the robot, but rather with an integrated system of robot- oriented construction and building which are essential for an economic implementation of this technology.

Robot Oriented Construction and Building System (ROCBS)

The “ROCBS” includes the building design, the building technology, the organization of building production which should be robot-oriented. The design must conform to the physical, geometrical and computational constrains of the robots and their robotic-subsystem. The building technology—materials and components—must be designed for the robot’s performance and capacity. The organization on the building site must be oriented towards robots working at different locations, transfer them from one location to another, and arrange in an appropriate manner the components and materials supply to robots. The management must be able to organize a robotized building site, and to operate -to program, activate and maintain—the robotic machinery. Due to the high capital costs that are tied up in robotic machinery, the operation of such a system can be economically justified only by a continuity of demand for appropriate building projects, which will allow constant and rational utilization of human and technical resources.

The robots will be initially employed in such as well structured as is the case for prefabrication. As far as onsite construction is concerned the simplest application is the automation of existing construction machinery—cranes, concrete pumps and like—and their preprogramming and teleoperation. A more advanced case involves an autonomous processing—smoothing, cleaning, etc., of large homogeneous surfaces—horizontal or vertical. A more complex application involves operation of a robot for more difficult tasks such as assembly and finishing of three dimensional elements.

The construction industry surely is in need for improved thinking about quality. Because of the multiplicity of materials and components available and the sophistication of client demands, building projects are becoming more and more complex, and the formation of totals quality becomes more obscure. In large design or construction organizations, the significance of one employee’s effort for the final result is usually difficult to grasp. Total quality control may be seen as an application of the systems approach. The purpose of this is to consider the goals and the wider context of the problem situation, instead of looking only at the means available and the immediate problem. Thus by means of TQC, the mission of a company can be broken down to a guideline for the everyday activities of every employee. Similarly, the position of each task in the overall process of project realization can be made more understandable. So, TQC is a way of managing the complexity of the construction project. It is interesting that the reduction of compartmentalisation is mentioned as one result of QC activities. Specification of a common goal and better understanding of one’s own and other departments role may contribute to this. Quality Control in the construction industry is divided into design QC, Construction QC and customer relation QC. In the design stage quality is defined in architectural requirements, engineering considerations and the proper use of materials and fixtures. Each of these areas poses many quality questions which have to be answered to suit the specific site, construction conditions, intended use and more.

Generally design QC should focus on considering customer requirements for the design and reducing construction mistakes. Customer state their requirements and architects find ways to satisfy this. The planner should examine the own design for clarity and completeness and try to avoid ambiguities, inaccuracies and over complexity that might lead to confusion on site. If mistakes occur during the design process they can never be corrected later during construction unless cost increase considerably.

Construction QC deals with quality in the actual production process. Given the personal and institutional differences in experience, training and quality consciousness, the actual construction process is performed differently from worker to worker and company to company, even when same plans are used.

To prevent errors and promptly identify them and correct them require a QC framework to be established which includes guidance on writing work specifications, checking quality, assigning QC responsibility, setting clear technical standards and coordinating work procedures. If errors occur most workers correct them without analyzing the causes thus mistakes show up again and again. Because construction skills and procedures are not well structured it is important to scientifically analyze work procedures and follow statistical methods so that quality data can be identified and QC implemented.

In the case of subcontractors QC becomes more crucial since bad coordination with general contractor results in gray areas where nobody is responsible for. There for standardized QC methods are to be implemented.

Although quality control at on-site can hardly be achieved, it will be automatically implemented as soon as robotic construction is realized in the framework of integrated construction and building system.

In many industries automation is very advanced. Functions of human labor are gradually replaced by machines. But as far as building industry is concerned, automation is not yet commonplace in all stages of manufacturing. The industrial building production is most advanced at the product level of materials and parts production, such as steel sections, cement and glass.

Human labor is only partially substituted by machines at the product level of building parts and groups. The productional functions of power generating and manufacturing are mostly replaced by machines except the controlling function. Automation is least advanced especially at the final stages of production hierarchy, for example the manufacturing of building kits and the final assembly. The human labor at on-site construction is only substituted for its power generating functions such as cranes. The functions of human labor requiring skill such as forming, adjusting and assembling are carried out and controlled by workers. Besides the fact of low productivity, aging workforce, lack of skilled workers and poor quality are also the death/accident rate and occupational disease of building industry is higher than that of other industries. Among the building industry, the prefab makers showed lowest rates except for on-site operation.

In cases were design and production of cars, ships and so on are performed in the same company and factories, the data for the standardized parts, materials, processes and working drawings will be sent from the technical department to the production facilities as CAD/CAM data.

In the case of building planning, design and production, the transmission of information is mainly executed by sending a set of drawings and specifications between the concerned people such as architects, engineers, general contractors and manufacturers of materials, parts and facilities equipment. In order to industrialize the building industry through rationalization, quality control and higher productivity it is necessary to increase the use of computers for sending data, drawings and informations between the participants of a project. Therefore it becomes necessary to standardize the information transmission and to identify the parts, materials, proçesses and drawings with codes and dates for immediate or future reference. Once this computer network is established it will also facilitate introduction of robotic construction machinery.

A prerequisite of these advanced and integrated production technology is a standardized communication and information system. Recent efforts to achieve this are the IRON and the MAP system. The latter was developed by GM of Detroit. MAP is a seven layer, braodband hierarchical system that provides a set of communications-related services from the lower level to the layer above with the top layer providing services to the application program. The upper layers are devoted to the processing of information and the user's functional requirements, while lower layers are devoted to communications related technologies. A complete message is collected at the top layer and passes down through the layers to the destination node and travels back again after arrival. This functional separation of network communication into layers shows the modular design of networks and facilitates the addition the addition of enhancements to a particular network layer without affecting layers below or above. This map strategy could also be applied in construction and construction robotics.

Industrialization is most advanced in the prefabrication due to clearly defined circumstances at the place of production, similar to applications of industrial robots in other manufacturing industries. In Japan and other industrialized countries the modular house industry reached a high standard of production technology through mass production of limited variety of un-differentiated building elements, components and units.

For example at the production line of Sekisui Chemical Sekisui Heim, for box units where more than 85 percent of the house is prefabricated, quality control became as thorough as for other industrial products. The steel frames of the unit are assembled from the roof-, floor-, and end wall frames which are welded together in a totally automated process using arc- and spot welders. Production process starts with cutting of prescribed length of highly rust resistant fused galvanized steel. Robots then weld connecting fittings to the columns. At the ceiling frame production line, 2″×4″ beams are attached to ceiling frame and electric wiring is installed. In the floorframe production line, insulation is laid on the floorframe and an automatic nailer installs the floor boards. Another automated process assembles columns fitted with connecting lugs to form a column frame. The frames are spot welded together in a fully automated process. The frame supports serve as jigs establishing the frame's dimensions. After the exterior wall panels that are manufactured on a subline, are fitted to the structure, the interior items and partioning panels are installed.

The utilization of robotics on the building site could eventually increase the work security and productivity while reducing building costs. In the steel industry the design processes are already linked to manufacturing and production planning through the utilization of a computerized system for drawing and specification information listing. This process will lead to CAM and finally to CIM. These proposals for future construction processes share a common basis with CIM and robotics in other industries. The design will be executed and simultaneously purchasing and production information is compiled, which are later sent to the factory where they are further distributed to the production facilities and robots. Up to now in the construction process however the stages of design and production preparation are separated and the design information can not be directly linked to the NC machine or robot. The same is true for the feedback of information and therefore mistakes are sometimes not realized until they are discovered at the site where it is very expensive to correct them. . However if robots are to be introduced into construction industry it becomes necessary to industrialize construction through standardization and modularization of parts and information according to the possibilities of robotic execution. In the longer run the use of sensors to detect movements and positions which are able to feedback information of. design process to robots.

The on-site construction process is of course different from that of a factory and the smooth linking of design information with the fabrication and production information cannot be easily realized, but nevertheless a potential exists for the future due to urging present problems in construction which are discussed in the next chapter.

In the buildings of today advanced technologies are mostly applied to subsystems that service the building. But even this differs considerably from e.g. maintenance cost of a car. This shows that there are too few criteria to check the quality of the product or its maintenance efficiency or the reliability of design. Some reasons this backwardedness are the complexity of functions of buildings, not standardized design methods and insufficient control of design quality, production quality and assembly quality. The recent trend towards information society brought the design of so-called “intelligent buildings” further emphasizing the demand for advanced building systems.

As more advanced technology such as OA, security systems and energy efficient equipment and maintenance robots will be used, a new design method is required to fulfill these extended requirements. All parts of subsystems of building have to be analyzed and tested, before they will be assembled to serve their total function.

To achieve this the partial functions have to be interfaced physically, functionally and geometrically. Another dimension of advanced technology applied to construction is the dimension of time. The various subsystems designed for specified life cycles require a certain degree of exchangeability thus contributing to the extension of total life cycle.

As we can understand from the change of construction component cost through the history architecture is not only expressed by terms of a space enclosed by walls and ceiling, but also more and more in terms of a couples environmental system of interfaced qualities of appropriate technologies.

Another more obvious sign of these changes is the historical change of the location of the production of the building. Whereas in earlier times the building was produced on site, the production location gradually moved to the factories where components of building are prefabricated. In the most advanced cases of prefabrication, quality control on the building group level can be achieved.

The majority of the administrative work normally includes communication, preparation, editing, retrieval, filling and copying of informations. The hours of creative work consumed by reading the information is about 25 percent of the total working hours in administrative sections according to a survey conducted by NTT.

Thus the major motivation for introducing OA is the improvement of productivity in order to strengthen competitiveness. OA should expedite office work and increase its efficiency. The establishment of an information control system is required in order to reduce office work operations. The introduction of OA involves reviewing the overall company structure even though its immediate purpose is only to rationalize office work and reduce costs.

In Japan the operation of buildings is called “Home Automation” referring to housing and “Intelligent Building” related to office buildings mostly.

After Factory Automation (FA) and Office Automation (OA), so-called Home Automation or HA is receiving increasing attention. HA stands for integration of monitoring, operating, communicating and controlling various functions at home.

HA systems are offered by all major electronic companies, such as Hitachi (home control system), Nihon Denki (Jema Hoe Bus), KEC (Kansai home bus system), Matsushita Denki Sangyo (Stavtec, Hals, HA system), Matsushita Denko (Napic Remote Control, Homen Mast, HA Installation System), MITI (MITI Home Bus), Mitsubishi Denki (House Keeping System, Home Automation System), MPT (HBS), NEC (Home Media Bus), NHK (Home Bus System), NTT (HAN), Sanyo Denki (Shains), Sharp (home Terminal System, House Info System, Home Bus System), Sony (Access 3), Toshiba (Newhome Media System, Home Control System).

Major functions of standard installation cover fire alarm, gas leakage alarm (detection and notification), oxygen shortage alarm (detection and notification), electric lock (unlocking function, when a visitor is checked), burglar alarm (sensor notifies when a door or window is opened or broken), emergency alarm (notification to the public emergency center), earthquake alarm (notification of an inherent earthquake while switching appliances to appropriate mode), guest monitor at door, interphone between rooms, doorphone, power control, HVAC control and control of water level and temperature of bathtub. As an example of HA follow as a brief outline of Mitsubishi Melon HA system.

Mitsubishi Electric thinks of HA as information oriented home management. center piece is the “in house total information system.” The next level is formed by “household control systems” and “lifestyle information utilization system.” On the third level we find “house keeping”, “home management”, and “life-culture.”

Last level consists of “fire and crime prevention”, “Energy control”, “environmental and equipment control”, “Data communications”, “health care”, “education and training”, “bossiness and culture” and “hobbies and entertainment.”

This means that home medical care, home banking, home shopping, at home ticket reservation, at home employment, electronic mail, home nursing, home study, tele-control-monitor ing-metering can be done without leaving home.

The major construction companies are all undertaking research into intelligent buildings. The aim is to make buildings easier and cheaper to run and to make them do new things.

The research is based on the idea that buildings should “know” what is happening inside and immediately outside themselves and “decide” the most efficient way of providing a convenient, comfortable and productive environment for the users. Intelligent buildings should also be able to respond quickly to users’ requests.

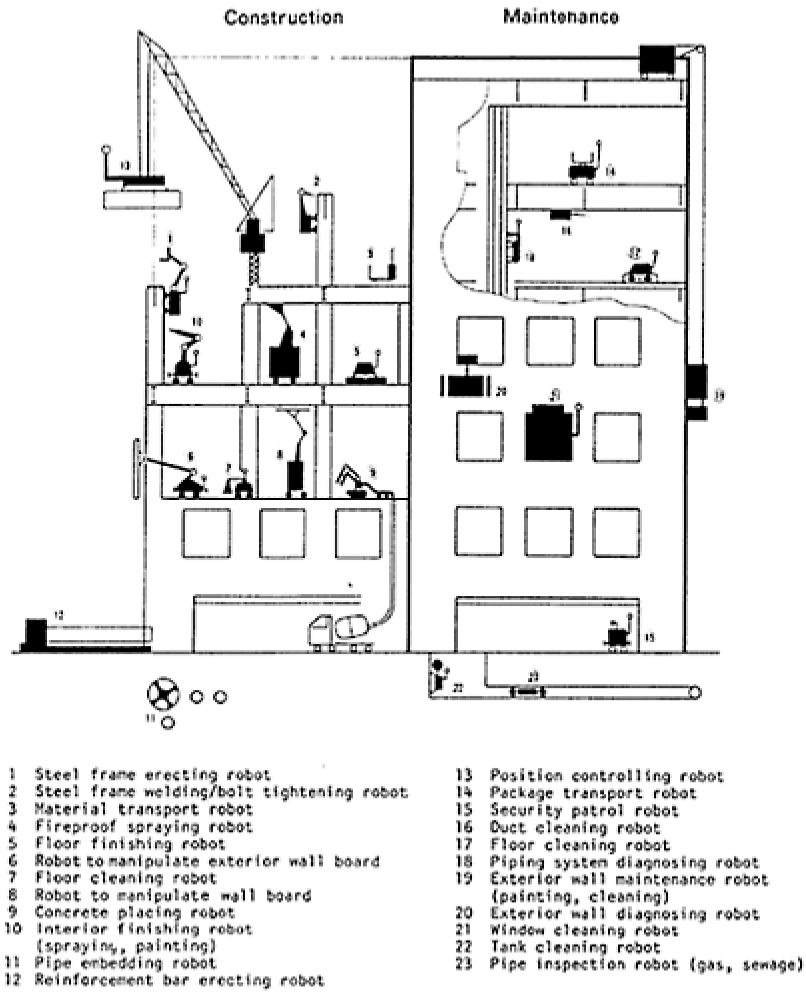
Due to the favorurable development of sensor technology, it became technologically and economically feasible to control various functions with electronic equipment.

Research into intelligent buildings is taking place in laboratories and in experimental buildings in Japan. In laboratories many different combinations of building equipment and fittings, electronic sensors and controls and various mechanical devices have been assembled. For instance hotel which is already existing, the bedroom where the gust could lie in bed and tell the room to run a bath of water of a stated temperature and depth, could ask the room to make a cup of tea, switch on the television to a stated channel, record and type simple spoken messages, draw the curtains and raise or lower the lights. Also the apartment in which telephone, television, video camera, voice control, burglar alarms, fire and gas detectors, lighting, air conditioning, the front door, curtains, cooker, dishwasher, bath, voice synthesizer, computer and control panels were all interconnected. It provided the equivalent of a very competent and compliant servant 24 hours a day.

The depreciation period for reinforced concrete building is 65 years. The overall cost of the Super Energy Conservation Building, assuming a life cycle of 65 years, is shown in the figure.

The initial cost (the construction cost) is a small part of the overall life cycle cost, while the running cost is a large one. Clearly, the Super Energy conservation Building has great advantages over an ordinary building with the same size (assuming building service systems are renewed three times during the 65-years life cycle).

In another example Takenaka, also one of the Big Six, have set up a working office in which ever aspect of the interaction between building and users' performance is monitored. The office is extremely flexible allowing light, sound, colour, temperature and humidity to be changed at will. Workers are provided with furniture, equipment, communications and information systems and spaces which can be altered easily to provide environments matched to the current work requirements. At one time the environment is relaxed and comfortable for creative problem-solving; at another more mechanical and structured and later in the day, there is a burst of sound, light and lasers to stimulate the workers to renewed efforts. The aim is to create offices which help managers make quick and accurate decisions on the basis of excellent information, which can also raise the productivity of general office-workers by providing a very comfortable and happy environment. All this and the results in terms of workers' performance are monitored in order to learn how offices behave as total socio-technical systems. Takenaka rely on manufactures to develop intelligent and controllable devices. Their task as a construction company is to understand the whole building-user system so that they can design and manage the construction of intelligent buildings. The scope of their research is very broad.



References:

Own reports from the working groups 1 and 2 of the Architecture Institute Japan and the committee for Advanced Construction Technology of the Ministry of Construction of Japan.

7

Strategic dialogue—a framework to improve developmental processes in construction companies

J.BORGBRANT

Introduction

Successful researchers and businessmen have at least one thing in common: they are very interested in discovering basic principles that are important for how to manage their workarea in an optimum way.

This paper describes some concepts and models that I use to help me to find these crucial variables.

Section 1 provides a description of a model for analyzing an organization from a holistic perspective.

Section 2 outlines a management philosophy that underlines that management is a process in which managers and co-workers have a mutual responsibility.

Section 3 deals with more characteristics to describe the management behaviour used in “Strategic Dialogue”.

Section 4 discusses “Strategic Dialogue” as a change strategy.

Section 5 describes a program for developing the managemet based on “Strategic Dialogue”.

Section 6 is a short summary and conclusions.

Naturally, the reader may react in many different ways to this article. For some it may be difficult to find anything new and useful, while others may find the concepts and models interesting. However this article is an attempt to make managers more aware of their own management style. At best the content can be a tool to stimulate the readers to find out more about the management philosphy that exists in their own organization, how the organization operates and what to do to speed up the process for management development.

I A Holistic and Mutual Management Function—a model for a common analys of an organization

To develop the organization and make change processes successful, it is necessary to develop a mutual management function. Management function is a concept based on the systems theory that different parts of a system mutually influence each other. It is important that management not be thought of only as authority by bosses over people at lower levels of the organization. We would make it clear that managers and co-workers are both participants in the management process. They are mutually responsible for outcomes.

Holistic mutual management means that everyone participates in the process of integrating the external strategy to satisfy customers and the internal strategy to develop technology, organization, and people to support this strategy.

If we want to manage this holistic and mutual management process it is necessary to develop a common framework. The framework must be broad enough so that different functions in the organization can recognize their own ideas and tasks.

The following provides a summary of a framework which may be used in order to make analyses of an organization.

Content / Level	Core	Climate	Principles	Resources
Environment	Market Customer Products Competitor	Opinions in society to work, management, business	Laws Agreements Taxes	Economy Technology Human resources Labour market
Organization	Vision and Business Idea Strategy	Organizational Culture Informal system	Organization Administration Principles Policies	Economic Financial Questions
Group	Work tasks Quantities and Qualities	Climate in teams/ groups	Structure in group	The situation of resources in the groups
Individual	Necessary Knowledge to do the job accurately Personal competence	Attitudes and basic assuption to work-content, work environment	Individual regulations	Level of individual competence

Figure 1. A model for analysing an organization.

There are two main variables in the model. One focuses on levels (Environment, organization, Group and Individual). AS a user you must decide where the border between environment and organization is. The decision is made from what you want to focus on. If your primary interest is making an analysis of your own department, the rest of the company belongs to the environment. Inside the organization (company, department or unit) you must find out the existing groups. These can be both formal and informal groups. Examples of groups can be market unit, production, economic, human resources. The individual level focuses on every individual. These can be people at different levels in the organizational structure for example, a production man, a salesman, a supervisor, a top manager.

The other main variable has to do with the content of the levels. This variable is divided into four areas (core, Climate, Principles and Resources)

Core stands for the main thing the organization contributes to the environment. It can be products or services for examples cars, houses, guns or consulting service.

Climate represents culture, climate and attitudes on the varions levels. It can be values in the society, cultures in the company, managers and other employees individual attitudes.

Principles is an area to which laws, agreements, regulations, policies, structures and administration systems belongs.

Resources is the area where the focus is on economic, technical and human resources dimensions. It concerns the economic situation in the country and company, the technical maturity of the country and the branch where the company operate. This field also includes the state and knowledge in the labour market, the profile of the employees in the company etc.

The discussion/analysis can be done from two perspectives, from the outside-in, and from the inside-out.

Outside-in analysis starts with questions about the market, business goals, strategies for change, organizational systems and sub systems (technical, administrative, social, etc.), and ends up in a discussion of how these conditions affect the indiviual’s situation and tasks.

Inside-out analysis begins with questions about how each individual experiences his work, feelings about motivation, social environment, the climate in the team and how the team works, how management functions and responds to suggestions and new ideas. It ends with a discussion of how circumstances external to the individual hinder or support work performance.

The idea is that management can find data that describe the focus as accurately as possible in the framework. The data must be in a form which allows communications in work groups and among co-workers at different organizational levels.

As can be seen from Figure 1 the model consists of 16 foci. Some of them focus on very familiar areas of discussion for some participants in the organization while others are unfamiliar. One main idea in a holistic management is to create a process in which both managers and co-workers play a mutual role.

It must be accepted that people have different perspectives, knowledge and interests in describing a particular situation or understanding a focus. The dynamic in the organization is created from the process of discovering what the situation really is. It is important that efforts are directed towards describing the reality for all the 16 foci.

The dynamics will increase when members in their organization examine the links between the foci and impact on each other. The impact can be between levels and areas.

A management style that provides this common framework must be very explicit and clear. The next section outlines a management policy that stresses more factors which are important in a holistic management process.

A Management policy for supporting a holistic management style

One of the most important concerns for the management is to use and develop the resources inside the group or company. The demand on managers to become aware of and to act on factors that exist both inside and outside the company is increasing. A very explicit and clear management policy needs to support a management style that allows co-workers to participate in the work, to stimulate themselves to develop as individuals, and to support changes.

The following represents the management philosophy expressed at the BPA Group.

In the company it is very important that every individual employee

– feels that he can participate and can accept the companys goals and business
– feels that co-operation, and a spirit of community exist in the team and finds the work environment good as a whole
– gets reward for what has been produced both in economic and psychological terms
– gives opportunities to take responsibilty and has opportunites to evaluate performance vis a vis known goals. This is a basis for good work performance.

The mangement style is characterized by

– coaching through goals
– continuosly evaluating results
– continous awareness of development and need for change
– using change strategies that are built on openness (frankness), and participation in longterm thinking
– emphasizing or accentuating learning through monitoring both work and management behaviour
– internal and external communication in the form of a dialogue

As a support for management behaviour there must be

– a form of decentralized directing that stresses the line manager’s responsibility for using and developing all existing resources
– a form of decentralized organisational structure with as few levels as possible. The different levels are linked together by managers who are “linking pins”. A manager is a co-worker in the group above his own team
– meetings arranged regularly at all levels from top management to shop floor workers
– personal meetings and regular appraisals between managers and co-worker at least once a year to discuss results, the future and individual development

The management policy can be put into action in the daily work through

– a dialogue in the team to evaluate (monitor) the daily management behaviour vis a vis the formed policy
– frankly expressing opinions on what support and hinders good work performance
– respecting every manager's and co-worker's opinion about existing goals, resulting management-style, needs and strategies for change
– managers attending to questions of work motivation, atmosphere in teams and stimulating co-worker's willingness to take responsibility for. their own deve lopment

III Strategic Dialogue—a number of characteristics

This section describes in more detail why strategic Dialogue may be regarded as a successful management model, It will also attempt to answer the following questions

– Who must contribute to get a successful process
– What the content of the dialogue should be
– Which data can be used in a Strategic Dialogue
– Which conditions are important for a successful Strategic Dialogue

Strategic dialogue is intended to create a process whereby work-groups develop a long-term perspective. Here both individuals and groups bring their interests as a basis from which they work, to understand the reasons for change and the interests and needs of other individuals or groups. In the dialogue, problems can be understood from the different perspectives of the top managers, the middle managers, the line workers, and the unions. Everybody's situation, interests and concerns are accepted as having equal value to that of management. The goal is to agree on a mutually beneficied vision.

Dialogue requires a democratic spirit even though decisions are not always by consensus, people must agree on the problem to be explored. They must respect each other's point of view and be willing to gather further information to resolve differences of opinion. There must be active involvment, open disagreement and creative conflict must be encouraged. Furthermore, good dialogue allows for an interplay of ideas, people need not be committed to ideas they suggest for exploration. Finally, dialogue requires leadership that draws conclusions on the basis of the dialogue and makes a deci-sion. At the end of each meeting, each member of the group should have a clear idea as to what is going to be done about the issue discussed, who is responsible for it, when it is to be done, and what the expectations are.

Sometimes there are non-resolvable differences in interests which must be negotiated. But decision and negotiation do not end the strategic dialogue which must be an on-going process in an organization that is adapting to changing conditions.

The function of a strategic dialogue is to develop both the organization and the individual members within the workteams. Such dialogue is designed to make the organization more effective and productive, as all employees have more input into the process. Workers have the opportunity to analyze their work and requirements, the formal roles and structures within the organization, and the administrative system. At the same time they can discuss their feelings and reactions, and observe the process of communication with each other. There is an on-going learning process and an arena in which to develop new knowledge about work and what it requires from people.

As was pointed out above, a Strategic Dialogue needs active contribution from both managers and co-workers. The idea is that the dialogue must be done in the ordinary "lineteam". There the managers are important as a link between two groups on the closest organizational level. Through this uniting all members in the organization will be involved.

A complement to the dialogue in the team are regular meeting between the manager and just one of his co-worker each time. These meetings—or appraisals- must be regular for example once or twice a year.

The content of the strategic dialogue must be about everything that has to do with the work. Results in the production (quality, quantity, costs, productivity) and how it is to work in the team (atmosphere, stress, environment) are in two different types of content. Ideally the content in the dialogue should be about all the 16 foci in the model presented in Fig. 1.

To make the dialogue useful it is important that everyone has an opportunity to take an active part in it. Therefore it is necessery to use different types of basic data. Three examples are

* observations
* investigated or provided data
* individual experiences

Observations stands for what anybody has registered (seen) inside or outside the company. It is important that everyone both manager and co-worker is prepared to communicate the observations. The observations can focus on both worker's and manager's behaviour.

Provided data stands for information that are more measurable and unbiased, for example statistics, production lists and economic tables.

Individual experiences stands for more intuitive information. It can be statements on information based on earlier experiences or just feelings that you have about the subject discussed. It is of course important to give this type of data a chance to be accepted even in a very logical and analytical atmosphere. For some people it is difficult to accept another person's opinions specially if they are only based on feelings.

There are many General Conditions that can support a successful strategic dialogue.

First of all the number of members in the team must be realistic. It is very difficult to manage a group process in a productive way if the group is too big. As a manager you must be very sensitive and aware of group dynamics if you have groups as large as 15–20 persons. The top management group needs to be smaller, for example 5±2 persons.

It is even important that the workgroup is managed by one manager. This statement suggests more groups with less members instead of large groups with a manager and some assistant managers.

A third condition has to do with the organizational structure. It is important that there is a clear structure for how the different work teams are linked together. This structure makes it possible to make the internal information system more efficient.

IV Strategic Dialogue—a basis for successful change

Let us make the assumption that all changes have impact on individuals release energy in themselves. This energy can be both positive and negative. Examples of positive energy are when an employee is involved, supports the change of ideas, and is keen to bring about the change.

When negative energy dominates the person tries to stop or at least hinder the changes. This resistance can manifested both overtly and covertly. Someone can, for example, offically support the idea but avoids behaving as the decision suggests.

In the following I will give a brief overview of three change strategies: expert, project and line dialogue.

We know that some change strategies involve a few employees in the beginning of a change process. Every stage of the change is prepared by experts. From a technical point of view the optimum solution is developed. The problem can, in spite of this, occur when the manager must inform the employees what has to be changed. The whole idea can disintegrate and no changes will be accepted by those it concerns. We can call this “Expert-strategy for change.”

Another change strategy is based on assumptions that employees who are the target of the change will support the change activities if they have been represented by one or more persons in a project group. The task for that group is to make the change ideas clear and prepare the practical aspects of the change process. This change strategy involves a high level of administration and organization. Boards, project—groups, subgroups and so on. This strategy may be called “Project Strategy”.

The third stragey is the Strategic Dialogue or Line Dialogue, The basic assumption in this strategy is that one large part in the general management behaviour is to make continues changes. Needs and methods for change is an ongoing process in the teams. At all group meetings, weekly or fortnightly, the agenda is built up to ensure change.

In group meetings the focus is put on strategic questions

* How the situation is: “Current Situation”
* How we want it to be: “Desired Situation”
* What to change
* How to change it (methods)

Meetings in work groups that are very important in Strategic Dialogue can also be summed up through the following questions: What can we learn from

– the core area we have worked through today
– the management behaviour that has occurred during this meeting

The following schedule is an attempt to clarify the differences between the three strategies.

	Expert	**Project**	**Line dialogue**
Management-approach	One in the top has the power	Formal procedure	Team managers (leaders) anticipate co-workers knowledge
Co-worker-	Machinery of	Involved through	Co-workers competence

approach	production that needs expert help	representatives	must be used in the change process
Organizational approach	Power is important	Conventionally regulated responsibility for example in a project organization	The team is the basis for change
Involvement	A few Executive Consultants and just a few internal co-workers	Employees are involved through representives	Teams that are impacted by the change ideas
Time aspect	Quick results Action oriented	Schedules in plans for action	Change is seen as a necessary and natural part of the ordinary tasks in the team
Role of consultant	Main role trough his individual competence	One of the representatives in the project organization	Is involved as a resource person in the team where the changes are made
Learning	Not especially important	Knowledge and behavior specifically referring to project administration improves	A central element for achieving a better management behaviour and to learn for future core activities
Conflicts	A question of information and selling	Like a question for negotiation	Creates higher motivation, participation and activity
Structure	Not aware of question about procedure. Stresses rationality and analyzing objective data	A combination of project administrative structure and content structure. Logical organization in subprojects. Looking for structures even in feelings	Close connection between the ordinary management structure, directing the business and structure for change
Process	A process, including co-workers thoughts and feelings isn't important. As few as possible must be involved so feelings and irrational behaviour can be avoided	Changes in plans and procedures are confusing and time wasting. The need for defining everything means that vaque processes are disregarded	Very conscious of processes. Processes in change activities are continuously analyzed. Learning from the process in the here and now is important.

Figure 2. Three different strategies for change.

V Management development—an approach to Strategic Dialogue in practice

In the program for management development there is a combination of on one hand education in traditional subjects: economy, finance, marketing, production planning and on the other individual training in, communication, group dynamics, conflict solving. In the program there should be quite a lot of time for analyzing the situation in the participants own companies and units. The products that everyone produces during the program, for example, tables, diagrams, summaries or visual descriptions must be used, tested and evaluated at home. This work is in itself a very important element in the management program. The effect of the program is of course measured in the ordinary business and work in the unit.

The case of BPA

The aim of the management program at BPA AB. is to provide a powerful tool to increase the profit (earnings) and to make the BPA GROUP stronger in a long term perspective. There will be a lot of occasions to practice both analyzing the environment and the different companies' internal situations. There will also be training in practical leadership and individual development.

The program is structured in seven blocks as shown in figure 3.

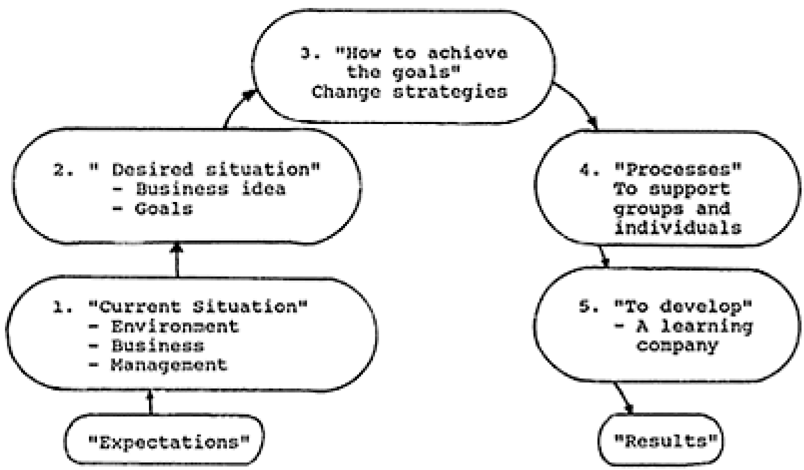


Figure 3. The blocks in BPA AB's program for management development.

Expectations

This block is arranged as an introduction to the whole program. Individual presentations and expectations are made. Philosophy, methodology, content and expected results of the program are discussed. The participants are asked to submit 5 variables that can be used to evaluate the effect of the program. Values of the 5 variables when the program starts are written down and stored in an envenlope. The same variables are measured when the program is completed. The effect of the whole program is analysed by every participant and their manager in relation to these variables.

An example of homework is to prepare an analysis of the “Current Situation” in the participant’s unit or company.

Block 1. “Current situation”

One week’s intensive work in a conference hotel. The aim of this block is to provide the participants with a broad frame of referance to be used when describing the company (unit) and their environment.

In this block there will be many occasions for discussion of the market, technical development, labour market and economic realities. The teachers or facilitators come from Government, unions, business confederations, universities but also from the BPA-Group, board and top management group.

A lot of time is spent on improving the ability to describe the company with regard to the broad frame of reference (The model shown in Figure 1). Some analyses are also carried out into participant’s own leadership. The description of the current situation that has been made during block 1 will be discussed, examined and corrected in the participant’s home unit.

Block 2 “Desired situation”.

This block starts with a report on the results from the homework. What reactions were there in the home team regarding the description of the “Current State”? The second week goes on with a focus on the “Desired situation”. The main task is to make clear goals at different levels in the company, unit group and individual.

There will be exercises to make clear descriptions of goals in business, for example, economic, marketing and human resources. Time is also given for practising formulating goals in the area of culture, climate and values. The participants also discuss the policy for management.

Block 3 “Change Strategies”

This block concerns the question “How to reach the goals”. There are discussions about different change strategies and methods based on the table, presented in Figure 2, Expert, Project and Line dialogue strategy.

An important aspect is about the type of data that you need for successful changes and how you use that data. It can be used as a basis for analyses or information given about deci-sions, policies or statements which have already been taken.

In this block the homework about the “Desired situation” is very useful. The idea is to find out how the participants can continue with their own change process at home.

It is important to bridge the gap between current and desired situation with things that need to be changed and how to do this successfully. The need and strategy for change must be worked on in an adequate way at home. If the participant prefers, for example, a Line dialogue he has to test that basic assumption in his own management behaviour.

Block 4 “Process”

When you start development activities in your unit or company it is normal to initiate some reactions or release energy. As stated in section IV, this energy is either positive and supportive of change or negative and resistance oriented. It is therefore very important to be open minded and interested in learning more about this process.

The content in block 4 concerns individual and group processes. The block differs radically in material and learning methods from the others in the program. The participants get a real opportunity to learn about themselves as individuals. How to communicate ideas, feel about stress, project their own values to others in groups, are some areas that are studied.

A lot of time is spent on developing more knowledge about what is happening in small and large groups and between groups in an institution. The learning method is a combination of practical learning and theoretical analysis.

The product of this week is aimed at a personal developmental level. It is intended to stimulate more active awareness and sensitivity to group processes in the participant’s own unit and workgroup.

Block 5 “To grow”

This block is the last one week meeting in the program. The aim of this week is to achieve deeper learning in those areas that have arisen as important during the program. The following examples can be cited:

– Information technology
– Ethics
– Mass Media
– Internationalization
– Personal health and environment at a construction place
– Marketing as a strategic issue

This block is more traditional in the learning methodology. There are clear subjects that are taught by lecturers from universities, expert organizations and other companies.

Results

After half a year break the last block “Results” will be managed. The aim of this block is to evaluate the effect of the program. What has been developed in the business, units, cultures, motivation and individual management behaviour. The aim of this block is also to make an economic analysis of the results. Here we use the five variables that are measured at the begining of the program. The values that exist now are compared to the earlier ones. What can we learn from the differences? What will the economic results be like if we try to put the variables in economic terms? This discussion is made together with the participant’s own supervisor or the executives for the three business areas Construction, Installation and Painting in the BPA GROUP.

VI Summary and conclusions

In this paper I have attempted to outline an approach to developing companies through a continuous change process. The basic idea that needs to be used is named Strategic Dialogue. The main conclusions to be drawn from this article are that:

* A manager needs a holistic strategic perspective to achieve a successful change process. A holistic model for the analysis of a company is outlined.
* A management behaviour that supports a continuous change process must be very distinct and described in a policy document. Acceptance of the philosophy by both the managers and co-workers in a company is vital.
* Strategic Dialogue is based on a management philosophy

  – where everyone must be involved through a “linking pin” system
  – which recognises that the content in the dialogue must concern all areas in the holistic model
  – where the data used in the dialogue is derived from Observations, Provided data and Individual experiences
  – that underlines a decentralized organization with groups managed by one formal leader

* Four central concepts must be made clear and explicit to enable a successful change process

  – Current situation
  – Desired situation
  – What to change
  – How to change

* A systematic program for management development is necessary

8
Information flows in building construction management

D.W.CHEETHAM, D.J.CARTER and R.A.EELE

Abstract
The paper outlines the results of an analysis of the management information system of a large U.K. Contractor. The company's Procedures Manuals were examined and the company management information system modelled on two sites and the regional office using systems analysis techniques. Recommendations for improving the system are made.

Keywords: Systems Analysis, Standard Procedures, Management Information Systems

1 Introduction

Building construction management is concerned with providing buildings of acceptable quality at an agreed price and to programme. The parties engaged in this endeavour; client, architect, quantity surveyor, other design team members, contractors management and head office supporting staff, site management, supervisors, operatives, suppliers and subcontractors all require information to perform the multitude of tasks associated with creating a building.

The communication of information between the parties has traditionally relied on the use of paper to convey drawings and written messages in addition to verbal communication. In recent years the construction industry has started to take advantage of the developments in information technology which allow storage, processing, retrieval and transmission of information by electronic means.

In many organisations systems for conveying information have been developed to satisfy organisational needs based on the real or perceived hierarchy of the members of the management structure and their need to have access to particular items of information. Information flows are thus related to decision making.

Changes in organisational structure of a contractor's business are caused by external factors such as economic conditions, success in tendering, changing workloads, evolving markets for various building types, changing contractual procedures adopted by clients and new prod-uction technology. Adjustments to meet these factors are often made without recognition to their impact on the existing information system. Most information systems have evolved to ensure that the company can organise building works, function as a commercial organisation and satisfy legal requirements for production of accounts and payment of taxes.

A large number of organisations co-operate to produce a building. Although they all come together on a particular project they will each be simultaneously involved with other firms on other projects. Consequently the contractor's s management information system has to cope with a wide range of information from many sources of variable quantity and quality. Despite this many of the procedures to handle this information are common across a wide range of project types.

2 Case Study Company

The company is a typical large U.K. contracting organisation with the capacity to carry out building contracts of all sizes and types throughout each of its regions. The regions are controlled from a national head office which sets targets and controls budgets. In the winning and running of individual contracts the regions are autonomous. Each region administers several projects at any one time from the regional office. Larger sites tend towards greater organisational self sufficiency than smaller sites.

2.1 Procedures manuals

Management systems and procedures are developed at national level. These systems are laid down in a company manual issued to all senior management within each region and are periodically reviewed and updated. Standard procedures developed by regions are described in the regional site procedures manual. The procedures manuals provide written details of how to carry out each procedure and provide examples of standard forms to be used. The manuals are sectionalised to be of relevance to particular departments.

Table 1. Contents of National Procedures Manual

1)	Company quality manual		
2)	Prep and admin. of manual	10)	Work instructions
3)	Prep of quality plans	11)	Drawings and variations
4)	Internal auditing	12)	Inspection and testing
5)	Storage of records	13)	Permanent works design
6)	Suppliers & subcontractors	14)	Planning
7)	Purchasing procedures	15)	Temporary works design
8)	Materials receipt & storage	16)	Concrete control
9)	Training	17)	Masonry control

Table 2. Contents of Site Procedures Manual

1)	Drawings	16)	Wages

2)	Information schedules	17)	Labour requests
3)	Variations & instructions	18)	Plant ordering
4)	Mail in/mail out	19)	Preliminaries
5)	Contract programming	20)	Internal valuation
6)	Weekly programming	21)	External valuation
7)	Site meetings	22)	Site monitoring
8)	Site reporting	23)	Sub contract pay
9)	Sub contract assessment	24)	Forecasting
10)	Sub contract ordering	25)	Final account
11)	Post contract procedures	26)	Quality control
12)	Material ordering	27)	Engineers records
13)	Deliveries	28)	Quality assurance
14)	Stores control	29)	Security
15)	Weekly costs	30)	Health and safety

Standard procedures are employed as a means to gain certainty so that everyone knows what to do and when to do it. This is especially important when introducing new individuals to the system, through training or where personnel are relocated between sites. But standard formats for reporting information are also required so that regional office can quickly assess the current situation and will provide a method for comparison between sites. The main system study was undertaken on two contrasting sites together with a systems study of the regional office.

2.2 Case study sites

The two contracts chosen for this study were a £60 million industrial complex and a £3 million hospital extension. The former was a fast track steel frame structure employing over 50 subcontractors and a large direct labour force. The project has been running for 2 years, the first stage is now completed. The hospital contract was a more traditional building with load bearing brick and block walls and precast concrete floors. The larger value, more technically complex contract involved many specialist designers, subcontractors and suppliers. A greater number of contractors management and administration staff were necessary to interpret the design and organise and control the site works. There was greater separation of functions on the larger site, for example administration is separated into departments concerned with costs, stores and security with a coordinating manager. Assistants in quantity surveying were allocated different work packages. Section managers supervised general foremen and there was a separate building services manager. Programming of works, commercial operations such as subcontract buying, quality assurance normally undertaken by regional office were undertaken on site for the industrial contract. The presence of these functions on site allowing better informal coordination. The smaller value contract had fewer management staff on site and depended on regional office for support.

3 Research Method

The techniques of systems analysis were used to create a model of the management information system. The objective being to discover what information is being communicated within the organisation under study.

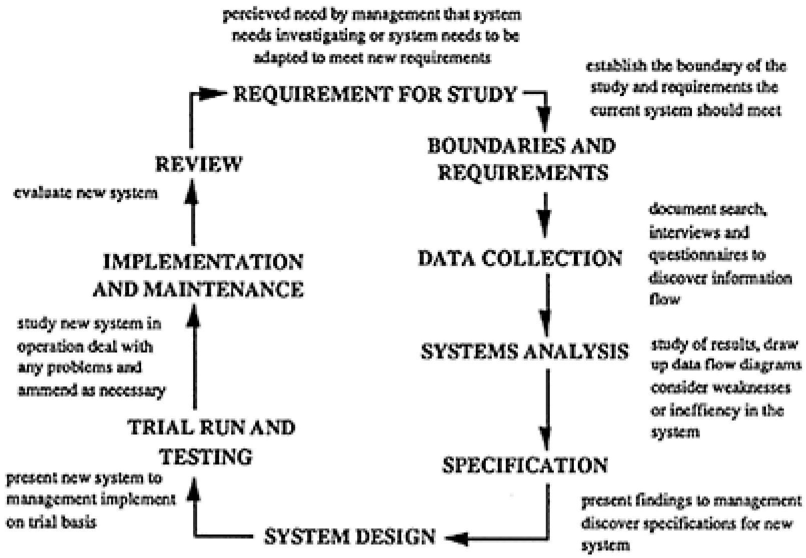


Fig.1. Stages of systems analysis

The analysis commences with an investigation in order to obtain a model of the current system which in turn also forms the basis of problem identification. A model of a future system is then developed which forms the start point for the design of a new system and ultimately a working implementation.

Interviews ascertained the information people required to perform their duties, the routing of this information, and the resulting information output. This process was supplemented by study of the procedures manuals. Various techniques of collection and presentation were attempted, one of the most successful of which proved to be the contact diagram.

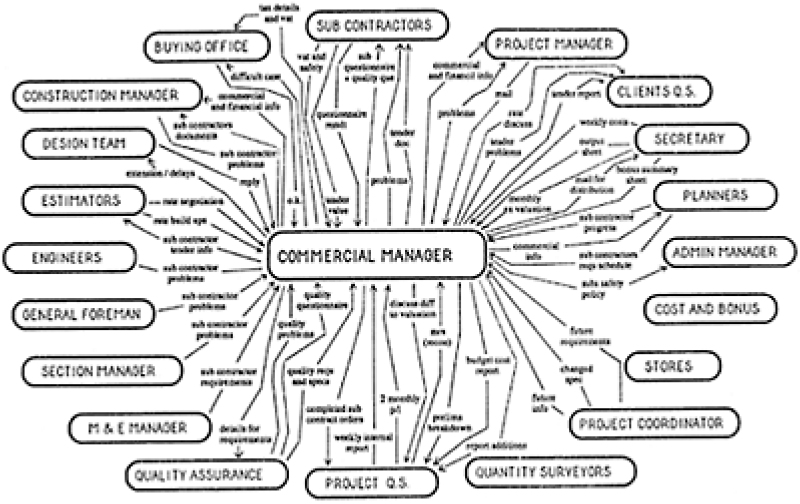


Fig. 2. Contact diagram showing the functional contacts of the commercial manager

Data flow diagrams were then drawn to show documents passing between defined activities in the form of input/ activity/output allowing the system to be analysed. The diagrams were drawn up as a series of interlocking sub systems presented as layered data flow diagrams covering several hundred activities.

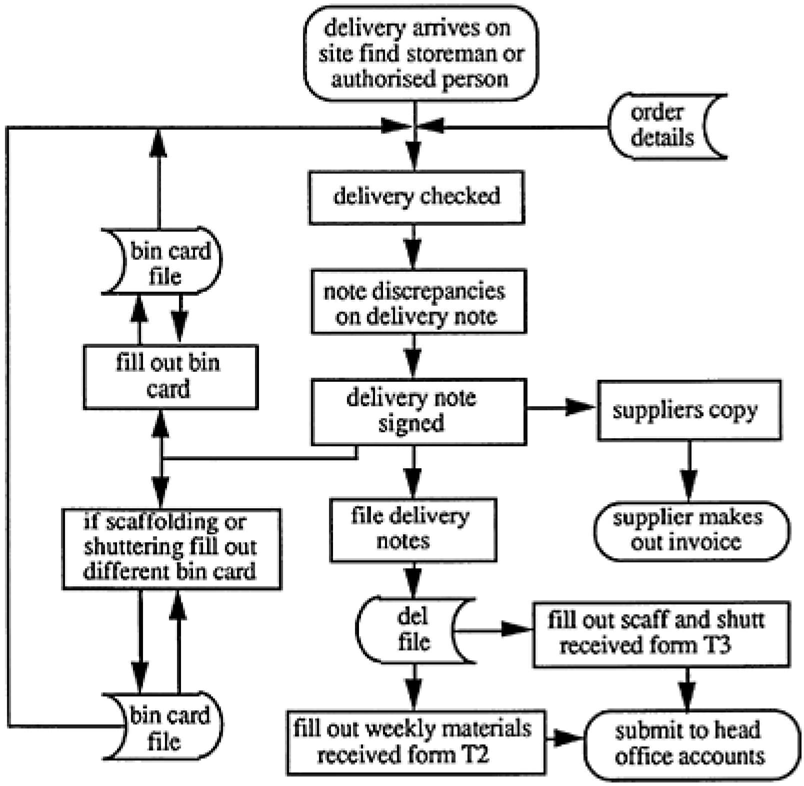


Fig. 3. Example data flow diagram for stores procedures

4 The Results

Examination of the site procedures manual revealed that some procedures were described in more operational detail than others. Detailed instructions referenced to standard forms were provided for procedures such as wages, drawing control, mail in/mail out, subcontract ordering, material ordering, deliveries, stores control, weekly costs, quality control and engineers records. Less detailed instructions were provided for the other procedures. This gave scope for the site to interpret them in different ways and allocate the duties to different job titles and functions depending upon the size of the management team.

As operational detail is clearly a matter for interpretation by each management team a comparison was made between the procedures developed and operated on each of the two sites. For those procedures for which detailed instructions were not provided variation could occur. This variation was seen in information input (data collection), procedures adopted for processing this information and the form of information output.

Table 3. Variation in procedures between the two sites

National Procedures manual	info. input	process	info. output
3) Prep. of quality plans	yes	yes	yes
Site Procedures manual	**info. input**	**process**	**info. output**
2) Information schedules	yes	yes	yes
6) Weekly programming	yes	yes	yes
7) Site meetings	no	no	yes
8) Site reporting	yes	yes	yes
17) Labour requests	no	yes	yes
19) Preliminaries	no	yes	yes
20) Internal valuation	yes	no	no
21) External valuation	yes	yes	no
22) Site monitoring	yes	yes	yes
24) Forecasting	yes	yes	yes
25) Final account	no	yes	no

There was variation between the two sites in the interpretation of national procedure 3— preparation of quality plans. The larger sites quality plan laid down responsibilities for the different team members, control procedures to be used additional to those described in the manual, the parties involved in the construction, the work stages and work instructions to be used. The smaller site used only a list of work instructions. The work instructions included safety instructions, information on special working methods (that differ from normal practice) and in some instances information on tolerances. The difference in control procedures required that a separate quality assurance manager was employed on the larger site to provide a check on the additional requirements.

There was greater variation in interpretation of the procedures described by the site procedures manual. The greatest area of variation lay within the procedures numbers 19–25 concerned with quantity surveying. The differences in quantity surveying procedures occur because the procedures manual focuses on the form of information output in order to ensure that the firm receives payment

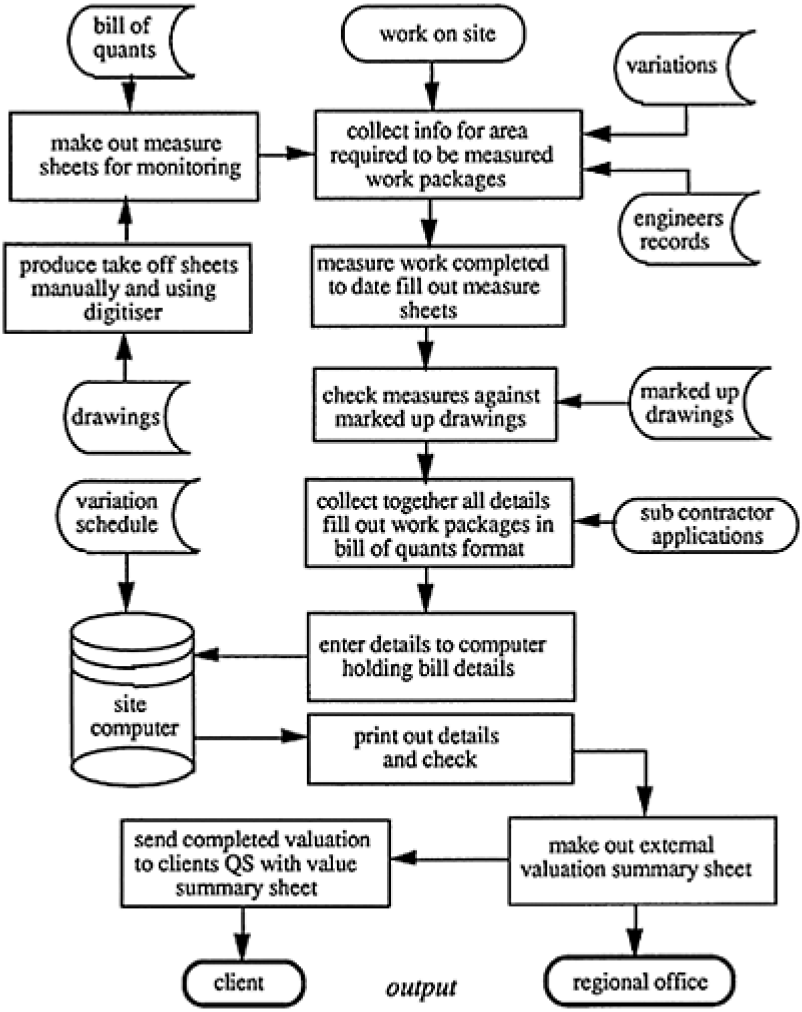


Fig. 4. Data flow diagram for external valuations on the industrial contract

from clients. They are less concerned with the methods used to generate this information. The commercial manager on the larger site was keen to innovate and encourage the introduction of computer systems to the site with the objective of improving efficiency in data handling.

The processes for generating external valuations were compared. The comparison of data flow diagrams showed that on the larger site work is physically measured and marked up on drawings, these measured values were compared carefully against subcontractors applications for payment on specific work packages. The smaller contract bases its control of costs on estimates of overall percentages rather than the precise measurement of individual elements. Despite the differences in preparation the same formats were used for the presentation of both the valuation bill and figures on it's summary sheet. Consequently the quality and accuracy of data used to generate these requests for payment cannot be ascertained by the recipient.

Output was usually in the form of specific standard forms. The systems analysis also showed where duplication of information and procedures existed. This duplication was most evident on the larger site due to its more departmentalised management structure. Examples were seen in the collection of progress information and monitoring of site progress by different departments each of which required the information in a particular format. Duplication was also found in the processing of cost information to determine the weekly costs and the monthly valuations.

5 Conclusions

Procedures manuals were seen to focus more on output (what was required) than the way to achieve it. This is clearly a reasonable policy for it accommodates the variations in size of projects gained by the region and specific contract conditions and types. The difference in scale and the smaller number of people on the hospital site often meant that individual members of the management team on this smaller site were able to see the whole site work progress and a larger part of the total management information system. This had implications for information input and processing within procedures. Where individuals can collect their own information there is a much larger potential for collecting data and checking it informally than where an individual is in receipt of someone else's information. The quality of decision making is influenced by the knowledge of the person making the decision as to the accuracy of the information with which they have been presented. This knowledge can be lacking where persons based at regional office receive data presented on standard forms.

The difference in scale and quantity of information was also seen to have implications regarding adherence to procedures. Where smaller quantities of information are involved and individuals are aware of the working of the whole management information system on site the strict adherence to formal procedures was often felt to be unnecessary. Informal methods were adopted and in some circumstances procedures were bypassed. Both sites were seen to suffer from a problem when interfacing with regional office. The ultimate use of information supplied by site was little known by many of those generating information and information was regarded as "disappearing to unknown destinations". Although in certain instances, such as planning on the larger site, this was not the case as these regional office functions were undertaken on site.

The aim of the procedures manuals to create certainty that all persons within the organisation are operating procedures in the same way. They often failed to achieve this aim for individuals used their initiative to ensure that site works progressed satisfactorily. There was evidence on both sites of some procedural requirements being bypassed due to requirements for faster information and flexibility; material ordering being one example. More informal methods such as not filling out all the required forms or contacting suppliers direct were noted.

6 Recommendations

A computer based system for making payments to subcontractors was developed and tested on a trial basis. This testing using live data in parallel with the existing manual system established that the computer generated output was both accurate and more rapidly produced. The system is compatible with other existing independent computer systems based on the larger site. It is now being considered for implementation by the company.

Proposals were also made to place stores records onto computer and to link them with the quantity surveying computer system so that information concerning materials orders, deliveries and stock control (materials on site) was readily available. This would enable those responsible for programming deliveries and receipt of materials more rapid access to information and also to allow the surveyors to exercise better cost control.

Possible improvements to the financial reporting system from regional office to head office and proposals for linking the planning function with costing were made in the context of the design of a master computer database management information system. This work continues.

9
The potential for automation and robotics in the design and production of buildings

M.M.CUSACK

Abstract
Construction projects contain a high manual input in all aspects of assembly. In the manufacturing industries where the application of robotics is at an advanced stage the importance of design for assembly is clearly demonstrated. This paper argues that attention must be focused on building design if the potential for robotic assembly is to be realised for construction projects. Three areas are addressed. First the assembly operations. Second, the developing environment of the building in which these assembly operations take place. Third, the creation of formal methods for cost effective site layout to facilitate robotic assembly. Methods of rule based generation of building descriptions are examined. The development of such descriptions of building designs offers the potential for effective planning for robotic assembly because the building design descriptions are created in a way which 'parallels' the construction operations required for their realisation.

Keywords: Automation, Robotics, Planning, Control, Building Assembly, Building Design, Rule Systems.

1 Introduction

To meet the demand from clients for continuing programmes of building—housing, schools, hospitals, libraries, offices etc. it is necessary to reconsider the methods used in the design and production of buildings. This is particularly appropriate at a time when a new young industry is emerging and provides increased opportunity for changes in traditional methods of working including the industrialisation of components both on and away from the site. It is essential to reduce the duration of projects and reduce the labour intensive nature of the industry due to the cost and difficulty of finding skilled labour. For this to be effective it is essential that the designer has a much greater understanding of the production needs of buildings and the potential of linking computer aided design to on-site use of robotics is an attractive proposition.

The intention of this paper is to explore the implications of the wide range of on site assembly operations in building construction and to examine ways in which the introduction of automatic and robotic methods of assembly affect the procedures for building design. It is argued that robotic assembly implies the need to examine building assembly operations as central to the design of the building.

The foundation of the relationship between design and automatic assembly have been examined in the field of manufacturing (1). The problems of flexible assembly systems have centred around the appropriateness of the design for robotic assembly. Robots are considered a vital part of such flexible systems because of the variety of manipulation which they can provide.

Assembly operations represent a concentration of manual tasks which have proved difficult to automate. Problems are compounded from basic considerations of the cost, time relationship (2, 3) and technical feasibility. The nature of the assembly operations lie at the heart of these problems. They are not concerned with the operations on a single component as is the case with machining but will bring aggregates of components together in specified spatial relations. These relations may be complex and their successful execution depends on many properties of the assembly design including lead in features on components, partial obstructions, the criteria for recognising when assembly has been completed and fixing methods.

In addition to the complexity of individual assembly operations are the problems of intricate sequences of these operations to complete the assembly. This problem is generally overcome by passing the partial assembly between robotic work stations designed specifically for implementing a particular type of assembly operation. This solution essentially avoids the introduction of flexibility and is often applicable only to large batch sizes and relatively constant products.

Many of the concerns of robotic assembly in manufacturing are similar to those of construction. The need for complex manipulations, sensors to determine the states of an uncertain and changing environment and the intelligence to make plans for action and recover from errors. Assembly in building construction does not offer the means to structure the assembly tasks to minimise these problems. The stationary nature of the building implies that components must be brought to assembly locations rather than subassemblies moved between assembly stations. In effect the assembly stations are moved around the construction site creating the need for autonomous site navigation not generally present in manufacturing applications. Further, the construction site is generally poorly structured with little control or explicit knowledge on the locations of equipment and components until they are finally in position on the building.

The comparison of building and manufacturing assembly implies that the design of assemblies, critical for successful automatic assembly in manufacturing, is even more so in building construction. The design of assembly components in terms of desirable component features for robotic assembly is not the main purpose of this paper which is to present the means by which the overall design of the building may facilitate robotic assembly.

Small changes to design practice in terms of component design and choice are only a minor consideration in this aim which rather seeks to expose the need for building designers to think more formally about designs in terms of assemblies of building components. Consideration of building designs in this way will not only allow attention to be focused on assembly operations to put individual components into place, but also to include the delivery and transfer of the components and the robotic devices used in the assembly to the site of assembly.

The introduction of robotic methods of assembly provides the opportunity to reassess the procedures and methods of design. This lesson has been learnt in a piecemeal fashion in manufacturing assembly. The effective and productive use of automated construction equipment is critically dependent on the nature of the building design at all stages of construction. It is the changing environment of the building design during construction that presents the major problems for robotic automation. The designer should be formally and explicitly aware of the stages in construction of a design. It is only in this way that the designer can make realistic decisions on the suitability of the design for robotic construction.

There are three levels at which the designer should consider the building design for robotic assembly. At the lowest level are the specific operations required to bring the components together. Second the developing nature of the building during construction. Third, the wider issues of site layout concerning the number, location and delivery of materials and components.

2 Assembly Operations

Research on the nature of assembly operations considers the strategies for the successful completion of single tasks (4). This work is largely confined to manufacturing assemblies. However, there is little knowledge on the assembly strategies for construction assembly operations. Specific design features, such as unidirectional assembly, lead in features and snap fixing methods have been identified for manufacturing assembly. Although, the considerations for building design for automatic assembly may be similar the relationship of these operations in assembly sequences is quite different in construction. Manufacturing assembly tends to be concentrated around a single identifiable product but in construction some components comprise the building ‘frame’ but most are placed on and fixed to this frame. A building assembly system will need to move over the frame between assembly operations. The robot will need to move itself to new locations.

Knowledge of building assembly operations is required by the designer in order to design for robotic assembly. Understanding the capabilities of automated assembly equipment is required at the design stage. This knowledge is often available in the field of component manufacture using machine tools, but is rarely so in the assembly of components which has been predominantly a manual operation. The flexibility inherent in these manual assembly operations has led to little consideration being given to the assembly operations at the design stage.

Building design thus requires an input on the characteristics of assembly operations if the robotic assembly methods are to be used effectively. It cannot now be assumed that all assemblies are equally difficult to make. The investment in, and availability of automatic assembly machines will limit the kinds of assembly which can be incorporated in a design.

It should not be assumed that this will necessarily introduce constraints on the nature of the overall design scheme. In many cases the effect will be to place limits on the component details particularly in the methods of fixing, the geometry of mating surfaces and the types of manipulations needed to bring the components into the final spatial relations. The limits may not affect the overall spatial properties of the components.

The attention to these detailed features of the building component design specifically concerned with the relationships between the components will have the effect of. increasing the designer's awareness of the importance of the spatial relations among the component's of the building. Assembly is the business of realising these spatial relations. The problems of assembly are essentially about the passage through a sequence of spatial relations as one component is moved into its final position relative to another. The strategies for robotic assembly are expressed in terms of these sequences of intermediate spatial relations, which represent sub-goals in the path to the goal of final assembly.

In order to consider the relation of building design and robotic assembly it is not sufficient to examine current component types and their assembly. As in manufacturing the problems of robotic assembly are as much about the design of the robotic systems as the design of the assemblies to make them suitable for robotic methods. The building design process must therefore adopt methods and procedures which produce designs appropriate for robotic construction. The emphasis should be on the ways that components are brought together to form the spatial and functional characteristics of the whole building.

The concentration on automating individual assembly operations has been identified (5) as a shortcoming in the development of robotic automation in construction. The examination of rule based systems arising from assembly operations will enable the planning of robotic methods of construction at the design stage, as well as the integration of these methods in the construction process.

3 Dimensional Coordination

If robotic construction is to be effective then it will be necessary to establish rule based generative systems for building design, based on the spatial relations among components. Rule based systems have the potential to ensure that dimensional coordination among the components in the design is maintained. The rules can be used to encapsulate a system of dimensional coordination for arranging the dimensional framework of a building so that components can be used within the framework in an inter-related pattern of sizes. To do this it is necessary to establish a rectangular three dimensional grid of basic modules to which the component will fit. The first step in producing a rational system capable of robotisation is to agree the basic dimensions of the enclosing fabric of the building at the design stage. The principle of relating components to a planning grid are not new and there are a number of British Standards which give recommendations for controlling limits to the dimensions and sizes for the structure and components. A process of dimensional coordination supposes a complete and careful appraisal of precise requirements at the design stage and decisions cannot be left until the building is being erected.

Dimensional coordination expressed as rules for design will lead to simplification of constructional details which will assist the mechanisation of construction both on site and in the prefabricated manufacture off site.

In order to take full advantage of the use of robots it will be necessary to adopt an agreed system of dimensional coordination, net only on a national but also an international scale. As part of this process an agreed standard of tolerances will also be an essential feature. This in turn presupposes a more comprehensive system of inspection and control to guarantee that manufacturing tolerances are maintained. The nominal dimensions of a component is fixed and indicates the zone in which the component must at all times fit.

The above considerations all lead to the requirements for design systems in construction which allow for the building to be described in terms of the assembly of components. The assembly operations incorporated into the design rules will be based on the examination of the nature of these operations and the strategies for their execution by robotic or other means. It is argued therefore that the need to design for efficient assembly on site using flexible robotic systems where appropriate, brings rule based systems of building design to the fore. This allows a formal description of the building in terms of the spatial relations among components and the spatial and functional characteristics of aggregate assemblies. In turn this allows the designs to be evaluated for robotic assembly and provides the input for planning construction. There are now pressing reasons to begin to formalise the nature of the building design process in terms of rules of design (6).

4 Rule Systems for Building Assembly Design

The examination of the importance of understanding assembly operations in construction has led to the conclusion that rules of design can be based on the assembly of components. The major advantage of such an approach lie in being able to ensure dimensional coordination within the rules used and in selecting those rules which correspond to robotically executable assemblies. However, it is essential to look further and examine how the generation of building designs using rule based systems should be guided and controlled to ensure design functionality as well as constructability. The problems here are considerable, since the application of individual rules can guarantee neither designs which meet functional specification nor sequences of assembly operations which are realisable, even though the individual operations are satisfactory. It is the combinations of rules which will have a semantic interpretation in the areas of function and construction.

Despite these difficulties the use of rule based design systems will bring the processes of design closer to those of construction, particularly the assembly processes on site. Designs will cease to be two dimensional formal compositions and become genuine three dimensional compositions of spatially related components. Design is thus no longer remote from the needs of construction in the same way that design and manufacture cannot be divorced in the progress towards effective manufacturing automation. The changes in building design arising from the introduction of robotic automation are not the central subject of this paper, but rather the framework and methods which are required to bring about these changes.

It is noted that the necessity of transporting the robot to the site of assembly as well as the components will impose more limitations on building design than the individual assembly operations. The rule based systems provide the appropriate tool to enable the examination of developing building geometry. This is the context in which the robot and components must move.

Before considering these issues, the development of rule based design formalism will be traced. In principle the methods provide the means to explore design spaces by rule applications within the rule based system. The control and selection of generated designs may be based on a wide range of criteria ranging from the aesthetic to the functional. In the present context the designs generated will be evaluated against the methods and devices available for robotic assembly.

It has been demonstrated that the formal methods of the shape grammar implementation (7) of rule based design systems can provide the means to describe architectural design spaces as coherent aggregates of spatial relations among building elements. This work has led to a deep understanding of the meaning of architectural style. The focus of this research has been on aesthetic considerations. The main argument of this paper is that the natural derivation of design rules from construction assembly operations allows similar methods to be used in the exploration of design spaces for the evaluation and planning for robotic construction.

The thrust of this shape grammar approach to the description of building design in the creation of a design language whose elements are generated by the rules (8). The language of architectural designs may be thus generated from the spatial relations to be realised by assembly operations. Robotisation requires a design language to express and convey ideas of shape, size and construction of the architectural components of an individual building or group of buildings. To have an optimum value the information conveyed by the language must be clear concise and subject to well defined interpretations.

The translation of a concept from a designer’s mind into something that can be created by a robot is a complex process and involves a series of intricate steps which eventually converge as the designer incorporates many individual and diverse ideas into the complete and final design. The rule based approach will enable the steps in this integration to be formalised. Design and production of complex structures requires the solution of many complex problems. Construction projects may be composed of thousands of individual activities, each with a sequential or parallel relationship. The total design and production budget is often in the many million pound category and an economic method of designing that takes account of production processes must be seen as an essential facet. It is essential that provision is made for testing or simulating the final building at the design stage through the creation of a three dimensional model within a CAD system. It is argued here that the rule based approach allows the building design at all stages of construction to be evaluated and methods of robotic construction assessed.

5 Building Design and Robot Planning

The rule based generation of building designs allows sequences of assembly operations which realise the spatial relations, incorporated in the rules, to be evaluated for robotic execution. The rules of design generation allow potential designs and sequences of assembly operations to be explored in terms of robot and component movements. The critical feature of a building design is that the developing design is the environment in which robot assembly devices are to operate.

To evaluate the design and plan for robotic assembly it is necessary to understand the emerging spatial properties of the design as the rules are applied. The problem here is that the spatial relations to be realised in assembly only represent a fraction of the spatial relations that arise from the rule applications. Spatial properties of the building design emerge as the design is generated. The design generation will be guided and controlled to produce some of these since they will form an integral part of the formal and functional specification of the completed building. However, many others will not be critical in meeting overall specifications but may nevertheless be important in providing information on the potential accessibility for robots and components.

Design generation in terms of available methods of robot assembly will require the addition of attachments for the robotic devices and the means of component delivery to the design. The means of robot support must be included in the design description.

The generative systems for building design will allow the overall development of the building on site to be examined because the design process parallels the development of the design on site. This is not just a means of simulating building development but of exploring the design space defined by the rules for solutions meeting functional and formal specifications as well as constructability criteria.

The design rules based on assembly operations enable sequences of these operations to be explored in terms of the emerging building geometry. Evaluation and choice is possible at the design stage, so that modifications to the overall design can be incorporated using backtracking procedures and the invocation of alternative rules.

The attention to automation of individual assembly operations is not sufficient to integrate robot assembly methods into construction (3). The developing building geometry and the environment in which the robot works must also be considered at the design stage. The robot environment on the construction site is often identified as a major difficulty. The robot moves to the site of assembly and components are delivered in a complex and uncertain spatial environment. The motivation for describing the building design in terms of spatial relation based rules is that knowledge of this environment is included at the design stage and can be used in creating well structured plans for robot actions.

Planning for robot assembly will require the spatial properties of large and complex aggregates of components which emerge from the rule applications, to be inferred from the sequences of rule applications. The process of design will require that the rule applications be controlled to direct the design generation towards those emergent spatial properties appropriate for robotic assembly. The sequence of rule applications corresponding to component assemblies must create at each stage a partial assembly on which the robots can work and to which both robots and components can gain access. The problem is therefore to specify the nature of the spatial environment for robot assembly, to guide design by this specification and to match emergent spatial properties against specification.

6 Planning and Control

The means to evaluate building designs for robot, assembly have been sketched. Precepts and guidelines need to be established for movement within the developing building of robots, components and materials as well as access to building and the general organisation of site layout. This will allow the planning of the priorities and sequencing of construction operations and provide the control structures to implement the plans on site.

Site layout is dynamic and changes physically during each phase of construction. These phases are specified by activities and it is important to determine a series of central focuses in each stage about which other activities revolve. In particular, points of access to site or developing building will determine the focal points of activities. It is likely that in a particular phase one activity, for example, concrete work, may have a coordinating priority. This may occur in a number of phases and therefore, the focus of this activity should be within reach of casting and placing areas, within crane sweep for horizontal and vertical movements and have access to hoists for vertical movement.

Once ground work and substructure have been completed the next phase introduces vertical movement and robots may be used in conjunction with cranes and hoists. As work progresses site layout requires adjustment and becomes increasingly determined by the building geometry. Planning and control of the construction becomes more complex with wider spans of control, a more dynamic approach to communications between activities and a more intensive use of robotic assembly.

Access to the points of activity must be provided as the building geometry develops. Doorways and windows are often used, but temporary access routes for robots, materials and components should be provided at design stage. Careful planning should enable floor and wall sections to be temporarily omitted to allow access without affecting structural integrity.

The movement of materials, components and robots within the building is a major problem in robotic assembly. Guiding frameworks, rails and ramps will need to be incorporated for the duration of a construction phase.

7 Prefabrication

In drawing comparisons between manufacturing and construction in terms of design for robotic assembly the continuing interest in prefabricated components should not be ignored. Prefabrication has resulted from an examination of the difficulties of on-site assembly operations. In this way there has been considerable influence exerted on building design. Prefabricated components may still leave difficult assembly problems on site, particularly with the access and fixing of geometrically complex components. However, they do offer the scope for robotic assembly of those components either off site or in specially prepared workplaces on site.

The prefabrication option can be assessed along with other assembly methods in the planning and evaluation procedures applied to the building design. Prefabrication now represents just one route to guide the generation of building assembly operations. It is based on a decomposition of the building into functional components. As a design philosophy it attempts to reduce the interactions between components and as a construction method it removes many assembly operations from the complex spatial constraints of the developing building geometry.

Rule based design systems allow construction plans to be generated as the design is taking shape. Many different construction methodologies can be explored with their associated impact on possible designs. There is no need to be constrained by a single methodology such as prefabrication.

8 Computer Aided Design

Methods of rule based design description have been advocated as most appropriate for the parallel generation of designs and their planning and evaluation for robotic construction. CAD systems for building design are generally used as a formal modelling framework for entering, recording and displaying the spatial features and characteristics of a design. This process involves the haphazard and informal applications of design rules and is generally structured according to levels of detail and types of service. The main purpose is to describe the design in all its complexity and to submit this for analysis of cost, structure, materials requirements, services and circulation. This distinction between formal design and functional analysis makes it difficult to assess a design for robotic assembly which requires that the stages of construction are available. Partially completed buildings are the environment in which the robot operates. Design evaluation for robot construction should be accommodated within the design process and be able at each stage to guide design generation. The CAD system for building design must therefore be able to accept and apply rules of spatial composition to generate assembly sequences for buildings.

These changes to the processes of design do not just deal with new ways of entering a design, previously formulated, into a CAD system or in structuring that information in a database for subsequent use in planning for automatic assembly. The thrust of the argument is that a rule based approach provides a structured approach to the examination of alternative designs in terms of assembly operations from which the rules are derived.

9 Conclusion

Building assembly operations can be used to provide the basis for rules to generate building designs. These rules are derived from the spatial relations between components and may be incorporated into shape grammars specifying languages of design. The design process can then include the evaluation both of individual assembly operations and the planning of sequences of those operations for robotic construction. The descriptions of building designs in this way allows the developing building geometries to be explored to aid planning and control of robotic assembly on site.

10 References

(1) Redford A. (1986) E.Lo. ‘Robotics in Assembly’, Open University Press
(2) Cusack M M. (1985) ‘A simplified approach to the planning and control of cost and project duration’, Construction Management and Economics. 3 pp. 183–198.
(3) Cusack M M. (1985) ‘Optimisation of Time and Cost’, Project Management. 3. (no.1). pp. 50–54.
(4) Hopkins S, Byrne C, Bland C, (1988) ‘The development of a toolbox of assembly strategies’ Proc. 18th ISIR, Lausanne.
(5) Slocum A H (1986) ‘Development of the integrated construction automation methodology’ Proc. Int. Conference, CAD and Robotics in Architecture and construction, Marseilles pp 449–468.
(6) Cusack M M, Earl C F, (1987) ‘Planning for robotics in construction projects’, 4th International Symposium on Robotics and Artificial Intelligence in Building Construction, Haifa.
(7) Stiny G ‘Introduction to shape and shape grammars’, Environment and Planning B, Vol 7 pp 343–351.
(8) Earl C F, (Jan 1985) ‘Creating Design Worlds’ NSF/UCLA Symposium on Computational Foundations of Architectural Design published Planning and Design Vol. 13 1986.

10
The impact of multicultural work teams on the management style of construction site managers

A.ENSHASSI and R.A.BURGESS

1 A.Enshassi, B.Sc (C.Eng.), M.Sc, Ph.D, MCIOB, ABIM, MIMS.
2 R.A.Burgess, B'ARCH, RIBA, PPCIOB, MBIM, FIMS.

Abstract

A review of literature reveals that there has been little research in the Middle East regarding the relationship between the culturally heterogeneous work forces and the managerial style of site managers. The intention of this paper, therefore is to explore the association between the cultural diversity of work forces who are frequently drawn from more than one culture and the managerial style of construction site managers. Data were obtained from 79 site managers in 6 Middle Eastern countries. The results indicate that the association between the cultural diversity of work forces and the style of site managers was weak and failed to reach statistical significance. In particular, the results show that construction site managers tend not to adapt their style according to the types of culture encountered. The paper recommends that construction companies operating in the Middle East need to recognise and consider the cultural training as an integral part of construction management development if they are to remain competitive and successful.

Managing work teams in the Middle East

The success of a construction project, whether it is carried out in the country of the contractor or beyond its borders, is determined in the main by the quality of its management. Projects which are undertaken beyond national borders may create special problems for managers, such as dealing with multi-ethnic work forces, operating within local laws, regulations, and social customs, and importing materials. This increases the pressure upon managers who require particular qualities and understanding in order to achieve their target in the most economical way.

A work force is one of the main resources available to any construction firm (Rabbat and Harris, 1982). In the Middle East many construction projects have work forces which come from more than one country, and show variations in language, attitudes, religion, and education. Such situations pose great difficulties, not only to managers with western backgrounds but also to local ones. However, the problems met by western managers are usually greater because they have been brought up in a completely different environment, usually with a work experience gained in developed countries.

Rabbat and Harris (1982) reported that labour disputes and conflicts arising from cultural differences (e.g. religion, values, attitudes, and social traditions) have increased in the Middle East which may lead to serious disruption and financial losses to international construction firms. The success of managers in this particular setting is to a large degree dependent on the interpersonal relationship between foreign managers and their subordinates which is influenced by the degree of cultural diversity of both parties (Malony, 1982; Imbert, 1987).

Rabbat and Harris (1982, p. 219) stated that: "management must adapt to the culture if conflict is to be minimised…efficiency, and thus productivity, can be greatly increased if conflicts among individuals and groups can be reduced". Imbert (1987) also emphasised the need of understanding cultural diversity and international labour productivity factors when operating in developing countries.

The Concept of culture

Culture reflects the patterns of life in any society regarding education, beliefs, customs, traditions and social structure. It consists of several elements, which embrace : values and attitudes, language (communication) and religion. These components have extremely strong relationships with each other, in other words each item has a considerable influence on the other one. Consequently, it is impossible to investigate one element in isolation; and at the outset it would be helpful to review other researchers' definitions of culture.

Layman (quoted in Hall and Whyte, 1960, p. 5) has defined culture in three terms, namely: the way people dress, the beliefs they hold and the customs they practice. Taylor (quoted in Phatak, 1974, p. 138) has defined culture as: "That complex whole which includes knowledge, belief, art, law, morals, customs, and any other capabilities and habits acquired by man as member of society".

Kluckhohn (1951, p. 86) defined culture according to several anthropological definitions: "Culture consists in patterned ways of thinking, feeling and reaction, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artefact; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values".

Hofstede (1984, p. 21) has given a more specific explanation of the cultural image. He says: "Culture is to a human collectivity what personality is to an individual". Hofstede refers to Guilford's (1959), definition about personality, that is "The interactive aggregate of personal characteristics that influence the individual's response to its environment", Hofstede, then, concluded that “Culture determines the identity of the human group in the same way as personality determines the identity of the individual”.

Kaplan (1972) reported that four theoretical subsystems were used to explain the cultural differences: ideology, social structure, techno-economics, and personality. Whitchill (1964, p. 69) gave a very broad description for culture: “Culture is not made in any esoteric sense but, rather, the whole complex of distinctive features characteristic of a particular stage of advancement of a given society”. This definition is very comprehensive and yet dynamic as well; it is suitable or valid to any time and for any change. Schuapp (1978, p. 9) explained the concept of culture in two parameters to serve the purpose of his study. lie defined culture as “The attitudes and values of a given society at a particular state of advancement”.

Fayerweather (1959) interpreted culture in his comparative managerial study of Mexicans and Americans as: the attitudes, beliefs, and values of society. Although this definition is not comprehensive, it does reflect significant elements which are basic to the study of cultural differences across nations.

Other studies (e.g. Megginson and Eugene, 1965) defined the concept of culture according to anthropological analyses. The classical definition includes all sociocultural elements: political, economical, law, social and characteristics of education. Such a broad definition will certainly leave the reader to his imagination to consider which element will be relevant for this study. The cultural integration between one community and another will depend upon various factors, such as: the degree of cultural differences, language, politics, and religious understanding. Hall and Whyte (1960, p. 10) highlighting the importance of communication and its relation to the culture, stated that: “We would be mistaken to regard the communication patterns which we observed around the world as no more than a miscellaneous collection of customs. The communication pattern of a given society is part of its total culture pattern and can only be understood in that context.

Hofstede (1984, p. 23) believed that the norms of society can rarely be changed by the direct adoption of outside values, but rather through the shift in ecological factors, such as those of technology and the economy. He added: “In general, the norms shift will be gradual unless the outside influences are particularly violent (such as in the case of military conquest or deportation)”.

This seems to underplay the importance of social norms such as rules, principles and behaviour, because in some countries these are fundamental concepts underlying the whole manners of conduct and thought which must be accepted as they can not be changed easily, even in the long term. For instance, the societies in the Middle East elicit their norms from the Koran and the Prophet’s teaching, which is considered essential in their daily lives; therefore it would not be possible to change them without a fundamental modification of religious understanding, though their influence may vary in rigour between religious parties.

In this brief review, several cultural definitions have been examined and discussed. As its aim is to provide an insight into the concept of culture, and to choose the most appropriate definition to serve the purpose of this study, a decision has been made to focus upon Fayerweather’s definition for the following reasons.

Firstly, the study aims to investigate the impact of work forces’ values and attitudes on the style of construction site managers who manage a mixed-cultural work group.

Secondly, the religious faith in the environment (that is the Middle East) where the study is concentrated is a fundamental element. However, it is necessary to take another element, language, into consideration for the following reasons: firstly, language reflects the nature of culture; secondly, the perception and interpretation of words or expressions vary from culture to culture, which might have an impact on the interpersonal relationship among work group's members who, probably, come from different cultures. Thirdly, in a construction project, communication between manager and work group members or among members themselves has a considerable effect on progress of the project.

Management style and culture

Management style can be defined as the pattern of behaviour that site managers, as leaders of their team, exercise during the process of supervising, planning, and directing resources on site. There is a large body of literature investigating the managerial style in industries other than construction, in which two main categories of managerial style have been identified, namely task orientation (or initiating structure) and employee orientation (or consideration) (Hemphill, 1950; Halpin and Winer, 1975; Stogdill and Coons, 1957; Flishman and Peters, 1962; Kerr et al, 1974; Blake and Mouton, 1964; and Fiedler, 1967, 1984).

For the purpose of this paper, the expressions of “task” and “employee orientation” are used. They can be defined as follows:

Task oriented managers are those who are concerned with the management of external task activities, such as organisation, control, efficiency, and productivity. Managers do not expect the work force to adapt work methods in which the have been trained and as they accepted them. On the other hand, employee oriented managers who give priority to the management of internal relationships among the work team members and themselves. They establish a rapport with their multicultural work forces by understanding the cultural differences and solving their problems.

There is still a debate surrounding the universality of management theories and their applications. On the one hand, several scholars believe that management style varies from one culture to another, and therefore managers should adapt their style according to individual situation. Phatak (1974) reported that, the greater the degree of cultural differences faced by a management team in an international company, the more likely that failures will affect them. Schein (1985) stated that, it is not possible to separate the process of leadership from the culture of a team.

Hofstede (1980, 1984) found distinct differences across cultures towards the perception and preference of the leadership style. Hundal (1971) reported that, although the leadership principles are universal, the methods and procedure in which they are adapted to each culture and work location decide their success and failure. In other words, the culture has an impact on the leadership style. Gonzales and McMillan (1961) stated that, the management practice in a multi-national organisation is culturally bound; the managerial practice must be closely associated to the influx of technology moderated by cultural norms of behaviour (Starbuck, 1976). Child (1981) eported that there are several factors associated with the divergence in management, namely organisation political, and cultural factors.

Whyte and Williams (1963) concluded from their survey that there is a common satisfaction and agreement between the American and the Peruvian workers regarding a supervisor who understands the needs and problems of his workers, and who is interested in improving their skills by training. On the other hand, they found that for the Peruvian workers there was a positive correlation between closeness of supervision and general satisfaction with the supervisor. The Peruvian workers expressed their preference and satisfaction for a supervisor who tells them what to do and observes their progress rather than one who offers general supervision and leaves the operatives on their own most the time. It can be clearly seen from the above discussion, that culture does affect workers' expectations and perceptions of managerial style. This indicate that managers should adjust their style according to the cultures being encountered.

On the other hand, other scholars believe that management theory and practice can be applied in every culture and situation without a need for adaptation to specific cultures. Negandhi (1983) pointed out that several management practices, namely planning and decision making, are not influenced by cultural diversity, but are contingent upon technological and market conditions. Negandhi lent support to the believe that management styles vary among cultures: he tended however, to refer such variation to technological and economic discrepancies rather than cultural differences. Haire, Ghieslli, and Porter (1966) concluded that there were many similarities in managerial attitudes and motivations among managers in all countries. Thiagarajan and Deep (1969) concluded from their survey that all managers preferred democratic supervision irrespective of the cultural differences. This seems to be consistent with Haire et al's result.

Al-Jafary and Hollingsworth (1983) found that managers in the Gulf region operated in a consultative managerial style as did their American counterparts. Massie and Luytjes (1972) said that there is a tendency towards a similar management practice in Western and Eastern Europe, South America, Asia and Africa. They referred to several reasons which contributed to this result, namely the increase of management education across cultures, management functions (e.g., planning and organisation) and participation in decision making. Based on the above, it seems to be very difficult to conclude that management style is universal or culturally bound.

Hypothesis

Based on the above review of previous research findings, the hypothesis which our project was designed to examine was that:

There is no association between the cultural heterogeneity of work forces and the style of construction site managers in the Middle East.

Methodology

Subjects and procedure:

The data were obtained from 79 construction site managers representing 62 international and local construction organisations which were drawn from 6 countries in the Middle East (Figure 1). 47 projects were being carried out by international organisations and 32 projects by local construction firms (Figure 2). Construction site managers were considered as individuals in charge of running and directing construction projects. Their main task was to obtain a high level of productivity from resources and from the work forces who utilise those resources. The criteria for the selection of site managers and contractors was basically contingent upon various factors, these were: construction projects must contain a work force composed of several cultures; site managers should have a direct and daily contact with all members of the team; accessibility, and willingness to co-operate. The names and

Figure 1. The Locations of Construction Projects

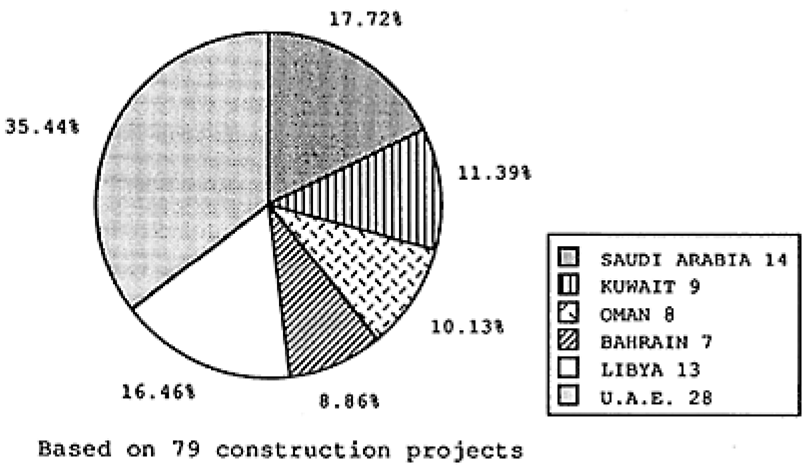
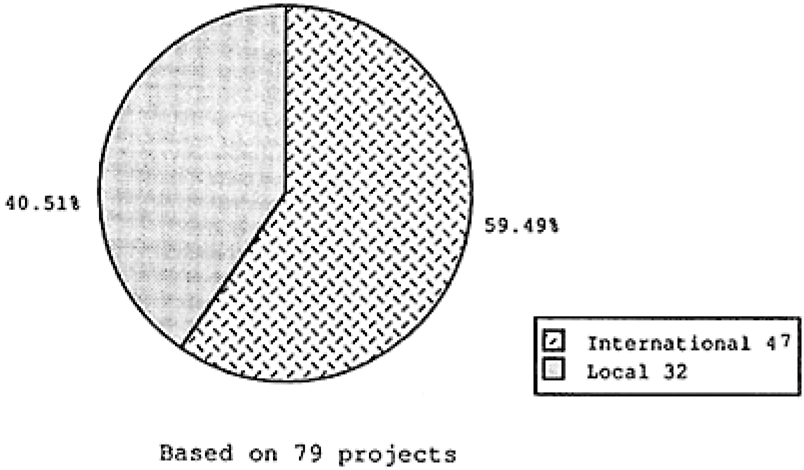


Figure 2: Categories of Construction Projects



addresses of construction companies were obtained from Engineering News Records' annual list of the top 250 international contractors; Department of Trade and Industry; Chartered Institute of Building (CIOB); and Middle East Association.

The focus in this study was on organisations that acted as main contractors and upon medium to large-scale contracts (medium with a contract value of between £0.75M and £2.5M, and large scale with a contract value of over £2.5M) (Figure 3). The reason for such a choice was to reflect the general distribution of project size in the construction industry which meant that small size projects were not included.

Data in this study were obtained by means of questionnaires distributed to site managers currently working in the Middle East. The sample included not only Western but also local site managers and others from third country national (from third world countries), representing both international and local construction firms (Figure 4). This might appear to be an arbitrary selection, but it was unavoidable because of the nature of the Middle East construction industry, which frequently involves more than one culture. Besides, it was felt that the research should reflect the general site managers' style when managing a mixed-cultural work force, whatever the culture of site managers, as they are eventually working in a similar condition, Table 1 shows the nationalities of construction site managers.

A total of 180 questionnaires were distributed, of which 79 were returned completed. Regarding the non-response subjects, some recipients did not reply at all to the letters, other insisted that their completed questionnaires were posted, and a few site managers apologised for not answering the questions, saying that they could not provide such information for reasons of confidentiality. Having said that, the returns were encouraging as 44% returns can be considered excellent for this type of sample, and sufficient to carry out statistical tests. The data were analysed using Cluster Analysis, Cross-Tabular, and Kruskal-Wallis one way analysis of variance (ANOVA) test available is SAS package.

Measurement

The style of construction site managers was measured by asking respondents to answer a question consisting of 14 statements which related to managerial practice on site. The statements were rated on a 5-Step Likert type scale from 1 (strongly agree) to 5 (strongly disagree). A group of statements (a, b, c, f, k, l, n) were related to task oriented managers' style, and another group (c, d, g, h, i, j, m) referred to employee managers' style (see Appendix A). The statements were mixed, but orientated capable of identification into groups at the analysis stage. It was hoped that such a method would avoid any possible bias, and reflect the real orientation of construction site managers.

The cultural diversity of multi-cultural work forces has been measured into three steps: first, site managers were asked whether differences in work forces' values and attitudes, languages, and religion make them modify their managerial style to suit the cultures encountered. The question was constructed in the form of statements and on a 5-Step Likert scale. Secondly, the degree of cultural domination in a construction project was measured based on the assumption of the percentage of individual cultures involved in a project. If one culture represented more than 80% of the work force, then it was assumed that such a project was dominated by one culture. Otherwise, it was assumed that such a project was dominated by more than one culture. The degree of cultural heterogeneity within a project was measured using an approximate index of the cultural diversity of the work force. This index ranged from a score of 1 referring to a homogeneous team of the same ethnic background, to a score of 9 indicating that there were 8 additional cultures in one project.

Limitations of study

Although the study in the main achieved all the aims of this investigation, there are some limitations which should be mentioned. Firstly, the convenience of the sample,

Figure 3: Size of Projects

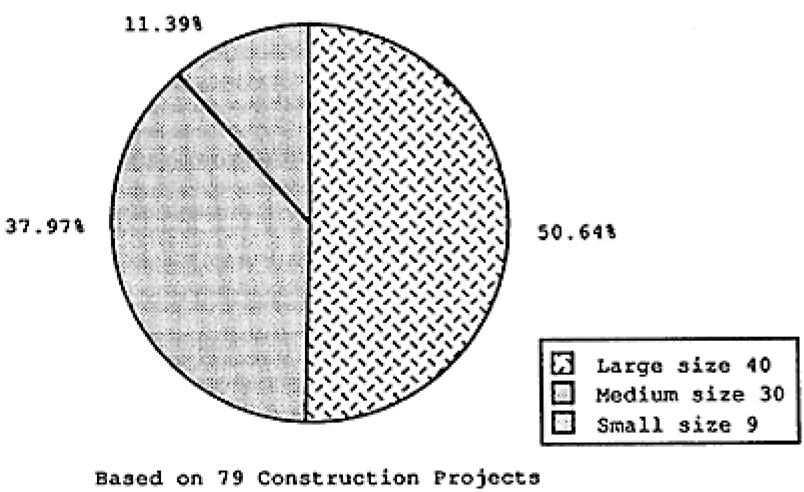
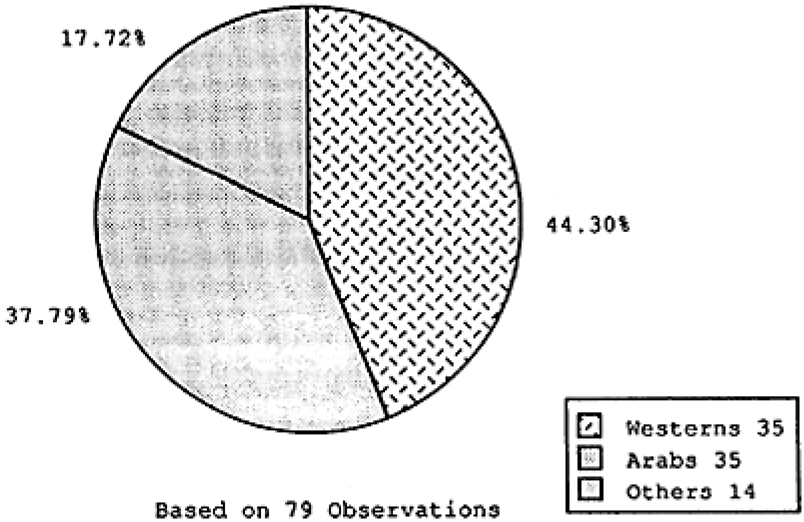


Figure 4: Cultures of Site Managers



although it is statistically viable, may cast some doubt on whether it presents the attitudes of those construction site managers who did not participate in this research and who manage multi-cultural work forces in the Middle East. Secondly, the sample was drawn from United Arab Emirates, Saudi Arabia, Bahrain, Kuwait, Libya and Oman without representation from other Mideastern countries, e.g., Jordan, Qatar, Iraq and Algeria, a fact that may qualify generalisations in the findings. Therefore, there is no claim for representing all Middle East Countries.

Results

Site managers' styles have been categorised into four groups, on the basis of the Cluster analysis result (Table 2). These four groups are: high task/low employee orientation managers' style; low task/low employee orientation managers' style; low task/high employee orientation managers' style; and high task/high employee orientation managers' style.

The average score on perceptions of site managers towards the impact of the cultural factors on their styles, was tested with the four categories of managerial styles, using the Kruskal-Wallis one-way analysis of variance (ANOVA) test. The results indicate that the probabilities associated with the occurrence under the null hypothesis is P>0.25, 0.93 and 0.46. Since these probabilities are larger than the level of significance of 0.05, the null hypothesis cannot be rejected. This means that there is no recognisable relationship between the perception of cultural variables and site managers' style in the Middle East.

Although the association was weak and failed to reach statistical significance, it might be interesting to look at the contingency tables of each variable with the four suggested managers' style (see Tables 3, 4, 5). The following can be noticed: First, Table 3 shows the cross-tabulation between the four style categories and the language factor which is combined in three categories (column 2: agree that language differences affect the style; column 3: neither agree nor disagree; and column 4: disagree that variation in work forces' languages affect the style of site managers). As can be seen in Table 3, the high proportion of respondents are located in column two and almost evenly distributed over styles 2, 3, and 4. The rest of respondents are located in column 4 and only three observations are in column 3.

About 79 per cent of construction site managers believed that the differences in the work forces' languages should make them modify or adjust their managerial style. 18 per cent of managers thought that the variations in language had no impact on their style, and about 4 per cent neither agreed nor disagreed. Secondly, Table 4 illustrates the four style categories which are cross-tabulated with values and attitudes. It can be seen that the results of Table 4 are to some extent similar to the results in Table 3. A near majority of respondents are situated in column 2 and almost evenly spread over styles 2, 3, and 4. The remaining subjects are located in columns 3 and 4. About 67 per cent of managers perceived that differences in a work forces' values and attitudes should make them modify their style. About 22 per cent thought that they should not adjust their style, and 11 per cent did not give a clear opinion.

Finally, Table 5 shows the contingency table between the style of managers and the perception towards religious differences of subordinates. In contrast to Tables 3 and 4 a very high proportion of respondents are placed in column 4, but similarly this high proportion is almost evenly spread in 2, 3, and 4 style categories. About 61 per cent of construction site managers disagreed upon the fact that the variations of work forces' religion or beliefs had a significant impact on their managerial style. About 30 per cent believed that they should adjust their style because of religious differences, and about 9 per cent neither agreed nor disagreed.

To sum up, it can be inferred from Tables 3 and 4 that the majority of construction site managers agree that language differences and the variation of values and attitudes of work forces are very important to their style. This agreement is

Table 1. Nationalities of construction managers who participated in the research survey

Nationality	Number in Sample	Percentage of Sample
British	20	25.3
Jordanian	12	15.2
Indian	11	13.9
Palestinian	6	7.6
Lebanese	3	3.8
Egyptian	3	3.8
Sudanese	3	3.8
Turkish	3	3.8
Japanese	2	2.5

American	2	2.5
German	2	2.5
Dutch	2	2.5
U.A.E	2	2.5
Greece	2	2.5
French	2	1.3
Italian	2	1.3
Pakistani	2	1.3
Irish	2	1.3
Bangaladesh	2	1.3
Srilankan	2	1.3

Sample size=79

Table 2. Classification of Site Managers' Style

Cluster	Managers' Style	Number in Sample	Percentage of Sample
1	High task/low employee	14	17.72
2	Low task/low employee	24	30.38
3	Low task/high employee	19	24.05
4	High task/high employee	22	27.85

similar between the four categories of management style. In other words, site managers said that they should adapt their style to suit the cultural environment in construction projects. Therefore, there is no clear evidence, at this stage, to conclude whether construction site managers really adapt their style or just practice their accustomed style when working with multi-cultural work force.

The two main categories of cultural domination on construction projects (that is when one culture predominates the other cultures, and when more than one culture are dominating) were tested with the four classifications of site managers using the Chi-square test. The results indicate that there is no visible association between the site managers' style and cultural domination ($P>0.05$).

The degree of cultural heterogeneity in terms of the number of cultures involved in construction projects was tested against the four management style categories using the Kruskal-Wallis one way analysis of variance test. The probability (P) was found to be 0.32. Since this P is more than 0.05, the decision in this case fails to reject the null hypothesis of condition differences. That is, there is no observable association between the degree of cultural heterogeneity of work forces and the site managers' style.

Discussion

In looking at the results described above, it appears that there is strong evidence of a discrepancy between the site managers' style and the multicultural work forces, i.e., there is no visible relationship between both variables. Having said that, it is not to be expected from statistics to find from cross-sectional data in studies of management style the kind of clear-cut relationship of cause and effect; rather than talk about causality one talks about the association between variables (Lawshe and Bryant, 1953; Youngman, 1979; Siegel, 1956; Norusis, 1986). However, the results do indicate several important issues that need to be discussed in more detail.

There is an indication that the association between the managerial style of construction site managers and the cultural diversity of work force were weak and failed to reach statistical significance. This suggests that the two varied largely independently of one another. This might lead one to believe that the cultural differences of a work force have no recognisable impact on the managerial style of construction site managers.

This is congruent with the findings of previous cross-cultural research, which suggested that cultural differences did not change the managers' style and showed that there were considerable similarities in managerial style across countries (Haire, Ghiselli, and Porter, 1966; Thiagarajan and Deep, 1969; Al-jafary and Hollingsworth, 1983). The results also support the finding of Massie and Luytjes (1972), that there is a tendency toward a similar managerial practice in Western and Eastern Europe, South America, Asia, and Africa. This also lends support to the universal school which assumed that no variations exist in managerial behaviour across cultures when the functions are the same.

On the other hand, the results of the statistical test do not lend support to the results reported by other researchers, namely that management style is culturally dependent, and therefore managers should adapt their style to match the work force's culture (Hofstede, 1980; Maloney, 1982; Imbert, 1987). The results are not congruent also with Schein's suggestion (1985), that culture and leadership practice cannot be separated, this suggests that there is an association between both variables. The results do not lend support to Hofstede's finding, that there are distinct differences across countries toward the perception and performance of leadership style.

Most modern management theories and organisational behaviour research showed that management style is a function of the leadership style, the subordinates, and the situation. Besides, while management theories can be transferable across cultures, management practices are not (Maloney, 1982). This suggests that site managers have to modify their style to meet their subordinates' expectations.

Table 3. Cross Tabulation Of Managers'style Categories By Respondents Perception Towards The Impact Of Language Differences Of Employees On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	8 (10)	1 (1.3)	5 (6.3)
2	Low task/low employee	19 (24.1)	2 (2.5)	3 (3.8)

3	Low task/high employee	18 (22.9)	0 (0.0)	1 (1.3)
4	High task/high employee	17 (21.5)	0 (0.0)	5 (6.3)

Sample Size=79
Percentage of sample=(100)

Table 4. Cross Tabulation Of Managers' Style Categories By Respondents Perception Towards The Impact Of Values And Attidudes On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	8 (10)	2 (2.5)	4 (5.1)
2	Low task/low employee	17 (22)	2 (2.5)	5 (6.3)
3	Low task/high employee	12 (15.1)	1 (1.3)	6 (7.6)
4	High task/high employee	16 (20)	4 (5.1)	2 (2.5)

Sample Size=79
Percentage of sample=(100)

Table 5. Cross Tabulation Of Managers' Style Categories By Respondents Perception Towards The Impact Of Religion On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	6 (7.6)	2 (2.5)	6 (7.6)
2	Low task/low employee	5 (6.3)	3 (3.8)	16 (20)
3	Low task/high employee	6 (7.6)	0 (0.0)	13 (16.6)
4	High task/high employee	7 (8.9)	2 (2.5)	13 (16.6)

Sample Size=79
Percentage of sample=(100)

Moreover, the nature of the construction industry in the Middle East regarding the composition of its work force, which is probably drawn from several cultures, and obviously shows differences in language, beliefs, values and attitudes leads one to believe that site managers should adapt their style according to the situation. Several scholars advocated this point theoretically and put emphasis on the need of managerial style adaptation or modification in the Middle East (Rabbat and Harris, 1982; Maloney, 1982; and Imbert, 1987).

The results of the contingency Tables 3 and 4 show that the majority of construction site managers, in this sample, believed that the variations in work forces, language and differences in values and attitudes should make site managers modify or adapt their managerial style according to the types of cultures being met. Moreover, most construction site managers who manage multi-cultural work force in the Middle East were unaware of their subordinates' cultural differences. These facts may offer an explanation for the non-response of site managers to adapt their managerial style in multi-cultural construction projects, preferring to continue practising their accustomed style.

In addition, the majority of site managers who had a direct involvement with a mixed-cultural work force did not receive any kind of cultural training regarding cultural differences and similarities of the work groups involved in construction projects. This can also lend support to the argument that managers did not adjust their style to the new environment as they did not receive cross-cultural training. It was also found, that there is no recognisable association between site managers' experience in the construction industry and their adapted style in the Middle East. This also suggests that site managers practice their accustomed managerial style, which has usually evolved as a result of many years of experience in the field.

In addition, the results indicate that site managers' effectiveness decreases when managing multi-cultural work groups and the productivity of such work teams also decreases lend more support to the argument that culture has an impact on the managerial style of site managers.

Indeed, based on the above discussion, it can be concluded that, there is no recognisable evidence that site managers modify their style to suit the new environment. These results are somewhat surprising considering both instinctive logic and psychological researches indicate that cultural differences should make managers modify their style because of the diversity in work-related values and customs and dissimilarity in expectations regarding managerial style. The management of heterogeneous work forces most probably requires a managerial style which is different from the managerial style demanded by culturally homogeneous work forces. Although the results of the statistical test does not give evidence of the association between the cultural diversity of the work forces and the site managers' style, it would be incongruous to ignore the cultural differences of the work forces, and their impact on managerial style.

The authors believe that construction companies operating with multi-ethnic work forces in the Middle East need to recognise and consider the cultural training as an integral part of construction management development if they are to remain competitive and successful.

REFERENCES

Ajiferuke, M., and Boddewyn, J., 1970, Culture and Other Explanatory Variables in Comparative Management Studies, *Academy of Management Journal*, Vol. 13, No. 2, pp. 153–178.

Blake, R.R.; and Mouton, J.S., 1964, *The Managerial Grid*, Houston, Texas: Gulf Publishing.

Child, J., 1981, Culture, Contingency & Capitalism in the Cross-National Study of Organisations, in B.M.Staw and L.L.CUMMINGS (Eds.), *Research in Organisational Behaviour*, JAI, Vol. 3.

Fayerweathere J., 1959, *The Executive Overseas*, Syracuse, N.Y., Syracuse University Press.

Fiedler, F.E., 1967, *A Theory of Leadership Effectiveness,* New york: McGraw Hill.
Fiedler, F.E.; and Chemers, M.M., 1984, *Improving Leadership Effectiveness: The Leader Match Concept*, New York: Wiley.
Fleishman, E.A., and Peters, D.R., 1962, Interpersonal Values, Leadership Attitudes and Managerial Success, *Personal Psychology,* Vol. 15, pp. 127–143.
Gonzales, R.F., and, Mcmillan, C. Jr., 1961, The Universality of American Management Philosophy, *Journal of Academy of Management,* April, pp. 33–41.
Haire, M.; Ghiselli, E.E.; Porter, L.W., 1966, *Managerial Thinking: An International Study,* New York: ohn Wiley.
Hall, E.T. and Whyte, W.F., 1960, Intercultural Communication: A Guide to Men of Action, *Human Organisation,* Spring, pp. 5–12.
Halpin, A.W.; and Winer, B.J., 1957, A factorial Study of the Leader Behavior Descriptions, in R.M. Stogdill and A E.Coons (Eds.), *Leader Behaviour: Its Description and Measurement*.
Hemphill, J.K., 1950, *Leader Behavior Description,* Columbus: Bureau of Business Research, Ohio State University.
Hofstede, G, 1984, *Culture's Consequences: International Differences in Work Related Values;* England, SAGE Publication.
Hofstede, G., 1980, Motivation, Leadership, and Organisation: Do American Theories Apply Abroad?, *Organisational Dynamics,* summer, pp. 42–63.
Hundal, P.S., 1971, A Study of Entrepreneurial Motivation: Comparison of Fast-and Slow-Progressing Small Scale Industrial Entrepreneurs in Punjab, India, *Journal of Applied Psychology,* Vol. 55, No. 4, pp. 317–323.
Imbert, I.D. C., 1987, International Construction and Developing Countries, *Proceedings CIB W65, 5th International Symposium,* Vol. 3, pp. 82–95.
Kaplan, D., 1972, *Culture Theory,* Englewood Cliffs, N.J.: Prentice Hall.
Kerr, S.; Schriesheim, C.A; MURPHY, C.J.; and STOGDILL, R.M., 1974, Toward A Contingency Theory of Leadership Based upon the Consideration and the Initiating Structure Literature, *Organisational Behavior and Human Performance,* Vol. 12, pp. 62–82.
Kluckhohn, C., 1951, The Study of Culture, In D.LERNER & H.D.LASSWELL (Eds.), *The Policy Sciences,* Stanford, C.A. Stanford University Press.
Lawshe, C.H.; and Bryant, F.N., 1953, Productivity and Attitude toward Supervisor, *The Journal of Applied Psychology,* Vol. 37, No. 3, pp. 159–162
Maloney, W.F., 1982, Supervisory Problems in International Construction, *Journal of the Construction Division, ASCE,* Vol. 108, No. CO3, pp. 406–418.
Massie, J.L., and Luytjes, J., (Eds.), 1972, *Management in International Context,* New York: Harper & Row Publishers.
Megginson, L.C.; and Eugene, C.M., 1965, Applicability of Management Principles in Underdeveloped Economies, in K.ETTINGER, *International Handbook of Management,* New York, McGraw-Hill book Co., Inc.
Negandhi, A.R., 1983, Cross-cultural Management Research: Trend and Future Directions, *Journal of International Business Studies,* Fall, pp. 17–28.
Norusis, M.J., 1986, *The SPSS Guide to Data Analysis,* Chicago, SPSS Inc.
Phatak, A.V., 1974, *Managing Multinational Corporations,* New York, N.Y., Prager Publishers.
Rabbat, O., and Harris, R.B., 1982, Managing Employee Conflict in Middle East, *Journal of the Construction Division, ASCE,* Vol. 108, No. CO2, pp. 219–225.
Schaupp, D.L., 1978, *A Cross Cultural Study of A multinational Company*, New York, Prager Pub.
Schein, E.H., 1985, *Organisational Culture and Leadership,* California, Jossey Bass Pub.
Siegel, S., 1956, *Nonparametric Statistics for the Behavioral Sciences,* Japan, McGraw-Hill Kogakusha, Ltd.
Starbuck, W.A., 1976, Organisations and their Environment, in *Handbook of Industrial and Organisational Psychology,* edited by M.D.Dunnette, Chicago: Rand McNally Publishing Company, pp. 1069–1124.

Stogdill, R.M., and, Coon, A.E. (Eds.), 1957, *Leader Behavior: Its Description and Measurement,* Columbus: Ohio State University, Bureau of Business Research.

Thiagarajan, K.M.; and Deep, S.D., 1969, A Cross Cultural Study of Performance for Participative Decision-Making by Supervisors and Subordinates, *Technical Report No. 33,* Rochester, N.Y., Management Research Center, University of Rochester.

Whitchill, A.M., Jr., 1964, Cultural Values and Employee Attitudes: United States and Japan, *Journal of Applied Psychology,* Vol. 48, No. 1, pp. 69–72.

Whyte, W.F., and Williams, L.K., 1963, Supervisory Leadership: An International Comparison. *Proceedings of the Thirteenth International Management Congress,* pp. 481–488.

Youngman, M.B., 1979, *Analysing Social and Educational Research Data,* U.K, McGraw-Hill Book Company (U.K) Ltd.

1. To what extent would you agree or disagree with each of the following statements:

1 Strongly agree

a.	I try to practice close supervision to reduce unexpected errors.	1 2 3 4 5
b.	I try to put emphasis in getting out a lot of work.	1 2 3 4 5
c.	I try to be as friendly and approachable to my subordinates as possible.	1 2 3 4 5
d.	I try to hold meetings for discussing work-force problems.	1 2 3 4 5
e.	I try to use threats and punishments to encourage good work.	1 2 3 4 5
f.	I try to insist work-force come to work exactly on time.	1 2 3 4 5
g.	I try to make my subordinates as satisfied as possible with their work.	1 2 3 4 5
h.	I try to encourage good work through my friendship with my employees.	1 2 3 4 5
i.	I try to be as fair and equal as I can in my dealings with subordinates	1 2 3 4 5
j.	I encourage subordinates to feel that they can come to me with their personal problems.	1 2 3 4 5
k.	I expect subordinates to follow instructions without a debate.	1 2 3 4 5
l	I try to keep a close eye on my subordinates work, to make sure that they understand the instruction.	1 2 3 4 5
m.	I allow subordinates to adopt work methods as they see fit, to get the job done.	1 2 3 4 5
n.	I have little tolerance of subordinates who question instructions or deviate from instructions.	1 2 3 4 5

11
Developing a knowledge based system for planning low rise house building projects

C.T.FORMOSO and P.S.BRANDON

Abstract
This research work is concerned with the development of a model of the expertise employed by construction planners for planning the production stage of low rise house building projects. A knowledge based system was developed using knowledge elicited from a panel of experts from the construction industry in the UK.

The system can be regarded as a knowledge based framework which supports the decision making process involved in planning house building projects at a tactical level. It was implemented using the knowledge based system shell Leonardo Level 3, which runs on cheap and widely available micro-computers.

This paper focuses on describing the main features of the implemented system.

KEY WORDS: Knowledge based systems, Construction Planning, House Building

1 Introduction

Construction planning is one of the knowledge intensive tasks within the construction process that is closely related to the aim of improving the effectiveness of construction projects in terms of cost, time, and quality.

Since the introduction of the first software tools for construction planning in the Sixties, computers have had relatively little impact in supporting decision making in this field. Most existing commercial CPM (Critical Path Method) based tools are completely knowledge independent, i.e. the expertise employed by construction planners for defining activities, estimating durations, establishing the amount of resources required, etc. cannot be captured and re-used in such tools (Levitt & Kunz, 1987). They are used only as electronic sketchpads where planners have to input all their decisions each time a cycle of planning is performed. Moreover, the reasoning used for making decisions is not made available to other people involved in subsequent stages of the project, for tasks such as interpreting and updating construction plans, evaluating project performance, carrying out real time control, etc. (Levitt & Kunz, 1987).

The recent development of knowledge based systems for supporting decision making in several different fields has demonstrated that knowledge engineering has a great potential for expanding human beings' capability to manipulate and utilize qualitative and experiential information.

Particularly in the field of construction planning, several authors have pointed out that knowledge based systems can have a major impact in the decision making process, by turning it into a less painstaking task, and freeing experts for the work which essentially requires human decisions (Levitt & Kunz, 1987; Hendrickson et al., 1987). In the long term, knowledge engineering has also the potential of providing the means for organizing, structuring, and refining a robust body of knowledge in this field, which has not been formally expressed yet.

2. General approach

The main objective of this research work has been to investigate the feasibility of using a knowledge based system for introducing more automation in the construction planning practice. The study has focused on modelling construction planning expertise concerned with a very specific task, in order to limit the amount of knowledge that had to be captured. The task chosen was the generation of plans for low rise house building projects.

Knowledge based systems have not proved yet to be capable of performing difficult tasks at the level of human experts, except in well structured, very narrow domains, with very clear boundaries (Brandon, 1990). Bearing in mind the current stage of this technology and the fact that construction planning involves a relatively wide domain of knowledge, the decision was made to develop a decision support system for construction planners, rather than a consultancy type of system which stands on its own.

One of the main restrictions for the development of this application was concerned with the hardware and software available. The limited amount of resources available for the research discarded the use of expensive knowledge engineering programming environments and workstations. Moreover, the development of an application on affordable widely available hardware, such as IBM-PC micro-computers, was more likely to attract the interest and the participation of the industry in this research project. The decision to use a commercial expert system shell, instead of building a system from scratch using a programming language, was made because of the limited amount of time available for devising the system.

The experts who provided expertise in this study were based in the main office of their respective companies, and were involved in planning the construction stage of house building projects at a tactical level. Their task consisted of producing a general plan of methods, which integrates the entire project. Such a plan establishes a number of key dates related to the production stage, and allows the experts to check the rates of allocation for a number of critical resources. Planning at this level is mainly used for feasibility studies, tendering purposes, as a contractual instrument, and also for monitoring the construction process in a broad basis. Site managers use general plans produced in the main office as a framework for their short term decisions.

Although some elements of CPM were found in the experts' decision making process, the planning strategy usually followed by the experts was not characterized by the bottom-up approach that is the essence of network techniques. The experts' crucial decisions were not primarily concerned with accurate duration estimates and resource allocations for individual tasks. Instead, they involved more aggregate aspects of the job, such as defining a breakdown of locations, sequencing the work through these locations, establishing the pace of work, and estimating the maximum amount of a number of key resources for the whole job. Consequently, the authors decided not to use CPM as a basic structure for developing the system, but rather to develop a heuristic model of the construction process, based on the knowledge elicited from construction planners.

3 Development of the system

3.1 Stages of work

The development of the system can be divided in three main stages: conceptual stage, model building, and model validation.

The objective of the first stage was to establish the boundaries of the knowledge to be elicited, as well as to define the role that the application could assume in the problem environment. A feasibility prototype was developed during this stage, using some expertise elicited from only one expert. A relatively simple rule based shell, named Crystal, was used for implementing the prototype.

The development of an early prototype played a key role in getting the interest of the industry in this research project, and also pointed out the requirements of this study in terms of knowledge representation.

The second phase consisted of performing a detailed elicitation of knowledge and implementing a full version of the system. Five experienced construction planners from three different companies provided expertise during this stage. The majority of the knowledge encapsulated in the system was obtained directly from experts, through informal and structured interviews. Other sources of expertise include the description of a number of past projects (i.e. construction plans, design, site report, etc.), and the literature about productivity in house building.

In the early stages of knowledge acquisition the interviews were very informal. As the main elements of the model were gradually being defined, the interviews became more structured, generally using the historical cases available as a basis for discussion.

The model validation stage consisted of performing a formal validation of the proposed model, at the end of its development. The main objective of this stage was to check whether the system had reached an acceptable level of reliability, and to identify a number of possible limitations of the model. A detailed description of the development and validation of the system is presented by Formoso (1991).

3.2 Choice of the shell

Among several micro-computer based shells available in the British market, Leonardo Level 3 was the one chosen for implementing the full system. The main reasons for this choice are discussed below:

(i) Much of the domain knowledge turned out to be essentially declarative. For instance, it was necessary to describe buildings in a hierarchical way, dividing them into a number of elements at several different levels of detail. Also, it was necessary to create a library of activities, in which each activity had to be linked to several attributes, such as duration, man-hour requirements, dependencies, link type, etc. Frame based formalisms have much more expressive power for structuring this category of knowledge than production rules. Leonardo is one of the few micro-computer based shells available in the British market that provide a hybrid knowledge representation scheme, including both frames and rules;

(ii) The development of the prototype indicated that a relatively large number of rules were needed for developing the system. In most rule based shells, as the knowledge base grows, it becomes more difficult to understand the interactions among the rules, to debug them, and to control their behaviour (Fikes & Kehler, 1985). The frame based formalism available in Leonardo provides a very efficient mechanism for organizing the knowledge base. The rules can be grouped into small, self contained rulesets, each one of them placed in a particular frame;

(iii) The basic rule language used in Leonardo is fairly readable, which makes the knowledge base relatively easy to be checked, updated, and expanded;

(iv) Construction planning requires a considerable amount of numeric calculation, which can be more efficiently performed by using conventional procedural routines. Unlike other shells, Leonardo has its own procedural language, which can be efficiently integrated to rules, without considerably affecting their clarity;

(v) Leonardo inference mechanism includes both backward and opportunistic forward chaining. This is an advantage in terms of efficiency and flexibility, if compared to shells that have only backward chaining;

(vi) There are relatively good facilities in Leonardo for developing the man-machine interface. These include standard screens, a screen designer utility, and the use of procedures for generating screens; and

(vii) Leonardo has a very competitive cost, and it does not require any expanded or extended memory.

4 Features of the system

4.1 General view

The main elements of the system are presented in Figure 1. The system is divided into three separate modules, named Input, Context, and Build. This partition was necessary in order to make the knowledge base easier to be managed, and because Leonardo had some limitations in terms of size of each individual knowledge base.

The three knowledge bases are chained together, so that after running one of the modules the user is given the choice of directly starting any of the other modules, without having to leave the system. The communication of data between the three modules is automatically executed by the system, through a number of external files, most of them configured as ASCII files.

There are also a number of external files configured as DBASE files, which store a number of small databases used by the system, such as the database of building stereotypes, and the library of output rates. Such files can be easily updated by using the database management system DBASE III Plus, which is one of the most widely used software packages of its kind in the UK.

The current version of the system is a fairly large application, if compared to other knowledge based systems developed for standard micro-computers. It contains approximately 1100 rules and 100 procedural routines.

4.2 Input module

In the Input module, the user is able to input a description of the particular project to be planned. This module encapsulates expertise on the way in which construction planners generate default information when the project description available is incomplete. This enables the system to be used during the early stages of the project, when very little information usually exists about the design and site conditions.

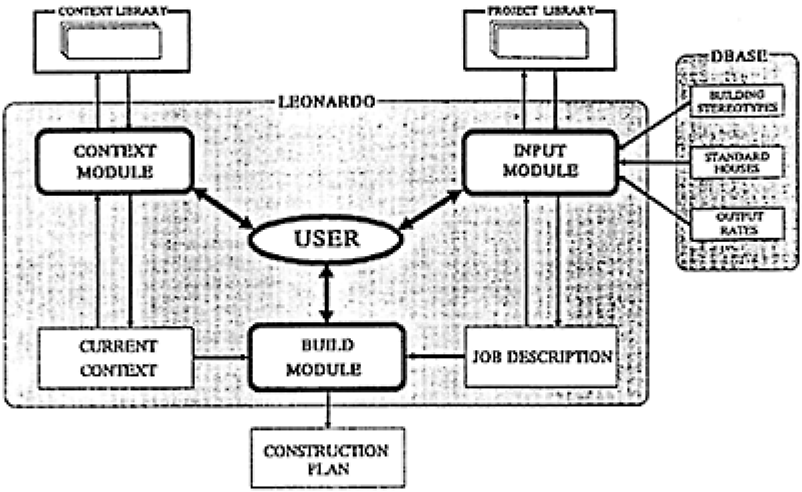


Fig.1. General view of the system

The variables used for describing house building projects in this study were grouped under five main headings, as follows:

(i) General information: includes a miscellaneous of variables related to different aspects of the job, such as contract conditions, restrictions from higher level management, availability of some critical resources;

(ii) Design parameters: comprises all the variables which describe the houses in geometric terms.

(iii) Site conditions: includes all variables related to the current state of the site chosen for the project;

(iv) Specification of components: this heading groups all the variables used for describing the specification of a number of building components that are considered to be of key importance for the construction plan; and

(v) Sequence of construction: contains a number of variables used for describing the sequence in which the houses or block of houses will be built.

This classification was created in order to organize the sequence in which the questions are asked to the user, as well as to take into account some relationships that exist between variables from the same group. From the point of view of the user, it makes much more sense if all the questions related to a particular aspect of the job are asked jointly, rather than spread over the consultation session.

The number of items that the user is required to input varies according to the size and complexity of the job, and the availability of information. It usually ranges from 20 to 200.

4.3 Context module

In the Context module, construction planning experts are given facilities for quickly altering some of the knowledge used by the system for generating construction plans. The portion of knowledge that can be modified in this module is likely to remain constant for a number of similar projects, but may vary according to changes in the environment in which house building projects are carried out, or according to the personal preference of experts.

The Context module makes the system usable for a large number of users. As some of the rules used for generating the construction plan can actually be altered in this module, its use must be restricted to expert users who are familiarized with the knowledge encapsulated in the system.

Several different context files can be created for each user of the system. The possibility of having a number of different sets of context parameters can be useful for contractors that have to carry out house building projects in different environments.

4.4 Build module

Based on the job description created in the Input module, the user can use the Build module for producing a general plan for the construction stage in a conversational fashion: the system suggests values for all the main parameters of the plan, and the user is required to confirm or overwrite them at certain key points. Some kind of explanation can usually be obtained for the suggestions made by the system.

This mode of operation aims at making the system flexible in terms of coping with different levels of expertise. The less experienced planners are likely to accept the suggestions made by the system, and learn from the explanations given. On the other hand, the more experienced users are given the option of altering the system's propositions, if they find convenient.

In general terms, the process of producing a construction plan in this module can be divided in three phases. Firstly, the system proposes the pace of work by choosing a building rate, expressed in terms of number of houses per week, for each of the main stages of work, i.e. foundations, shell, and finishings. After that, the system breaks down the job into activities, estimates the duration of bar-chart activities, and establishes precedence relationships between them. In the final phase, the system can print or display the construction plan in different formats, and also extract the amount of key resources required in each week.

Once a construction plan is generated, the system tests it against: a number of constraints that might have been imposed by higher level management or by the client, such as maximum duration, maximum period for the first handover, or minimum handover rate. If any of these constraints is not satisfied, the system is capable of suggesting changes in the plan. Sensitivity tests can also be performed by using “what if” scenarios at the end of each session: the user can change the value of a number of key variables, such as availability of resources or imposed restrictions, and go through the the Build module again.

The programme generated by the system is not very detailed, since the system was designed to be used at a tactical level. The number of activities usually ranges from 65 to 85. Although each activity involves only one type of trade, the work breakdown does not correspond to the traditional concept of work package, i.e. an amount of work carried out by a single gang without being interrupted by any other trade: for several activities, some kind of interaction between different gangs is assumed to occur.

The majority of activities overlap with a score of preceding and succeeding items, most precedence relationships being expressed in terms of start-start link or end-end link. The time scale of the plans is expressed in terms of weeks.

Figure 2 presents a screen generated by the system which displays a section of a construction programme. While non-repetitive activities are represented by bar-charts, the repetitive ones are represented by the number of work places handed over each week. Also, there is a third type of activities, named “stretched”, which are represented by a thin line. Stretched activities are those carried out by gangs, normally sub-contracted, that do not remain on site continuously: they come and leave the site several times during the project, carrying out the job only when a clear run of work is available. Such activities usually have a duration much shorter than the period available for their execution.

5 Main lessons learnt from the system implementation

The implementation of the system in Leonardo can be described as relatively successful. Its impact in the construction planning process in terms of time savings is fairly good: the user takes between 35 minutes and 2.5 hours to perform a task that can take from one to five working days, when executed manually. Besides this advantages, the system also offers a number of facilities that enable planners to extend their role in the planning task, such as performing sensitivity analysis, or quickly generating a number of alternative plans.

The main lessons learnt from the implementation of the system are outlined below:

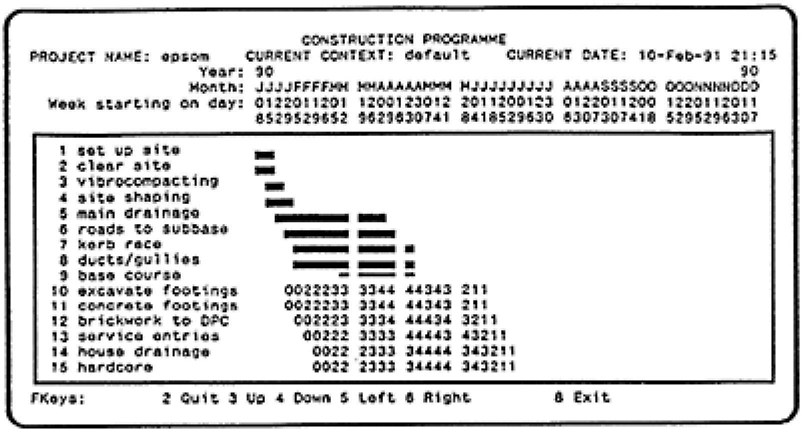


Fig. 2. Screen displaying a section of a plan

(i) Both rules and frames in Leonardo can be designed in a fairly readable way when expressing pure domain knowledge. However, as Leonardo contains no formalism for representing meta-rules, these have to be represented in the same way as rules related to domain knowledge. To some extent, this reduced of clarity in the knowledge base, as well as limited the flexibility of the inference mechanism;

(ii) The very good clarity of some sections of the knowledge base allowed early versions of the system to play an important part in the knowledge acquisition process. The experts were able to criticize some aspects of the model by checking directly frames and rules implemented in the system. To some extent, this reduced the need for keeping a very detailed paper model of the knowledge;

(iii) The default facilities available in Leonardo for enabling the user to control the interaction with the system are relatively limited. Consequently, whenever it was necessary to transfer the control over the consultation to the user, some special purpose facilities had to to be designed, by using procedures or the screen design utility. These usually implied a reduction in the explicitness of the knowledge base;

(iv) As in most other shells, the default explanation facilities provided in Leonardo are based on tracing the rules used by the system. Although these facilities are very useful during the development stage as a tool for debugging rules, they very rarely provide an acceptable explanation to the user;

(v) The development of the application has confirmed the importance of the cost of devising the man-machine interface in relation to the total cost of implementing the system, Approximately 60% of the time necessary for the implementation of the system was actually spent in developing the man-machine interface; and

(vi) The development of an early prototype played a key role in forming a panel of multiple experts, and in keeping them motivated. However, two important pitfalls related this approach were identified in this particular study. Firstly, as the early versions of the system were intensively used during the knowledge acquisition process, a considerable amount of effort had to be spent in keeping the man-machine interface attractive to the experts and the system reasonably debugged. Secondly, as the implementation of the system started when the general structure of the model had not been formed yet, several of the early upgrades of the system required fundamental alterations in the knowledge base, which were relatively time consuming.

6 Conclusions

This paper presents a summarized description of a knowledge based framework that has been devised for supporting construction planners in the decision making process involved in planning house building projects at a tactical level. The framework contains domain knowledge that can be used for generating construction programmes in a very short time, being able to cope with situations in which the information about the design, site conditions and location is incomplete.

As far as the literature in this field is concerned, this is the first knowledge based software tool specifically designed for planning repetitive, low rise, house building projects.

7 References

Brandon, P.S. (1990) Expert systems—after the hype is over. In: International Symposium on Building Economics and Construction Management. Sydney, Australia, June 1990. **Proceedings.** V. 2, pp. 314–344

Fikes R. & Kehler T. (1985) The role of frame-based representation in reasoning. **Communications of the ACM, 28**(9): pp. 904–920.

Formoso, C.T. (1991) **A knowledge based framework for planning house building projects.** Salford, University of Salford. Ph.D. Thesis

Hendrickson, C. et al. (1987) Expert system for construction planning. **Journal of Computing in Civil Engineering,** New York, ASCE, 1(4): pp. 253–269.

Levitt, R.E. & Kunz, J.C. (1987) **Using artificial intelligence techniques to support project management.** Stanford, USA, Stanford Univ. Working Paper #1

12
Construction contracting/ subcontracting systems in Japan

S.FURUSAKA

Abstract
Various contracting/subcontracting systems exist in Japan such as the discretionary contracting system, the comparison system of cost estimates, the designated competitive bidding system and the design/build contracting system. The design/build contracting system is very popular in private sector construction projects. The open competitive bidding system is seldom adopted for both private sector projects and public sector projects. The construction management contracting system is not yet adopted. The subcontractors in Japan often have a very close relationship with a general contractor. This exclusive relationship has direct effects upon the case of subcontracting practice. Differences between specialist trades seem to be closely connected with subcontractor selection principles and principles for distribution of responsibility among the general contractor and each subcontractor. Subcontractual relationships are more likely to be based on negotiation between the general contractor and only one subcontractor than on competition. For reinforcement work, 70 percent of the contractors decide the subcontractor of the work first, and 65 percent of them do not adopt the comparison system of cost estimates.

Keywords: Contracting System, General Contractor, Exclusive Subcontractor, Construction Management, Subcontractor Selection, Bidding, Construction Industry

1 Introduction

Construction projects are undertaken by a multitude of firms, which are assembled for brief periods of time, then disbanded. The success of the project depends largely on whether the project team including the architect, the general contractor and subcontractors has been properly engaged and managed. The client has the freedom to arrange the project organization, while the general contractor has the freedom to define the scope of work for each work trade and to select the subcontractor based on the particulars of each project.

The purpose of this paper is to present the real state of the construction industry and contracting/subcontracting systems in japan

2 Construction industry in Japan

The construction market in Japan is extremely important, since it represents 18.5 percent of the gross national product (GNP). GNP at current prices in 1990 amounts to $321 billion (exchange rate: $1=130 Yen) and the construction investment at current prices amounts to $59 billion. Fig.1 shows GNP index and the construction investment index (Fiscal year 1981 base), and the ratio of the construction investment to GNP. The ratio changes with 15 to 20 percent in the last ten years. In Fig.1, GNP. N, GNP. R, INV. N and INV. R mean GNP at current prices, GNP at constant prices, the construction investment at current prices and the construction investment at constant prices respectively.

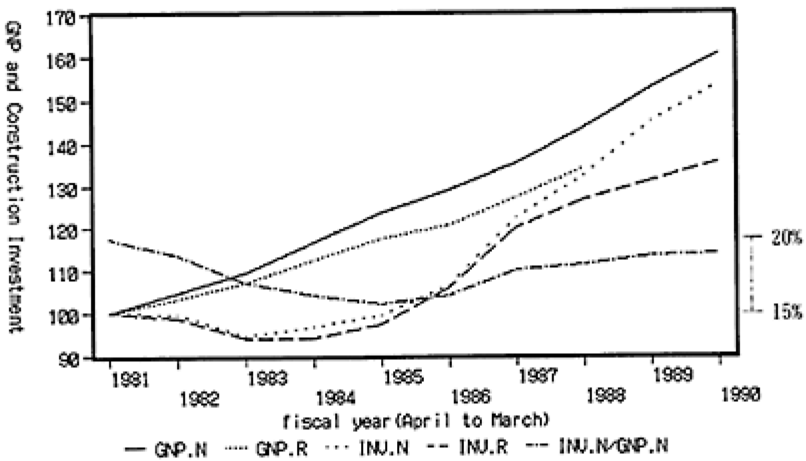


Fig.1. GNP, construction investment and ratio of construction investment to GNP (Fiscal year 1981 base)

Source: MONTHLY OF CONSTRUCTION STATISTICS

On the other hand, the construction industry in Japan is now huge, with more than 510,000 licensed construction enterprises. This includes both specialist and general contractors, and then the industry contains many small firms and a small number of large contractors. Most of the former are specialist subcontractors and local general contractors. The latter are large general contractors. The contractor who has license of civil engineering work/architecture is usually called “a general contractor”.

[FURUSAKA 1990] Most of all construction projects are carried out by these general contractors. Particularly the contracted value of projects by Top 50 general contractors is about $16.8 billion (year 1989), that is, it represents 30 percent of the construction investment. Hereinafter we use the term “Top 50 general contractors” as Top 50 general contractors of the contracted value of construction projects and use the term “Top 10 general contractors” as Top 10 general contractors of the contracted value of design/build contracting system’s construction projects. Two construction companies ranked the ninth and tenth in 1989 are different ranking according to the contracted value of construction projects and building construction projects, however the ranking according to the contracted value of building construction projects makes no great difference from another ranking in practice.

3 Construction contracting system

3.1 Construction contracting system in private and public sector

Various contracting/subcontracting systems exist in Japan. In private sector construction projects, two types of contracting systems are usually adopted. One is the discretionary contracting system (DCS), the other is the comparison system of cost estimates (CSCE). Based on Ministry of Construction [MOC 1988], DCS is the system in which the commissioning company selects the firm it deems most suitable for the work on the basis of the type of construction involved and project’s specific needs. CSCE is the system in which several firms that are thought to be suitable for the work are invited to present estimate, and the firm whose estimate is considered the most suitable will be selected.

In selecting the contractor, the commissioning company considers not only the contract price, but also operational ability, credit, design capacity, and such factors as convenience of communication. Therefore design/build contracting system (DBCS) is very popular in private sector construction projects.

In public sector construction projects, most of construction contracts are awarded through the designated competitive bidding (DCB). DBCS is not used in public sector construction projects. The open competitive bidding is seldom adopted for both private sector projects and public sector projects because of the advantage of being able to exclude those firms whose operational capacities are insufficient, or who might provide inferior work.

3.2 Contracted value of each contracting system

We cannot determine the value of each contracting system of construction contracts carried out by all general contractors accurately because of the lack of data. Therefore we will estimate the quantitative ratio of each contracting system. Fig. 2 shows the ratio of the 467 building construction projects finished in 1988 (MRC 1990). DCS is the most popular contracting system and the ratio is 60.8 percent. The large general contractors tend to increase DCS contracts in the last five years. Fig. 3 shows the ratio of DCS to orders received for building construction projects by each company that is one of the Top ten general contractors. Then, as above mentioned, DECS is very popular. In the same 467 building construction projects, DECS is adopted with 39.9 percent

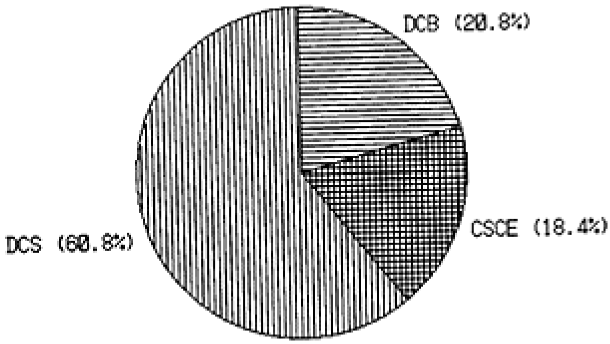


Fig. 2. Ratio of building construction projects by contracting systems

Source: MRC:88 Cost Analysis Information for Building Works

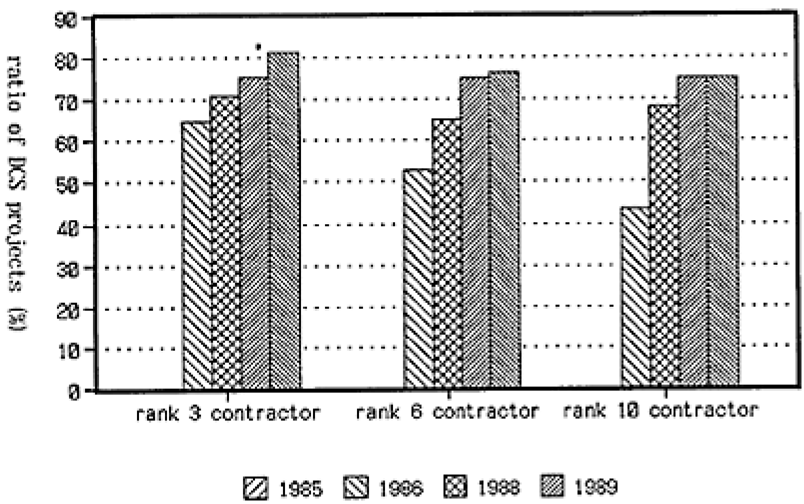


Fig. 3. Ratio of DCS by each company

Source: Financial statement 1987, 1990

Fig. 4 shows the contracted value of construction projects and only building construction projects by Top 50 general contractors, and the contracted value of building construction projects and DECS projects by Top 10 general contractors. During the past four years (1986 to 1989), the contracted value of construction projects by Top 50 general contractors has increased from $9.8 billion to $16.8 billion, the value of building construction projects by them increased from $6.2 billion to $11.8 billion, the value of building construction projects by Top 10 general contractors is from $3.8 billion to $7.2 billion and that of DECS projects by them is from $ 1.5 billion to $3.3 billion. Fig. 5 shows three kind of ratios. First one is the ratio of the contracted value of building construction projects to the contracted value of construction projects by Top 50 general contractors. Second one is the ratio of the contracted value of building construction projects by Top 10 general contractors to the contracted value of building construction projects by Top 50 general contractors. Third one is the ratio of the contracted value of DECS projects to that of building construction projects by Top 10 general contractors. During the past four years, the ratios of the first one and the third one have an increasing tendency every year. The ratio of the second one is about 60 percent every year.

Furthermore Fig. 6 shows the contracted value of building construction projects and DECS projects by each company of Top 10 general contractors in 1989. The ratio of DECS projects changes with 30 to 60 percent among Top 10 companies. In general a large company has such a tendency that DECS projects ratio become

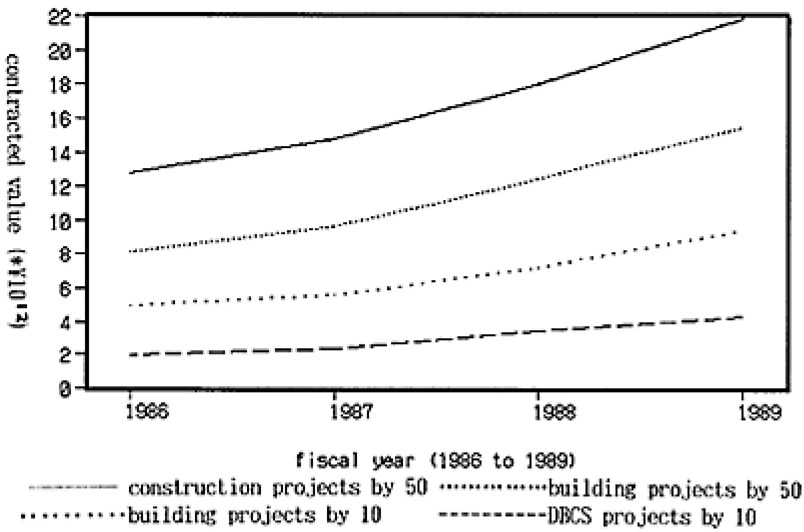


Fig. 4. Contracted value of construction projects by Top 50/10

Source: MONTHLY OF CONSTRUCTION STATISTICS NIKKEI ARCHITECTURE 1981 to 1990

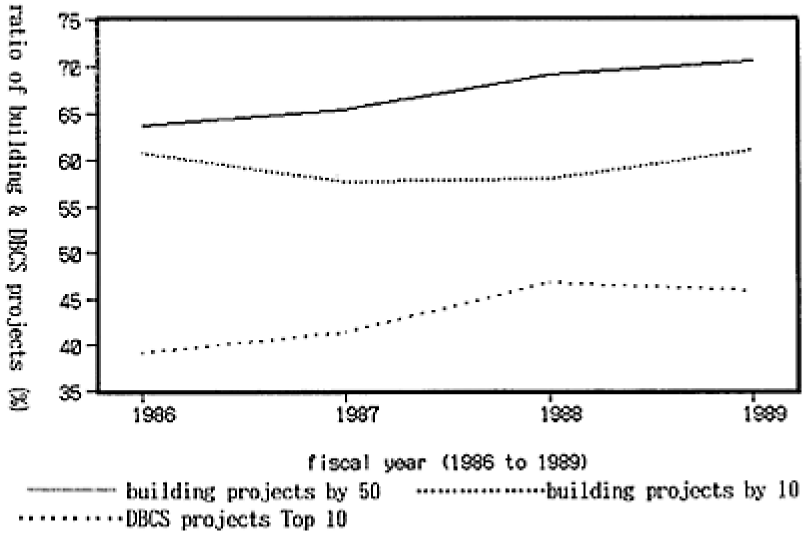


Fig. 5. Three kind of ratios of contracted value

Source: MONTHLY OF CONSTRUCTION STATISTICS NIKKEI ARCHITECTURE 1981 to 1990

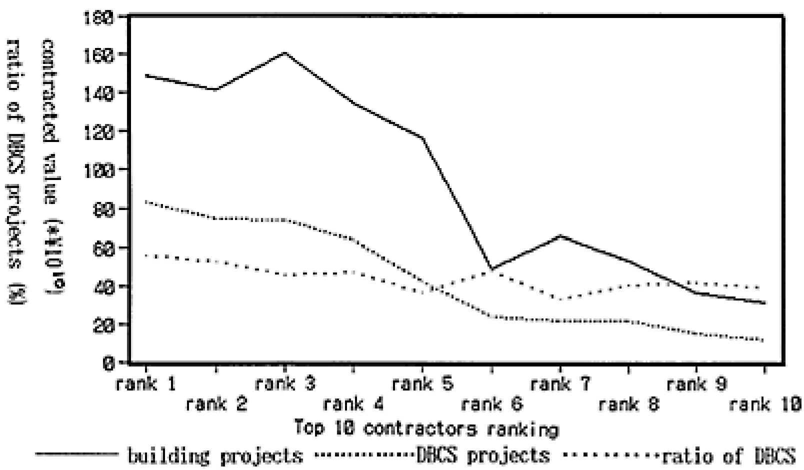


Fig. 6. Contracted value of building construction projects and DBCS projects by each company of Top 10 general contractors in 1989.

Source: NIKKEI ARCHITECTURE 1981 to 1990 higher. Fig. 7 shows the contracted value of building construction projects and DECS projects ratio by each company ranked the first (A company), sixth (B company) and tenth (C company) in the past four years. We can find the similar tendency during the past four years.

While some general contractors examine the feasibility of construction management contracting system (CMCS) in Japan, we do not yet adopt CMCS.

4 Subcontracting system

4.1 Exclusive subcontractors organization

The subcontractors in Japan often have a very close relationship with a general contractor. Many specialist subcontractors will have worked for particular general contractors over many years, and in many cases they will work only for that one general contractor. Based on this special relationship with the general contractor, they form an organization of subcontractors for each general contractor, if the general contractor has some branch offices, the specialist subcontractors form the organization for each branch of the general contractor. In this paper this organization is called "exclusive subcontractors organization", or in Japanese "kyouryoku-kai". Therefore this exclusive relationship has direct effects upon the case of subcontracting practice, in general, the exclusive subcontractors organization includes many trades such as scaffolding work trade, form work trade, reinforcement work trade, steel structure work trade and so on. The average number of exclusive subcontractors per

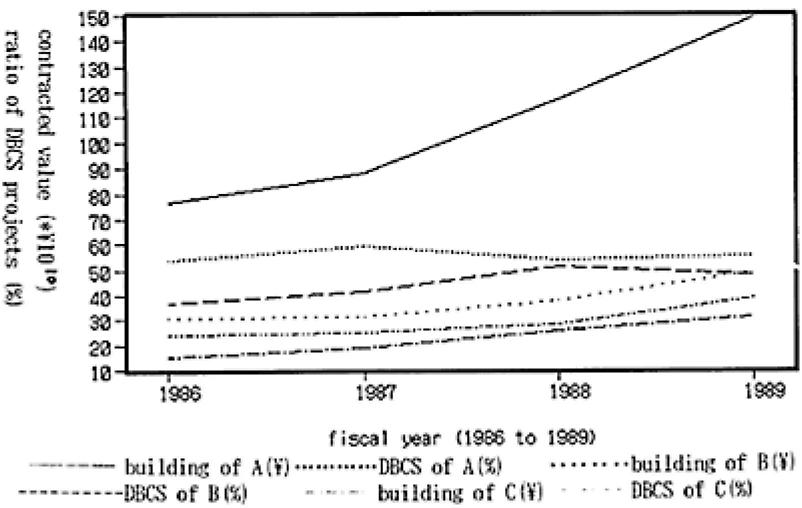


Fig. 7. Contracted value of building construction projects and DECS

projects ratio by each company in the past four years

Source: NIKKEI ARCHITECTURE 1981 to 1990

organization for any trade is about 10.

Table 1 shows the number of general contractors by the ratio of ordering work from exclusive organization. The first column is the kind of trade, and the second to fifth columns show the number of contractor's who are classified according to the ratio. Fig. 8 shows the ratio of the number of general contractors ordering work from exclusive organization. Fig. 8–1 is for scaffolding work and Fig. 8–2 to Fig. 8–4 are for form work, reinforcement work and steel structure work respectively. Let us illustrate how to see the table. In the box of trade "form work" and the ratio of received work ″60–79″, we can find a figure of 14. This figure means that there are 14 general contractors that order 60 to 79 percent of the form work from the exclusive subcontractors organization.

The following phenomena can be recognized from those figures;

(1) The percentage for the exclusive subcontractors organization of structure work trades to carry out more than 80 percent of the work value is high. For example, the ratio of the received work of the scaffolding organization is very high, namely, 81.7 percent of the contractors (58/71) ordered over 80 percent of the work from the organization. However we cannot find such a tendency on the ratio of the received work of the steel structure work organization.

(2) These differences between specialist trades seem to be closely connected with subcontractor selection principles and principles for distribution of responsibility among the general contractor and each subcontractor.

Table 1. Number of general contractors by ratio of ordering work from exclusive organization

trade	range ~39	ratio of 40–59	ordering 60–79	work 80~
scaffolding work	3	3	7	58
form work	3	6	14	48
reinforcement work	3	7	12	49
steel structure work	26	10	17	19

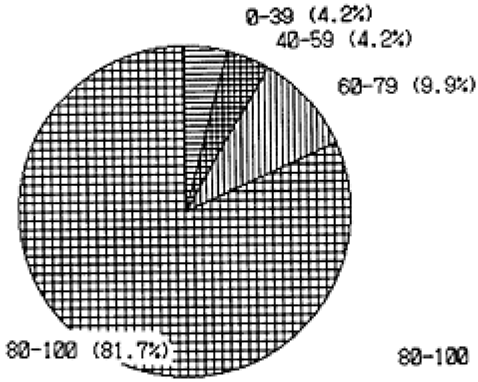


Fig. 8–1. Scaffolding work

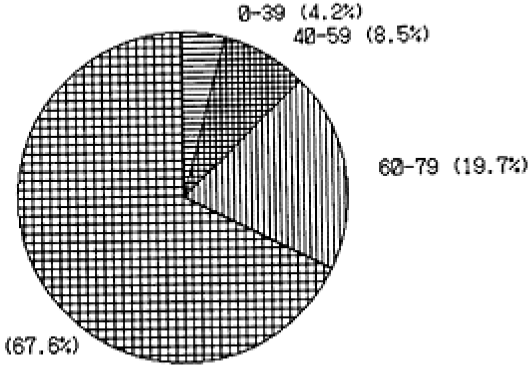


Fig. 8–2. Form work

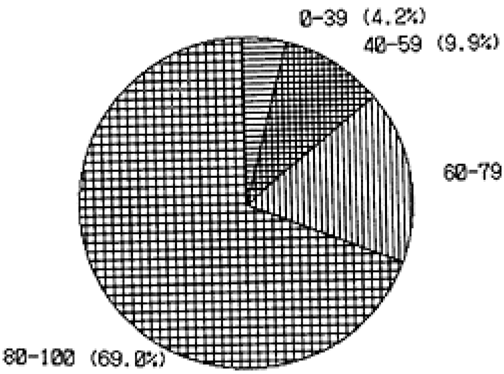


Fig. 8–3. Reinforcement work

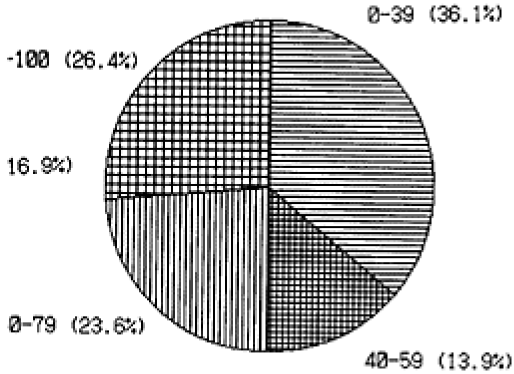


Fig. 8–4. Steel structure work [0–39] [40–59] [60–79] [80–]: ratio of ordering work from exclusive organization

Fig. 8. Ratio of number of general contractors ordering work from exclusive organization

4.2 Which decision is made first, scope of work or subcontractor selection

For three kind of structural work trades, including form work, reinforcement work and scaffolding work, the subcontractor selection is made prior to definition of the scope of work. Conversely for the steel structure work trade, definition of the scope of work is done prior to the subcontractor selection. Table 2 to Table 5 show the number of contractors by these priorities. Each column means whether the general contractor adopts CSCE, above mentioned. In subcontracting practice in Japan, CSCE is called “Aimitsumori”. The second column shows “always adopt”, the third column to the sixth column show “frequently adopt”, “occasionally adopt”, “seldom adopt” and “never adopt” respectively. For example, for reinforcement work, 70.7 percent of the contractors (58/82) decide the subcontractor of the work first, and 65.5 percent of them do not adopt CSCE. Namely, subcontractual relationships are more likely to be based on negotiation between the general contractor and only one subcontractor than on competition. Conversely, for steel structure work, 85.5 percent of the contractors (71/83) decide the scope of work first, and over 90 percent of them adopt the “Aimitsumori” system.

Table 2. Number of contractors by subcontractor selection (form work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	0	5	19	24	13	61
scope of work	3	3	11	4	1	22

total	3	8	30	28	14	83

Table 3. Number of contractors by subcontractor selection (reinforcement work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	1	4	15	27	11	58
scope of work	3	4	13	3	1	24
total	4	8	28	30	12	82

Table 4. Number of contractors by subcontractor selection (scaffolding work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	0	3	14	33	14	64
scope of work	2	6	6	4	1	19
total	2	9	20	37	15	83

Table 5. Number of contractors by subcontractor selection (steel structure work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	6	2	4	0	0	12
scope of work	43	21	6	1	0	71
total	49	23	10	1	0	83

4.3 Distribution of responsibility between general contractor and subcontractor

The basis responsibility required between the general contractor and the subcontractor in the subcontracts can be divided into

provide shop/working drawing
supply material/machinery
provide labor force
provide management/control

and those responsibility are different from each trade. And then the contract approach to the subcontractor can be either by bidding or negotiation. The principle of distribution of responsibility among the general contractor and each subcontractor is shown in Table 6. In general, the following phenomena can be observed:

(1) The general contractor scarcely carries out the work directly, and all the construction work is almost subcontracted. It is the subcontractors who physically carry out the work, combining labor and material into production.
(2) For the specialist trades such as reinforcement work and concrete work, the general contractor will provide material while the subcontractor will only provide labor. For material oriented trades, machinery oriented or construction method oriented specialist trades, the subcontract usually includes labor and material.

For lift machinery, electrical and mechanical installations oriented specialist subcontractors, the subcontract includes shop/working drawing, material/machinery, labor and management/control.

In general, the responsibility for management/control tends to be transferred from the general contractor to the subcontractor. Also, there is a tendency for the labor oriented subcontractors to upgrade their capacity. Therefore they tend to provide both labor and material instead of labor only. Subcontractors such as piling work and steel structure work have been upgraded and are recognized as having a higher overall capacity.

Table 6. Distribution of responsibility

	shop/working drawing	material/ machinery	labor	management/ control
g.t. work	G.C.	G.C.	Sub.	G.C.
excavation work	G.C.	Sub.	Sub.	G.C.
form work	G.C.	Sub.	Sub.	G.C.
reinforcement work	G.C./Sub.	G.C.	Sub.	G.C.
concrete work	G.C.	G.C.	Sub.	G.C.
steel structure work	Sub.	Sub.	Sub.	G.C./Sub.
finishing work	G.C.	Sub.	Sub.	G.C.
lift machinery	Sub.	Sub.	Sub.	Sub.
E/M installations	Sub.	Sub.	Sub.	Sub.

Note: G.C.=General contractor, Sub.=Subcontractor, g.t. work=general temporary work, E/M=electrical and mechanical

5 Conclusion

The Japanese construction market is open to all firms with its system in no way discriminating between foreign and domestic companies. However it is very difficult for outsiders to get a job in the Japanese contracting/subcontracting environment. Of course outsiders does not always mean foreign companies. In the case of contracting practice between the owner and the general contractor, DCS, CSCE and DECS are very popular in private sector construction projects. Furthermore in subcontracting practice between the general contractor and the subcontractor, the general contractor usually adopts DCS for selecting the structural work trades, including form work, reinforcement work and scaffolding work, while he adopts CSCE for the steel structure work and electrical and mechanical installations oriented specialist subcontractors.

On the other hand, due to such a close relationship between the subcontractor and the general contractor, the contract approach is much different from the other countries, and then the following advantage can be observed.

(1) They require no pre-qualification for the subcontractor part i c participation ion.
(2) With such a constant and long-term relationship, the subcontractor will start its work before reaching a contract agreement or confirmation of price.
(3) In most of the cases, the project manager will request from the general contractor that certain preferred personnel are located in the project,
(4) The subcontractor will work very close to and entirely under the supervision of the general contractor.

What is the suitable contracting/subcontracting system and relationship for the owner depends upon the construction industry-environment and type of project.

ACKNOWLEDGEMENTS

The work described in this paper has been carried out in the Furusaka Laboratory of the Department of Architecture, Faculty of Engineering, Kyoto University. I wish to express my indebtedness to Instructor of Kyoto University, K.Endoh for valuable advice and many suggestions.

REFERENCES

Chi, N.Y. (1988) Comparative Study on Organization and Management of Construction Projects, Thesis for Doctor's degree, Kyoto

Endoh, K. Furukawa, O. Furusaka, S. and Sasaki, Y. (1990) Organizational Behavior of Subcontractors for Structure Work, in Proceedings CIB'90 W55/W65 Joint Symposium, Sydney, Vol. 6, pp. 173–184.

Furusaka, S. Furukawa, O. and Endoh, K. (1990) General Contractor Site Organization and Sub-package for Building Construction, in Proceedings CIB'90 W55/W65 Joint Symposium, Sydney, Vol. 3, pp. 278–288.

Furusaka, S. Furukawa, O. and Endoh, K. (1988) General Contractor Site Organization and Sub-package for Building Construction, in Proceedings 4th Symposium on Organization and Management of Building Construction, Architectural Institute of Japan, Tokyo, pp. 79–82.

Management Research Society for Construction Industry, (1990) MRC: 88 Cost Analysis Information for Building Works. Taisei-Shuppann Inc., Tokyo, Japan.

Ministry of Construction, (1988) From Obtaining Constructio Business Licenses To Winning Contracts. Ministry of Construction, Tokyo, Japan

13
The sequential procedure: a new productivity route in the building industry

M.GIBERT

Abstract
The sequential procedure, which appeared in the course of the ′80s, attempts to overtake both conventional site organisation founded on the breakdown of work into the various building professions and on attempts made to introduce Taylorization into the building industry, attempts which have failed due to the specific character of on-site work.

Based on the concept of a sequence, defined as a regrouping of tasks referring to functions fulfilled for the building to be erected, the sequential procedure enables productivity gains by minimising non-productive periods.

It constitutes an evolutional element in the relations which exist between economic agents in the concatenation, and can lead to a change in the industrial organisation of building industry enterprises.

Keywords: Sequence, Productivity, Site-organisation, Polyfunctionality.

1 Introduction

In the early ′80s, economic reflections on the determining factors in favour of productivity in the building industry sector were seen to lead to a double statement of failure.

In the first instance, the failure of the Taylorian and Fordian principles had at the time become obvious. The specific nature of work performed on site and the high level of diversity in demand in point of fact stand radically against the principles involving task repetitivity and labour specialisation, against that of a clearly defined division between manual labour and intellectual work, and also against the principle involved in the bulk production of standardised products.

It then became evident that site organisation, founded on the breaking down of work into the various building industry professions and traditional crafts, in the ultimate analysis represents a significant obstacle against any improvement in the level of productivity. Certainly, the professional craftsman can build up a productivity factor due to his capacities both in anticipation and in the mastering of incidents which occur in large numbers on the site. For that matter, the upholding of an extended separation in the field of labour leads to a multiplication in non-productive periods, which relate to time wasted by professionals when they wait for each other and to time lost in the course of numerous travels completed by workers between the head office of the enterprise and the site. Globally speaking, it is apparent that the survival of the traditional crafts involved callts down more drawbacks than advantages in the field of productivity.

It is this double statement of failure which is at the origin of reflections undertaken relative to the sequential procedure, which appeared (especially in France) in the course of the ‘80s. Initially concentrating exclusively on the field of site organisation, it gradually extended to the Building Industry’s production process as a whole, and thus especially to the design phase.

2 The initial reflections

In its original principle, the sequential procedure attempts to design the site in the form of successive realizations of autonomous sequences. The fundamental object, in the field of productivity, is to create a working environment in a manner which enables each enterprise to work without interruptions, and without limitations in simultaneity with respect to one or several other enterprises. The sequence is defined in terms of the regrouping of tasks referring to the functions fulfilled by the building industry, and no longer in terms of traditional techniques and professions. It is in this manner, for instance, that a so-called “walled and roofed” sequence is defined, without explicitly referring to the techniques and crafts involved in masonry, in woodwork and roofwork, and in external joinery.

The regrouping of such tasks into the different sequences is completed with respect to the following criteria:

> Functional unity of place (structures, partitions…) and space related (lodging, staircase…), Unity in time, the tasks in a sequence must be realized with a sufficient level of synchronisation for the sequence to be completed and accepted without reservation within a period of time which is compatible with the global site agenda, Unity of means, the tasks are organized more around the working methods (mounting, assembly, bonding…) than around a technique.

The creative Utopia seen in the initial stages of the sequential procedure leads to organizing the site around three sequences: walled and roofed, technical equipment and finishing tasks. An attempt was made in this manner to find an intelligent compromise between an ideal form of total polyvalence and the reality of individual and collective know-how.

> But the realization of the initial experimental sites pointed to a certain number of difficulties:
>
> Few indeed are the enterprises with the capacity to realize a complete sequence. Due to this fact, a perversion in the procedure has been observed, which consists either in sub-contracting the tasks which the

enterprise in charge of the sequence cannot realize to various speciality operators, or to import the various required professional competencies into the midst of the enterprise holding the prime contract. In these two cases, the effect expected from the procedure on the productivity level is markedly reduced, or even cancelled;

In the few cases where the enterprise attempts to obtain the real versatility which is essential to the realization of a complete sequence, the method generally applied consists in referring to the massive use of products and components acquired from the industry and installed by the enterprise's work force. A double drawback results: on the one hand a relative inadequacy on the part of the industrial products and components manufactured in large batches for constantly singular sites; on the other hand a strong reluctance on the part of the work force to relinquish a professional qualification in favour of a layer/ fitter profile which is considered to amount to a source of devalorisation.

That is why a second stage in the sequential procedure has appeared over the last two or three years.

3 A new stage

This new stage again concerns the organisation of the site proper but, contrarywise to the initial experiments, it extends the scope of the reflection to the complete building production process.

As this involves a site, we observe an increase in the number of sequences and an adaptation of the quantity and content of the sequences to the nature of each site.

Inserting this procedure into the fabric of the enterprises concerned has called down two particularly beneficial effects. In the first instance, the required conversion in the enterprise's competency is easier to obtain. For instance, a masonry enterprise will no longer be entrusted with the whole so-called "walled and roofed" sequence, but only with the integration of electrical and plumbing components in the concrete. A certain trend will then be seen in the modification of the limits of traditional crafts, the most charateristic example being that of the enterprise entrusted with the laying of the gypsum boards which henceforth extends its intervention to the laying of indoor woodwork and to the integration of electrical cables within the partitions. Starting at that point, the profile of the multipurpose layer/fitter becomes unclear, and thus leads to a new type of professional craftsman with a form of competency which refers to a traditional craft, with an added level of laying know-how which is contiguous to this profession. The result is a higher rate of acceptancy in favor of this procedure for building industry labourers.

The second major evolution contributed by the sequential procedure consists in no longer inserting reflection only into the sole process of on-site work, but to extend it to the production process as a whole.

Quite particularly, one has become conscious that the increase in the level of productivity related to the reduction in the number and complexity of interfaces between crafts could not be fully effective unless the concern for productivity was taken into account as of the stage of architectural and technical design. It has thus become apparent that cooperation between the architect and the technical design offices on the one hand and the shell construction enterprises and technical second tier enterprises on the other hand could enable the safeguarding of both the architectural principle and the productivity requirements.

In a concrete manner, this cooperation enables the elaboration of design related solutions which minimise the interfaces between the different crafts and the scheduling of adapted products and components (especially by manufacturing these in the workshops of the enterprises concerned). Under these conditions one ends up with a site which is divided into sequences no longer in an artificial manner but in a manner coherent with the reality both of the site and of the enterprises in charge of the construction.

And, in the end effect, the pivotal phase between the design of the project and the site is also stressed, that is to say the phase during which the realisation is designed, which is also referred to as the site preparation phase. In particular, the definition of a work schedule which is both strict and acceptable to all the enterprises and a reflection on the harmonization of the work rhythms in the different realization teams is assuredly a sign of increased productivity, inasmuch as a strengthened control of the site quite naturally guarantees the observance of engagements undertaken in the course of the realisation phase.

4 Conclusion

In the final effect, the sequential procedure has enabled the notion of the function to be taken into account rather than that of technology, a fundamental substitution on the productivity level, as it is enables a reconsideration of the traditional organisation of the building industry crafts which led to slowing the increase in the level of productivity without for that matter imitating a Taylorian organisation of day-to-day work which is inadequate for the building sector and, for that matter, equally challenged in the other sectors of the industry.

If the initial expectations, based on the extended polyvalent capacity of men and enterprises have not been totally borne out in fact, a new definition is however appearing for the roles of the different actors in the production process, which bears the capacity to increase productivity levels.

As we are referring here to the industrial organisation of enterprises in the building industry, an appreciable evolution is seen in the paradigm founded on the general enterprise in charge of realizing the shell construction and simple coordination between second tier enterprises who are limited in the strict execution of work referring to their speciality. This evolution can, on a medium-term basis, lead to a new industrial organization founded on three major classes of enterprises. The first concerns the general enterprise which sees its role considerably strengthened up-stream of the realization phase, and contributes an effective participation to the project design stages, and also down-stream with the transition from a simple form of work coordination to a real form of control over all the professions involved. The second class relates to second tier technical enterprises, and/or having the capacity for workshop prefabrication. The role of these enterprises at the project design stage appears to be especially strengthened by the sequential procedure. Finally, the third class includes the non-technical second tier enterprises. It is no doubt amongst these enterprises that the clearest format for evolution towards a polyvalent form of task execution is to be sought, and this is the format upon which the sequential procedure was initially founded.

5 References

Atero (F.Boneu, J.Hamaide, J.Vienney) Comment élaborer de nouvelles qualifications en séquentiel, PCA (1987)

Auxirbat (L.de Ste-Marie) Faisabilité de nouveaux allotissements. PCA (1985)

Bipe/Becker. La démarche séquentielle. PCA (1985)

Cardonnel Ingénierie. Le séquentiel partitions-fluides dans l'habitat. PCA (1988)

CEBTP (O.Roland, MP.Colombard-Prout) Vers l'industrialisation flexible, le cas de la maison individuelle. PCA (1987)

CERTES (J.Bobroff, E.Campagnac) La démarche séquentielle de la SGE-BTP. Quels atouts pour les travailleurs et les PME? PCA (1987)

CERTES (E.Campagnac) Démarches ensemblières, quel mode de cooperation avec les PME? PCA (1987)

G.Dioguardi. L'impresa nell'era del computer. Edizioni del sol. 24 ore. Milano (1986)

DRE Ile de France. Analyse du chantier Bouygues de Aulnay sous bois. PCA (1988)

B.Flouzat. Etudes de cas d'expérimentation de la démarche séquentielle. Direction de la Construction (1987)

M.Gibert. La démarche séquentielle (document ronéotypé) CETE Lyon. (Février 1990)

J.Hamaide. Communication au séminaire "Polyvalence et autonomie dans le bâtiment: quelles competences?". PCA (1987)

Rhône-Alpes Conseil. ARC Grenoble. Gières. Organisation séquentielle du chantier. Direction de la Construction. (1989)

SCIC (G.Pierre). Démarche séquentielle. Direction de la Construction. (1987)

SEDES (A.Comoy) Nouvelles formes d'organisation du chantier. Nouvelles relations d'acteurs ou nouveaux acteurs? PCA (1988)

C.du Tertre. Flexibilité organisationnelle et productivit dans le bâtiment. PCA (1988)

14
Broadgate—a case study in the application of organisation design for professional construction management

C.GRAY

Abstract
The Broadgate project in the City of London is probably one of the most significant applications of professional construction management in the UK to date. To achieve the necessary levels of co-operation between trade contractors and designers much more responsibility was placed onto the trade contractors and it wasn't until the analysis of their organisational requirements was complete that an understanding of the underlying problems was possible. A technique for organisational analysis normally used within the management structures of single enterprises was developed and used for analysis of the multi organisation structure of a construction project. The primary responsibility of the trade contractors is revealed as is their central position between the design team and the construction manager.

Keywords: Construction Management, Organisation Design, Levels of Discretion

1 Introduction

1.1 Description of the project

The Broadgate project is a major commercial development of over 500 000 square metres of office space built to shell and core standards which is either left to the tenants to fit out or is finished to a basic specification. The space is divided into 14 separate buildings which have been constructed over the period 1986 to 1991. At the peak 6 buildings were being constructed simultaneously. The client, Rosehaugh Stanhope Developments PLC (RSD), has taken direct control of the construction of the project by using professional construction management and it is the development of the management structure of the project that is considered here.

1.2 Speed of construction

For commercial reasons the buildings have been built very quickly (see figure 1). Speed of construction is shown as rate per week, which is the gross floor area divided by the overall number of weeks to build. By comparison with normal UK practice the rate of construction is significantly quicker. To achieve such speed of construction has meant significant change in three major areas: the construction technology with the extensive use of pre-assembled units, site operation organisation through strict work area control and a simplified management structure.

1.3 Management philosophy

The basic thrust of the management approach has been to harness the skills and knowledge of the specialist trade contractors by placing total production responsibility into their control. This is unconventional in UK practice where for instance site management is normally undertaken in detail by the contractor in close collaboration with the sub-contractor. This is changing, but it was not quick enough for the Broadgate project which, in order to achieve the speed of construction, attempted to utilise the design and production knowledge of the specialists and thus there was the need for a new form of site organisation which would allow the trade contractors the freedom they needed, but at the same time work within the many conventions of UK practice.

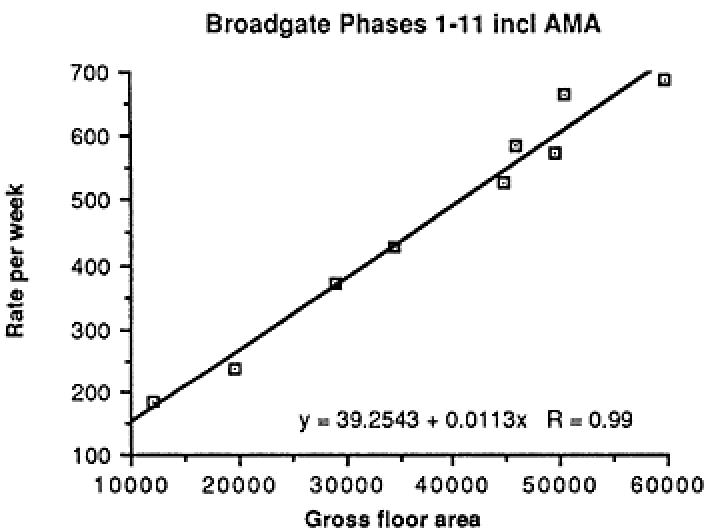


Figure 1 The speed of construction of Broadgate relative to conventional UK performance

In the early days of the first two phases of the project there was considerable conflict between the traditional views of the site management and the trade contractors and the more dynamic approach of RSD. The client had set the principles in the contract agreements, but there was a big barrier to the immediate and full implementation of the approach which was thought to be due to the inflexible attitude of the site personnel of the trade contractor and construction manager. In fact there were more fundamental issues in that the organisational structure had not been designed for the new requirements.

In order to understand the issues more fully an analysis of the existing organisation was undertaken and then a new organisation hypothesised which was then implemented and improved on the later phases of the project.

2 Levels of discretion

The technique of analysis that was used was that of stratified systems theory (Stamp, 1986). There are six levels of decision making, within the hierarchy of production management, that are of importance in this particular context. From level 1 to level 6 the timespan of the work (that is the period between making a decision and seeing the practical results) gets greater and the decisions become more complex. The key personal skill which differentiates between the levels is the ability of the individual to abstract and conceptualise the type of work in his own and lower levels.

> Level 1 *Direct operating tasks* which involve working directly on physical objects or serving people, one unit at a time. The work is anchored in the rule which means that the worker is only concerned with his task and does not recognise any of the aspects which control his task or activity.
>
> Level 2 *Direct operating—method* which involves supervisory workers putting together a number of tasks and choosing methods for tasks appropriate to a given situation. The worker has his discretion limited by the framework of rules which control the tasks.
>
> Level 3 *Alternative operating systems* which involve the general management activity of comparing and contrasting alternative operating systems and ensuring that these operating systems have the resources that they require. This requires an ability to understand the rule framework which controls the tasks and create new working patterns by reapplying the basic rule structure to the new task.
>
> Level 4 *Direct operating—systems* which involves the management of a unit moulding operating tasks and operating methods into a system of direct work and making adjustments to the system that changing trends require. Here the rule structure is questioned to seek ways in which it can be developed or extended.
>
> Level 5 *Complex systems* which involve the comprehensive management of operating systems which may require the modification of the context within which other levels operate. At this level the rules and the rule structure are created in response to the analysis of the situation. There is also the recognition that there are many possibilities and that the rules are open ended.

Level 6 *Direct deployment of complex systems* which involve interpreting the overall strategy into operational plans for total business units. This level is outside of the rule framework and is the one that questions and sets the new rule framework.

This is more clearly expressed by looking at the levels which occur in a project organisation:

Level 1 Direct construction work which requires appropriate assembly knowledge and skills but involves no management responsibility.

Level 2 First line management or a foreman of a team of construction workers. The foreman manages the task allocated to his team.

Level 3 Site management which involves selecting methods of working for several construction teams and ensuring that they have the resources they require to complete the tasks.

Level 4 Construction management which involves managing the site organisation including selecting the methods of work and adjusting them as circumstances require.

Level 5 Project director which requires the comprehensive management of all parts which together form the large scale construction project, including shaping their operating environment and creating the policies and systems they will use.

Level 6 Managing director who initiates the creation of the total business represented by the project.

In designing an organisation all of these levels must be present within the authority and control system. They must also be aligned so that authority and responsibilities are clear and unambiguous although each higher managerial level is capable of handling increasing levels of ambiguity. The formal relationships must also not inhibit the authority and responsibilities between the levels. However when this is applied to a multi organisation and multi function structure such as at Broadgate then a rethink of the traditional relationships is required. This is best explained in terms of: the conventional industry approach, the organisation initially developed for Broadgate and then the developed approach which was required to fulfil the simplicity of the RSD philosophy.

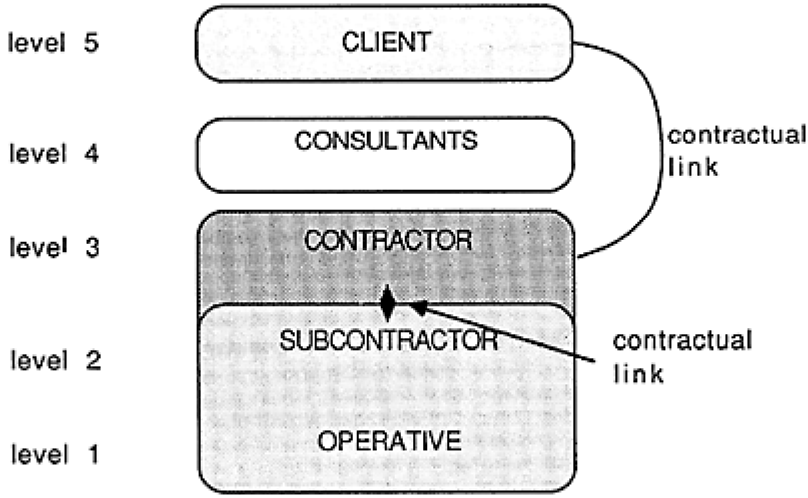


Figure 2 Levels of organisation within a conventional contractual relationship

3 The conventional contract relationship

The general contractor's management, as shown in Figure 2, by working at level 3 manages the subcontractors on a daily basis. The direct contractual link between the client and the contractor is between levels 5 and 3, with level 4, the establishment of the rule structure for the project, being undertaken by the design consultants. The effect of the consultants operating at level 4 is that they set the rules but have no direct responsibility or authority for the outcome. In this way the continuity of responsibility is broken by the role of the design consultants at level 4, which is one of the fundamental problems of the UK construction industry. To try to solve this fundamental problem the traditional approach has been to develop complex and legalistic procedures which stifles initiative and progress.

4 The initial Broadgate management structure

The initial Broadgate management structure was a transition between the complexity and confusion of the traditional approaches and the inherent simplicity of the construction management approach. Two key changes emerge: the removal of the design consultants from within the client/ contractor relationship and thus from the line of responsibility for production, and increased demands on the trade contractors.

The essential feature of the Broadgate model (Figure 3) is that there are four primary parallel organisations: RSD, the Construction Manager, the Trade Contractors and the Designers, each of which should provide a continuous sequence of levels within their organisation. It is also essential to get compatibility of capability across the levels. This caused considerable difficulty by placing new demands on the trade contractors, managers and designers. In many cases these demands were met by apparently demoting senior managers to perform site management tasks, due to the increased scope of the management tasks at the particular level.

The trade contractors were being required to operate at both level 5 and 3, which would normally be done by the architect and contractor respectively. The trade contractors were, therefore, under considerable pressure to develop their managerial capability. Additionally as shown by the authority arrows the site manager is the focus of the production and design authority hierarchies.

To assist the trade contractors to cope with this situation two roles were introduced by the construction manager: the assistant site superintendent and the project manager whose jobs were essentially that of guiding and ensuring that the trade contractors fully understood and complied with their responsibilities of on site and off site management. However, the roles did not have the power of direct line authority and were ambiguous individually and between themselves. Because of the ambiguity the personality of the individual had a powerful effect on the way the role was interpreted and so there were many different interpretations of the roles evident on site and some inevitable confusion.

5 The developed construction management structure

Two further crucial changes were needed to maximise the potential capabilities of the RSD philosophy (Figure 3). The fundamental shift was to complete the integration of the production management role into RSD so that only one apparent contractual relationship; that between RSD and the trade contractors, was perceived by everyone. This gave rise to a new set of roles and relationships.

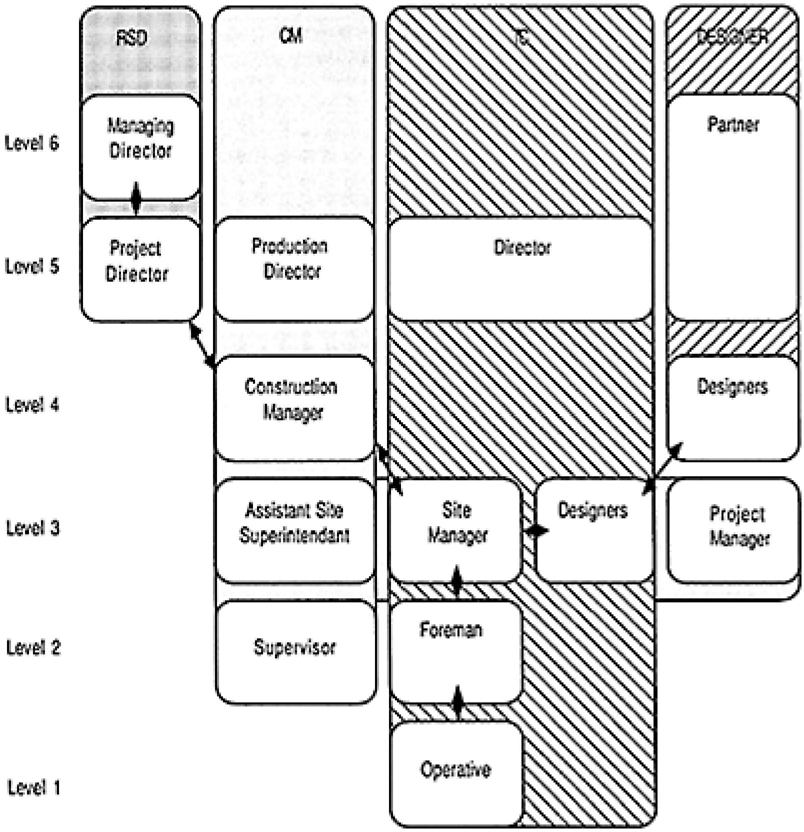


Figure 3: The initial Broadgate management structure

5.1 The Relationship Between RSD and the Construction Management contractor

The construction management approach required that a completely integrated relationship between RSD and their production management team was clearly established. Within their particular form of construction procurement RSD were acting as the client and contractor (in the conventional sense of coordinator of work) for each project. However, because of the size of each project, RSD's own skills needed to be supplemented by high calibre construction skills of an operational and administrative nature. RSD set the objectives, defined the tasks and established the visionary leadership for the project. The Construction Manager was, in effect, a specialist contractor supplying operational management skills.

The Construction Manager's team who were predominantly drawn from people with traditional or management contracting backgrounds consequently had to subjugate their traditional role and effectively became part of the RSD organisation. A simple change of the adoption of the site name—Broadgate in a high profile to the exclusion of any other contractor name boards had the effect of establishing the correct relationship between the client and the trade contractors.

5.2 The relationship with the specialist contractors

The assistant site superintendent and project manager role was phased out (Figure 4) as the trade contractor's management increased in competence so resolving the ambiguity over who should direct the site teams. This was the clear responsibility of the trade contractors. Some trade contractors had already appointed project managers, but their capabilities needed to be enhanced by training in their role to the right level, so that they could fully take over the integration of the off site and on site tasks.

5.3 The relationship with the design team

There were two important issues concerning the management of design; content and schedule. For content there were two providers; the design team and the specialist trade contractors, but for schedule there are three separate sets of needs to be met; the design team's needs, the specialist contractor's needs and the construction site needs. A key feature of this project was that the input to the design by the trade contractor was recognised as forming a larger part of the design than on other, more conventional, projects. The trade contractors were also expected to co-ordinate their design amongst themselves as well as obtain all approvals.

The trade contractor's project manager had to act as the coordinator between the demands of the site and those of the designer. By upgrading the skill and competence at this level the project manager was more effective in performing the trade-off between design and production.

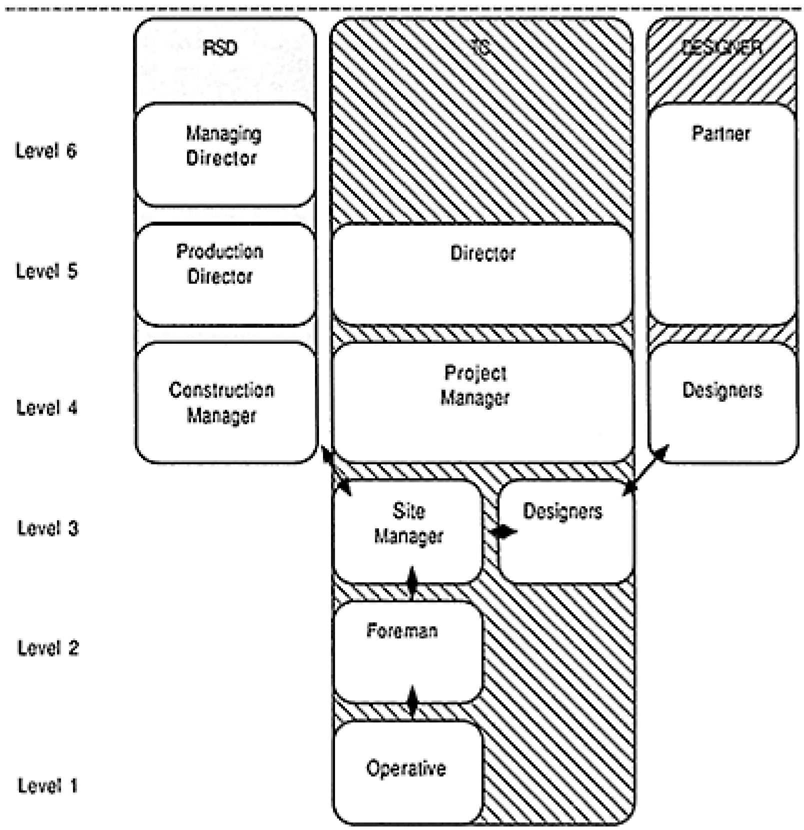


Figure 4: The developed production management organisation

6 Conclusion

It is clear that in order to achieve the speed of construction required by clients such as RSD the whole project organisation must be focused onto the production process. The development of the management structure that has been described arose from conditions off expediency. Eventually a clear and unambiguous management structure was achieved which considered not just the site organisation, but the organisation of the trade contractors and designers.

contractors and designers.

The organisational structure of every participating company must be structured in a way which achieves a clear hierarchy of decision making and when in combination with other organisations achieves a harmony laterally. Where gaps exist then problems of communication and understanding arise and there are ambiguities in the authority structure. Normally these are resolved over time, but where time is not available then organisational design assumes great importance. The traditional hierarchial representation of organisational structures does not represent the types of skill nor the responsibility level that is actually required to achieve the necessary decisions. The charting approach in this paper has pointed to the deficiencies in the traditional methods and offers a new approach to the difficult problem of organisational design.

7 References

Stamp G (1986) Some observations on the career paths of women, **J Applied Behavioral Science,** 22, No 4, pp 385–396

15
The cost/time/quality integrated bidding system—an innovation in contract administration

Z.HERDSMAN and R.D.ELLIS

Abstract
The vast majority of construction contracts are procured using the low bid system. In the low bid system, price is the sole basis for determining the successful bidder. This traditional approach has certain drawbacks. In recent years, several innovative modifications to the low bid system have been tried. This paper presents the results of these trials and proposes a more comprehensive approach to bid award criteria. A presentation of a multi-parameter bidding system is made. The multi-parameter bid award system would include various owner-selected parameters such as cost, time and quality. Quantification of these parameters and bidder evaluation methodology is included. Finally, a discussion of the advantages and disadvantages of a multi-parameter bid award criteria system is also presented.

Keywords: Bidding, Time, Cost, Quality, Innovation, Contract Administration.

1 Introduction

In recent years, we witnessed a trend towards looking for new innovations in contract administration. This phenomena was caused by a long list of failures in past projects, especially in the public sector. The major disappointments in project performance were: extensive delays in the planned schedule, cost overruns, very serious problems in quality and an increased number of claims and litigation. A common opinion is that the consumer (the public) does not get the best product for his money.

In order to change this situation, many public (and private) agencies are trying to find new methods to improve the current procedures. The authors (Ellis and Herbsman, 1990) and other researchers (Bower, 1989; Harp, 1990) are convinced that one of the major factors behind those failures is the current bidding system used in the public sector. In order to analyze why this system creates so many problems, one has to understand the historical background of the development of this system which is commonly known as competitive bidding or the lowest bidder award system.

2 Competitive Bidding—An Overview

The competitive bidding concept is rooted very deeply in the American tradition. Harp (1988) shows that competitive bidding has been in practice in New York state since 1847. The principal statutes for highway and bridges contracting in New York state date back to 1898 legislation, which required competitive bidding.

The basic idea behind this concept was that the lower bidder system protected the public from extravagance, corruption, and other improper practice by public officials. The original function of the competitive bidding requirement was to assure that the public received the full benefit of America's free enterprise system by providing public construction at the lowest price offered by competitive bidding (Cohen, 1961; Netherton, 1959).

Over the years, a few modifications to the initial concept occurred. The terms "responsible bidder" and "public interest" have been added to the statutes which control the authority to let and award public works contracts. Other modifications created the concept of prequalified bidder lists and so on. However, the original concept from the 19th Century remains intact. It is very important to understand that not every country around the globe is using this concept in the public works sector. Many nations are using non lower bidder systems.

2.1 Non lower bidder systems

A few countries, such as Italy and Portugal in Europe and Peru in South America, are using a system in which the successful bidder is not the lowest one. The philosophy behind this concept is that the "best bid" is the most reasonable one, not the highest, not the lowest but the one closest to some average. There are many variations of this concept. The Peruvian government bidding system provides an example of one such variation (Henriod and Lanteran, 1988). The procedures are as follows:

1. When three or more bids have been received:
   (a) the average of all bids and the Base Budget will be calculated.
   (b) All bids which lie 10% above and below this average will be eliminated.
   (c) The average of the remaining bids and the Base Budget will then be calculated.
   (d) The contract will be awarded to the bidder whose bid is immediately below the second average or, should none of the bids lie below the second average, the award will be made to the bid which more closely approximates the average.
2. If less than three bids are received, the bidding agency may cancel the process and award the contract to the lowest bidder or to the only bidder if this were the case.

Another similar practice is that of "bracketing," i.e., considering only those bids which lie within a certain range above and below the engineer's estimate. In this system, the lowest responsive bid within the range gets the award.

Some countries such as France or Portugal (World Bank, 1988) try to disqualify what they call "abnormally" low bids. They define abnormal as "any bid whose price appears abnormally low and consequently may cause implementation problems."

The authors analyzed these systems and came to the conclusion that even though these methods have their merits, they would not be generally accepted in the United States because of 150 years of a traditional competitive bidding system.

2.2 Advantages and disadvantages of the competitive bidding concept

The competitive bidder system has one major advantage. It assumes that the bidding process will be independent from any sort of pressure (political, social, economic). Its objectivity is assured because price is the sole criteria for evaluating bids. For many participants in the construction industry, this reason alone makes it all worth the disadvantages related to this practice. However, the disadvantages are numerous. The major one is that the selection process is based only on one element-cost, and other elements such as quality and time are not accounted for. Many other problems have occurred during the last 150 years: unreasonably low bids, bid rigging, unqualified contractors and so on. To compensate for these handicaps, a few adjustments have been made during the years such as qualification lists, deleting "abnormal" low bids, etc., but many construction participants agree that these are temporary solutions and a major change is needed.

The competitive bidding system is very deeply rooted in the American free enterprise tradition. The authors and others are convinced that a total change from the lower bidder system would not be feasible in the short range and would be even more difficult to sustain in the long range. Only a major modification which would remain in the form of the competitive bidding concept would be accepted.

3 The Multi-Parameter Bidding System

The proposed system is based on the idea that the selection process of the contractor will be based on more parameters than just cost. The successful bidder will be selected according to the lower combined bidding value. Most logically, this number will be represented by a dollar value but it can be represented using points, percentages, etc.

The major parameters will be:

Cost—C
Time—T
Quality—Q

Secondary parameters can also be incorporated into the system such as:

Safety—S

Durability—D
Security—S
Maintenance—M
and a few more.

The number of parameters and their related weights will be chosen by the sponsor. Let us demonstrate this concept with an example. The public agency decides to use four (4) parameters. These parameters and their assigned weights are given in Table 1.

Table 1. Parameter List

Number	Parameter	Weight
1	Cost	70%
2	Time	15%
3	Quality	12%
4	Safety	3%

The successful bidder will be the one that has the lowest combined bidding value of the four parameters.

The multi-parameter bidding system remains within the framework of the competitive bidding concept. A few legal experts have stated that as long as the parameters, their system of measurements and their relativity weights are specified in the bid documents, this concept complies with the existing legal status of the current competitive bidding system.

3.1 Quantification of the parameters

The quantification of the parameters is the major problem in developing the multi-parameter concept. There is no clear-cut answer as to which is the best method and many variations can be developed. When additional research has been done, better and more accurate techniques will be established. The following pages describe a few of the options for some of the parameters.

3.2 Cost

Cost refers to the bid price submitted by the bidder. As in the traditional low bid system, cost will be measured in dollars.

3.3 Time

The authors have done extensive research related to this parameter (Herbs-man, 1988) and conclude that there is a very easy, systematic way that can be used. The time element can be quantified using a time value. The owner would establish the value of the time and the contractor would bid a performance time. For example, if the contractor bid 250 calendar days and each day is valued at $10,000, the time value will be 250×$10,000=$2,500,000 and this figure would be added to the cost value. If the owner chooses only two parameters to bid, then it becomes a cost/time bidding system. The cost/ time system has been tested in a few states and the authors have gathered data on 16 projects that were bid using this cost/time concept. This can be demonstrated using a real example from a project in Mississippi. The time value was established by the owner as $7,000/day. The bid tabulation is given in Table 2.

Table 2. Results of Bid Tabulation Using the Cost/Time Concept

Bidder No.	Bid Cost Base	Days Bid	Time Value	Total Amount
1	$15,636,180.56	450	$2,250,000.00	$17,886,180.56*
2	$16,070,558.46	426	$2,130,000.00	$18,200,558.46
3	$15,628,815.06	523	$2,615,000.00	$18,243,815.06
4	$16,231,527.80	646	$3,230,000.00	$19,461,527.80
5	$15,835,768.22	780	$3,900,000.00	$19,735,768.22

*the lowest combined bidder

The time value is established by the owner. There are many ways to figure the value. For example, in highway construction it is done routinely by transportation economists. Fig. 1 is an example from a project in Kentucky where the value was calculated as $5,400/day.

The authors researched the results of bids conducted by seven state transportation agencies using the cost/time bidding system. (Ellis and Herbsman, 1990). A total of fourteen projects were included in the study. Use of the cost/time bidding system resulted in a significant savings in project time and a corresponding cost savings to the owner on eleven out of the fourteen projects. The results of this study are summarized in Table 3. The data presented includes the Case Study No. (1), State (2), Successful Bid Price (3), Savings to the Owner (4) and Time Savings (5).

HIGHWAY ROAD USER COST (RUC) FORMULA

RUC=(Gasoline Consumption×$1.50/gallon)+(VMT×$0.17/mile/vehicle) +(0.90 VHT×$0.50/vehicle/hour)+(0.10 VHT×$7.00/vehicle/hour)

where:

1. Gasoline consumption is shown in previous table.
2. $1.50/gallon estimated price for 1985.
3. VMT is vehicle mile of travel as shown in previous table.
4. $0.17/mile/vehicle is vehicle operating cost excluding price of gasoline, taxes, tolls and parking.
5. 0.9 VHT is vehicle miles of travel attributed to passenger vehicles.
6. $0.50/vehicle/hour is updated value of non-commercial or non-business auto trip time.

7. 0.10 VHT is vehicle miles of travel attributed to commercial vehicles (trucks).
8. $7.00 vehicle/hour is updated value of commercial truck trip time.

Without Sections 2A and 2B:

RUC=(1,292,000 gallons×$1.50/gallon)+(16,336,490 vehicle miles× $0.17/mile/vehicle)

+(0.90×708,897 vehicle hours×$0.50/vehicle/hour)

+(0.10×708,897 vehicle hours×$7.00/vehicle/hour)

RUC=$1,938,000+$2,777,203+$319,004+496,226

RUC=$5,530,435

With Sections 2A and 2B:

RUC=(1,291,000 gallons×$1.50/gallon)+(16,358,302 vehicle miles× $0.17/mile/vehicle)

+(0.90×702,296 vehicle hours×$0.50/vehicle/hour)

+(0.10×702,296 vehicle hours×$7.00/vehicle/hour)

RUC=$1,936,500+$2,780,911+$316,033+491,607=5,525,051

Daily Road User Benefit (DRUB):

DRUB=$5,530,435−$5,525,051=$5,384

From these calculations the Daily Road User Benefit to the motoring public from the construction of Section 2A and 2B of the Jefferson Freeway is $5,400 per day.

Fig. 1. Calculation of Daily Road User Cost

Table 3. Summary of Case Study Results

Case Study No. (1)	State (2)	Successful Bid Price (3)	Savings to Owner $ (4)	Time Savings To Owner Days (5)
1	Delaware	3,034,765	250,000	50
2	Kentucky	17,886,181	1,387,635	219
3	Mississippi	4,721,599	166,331	49
4	Kentucky	16,329,262	2,885,000	577
5	Kentucky	12,583,349	315,000	63
6	Kentucky	9,186,877	1,620,000	324
7	Kentucky	18,554,123	715,000	143
8	Delaware	2,306,380	175,000	35
9	Maryland	35,087,606	0	0
10	Missouri	1,637,015	(460,000)	(23)
11	Georgia	1,361,009	(147,000)	(21)

12	Texas	39,833,648	150,000	30
13	Texas	39,781,121	300,000	60
14	Texas	15,867,833	55,000	11

The savings to the owner have been calculated taking into account the contractor's price and proposed time, as compared to the owner's cost estimate and normal time. The owner's established time value was used to calculate the value of any time savings.

4 Quality

This parameter is the most complicated and difficult to quantify. There are two totally different approaches to the subject.

4.1 Past performance

This approach takes in consideration past performance and using subjective opinions in evaluating the performance on a scale. The details of the evaluation process are varied from different organizations but all are using the same concept. For example, the Florida Department of Transportation uses it on a permanent basis by using the resident engineer as the evaluator. Although it is based largely on subjective opinion, it is very rare that the contractor (who has a right to appeal) challenges the evaluation. A better quantification method for past quality performance can be based on past test results. This way the evaluation will be less subjective. The details of the quantification system have to be developed using existing standard testing procedures such as concrete strength, pavement strength, tolerance measurements, etc.

4.2 Future performance

A few researchers (Byrd, 1989; Marek, 1989, “Yarbrough, 1990) are against any subjective evaluation and they prefer bidding on quality the same way that the contractor will bid on cost and time. This approach has its merit although it needs more research for various tests. A demonstration of this concept would be the following example: One of the most important factors in highway construction is the roughness of the pavement. This item is measured by inch/ mile using a “profiler.” The contractor can bid on the quality of the road by using the parameter (inch/mile). An 8-inch/mile would be better than a 13-inch/mile. The state decides the value of every inch/mile (within certain limitations). Similar measurements can be developed for various types of work.

Both of the two approaches have their merits and handicaps, and more research needs to be done. Even with all the problems associated with quantification of quality, this parameter has to be an essential part of the multiparameter system.

4.3 Measuring quality

An example of quality quantification is provided by the Construction Quality Assessment System (CONQUAS) now in use by the Construction Industry Development Board in Singapore. The CONQUAS system consists of a structured program for inspecting, measuring and recording the quality performance of contractors. Under this system, contractors are assigned quality performance scores on past jobs. A contractor's quality record becomes an essential part of the contractor's performance record. For public projects, contractor's with superior quality scores are given a pricing advantage on competitive bids.

The philosophy of Singapore's Construction Industry Development Board is summarized by Chow Kok Fong, General Manager: "Construction quality is taken too frequently as an abstract notion."—"A commitment to construction quality is only possible if progress in this front can be registered in some manner" (Fong, 1990). According to the CIDB, the CONQUAS system has been applied to over 120 private and public sector projects.

4.4 Minor parameters

In addition to the major three parameters (cost, time, quality), there may be more parameters that can be incorporated into the system. Most of these parameters would be specific to particular industries and these agencies would have the responsibility of figuring the weights and the quantification methods for these parameters.

Such additional parameters could include safety (very important in tunnel and dam projects), security (in military projects), aesthetic quality (shopping centers), and many more. It must be emphasized that new parameters can be added all the time, and their relative importance can be measured by adjusting the weights.

5 The Total System

The multi-parameter bid system would be designed by the owner to include those parameters considered to be most essential. It seems likely that the selected parameters may vary with different owners and with different projects. Regardless of the parameters chosen, all bidders would be fully advised of the basis for successful bidder selection prior to bid preparation.

The total system can be demonstrated with an example. In this case, the owner has established a bidding system based on four parameters. These parameters and their assigned weights are listed in Table 4. This information is provided to the prospective bidders as a part of each bid package.

Table 4. Bid Parameters

No.	Description	Weight %	Quantification Method
1	Cost	60	the actual cost value
2	Time	20	based on $2,000/calendar day

3	Quality	15	past performance in points[(1)]
4	Safety	5	historical accident records[(2)]
	TOTAL	100%	

[(1)]based on average performance in the last 36 months represented in points per hundred, i.e., 97/100, 85/100 and so on.
[(2)]based on number of accidents per $1,000,000 cost and depending upon the severity of the accidents.

Table 5 presents a tabulation of the bid results. The COST amount is the bid price proposed by the bidders. The TIME amount is the time in calendar days proposed by the bidders for performance of the work. The QUALITY and SAFETY items have been established from the bidders previous performance records.

Table 5. Bid Tabulation

Bidder	Cost ($)	Time (Cal-Days)	Quality (points per 100)	Safety (No. of acc.[(1)] per 1,000,000)
A	1,100,000	250	89	12
B	1,300,000	230	97	9
C	1,250,000	240	91	17
D	1,100,000	300	85	25

[(1)]the number of accidents were weighted on a scale: severe accidents (3 points), medium (2 points) and light (1 point).

Given this bidding result, the total bid scores for determining award are listed in Table 6. In this example, Bidder A appears to have made the best proposal. If the project was awarded to bidder A, the contract amount would be $1,100,000 and the specified duration would be 250 calendar days.

Table 6. Bid Calculations

Bidder	Cost Value C	Time[(1)] Value T	Quality[(2)] Value Q	Safety[(3)] Value S	Total[(4)] B
A	1,100,000	500,000	121,000	12,000	1,733,000
B	1,300,000	460,000	39,000	9,000	1,808,000
C	1,250,000	480,000	112,500	17,000	1,859,500
D	1,100,000	600,000	165,000	25,000	1,890,000

The calculations are based on the following formulas:

[(1)]Time Value: Calendar day×$2,000/day=CT

(2)Quality Value: 100-points/100×C_L=C_Q

(3)Safety Value: No. of Accidents (1, 2, 3 points)×$10,000=$C_S$

(4)Total Combined Cost $C_B=C_C \times C_Q+C_T+C_S$

6 Summary and Conclusions

The existing bidding system, which is the competitive bid (or low bidder system) has created many problems in past years. Many modifications have been added to the original concept but the system remains basically unchanged.

The successful bidder is chosen by the lowest, responsible cost. Other factors such as time, quality, etc., have not been taken into consideration. Many practitioners believe that the current bidding system has caused many failures in the form of delays, low quality and numerous other claims. However, a total change of the current bidding system could result in major resistance from various sectors of the construction industry.

The paper introduced a modified bidding system within the legal and conceptional frame of the current practice.

In the modified multi-parameter bidding system, the award would be granted on the total combined cost of a few parameters such as cost, time, quality, etc.

The "weight" of each parameter would be decided by the owner, so he can give a relative opinion of the importance of each parameter. Quality can be a 30% value in one bid and 50% in another. As long as the weights and the quantification method are known in advance by each bidder, the proposed system is legally very sound.

The authors have analyzed a limited version of the new system, bidding on cost and time, and the results show a significant savings in time without any major increase in cost. For the other parameters such as quality, more research must be done on quantification methods. It will not be easy, but it can be done as has been shown in the case of time quantification (road user cost). The proposed multi-parameter system has the potential of improving the construction performance in the USA by giving advanced contractors an incentive to use all of their abilities to give the owner a better product. Its strength is the flexibility of the system while remaining within the framework of the competitive bidding system.

7 References

Bower, Dwight M. (1989) Innovative Contracting Practice. **Proceedings,** ASCE Highway Conference, San Francisco, California, April.

Byrd, L.G. (1989) Partnerships for Innovation: Private Sector Contributions to Innovation in the Highway Industry. **National Cooperative Highway Research Program Synthesis of Highway Practice 149,** Transportation Research Board, Washington, D.C.

Cohen, A.Henry (1961) Public Construction Contracts and the Law. **1961 Treatise,** F.W.Dodge, New York.

Ellis, Ralph D., and Herbsman, Zohar J. (1990) Cost Time Bidding ConceptAn Innovative Approach. **Transportation Research Record No. 1282,** Transportation Research Board, Washington, D.C.

Fong, Chow Kok (1990) The Construction Quality Assessment System-CONQUAS. **CIDB Review,** The Construction Industry Development Board, June.

Harp, W.Darrell (1988) Historical Background Low Bid Concept. A paper presented in the Annual Meeting of the Task Force, Denver, 15 pages.

Harp, W.Darrell (1990) Innovative Contracting Practice-the New Way to Undertake Public Works Projects. **Hot Mix Asphalt Technology,** Winter.

Henriod, Ernesto E., and Jean Marie Lanteran (1988) Trend in Contracting Practice for Civil Works. A paper presented to the Task Force on Innovative Practice, August, Denver, Colorado, published by the World Bank.

Herbsman, Zohar J. (1988) Evaluation of Scheduling Techniques for Highway Construction Projects. **Transportation Research Record No. 1126,** Transportation Research Board, Washington, February, pp. 110–119.

Marek, Charles (1989) Overcoming Barriers to Innovative Contracting Procedures-Testing Equipment and Procedures. **Hot Mix Asphalt Technology,** National Asphalt Pavement Assocation, Winter.

Netherton, D.Ross (1959) Selected Studies in Highway Law, Vol. 3.

Sample Bidding Documents-Procurement of Work (1985) A Report published by the Inter-American Development Bank, Washington, D.C., September.

Yarbrough, Roger L. (1990) In Search of Performance Excellence: Moving Away from Method Specifications. **Focus,** Strategic Highway Research Program, May.

16
The management of construction projects with particular reference to human resources

I.D.C.IMBERT

Abstract
This paper looks at the nature of the construction process, clearly enunciating that it consists of two distinct but interdependent phases—design and building. It makes a case for having these phases closely integrated and placed under the control of a single management entity. Emphasis is placed throughout the paper on the dominant role of human resources in the activity of construction management and the necessity for education and training at all levels and across a wide variety of operations and functions in the construction process. The importance of planning, organisation and control in the management of construction projects is highlighted and the problems encountered in managing human resources stressed. Special mention is made of housing and environmental issues because they exemplify the complex and socio-technical nature of construction and indicate the need for a multi-disciplinary approach, especially in the areas of planning and design,
Keywords: Construction, Education, Environment, Housing, Human Resources, Management, Training

1 Introduction

The management of construction is an activity dating back to mankind's earliest attempts at building dwellings and other structures. It has developed throughout the millenia as an empirical art which has finally evolved into a specific human discipline. It did not, however, acquire a particular name or description until the term *construction management* began to emerge in the last few decades. The term is still undergoing definition, views as to its meaning and nature being as varied and numerous as there are books, papers and symposia on the subject. What seems to be in little doubt, however, is that the construction process is resource-based, proper utilisation of resources being at the core of its successful management.

The resources generally utilised may be broadly classified as being financial, human and physical and, since it is becoming clearer every day that human skills are of primary importance in providing and mobilising all these resources, the focus of attention in the management of construction is increasingly being directed towards the subject of human resources itself. This has been given further impetus by a growing recognition that the construction process is primarily a “people” activity and that successful management of people is essential if desired outcomes are to be achieved.

Discussion of this topic, which forms the central theme of the paper, is best begun by looking at the nature of the construction process itself.

2 Nature of the Construction Process

The construction process may be divided into two distinct but interdependent phases, the first one commencing at the point in time when a facility, be it a simple cowshed or a major highway system, is conceived in an owner’s mind. A study of the owner’s requirements is followed by a consideration of various design alternatives from which flows a final design and its related documents. The stage is now set for the second phase of actual building and completion of the facility.

Throughout both phases, there are a variety of factors which influence decisions and activities and which are very complex in their interaction. Although it is not proposed to examine these factors in any detail, a few examples are nevertheless given in order to emphasise the degree and extent of human skill required for effective understanding of their influence and the necessity for such understanding to become an integral part of the management of the construction process. These examples are site location and availability, weather conditions, telecommunications, financial resources, legal and environmental requirements, building methods, the provision and deployment of equipment, labour and materials and the control of time and cost. The last two factors, in particular, and the interaction between them are so important that they require the strictest attention. Indeed, it cannot be overemphasised that time and cost are the elements of the second phase most profoundly affected by the end results of the first and that it is essential that the final design and, in particular, the preparation of specifications be undertaken by people with sufficient experience, skill and foresight. This is as true of a simple dwelling as it is of a large power station.

The interdependence of the two phases leads to the inescapable conclusion that they should be closely integrated and placed under the control of a single management entity so that owner, designer and builder can be brought together as a team (Imbert 1981). At least, this is what logic and good sense tells us and that is what used to happen in much earlier periods of human history. The construction of the great edifices of the ancient world, the Great Wall of China, the cathedrals of medieval Europe and, more recently, structures such as the Eiffel Tower and the North American railways exemplifies that reality. In modern times, however, the construction industry has been overwhelmed by an increasingly bewildering array of crafts and professions whose members jealously guard their individual authority and independence. This is a reality which often defies attempts at establishing unity of purpose and endeavour and thus, despite the best efforts at ensuring management of what should be an integrated process, there is often a separation of responsibility between its phases and also within each of them—a separation which does the industry no good and has come to be recognised as a serious impediment to cost-efficient production. Indeed, it is this situation and the consequent need to impose order on a series of disparate entities, activities and specialist groups which have led to the recent emergence of the specific discipline known as construction management, undoubtedly adding to the array of professions previously mentioned but surely contributing to a more integrated approach to the construction process. Let us, therefore, take a closer look at this discipline and examine briefly its major elements, especially in terms of human skills and interaction.

3 Major Elements of Construction Management

Although construction management is still undergoing definition, as indicated earlier, its major elements have been fairly clearly identified as planning, organisation and control. In this context, planning connotes the determination of all construction activities and operations, their sequence and interaction and the formulation of specific arrangements and schedules for their performance. The work must then be so organised that these activities and operations are effectively co-ordinated. This requires the assignment of resources within a distinct framework, streamlined channels of communication and clear definition of lines of authority and areas of responsibility of personnel. Throughout the entire process, control must be exercised, progress being continuously monitored and corrective action taken whenever and wherever necessary. This element of construction management includes surveillance of design and building production, conformance with specifications, revision and updating of plans and schedules, appropriate record-keeping, analysis of performance in terms of quality, time and cost and ensuring that all concerned are kept fully informed. This control function is of paramount importance in these inflationary times when it is so necessary to curb construction costs while producing work of enduring good quality.

As we analyse and examine these elements, what becomes clear is a recognition that the degree of success achieved in them is directly related to the range and extent of the managerial skills available and there is little doubt that, the greater they are, the more efficient will be the conduct of management of the construction process. In this context, it is important to realise that management in construction is both multi-level and multi-function in nature. Thus, we distinguish between the levels of foreman and site manager and between the functions of equipment and purchasing managers, Moreover, we know that many management viewpoints of the use of resources can exist at the same time. For example, whereas a craft supervisor may be concerned with the provision of resources required for a given operation, a site manager has to deal with deployment of such resources for several operations, a project manager with their total utilisation and a financial controller with their time-cost profiles. Similarly, a design manager is usually more concerned with deploying resources so as to keep several projects on stream than would be a section leader whose immediate responsibility is to ensure the expeditious design of a particular project.

What emerges from this discussion is that not only are the development and improvement of managerial skills of paramount importance but that sources of conflict are also inherent in the multi-level, multi-function nature of management in construction. Education and training of managers at all levels and across a wide variety of operations are, therefore, essential, One important by-product of such education and training is the increasing realisation that, since skilled manpower is the construction industry's most precious resource, the skills of all construction workers, be they managers, designers, site foremen or craftsmen, need continuous upgrading and updating. This is what is known today as human resource development and the author wishes to emphasise that experience has shown, and continues to show, that such development is not only essential for successful construction management but also has effects which reach far beyond the construction industry and influence economic planning, policy-making, technological progress and the provision, quantum and distribution of the very resources required for construction.

It would be inappropriate to leave the discussion of education and training without emphasising the difference between the two while recognising that training is an essential element of education in the construction industry. Training is directed at imparting skills and techniques for specific activities and operations whereas education is an exercise which imparts not only knowledge but ideas and perspective, enabling people to think creatively and understand the conduct of human affairs. Training is necessary at all levels and for various functions in construction, the broader activity of education becoming more important as the management tree is ascended. Thus, a concrete foreman must be trained in basic concreting operations whereas the concerns of a senior supervisor would be matters such as quality control, equipment deployment and materials management. Senior managers, in both the design and building phases of the construction process, need to acquire a broad perspective of administration, industrial relations and human behaviour, gain sound knowledge of contract provisions and specifications and receive training in the techniques of planning, organisation and control which are themselves, as already stated, the major elements of construction management.

This brings us right back to the start of the foregoing discussion on these elements and now takes us beyond the subject of human resource development into a discussion of the actual management of human resources themselves, such management being itself inextricably linked with planning, organisation and control.

4 Management of Human Resources

The management of human resources in construction confronts us with a problem full of uncertainties because people are complex and volatile (Kalu 1990), human behaviour being subject to all kinds of whims, attitudes and motivations. This makes performance upredictable and, since performance is a function of the people involved in the construction process (Maloney 1990), construction managers need a wide array of psychological skills and a perspective which sees the process as a series of networks of people and relationships. Moreover, since construction activities and operations tend to involve groups of people rather than individuals, group behaviour needs careful study and managers should endeavour to organise groups which can achieve internal consensus about goals, expectancy and performance and interact efficiently with each other. A recent study on this subject provides interesting reading (Thomas et al. 1990).

Success here is dependent to a large degree on the establishment of good communication systems. These are vital for giving and receiving information and for creating and maintaining relationships between people. Effective communication creates good teamwork which is conducive in turn to more effective communication. It also stimulates that freedom of expression which is such a critical element of the feedback process necessary to successful management. This cannot be overemphasised.

An aspect of the management of human resources which merits attention is the capacity to encourage and reward creativity. In a world which is undergoing rapid and complex change and in which the construction industry, highly conservative though it may be, is itself subject to change and uncertainty, new ideas and techniques are essential. So are ways of improving existing methods and utilising resources more effectively. Research plays a very important role in this context and this is an area in which the construction industry lags sadly behind most major industries, particularly in terms of funding.

Another important aspect is that related to the first phase of the construction process. This has not received the application of management systems and methods in the way that the second has and the author's experience indicates that one of the major reasons for this is the inherent human conflict which usually exists in this phase. Even in small projects, conflicts often arise between owner and designer because of their differing perceptions of management responsibility and authority. The effects of such conflict are clearly evident in large and complex projects where there are several designers or design teams of different disciplines. The problems are often compounded by the fact that designers generally consider suggestions from other professionals, be they designers themselves or people such as builders, managers, planners and accountants, as an impertinence and an intrusion into their spheres of expertise and responsibility. Co-ordinating the activities, aims and interests of all concerned is a task requiring supreme managerial skill and human understanding and people having those attributes are both rare and high-priced. Thus, the task is often ducked or poorly performed. Nevertheless, since this first phase has such an enormous influence on time, cost and performance in the second phase, it is incumbent on the construction profession to give it far more attention than it has received hitherto.

5 Housing and Environmental Issues

Although the paper deals with the subject of management of construction projects in general, it is felt that the housing domain, at which the Symposium is mainly directed, should receive some discussion. At this juncture, it should be noted that management of the construction process embraces not only the actual implementation of projects but also decision-making about their worth, necessity, location, choice and funding in terms of social, economic and environmental priorities. This is an essential element of the first phase of the process, especially in the area of housing.

The provision of housing is not only a matter of constructing adequate shelter for people but also one of locating such shelter in environmental conditions conducive to good health and improved quality of life. Research in the social sciences has shown that people function better in such conditions, thus becoming more productive and contributing to improved social and economic activity. Thus, planners, designers and builders are faced with a complex, socio-technical issue in which a variety of forces are at work. These forces, which may be broadly classified as social, economic, political, technological and environmental, are often diffuse and nebulous and frequently function at an intangible and abstract level. It is the failure to realise the nature of the: issue and the existence of these forces which has often led to the production of sterile and disfunctional housing environments, many of which have proved to be real disasters.

A key element in ensuring success in this area is community participation in the activities of planning and design, a participation which allows users of a housing environment to be involved in decision-making without in any way displacing the role of the technical experts. Indeed, it supplements the work of the experts and helps them, to obtain information about the special needs and characteristics of a particular community. This has the effect of minimising conflicts which result from the differing social and economic perceptions and motivations of the various participants and avoiding the production of unsuitable and inappropriate housing schemes. Had this type of participation and communication occurred in many housing schemes in the past, some of the concrete jungles which have created such social and psychological disharmony might never have come into being.

The foregoing discussion indicates that the provision of suitable housing requires the existence of planners, designers and builders with highly trained intellects, wide interests and developed skills who are alive to the needs and realities of their own societies and combine technical competence with political sagacity, economic wisdom and environmental sensitivity. In this regard, appropriate education plays a most significant role and should emphasise the need for a multi-disciplinary approach to the planning and design of housing. Indeed, educators should stress that outcomes will really be successful only if they emanate from the combined efforts of professionals such as urban planners, architects, engineers, economists, sociologists, psychologists and experts in legal, financial and managerial affairs. It should also be stressed that design is a socially responsible activity, tailored to suit the cultural realities, development priorities and environmental requirements of a particular locality, region or country.

The human skills required for dealing with the provision of housing, which is taken as a specific example of certain essential aspects of the management of the construction process, reveal the importance of human resource development, which was discussed earlier in the paper. The housing issue also provides a focus oń environmental issues which need to be given special emphasis and to be uppermost in the minds of designers, builders and managers in all areas and aspects of construction. Indeed, it is the increasing attention paid to environmental issues in construction which has been primarily responsible for the emergence of the concept of sustainable development which is now in vogue. This is a concept which is receiving considerable attention today and which will increasingly dominate the thinking of construction professionals and others as time goes on. Future symposia on the built environment will undoubtedly have this concept as a major item of discussion.

6 Conclusion

The paper has looked at the nature of the construction process, its two interdependent phases of design and building and the planning, organisation and control therein. It has made the point that construction is a resource-based process and emphasised throughout the predominant role of human resources in the management of construction projects. It has paid particular attention to human resource development and outlined the problems encountered in the management of human resources themselves. Housing and environmental issues have been given special mention, being used to exemplify the complex nature of the mangement of the construction process and illustrate its socio-technical character, especially in the areas of planning and design.

7 References

Imbert, I.D.C. (1981) Research, education and training necessary for the management of construction, in **Proc., CIB W-65 3rd Int. Symp. on Organisation and Management of Construction,** The National Institute for Physical Planning and Research, Dublin, pp. B.2. 138–150.

Kalu, T.C.V. (1990) New approach to construction management. **J. Constr. Engrg. and Mgmt.,** ASCE, 116(3), 494–513.

Maloney, W.F. (1990) Framework for analysis of performance. **J. Constr. Engrg. and Mgmt.,** ASCE, 116(3), 399–415.

Thomas, H.R.Maloney, W.F.Horner, R.M.Smith, G.R. Handa, V.K. and Sanders, S.R. (1990) Modeling Construction Labor Productivity. **J. Constr. Engrg. and Mgmt.,** ASCE, 116(4), 705–726.

17
Construction business failure and risk management in the USA

R.KANGARI

Abstract
Business failure is an extremely disruptive force in the construction industry. The chance of failure for a construction company has increased over the past ten years. In recent years the average age of a construction company at failure has been declining. The construction industry in the U.S. has several unique characteristics which sharply distinguish it from other sectors of the economy. These unique characteristics contribute in many ways to a high rate of failure in the industry. This paper investigated the effect of macro-economic factors on business failures in the construction industry. Construction companies must always be aware of the possibility of business failure. Constant monitoring of their financial condition through the use of financial ratios is important. Overall industry indicators must also be monitored and trends be analyzed to determine swings in failure probabilities.

Keywords: Business Failure, Construction, Economics, Finance, Management, Risk.

1 Introduction

The prospect of business failure is not a topic most businesses care to acknowledge. In construction however, failure is a real possibility. The construction industry has characteristics which sharply distinguish it from other sectors of the economy. It is fragmented, very sensitive to economic cycles, and highly competitive because of the large number of firms and relative ease of entry. It is basically due to these unique characteristics that the rate of construction business failures has become very high. Understanding the mechanism of failure is key to attempting to avoid failure. Corrective action can not be taken if trouble is not acknowledged or foreseen.

Unlike the study of how to succeed in business, the study of business failure has not been given much attention. This is particularly true for the construction industry in the United States. Although some financial institutions have collected information about business failures but no comprehensive study of the cases of bankruptcy for construction companies has been completed. What is missing is a mean to synthesize this information into a particular means of avoiding failure, and to find common elements of business failures in the construction industry. If this could be understood, then perhaps ways to prevent or reverse a company's collapse could be found.

The increasing number of business failures in construction makes the understanding of this issue critical This paper examines the mechanism behind the financial failure of construction companies.

The number of business failures has dramatically increased in this decade as indicated by Dun and Bradstreet Business Failure Records (1982–1989). Failure rate among the construction companies has reached a critical high level, this indicates that a good deal of research is needed to investigate prediction on business failures in the construction industry.

Understanding the causes and symptoms of business failure helps in the identification and early warnings of impending financial crisis. This is important not only to analysts and practitioners in construction firms in predicting their financial distress for providing new direction for the firm, but it is also important to commercial lending institutions, bonding companies, investors, and clients.

2 Background

Previous studies conducted on business failure by Altman (1968, 1971, and 1977), Beaver (1966, and 1968), Edmister (1972), Holmen (1988), and Scott (1981) are mainly focused on industries other than construction. Due to the limitations of information, no comprehensive research is conducted for developing a mathematical model for failure analysis of the US construction companies.

Preliminary studies on modeling a construction firm's failure are conducted by Abbinante (1987), Argenti (1976). The information was obtained from reporting services of Dun & Bradstreet's Business Failure Record (1982–1989), Robert Morris Associates (1985), Department of Treasury's (1983–1988) annual publications, Leo Troy's Almanac (1987), Value Line (1988) publication, and Standard & Poor's Corporate Records (1989).

However, most of these models have not been able to provide an accurate method of financial failure analysis. It can be concluded that "detecting failure using 'common sense' may well be the best prediction of bankruptcy. It only requires being attuned to the realities of the marketplace for obvious signals of failure." It was also concluded that the usefulness of prediction models developed from financial ratios and by statistical methods could only be increased by concentration on individual industries. It was suggested that a prediction model developed from financial ratios and then linked with non-financial analysis would produce a most effective screening procedure for the construction industry.

3 Causes of business Failures

Statistics on bankruptcies are maintained by the U.S. Bankruptcy Court System, however, the statistics are not broken down into areas like construction. The largest source of information on failures in the U.S. construction industry is Dun and Bradstreet Corp. It is a private corporation which maintain a database on various aspects of the business world. It publishes some of this database in various forms including failures in the construction industry. According to Dan and Bradstreet, a business failure is defined as a business that ceased operation following assignment or bankruptcy, ceased operation with losses to creditors after such actions as foreclosure or attachment, voluntarily withdrew leaving unpaid debts, were involved in court actions such as receivership, reorganization of arrangement, or voluntarily comprised with creditors.

The major causes of business failures are identified by Dan and Bradstreet as:

Economic factors.
Management incompetence and lack of experience.
Inadequate sales.
Expenses.
Fraud and neglect.

The most significant failure cause is economic factors. Major economic factors are:

Bad profits.
High interest rates.
Loss of market.
Low customer spending.
Difficulty collecting from customers.
No future.

Of these subcategories, bad profit is significant. Bad profit account for approximately 74% of the failures in the economic factors category. Since economic factors account for approximately 70% of all failures, alternatively it can be said that bad profits account for slightly over half of all failures.

4 Analysis of business failure for construction

The rates of failure experienced in the last five years are the highest since the Great Depression. The probability of failure for the average construction company is high. The realization that a firm must live with the chance over its entire life adds to the significance of rises in the failure rate. In addition the rate is not equal for all firms. Well established firms intuitively have a much lower probability of failure than newer firms.

The erratic behavior of the construction failure rate can be related to industry forces which also vary over time. These industry forces which are tied to the causes of failure include the:

Amount of construction activity.
Interest rates.
Inflation.
New business activity.

In general, increase in loan rates would result in corresponding increases in failure rate. This was evident during the period 1979–1981. However before that period the relationship does not hold. This can possibly be due to a time lag between the rise in loan rates and the rise in failure rate.

After 1982 however the lag between the two factors (loan rates vs failure rates) does not seem to hold. Specifically, the period 1984–1986 shows slight declines. The prospect of a time lag between changes in loan rate and changes in failure rate therefore seems uncertain. While it is logical that it would take a certain period of time for the new interest rates to effect company performance, the relationship between the two variables is unclear. An increase in loan rate take a period of time to cause increases in failure rate while decreases in loan rate almost immediately cause decreases in failure rate.

The decreases in loan rate from 1984–1986 had corresponding slight decreases in failure rate. The increases in loan rate on the other hand had corresponding significant increases in failure rate. This relationship would seem to suggest the need for additional forces to explain this lack of decrease. In addition, the substantial increase of failure rate from 1983–1984 is unexplained from just loan rates.

Another comparison with failure rate related to interest rates can be made using mortgage rates. Mortgage rates are applicable for a couple of reasons. First while they are not directly involved in interest payment made by contractors, they are a good indicator of loan interest rate activity. Changes in mortgage rates are extremely similar to changes in loan interest rates.

Secondly, mortgage rates are an excellent indicator of residential construction activity. Rises in mortgage rates inevitably reduce residential construction activity. Residential construction is a significant portion of work to many of the construction companies, therefore, changes in residential activity should effect construction business failures.

Severe rises in construction cost and overall inflation related to construction can have an effect on a contractor’s profitability. Failure to anticipate cost change and guard against incurring additional costs can limit chances for success. Large increases in construction costs could affect construction failure rates.

The lack of experience and financial reserves, places a new construction business in a precarious position. The lack of a reputation and standard customers adds to the already unstable condition.

5 Risk Management

With today’s sever competitive and tough economic conditions, risk management has become an increasingly important part of overall organization. The evaluation and analysis of risk associated with a project is a topic of both practical and theoretical interest. The topic is of practical interest because risks associated with projects have potentially serious financial impact on all the parties involved, and is of theoretical interest because it is a complex and difficult problem to model.

Risk management is a systematic approach to risk identification, goal description, risk sharing and allocation, risk evaluation, risk minimization and response planning.

Risk identification is usually done by developing a list of most significant uncertainty factors and their description. This list includes the principal risks of all major parties involved in a project. Uncertainty factors that affect productivity, cost, schedule, quality, and performance should be included in this list.

Goal description or risk policy planning is the explicit listing of a set of procedures and goals for risk management of a project. Risk policy might be: ignoring risk without action; recognizing risk but taking no action to reduce it; recognizing risk and taking an action; transferring or sharing risk. These policies may also be combined to form a new policy. For example, a manager may elect only to recognize those uncertainty factors which have a very high impact on a project's duration and ignore other risk factors.

Risk allocation defines the proportion of risks to be shared by various parties involved in a project. It is the process of assigning responsibility of the results of uncertainty factors. The contract documents allocate risks and establish the relationship of the parties in a contract.

Risk evaluation is the process of estimating the severity of impact, probability of occurrence, and sensitivity of the project to changes in project related uncertainty factors. Most conventional risk evaluation models are based on quantitative techniques which require numerical data. However, information related to an uncertainty factor in most cases is not numerical. Rather this information is words or sentences in a natural language. These linguistic variables can be provided by a user or the expert system. Fuzzy set theory provides an approximate model for evaluation of a project's risk by linguistic approach.

Risk management involves many different problems ranging from complex process analysis to sophisticated contractual and cost analysis. Most managers rely primarily on their judgments, rules of thumb, and expertise. In spite of the importance of heuristic rules and expert opinions in risk management, this area has remained generally unexplored. This lack of consideration for empirical knowledge has created a large gap between researchers and practitioners. The conventional algorithmic models developed in the past few years for risk analysis are not generally accepted by management for decision-making under uncertainty. A major reason is that these methods are generally based on mathematical models and do not fully include heuristic information, rules of thumb, professional experience, and subjective judgments of an expert. These are extremely important in a practical risk management system. Further, most conventional models are not friendly, help and explanations are not readily available, and the user can not ask for the line of reasoning.

6 Summary

Business failure is an extremely disruptive force in the construction industry. A project encountering a bankrupt contractor will suffer in completion time, quality, and cost. To avoid this possibility an owner must adequately screen possible contractors. Bonding must be used to minimize the possible effects of a bankrupt contractor.

Construction companies themselves must always be aware of the possibility of business failure. Constant monitoring of their financial condition through the use of financial ratios is key. Overall industry indicators must also be monitored and trends analyzed to determine swings in failure probabilities.

The chance of failure for a construction company has increased over the past ten years. A possible factor in the increase is bankruptcy laws have become more easygoing. Consequently the protection afforded debtors by law may be very appealing. A contractor who once may have attempted to cancel debts without the use of bankruptcy is more likely to choose the bankruptcy route now.

The prospect of reorganization through bankruptcy courts certainly has its advantage for companies burdened with large unmanageable debts. Bankruptcy can be a way of shedding the debt while leaving behind the main causes of the debt through reorganization. Alleviation from unwanted union agreements and of poor management are two key areas when the reorganization route is considered.

Although precise causes of construction business failure are hard to define, most are related to financial management problems. Construction's reliance on a cash-flow cycle for each project with negative cash-flows occurring at the start of most projects makes financial management a prime concern. Construction companies capable of properly managing money and keeping close tabs on cost control are at an advantage. Companies must constantly strive to do things quicker and more efficiently since overall labor cost is a prime difference between individual contractors.

From a macro-economic standpoint the rate of failure in construction is related to the amount of construction activity, loan interest rates, and the number of new businesses entering construction. New business activity has been relatively high in the recent past however it is primarily the new businesses which have been failing.

A company desiring to enter the construction field now must be very certain that a market exists for his business. In addition to be technically competent, he must have fair amount of business savvy. Insuring the growth of the company does not exceed the company's capacity is of prime importance. Small business failure models indicate high current liabilities relative to current assets is the one key indicator of failure. A new business must be cautious of its first 3–5 years of operation. Failure rate in that time is by far the greatest.

A company must also be aware that avoiding failure does not ensure success. It is suspected that many more companies exit the construction field due to lack of success than because of failure. To succeed, a company must not only avoid failure by remaining solvent, it must earn enough profit to help the company expand, meet all debts, and exceed the rate of other investment opportunities.

7 Conclusions

The analysis of business failure shows that the number of yearly failures in the construction industry have risen dramatically. The sharp rise in failure rate from 1979–1982 can be attributed to low construction activity and high interest rates. With construction activity increasing and interest rates falling between 1982 and 1986, the construction failure rate has remained high due to new businesses.

In recent years the average age of a construction company at failure has been declining. The higher age at failure is indicative of the effect that overall economy has on all companies even established firms. As a contrast, recently the age at failure has been declining which indicates the companies which are failing are in general small, unexperienced companies who are unable to get a foothold in a tight competitive construction industry. The most difficult time for a new company is the first three years. After that time the probability of failure starts to drop.

Contractors should use financial models developed for failure analysis to predict changes in construction failure rate. These models can assist companies in determining when failure rates will be high, so management decisions can be to lower the chance of business failure. The financial models also demonstrate the impact that new businesses have on failure rate.

8 Acknowledgment

The author would like to acknowledge the contribution of Mr. Eric C.Milner, a graduate student in the Civil Engineering School at Georgia Institute of Technology.

9 References

Abbinante, F.N. (1987) Bankruptcy Prediction in the Construction Industry. Special Research Report, Georgia Institute of Technology, Atlanta, Georgia.

Altman, E.I. (1968) Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. Journal of Finance, American Finance Association, New York, N.Y., September, pp. 589–609.

Altman, E.I. (1971) Corporate Bankruptcy in America. Heath Lexington Books, Lexington, Mass.

Altman, E.I., Haldeman, R.G., and Narayanan, P. (1977) Zeta Analysis: A New Model to Identify Bankruptcy Risk of Corporations. Journal of Banking and Finance, North-Holland, Amsterdam, pp. 109–131.

Argenti, J. (1976) Corporate Collapse: The Causes and Symptoms. John Wiley & Sons, New York, N.Y.

Beaver, W.H. (1966) Financial Ratios as Predictors of Failure. Empirical Research in Accounting: Selected Studies, Supplement of Accounting Research. Institute of Professional Accounting, Chicago, Illinois, pp. 71–111.

Beaver, W.H. (1968) Market Prices, Financial Ratios, and the Prediction of Failure. Journal of Accounting Research, Institute of Professional Accounting, Chicago, Illinois, Autumn pp. 178–192.

Department of the Treasury. (1984) A General Description of the Corporation Source Book. Publication No. 647, U.S. Government Printing Office, Washington D.C.

Department of the Treasury. (1983–88) Source Book Statistics of Income. Publication No. 1053, U.S. Government Printing Office, Washington DC.

Dun & Bradstreet, Inc. (1982–89) Business Failure Record. Dun & Bradastreet, New York, N.Y.

Dun & Bradstreet. (1982–89) Industry Norms and Key Business Ratios. Dun & Bradstreet, New York, N.Y.

Edmister, R.O. (1972) An Empirical Test of Financial Ratio Analysis for Small Business Failure Prediction. Journal of Financial and Quantitative Analysis, University of Washington, Seattle, Washington, March, pp. 1477–1493.
Gupta, L. (1983) Financial Ratios For Monitoring Corporate Sickness. Oxford University Press, Delhi.
Holmen, J.S. (1988) Using Financial Ratios to Predict Bankruptcy: An Evaluation of Classic Models Using Recent Evidence. Akron Business and Economic Review, Bureau of Business and Economic Research, University of Akron, Akron, Ohio, Spring, pp. 52–63.
Robert Morris Associates, Inc. (1985) RMA Annual Statement Studies. Robert Morris Associates, Philadelphia, PA.
Scott, J. (1981) Probability of Bankruptcy. Journal of Banking and Finance, North-Holland Publication Co., Amsterdam.
Standard and Poor. (1989) Corporate Records. Standard and Poor's Corporation, New York, N.Y. June.
Troy, L. (1987) Almanac of Business and Industry Financial Ratios. Prentice-Hall, N.J.
Value Line. (1988) Investment Survey. Weekly Publication by the Value Line, Inc., New York, N.Y., October.

18
Pre-construction management strategies for economical and quality housing production

A.LAWRENCE and N.OFFER

Abstract
The quality and economy of housing production are of universal concern. The ever-increasing number of dissatisfied occupants of recently-construction housing units mandates an exploration of alternative design/build approaches. The focusing of these alternative approaches on the strategic maximum utilization of labor and technological resources is of vital importance. The following conceptual framework may prove applicable to the production of higher-quality housing and the resolution of cost of construction issues. Pre-construction management strategies are emphasized within the interdependent and interconnected phases of the design/build method of housing production.

Keywords: Design/build, economy, quality, strategic construction

Introduction

Consumers have been extremely dissatisfied in recent years with the poor overall quality of housing construction. The importance of this dissatisfaction issue is most apparent during initial occupancy by the consumer of a new housing unit when building systems and components exhibit poor performance. Consumers feel that they are paying increasingly higher prices for poorer and poorer levels of quality. Given that many current approaches to housing production are not satisfying consumer requirements, what strategies at what level can help to solve many of these problems?

In viewing the traditional design approach to housing, one systematic shortcoming appears to be the “arms-length” separation between design and construction. As a consequence of this separation, when quality problems become apparent either during or after completion of construction, no one wants to claim responsibility. The designer blames cost/quality problems on the constructor and the constructor blames cost/quality problems on the designer. Clearly the two warring camps of designer and constructor means no resolution of either cost or quality problems. Instead a team approach to these problems would utilize construction expertise during the design development phase and through the construction documentation phase. By this team approach between designer and constructor, the optimum utilization of building materials, systems, technologies, and labor resources during the construction phase will be enhanced. This will lead to housing production with improved cost and quality characteristics. To be successful an overall strategic approach is necessary. Most participants in the design and construction process tend to take a narrow tunnel-vision view based on a tactical approach alone. This tends to result in day-to-day decision-making where the chances for significant success on quality and economy issues are much less.

Programming And Preliminary Design

At the outset of the design process it is most important that a thorough budget evaluation be performed to compare allocated funds with the housing product goal. Accurate cost estimating here is extremely important and at the start of this process constructor expertise can assist in this area. Constructors are constantly in contact with prices for labor and materials thus being able to better provide realistic information to the designer. This helps to assist the designer in projecting the realistic impact of ambitious design concepts and various levels of amenities. Accurate cost estimating at the front end can mean a savings in design costs since redesign when costs come in over initial project budgets is avoided in numerous cases.

Helpful to this design stage is to detail cost estimates for different budget levels. An example of this might be for the interior finishes on a housing project. Three budget levels of doors and frames could be analyzed as follows:

Doors And Frames

Low	91.44 cm×203.2 cm paint grade solid core wood door with hollow metal frame and standard chrome finish hardware
Target	91.44 cm×203.2 cm plastic laminated solid core wood door with hollow metal frame and standard chrome finish hardware
High	91.44 cm×203.2 cm stain grade solid core wood door with hollow metal frame and satin finish hardware

Similarly various budget levels and concurrent cost estimates can be provided for each major element of the housing project including roof, structural, exterior skin, mechanical, and electrical systems. Jointly with the team approach between designer and constructor an optimum mix can be chosen to produce a housing product with the lowest cost and highest quality.

One ignored-technique in the housing area of achieving both cost and quality goals is through value engineering. Value engineering is not just a standard cost reduction strategy but instead it is an all-encompassing analysis based on a functional approach. Value engineering is a system of thinking that questions the why and not the how of an item. Value engineering looks at all costs including life-cycle costs. An example of this might be where the designer and constructor for budgetary reasons choose an inexpensive window system. But if this window system means that additional tons of air conditioning are required, this is not a sound decision from a value engineering standpoint. Not only will initial mechanical system costs be higher because additional air conditioning is required but energy operation and maintenance costs for the consumer in the housing unit will rise. Another example of sound value engineering was performed on a low-rise condominium housing project. The original condominium project design was to be for cast-in-place concrete floors. Value engineering efforts between the designer and constructor resulted in precast concrete panels for the floors which provided the same value but at a significantly reduced cost. A standard cost reduction strategy would most likely focus solely on how can we form these concrete floors cheaper. Granted that cost savings can come from standard cost reduction strategy but not with the magnitude of value engineering efforts. A sidebar benefit of the precast concrete floors was an overall net reduction in construction time resulting in faster occupancy.

For value engineering to succeed requires a team approach between designer and constructor each pooling their areas of expertise. As part of this team effort, other industry participants such as manufacturers and suppliers should be involved to make the value engineering process a trilateral approach. This is important because often improper cost decisions are made due to the failure to take advantage of changing technology or to understand the impact of new processes, products, or materials. In addition there can be a reluctance to seek advice which often results in project decisions based on wrong beliefs. Besides the team approach to value engineering, formal training in these techniques is important to facilitate the process. One common mistake in value engineering work is the attempt to analyze everything. This is typically not feasible even on the smallest of construction projects. Instead value engineering work should mimic Pareto's Law Of Optimality which means that 80% of the cost of a project is represented by 20% of the project elements and hence 80% of the value engineering effort should focus on this 20%. On one large housing project, a US $1.00/sq. m. savings in entry floor covering material saved US $200,000 while achieving both improved wearing and aesthetic quality. Who then cares about a US $1,000 total cost item? Focus on those high cost areas instead.

Other project areas to focus on concern such cost issues as standardization. Standardized construction details in design plans means the easier achievement of consistent quality by constructor crews in the field. When repetition in design through standardization is emphasized, constructor crews find it practical to utilize jigs and templates. Such items as jigs and templates mean more consistency in the work. Standardization also results in less mistakes as through repetition, constructor crews become more familiar with project requirements. In addition, with much of the same type of work available it now makes sense to divide constructor crew members up and have each one perform a specialized task. This division of labor based on functional specialization was one of the keys of the industrial revolution that brought high quality products at a low cost to the consumer. The industrial revolution unfortunately in many respects has bypassed the construction industry. Indeed, in many countries, government statistics show that manufacturing productivity is increasing at a- rate of approximately two-and-a-half times faster than construction productivity. One reason for this is a lack of standardized designs that inhibit industrialization efforts in construction.

In costing out a project, the input of local and regional governmental entities is extremely important. Initial consultation with these governmental entities during initial design efforts can help to clarify design parameters and procedures that are necessary to meet various regulations. This consultation also assists with the reduction of time required for design review and the securing of required governmental permits. A tremendous amount of time and effort can be saved by this prior consultation. Various local governmental agencies often differ significantly on what they will allow for a project. A team approach is essential here as well to achieve good working relations with the governmental personnel. They may thus even cooperate further on a project by making such allowances as flexible zoning to facilitate a mix of housing types.

Some governmental agencies can provide a wealth of basic design information. As an example, certain governmental agencies in various localities supply, at no charge to the designer or constructor, scaled construction detail drawings of standard foundation designs, retaining wall designs, etc. which are engineered for local terrain conditions with regard to landslides, earthquakes, and floods. Other governmental groups can provide basic weather or climatic data and other geological information that can be useful in project site utilization and solar design considerations.

Design Development

In this stage preliminary design concepts are further refined and more detailed cost and quality issues are addressed with again input from the constructor regarding cost estimates and the feasibility or constructibility of different design approaches.

Recently-developed computer software programs in conjunction with increasingly powerful computer hardware platforms can be extremely successful in improving overall results in this stage. While typical input to various computer programs whether they be design, cost estimating, or scheduling programs may not in some instances save time over a “paper-and-pencil” approach, revisions with computers are made much more quickly. This means that the impact of various alternatives can be evaluated more effectively. As one example, the site earthmoving requirements for one housing project were input into a computerized earthmoving software program. Given original design elevations substantial quantities of fill material would be required at the housing project site. However, since all relevant project site elevation information was already stored in the computer data base, by examining a series of alternatives, cuts and fills on the excavation work were modified resulting in no importation of external fill material. Without the computer power available from both software and hardware, comparison of alternatives has often been ignored because of “not enough time.” Similarly computerized cost estimating programs can help greatly in accurate value engineering decisions. The rapid development of computerized design software is also very useful. Many of these computerized design packages function in a 3-D fashion so that volume is not ignored in a design which better helps to avoid conflicts such as between structural systems and mechanical air conditioning ductwork. Advanced computerized building design packages in use by some firms can actually give a person a “walkthrough” look at the design before it is finalized. What this means is that the “walk-through” program shows a person how the design will look from every angle and every position in the housing unit in real time on the computer monitor. One reason for both developer and consumer dissatisfaction is the failure to comprehend from design drawings how a project will actually look when completed.

Scale and full-size models can obviously help but for reasons of cost and practicality can not be done for every project. In addition, it is almost impossible to adequately show the total impact of various consumer options that may be chosen. But these powerful software programs utilized correctly make this easy.

An important ancillary benefit of these computer programs is that they help to eliminate costly change orders and redesigning. It is often difficult to achieve cost and quality goals when new work has to be ripped out, butchered and modified in order to satisfy a client who didn't understand what the final design would actually resemble.

Many firms are using computers on the surface for areas such as basic design but they are, unfortunately, not taking full advantage of the capabilities available.

Construction Documentation

Construction documents delineate and optimize the strategies for the cost effective utilization of all available resources. Since construction documents are legally binding channels of design communication, they control and ensure compatibility among materials and building systems with instructions as to fabrication and installation procedures. High quality in construction documents is essential to ensure that there are no gaps or overlaps in this area while at the same time avoiding contradictions. Many designers perform a complete and professional job when it comes to the design plans for a housing project. However the actual written specifications are typically done as an afterthought, often as sort of a "cut-and-paste" approach off of construction documents from past projects. This is a serious mistake which leads to serious cost and quality problems in many housing projects.

While design plans show the <u>form</u> of construction, the importance of specifications is that they delineate the <u>quality</u> of construction. Due to the shear volume of technical information required in the housing construction process a systematic process of communicating this information is essential. Some designers still follow the practice of placing part of the specifications information on the design plans and with the remainder of the specifications information in the written documentation for the project. But if a specifications quality change is made during the design phase, will it be picked up everywhere it is listed, whether on the plans or as part of the written documents? The answer, of course, is usually not which means inconsistencies which can lead to confusion and the possibility for error during the construction process. Following a distinct line of demarcation between graphic documents and written documents will avoid many mistakes, change orders and disputes. Thus the graphic documents should only show the size and extent of construction along with the geometric relations between various construction components.

Since the volume of construction specifications is continually growing, an organized system of specifications is extremely important from both a design and construction standpoint. The Construction Specifications Institute has developed a sixteen-division format which readily assists in organizing project information. An example of one division might be electrical. Thus during construction, if a question came up regarding type of lighting fixtures required, consultation with the lighting category in the electrical division would provide the answer. A thorough set of specifications will define requirements to assure use of correct materials, workmanship, methods of procurement and/or methods of assembly. In addition, decisions need to be made with respect to performance or prescriptive specifications for various items. A performance specification allows a constructor to be more creative since as long as the requisite performance standard is met, opportunities for product substitution are wide-ranging. Thus a performance specification may set basic requirements for a roof system. If the constructor can meet the performance requirements they have more flexibility. On the other hand, prescriptive specifications narrowly define what is required and limit any flexibility for change by the constructor. Producing the specifications must answer the question of what method will produce the specification that can best describe the required item or produce the required results for the housing project.

There is a direct correlation between clear and well-organized construction documentation and competitive construction pricing on the part of constructors. Good, well-thoughtout documentation means less uncertainty on the part of those assembling construction bids for a project.

This means that they can assemble those bids with a minimum amount of contingency with the resultant savings passed onto the consumer. On the other hand, inadequate and unclear documentation means that construction bids will carry substantial contingency amounts to protect against the uncertainty involved. At the same time, the unscrupulous contractor will view these uncertainties as a method to unfairly claim change orders and extras if awarded the contract. This means an unfair and unnecessary burden is placed both on the constructors that were high bidders on the project as well as the consumer that ultimately pays for these problems.

Bidding, Pre-Bidding, And Pre-Procurement

There are essentially three ways to obtain meaningful construction project bids. The first is the single pre-bid which then becomes the basis for a negotiated contract price with one sole constructor. The second is the competitive bidding approach wherein the lowest bid among the constructors is awarded the project. Whether the lowest bidder is the most responsible constructor to carry out the project is often open to debate. The third approach is that of design/build in which one firm is contracted with to carry out the entire project. Whether it is one firm to take responsibility for design and construction or not, certainly as pointed out before in this paper, a thorough integration of construction expertise needs to be infused into the design process.

This means that somehow the expertise from these separate areas in order to perform such work as value engineering needs to be integrated into either a formal or informal design/build approach. If the design and construction functions are to be kept separate, one alternative is to bring constructor expertise to bear through the payment of a fixed fee during the design process to compensate for these services. While this may seem like an unnecessary expense to some, properly executed, the integration of construction expertise in such areas as value engineering during design has resulted in paybacks of six-to-one or greater for the fees spent. Obviously six hundred percent savings are significant. It is very important that the value engineering be integrated early in the design phase.

A stop-gap measure is to include value engineering as part of the construction contract. However, these value engineering construction contract provisions often prove unworkable in practice because of the short timeframes involved which means that slow approval of value engineering ideas potentially delays the project so much that it causes other ripple-effect delays for the constructor.

In any one of the above approaches to housing construction it is essential that all bids are obtained from pre-qualified contractors. Bidding in the private sector for housing construction means that it is relatively easy to limit the bidding to a closed list of selected contractors.

Open bidding which is required by governmental regulations when construction may be financed by governmental funds means that particular attention must be paid to pre-qualification standards for constructors. To not do so merely invites future problems. A detailed and thorough investigation of past constructor projects is advised given the importance of this decision. In some cases, in order to ensure quality, the names of the constructor's personnel who will actually be managing construction on the project site are written into the final signed contract documents.

While this may seem an extreme step it does show seriousness of purpose and sets a tone for the entire project. Specific goals can be delineated at pre-construction conferences to ensure that everybody understands what will be required.

Since construction materials may represent fifty percent or more of the total cost of a housing project, opportunities to save costs in this materials area should be aggressively pursued. Often major portions of construction materials and building components can be purchased ahead of engaging a constructor. The result of this is that the constructor has less potential for risk in the bid and thus again lower contingencies result. In addition, the constructor does not have to finance material purchases which means lower overhead charges for the project. If building several projects all involving different constructors, volume buying opportunities result that could never be achieved by any one constructor. Material buyout opportunities in advance of construction may mean significant savings due to elimination of future inflationary price spirals which can be a serious problem in certain countries around the world at times. Various construction materials such as fabricated or custom items may have a long-lead time for delivery hence pre-procurement of these items can reduce delays in the construction process.

Pre-Construction Planning

The activities of the constructor before construction starts have a substantial impact upon the cost and quality of the final housing product. One of the most essential activities for the constructor to undertake is pre-construction planning. Certainly some form of planning always takes place before construction starts. But the kind of planning that is seldom done is a more intensive way of planning of tasks well in advance of doing the tasks. These are detailed written instructions to get the job done the best way possible. With this level of detail it becomes easy to spot shortages and pitfalls in the planning stage rather than in the doing stage so that when work starts everything is there. Thus managers at the construction site become involved in coordinating the work rather than merely "putting out fires." This prevents redoing work which, of course, leads to poor quality. The detailed pre-plan for each component of the work must spell out the work instructions, tools, materials, and a place to perform the work. What these then means is that construction crews can start with a good method and get better. From the detailed pre-plan, the place to perform the work may be changed. As an example, certain activities if pinpointed that they will take place during severe winter weather can be rescheduled to take place in a prefabrication shop rather than out in the field. The prefabrication shop gives the benefits of controlled costs in a controlled environment. In other cases, outside concrete work during winter weather if not critical to the overall project schedule may be halted for better weather.

One constructor found significant cost savings with this since winter concrete work consumed as much as two-and-a-half manhours per cubic meter of concrete for temporary winter protection including concrete heating and protective mats.

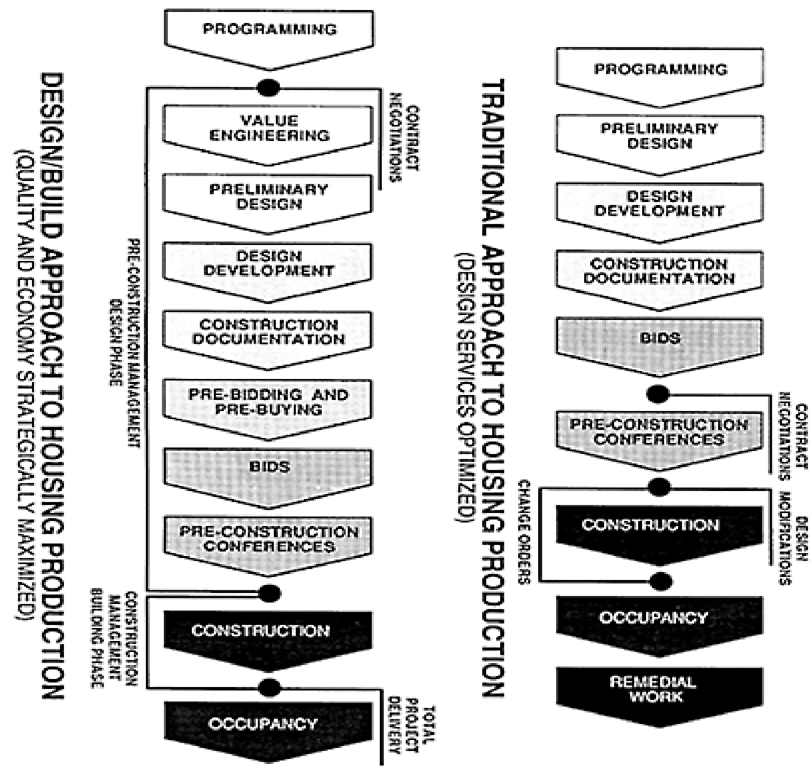
Another element in this strategy is to involve people on the construction job in the making of the construction job. Everybody wants recognition and self-respect. When people feel special they tend to produce better-quality work. Unfortunately, most construction organizations pay their craft personnel from the neck down. That is to say they hire only the unthinking physical ability of these people. Yet by getting these people involved in pre-construction planning, firms can draw on thousands of years of experience for nothing. Similarly at the end of a project, sitting down with craft personnel and writing up a project report on the job can be very valuable towards pre-construction planning in the future. Keeping reports on such items as detailed records of concrete form changes can be very useful. What worked and didn't work on past projects. Unfortunately, often many quality and cost improvement ideas from past projects are lost when these jobs are completed.

Detailed construction production budgets at the crew level that specify on a daily basis quantities of work that must be completed are also important. The production budget lays out in a realistic manner how much work must be completed in order to meet cost, schedule, and quality goals for the project. Often cost and quality targets are not met because no one from the project manager down to the crew-level supervisor is paying attention until that activity budget is exhausted. Then there is a "quick, hurry-up" attitude to get the work item completed. Naturally any quality goals are ignored in this process. Production budgeting can help to eliminate certain of these cost and quality problems. Crew-level supervisors need training in these techniques.

Finally managers need to pay more attention to the work actually going on in the field. Sad to say, some managers feel that they can run a job by remote control. As long as they have their regular computer reports, they tend to sit in the office and ignore the job. In fact it seems as if one way to measure a manager's progress is by how far and how often they can stay away from the project site. As long as the work gets done somehow it is ignored and quality problems get shoved aside. Instead of remote control management, strategic construction management mandates that managers get involved at the inception of a project out in the field where the rubber meets the road.

Conclusion

Achieving the goals of economy and quality in housing construction is not easy. But by taking a strategic approach toward these goals and focusing on both design and build aspects of the total picture, significant improvements can be made. A strategic total approach must be emphasized however. Problems with achieving economy and quality goals result because often concern is with only one phase of the endeavor failing to take a strategic approach to the overall process. By focusing on only one aspect, failure to satisfy consumer demands from a quality and economy standpoint is almost assured. This often means costly remedial work is necessary. As can be seen from the diagram, the traditional approach to housing production can lead to these problems. Instead the design/build approach in one of its various forms by helping to assure a closer fit between both design goals and construction realities will provide for less consumer dissatisfaction upon occupancy. Instead of warring camps between designer and constructor, a cooperative approach results.



19
Proposal for training in management and in safety and health as an integral part of management of construction work

P.LORENT and P.PAOLI

Abstract
This training is designed to enable those involved in construction to improve at one and the same time economic performance, product quality and safety in the construction industry in the face of the radical changes going on in the sector.

The prospect of the completion of the Single European Market in 1993 means that the demands of competition, already highlighted by the stepping up of internal competition as a result of the opening of borders, and the effects on working conditions are vital considerations.

This is the basic principle behind the computer-assisted training course.

1 The organization of construction work and the social cost of the sector

1.1 Radical changes in conventional project management

The clients were the first to develop the idea of a link between the programming phase and the initial plans for a buildings—between the launching of the project, and the design and realization of the product.

Designers are required to take an increasing number of parameters into account to ensure that operations are both technically and economically realizable. Consideration of construction conditions plays an important part in assessment of the cost of the project and a better guarantee of conformity between the design and the finished product.

At the same time many contractors are taking a more direct interest in the phases prior the construction (design of building, detailed drawings, assessment of the cost of all trades and preparation of the site) and increasing their supervision at the downstream stage. Their involvment in the early stages is of strategic importance—it gives them some control over the design and the completion cost which are committed largely at the planning stage.

1.2 A marked increase in 'upstream' management

The way in which construction work is organized varies considerably from one country to another but, whatever the situation, there are certain common trends, e.g.:

> It is found necessary nowadays to provide more overall management of the process, on the basis of the integrated system, to control the economics of increasingly diverse and complex projects.
>
> The control of quality, cost and completion time depends more on the management of the interfaces between the various stages in the process from desing to completion than on the local productivity at each stage.
>
> The most important interfaces for the efficiency of the system as a whole comes between design and realization. Controlling the economics of a project means being familiar with the constraints of execution so that these can be taken into consideration at the earliest possible stage.

1.3 The social costs resulting from failure to consider, or bad management of, health and safety

Another good reason for the construction industry to invest in project management is the economic and social cost associated with poor and unsafe working conditions on site and the effects of this on the environment. Most of these costs can be avoided if these constraints are taken into consideration before work starts.

> The costs associated with failure to attend to health and safety are particularly high in the construction industry. This is all the more serious because human life is at risk. Although there has been some improvement, the construction industry still has a sad record. Being very labour intensive, it employs 10% of EEC employees and is responsible for 15% of all occupational accidents and 30% of fatal accidents in all industries. An analysis of fatal accidents on site shows that 2/3 of these can be attributed to design faults (architectural features, choice of materials or equipment) and organizational problems (such as the presence of several trades on site at the same time). Many of these accidents could be avoided if the risks were better understood at the pre-site stage. Although the main factor is the heavy human loss, the financial cost is also high. It is estimated that the total cost (direct and indirect of accidents is 3% of the turnover of the construction industry and about 10% of the total wage bill. The cost of preventing occupational accidents, on the other hand, would amount to only 1.5% of the turnover of the sector.
>
> High costs are associated with poor working conditions. Conditions are still particularly tough in the construction industry. This accounts, to some extent, for the rapid turnover and absenteeism. Surveys of construction firms show that: absenteeism represents 22% of the total wage bill; turnover on site affects 30% of the personnel. Working conditions depend in part on standards of management. Underqualified staff, unsuitable

equipment, bad workplace layout can mean both poor working conditions and high costs: deadlines not met, lost production, repairs etc.

The cost associated with poor qualify affects the economics of the whole project and the time spent correcting defects may, in its turn, may have an effect on working conditions. These cost may represent as much as 10–18% of turnover and 20–45% of the total wage bill. Furthermore, surveys have shown that 80% of bad work on the site is attributable to errors upstream (design-management). Only 20% is the result of errors in execution.

2. Training in project management

The purpose of this training is to improve both working conditions and product quality, cost and use. To achieve this objective the cooperation of all parties involved is required. This presupposes establishing a link between all stages in the process and means asking the right question at the right time, i.e. before it has become clouded by other issues at a later stage in the construction process.

2.1 Project 'enhancement': gearing the approach to today's markets

The 'project conduct' guide proposes two 'enhancement axes'—'products' and 'processes'.

There are two ways of enhancing the horizontal or 'products' axis—by looking at the products being produced (quality, durability, ergonomics, safety, health) and by looking at whether they fulfil the needs of the future users (ergonomics, maintenance, etc.).

The vertical or 'process' axis can be enhanced by looking at cost (deadlines, budget) and working conditions (safety, health, ergonomics, productivity). The procedure consists of widening the scope of the project by asking the parties concerned a series of questions.

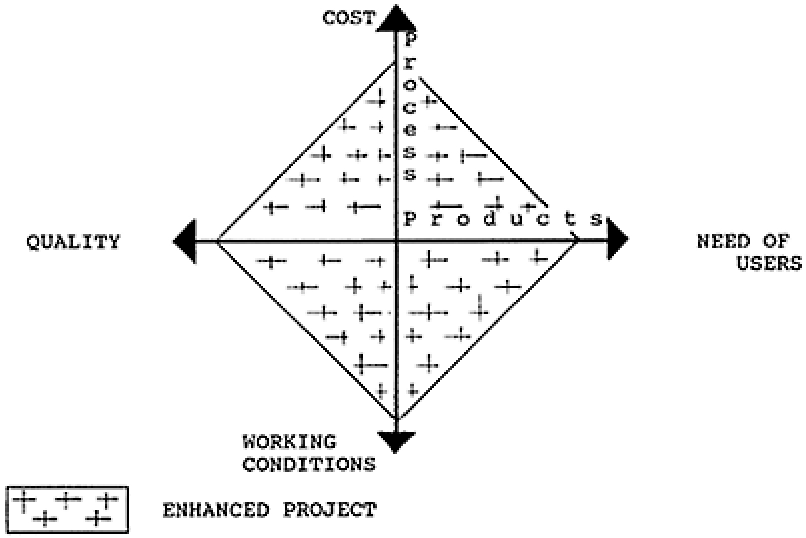


Fig. 1. 'Enhancement' axes for various functions.

2.2 Mobilisation at all levels: the functions are of necessity interrelated

The second part of the new approach is to consider the many ways in which the functions (product management, design, site management, execution) are interrelated, with specific reference to the 'project enhancement axes'.

2.3 An 'anticipatory' approach

Managing a project means determining, at a very early stage, the deadlines 'critical paths' in design and realisation and key moments.

The software used for training is such that the problems can be determined in advance so that any possible sources of malfunction and the moment when these are likely to occur can be pinpointed in order to avoid "hidden costs"—the cost of forgetting or making a mistake.

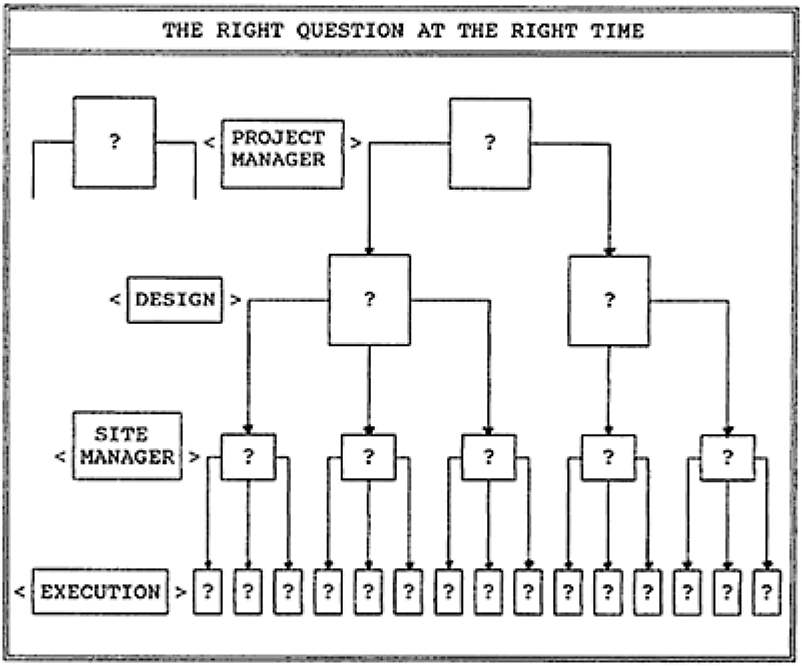


Fig. 2. Relationship between the four procedures: project management, design, site management, realisation.

2.4 An approach which is compatible with various types of organization

One of the advantages of the proposed approach is that it can be applied to the wide variety of types of organization encountered in:

Programming (project management).
Design.
Organization, planning and supervision (site management).
Execution.

All these procedures overlap at certain points and at these points the interaction is particularly important.

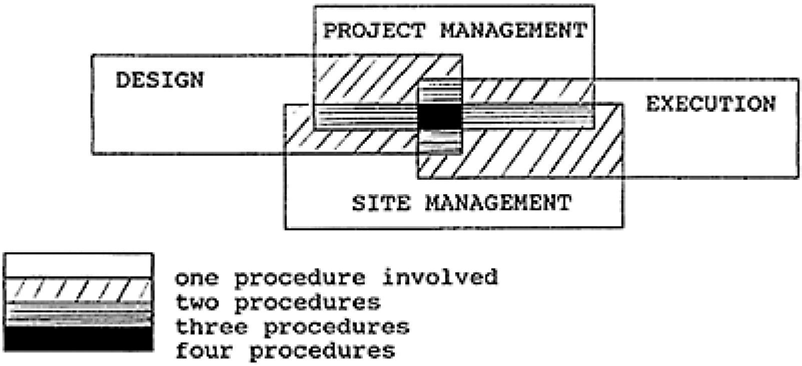


Fig. 3. Concept of constructibility and interactive relationships—scope for negotiation.

3 Methods and use of project conduct software

3.1 Methods and presentation

Clear instructions, based on principles applicable to all procedures: the project conduct software must be suitable for a variety of types of organization and must therefore remain flexible.

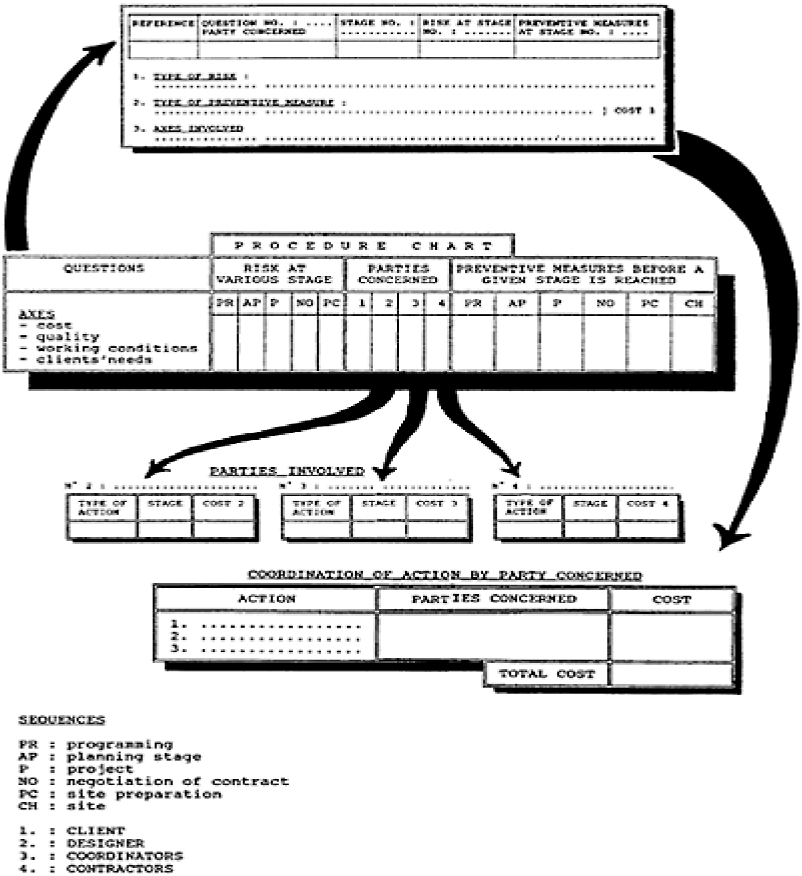
It is therefore presented in the form of procedure charts for:

Clients (project management).
Designers.
Persons responsible for planning and methods (site management).
Contractors executing the work, safety experts, inspection bodies and workers.

Each chart will present, alongside the enhancement axes, a series of key questions enabling the parties concerned to pinpoint the critical points in the project so as to judge the best moment to plan, negotiate or propose solutions, and the best way of achieving this.

These questions affect all parties involved: they are the questions which they may ask either themselves or others in a wide variety of situations. The main purpose is to ensure that the various stages and the relationship between functions is anticipated as this will have a decisive effect on improved performance.

The diagram below shows the possible relationships; between the preventive measures taken by parties involved and between the channels of communication enabling the parties responsible for each procedure and the party in receipt of the question to transmit the necessary information and thus facilitate multidisciplinary coordination.



3.2 Use of software

Because of its flexibility the are can be used:

For project management training courses (3 to 4 days according to the project).

The training course is based on a construction project and the participants work in four separate groups, each responsible for one of the following tasks: project management, design, site management and execution.

The enhancement problems raised by the groups are then submitted to the parties concerned at plenary, tripartite or bilateral meetings, according to need. Preventive measures are negotiated at these joint sessions and the solutions found are noted by the course leaders.

The groups may also include—in the case of project management for example—representatives of the client, health and safety and inspection organizations and experts representing the workers who would be involved on site during construction and operation.

For the design and realization of construction projects.

The ‘project conduct’ guides are designed to enable the users to have an investigation carried out at any stage in design or site work so that they can look at and control working conditions, costs, quality and final use.

By inspection bodies, employers and workers and health and safety organizations.

The project conduct software thus offers two project enhancement axes: the “products” axis and the “process” axis. The process axis is concerned with enhancing working conditions on site at all stages in the project through the project manager, designers, site manager and contractor. It will clearly be of great value to the bodies responsible for monitoring the application of health and safety measures on site. The questions the parties concerned are asked about working conditions on site enable them to improve standards of safety and working conditions by intervening at the right point in the progress of the project. Furthermore, through the software files risks can be pinpointed and the persons responsible for preventing them established; a chart can then be drawn up showing the stage in the project at which the preventive measures associated with the risk would be most appropriate. These files also provide a means of checking wether the anticipatory measures selected have been applied.

4 Conclusions

The need for social/technical training at all levels.

The construction industry, in which 90% of undertakings employ under 10 workers, can be regarded as an industry which produces prototypes by techniques and management and construction methods which may vary—sometimes considerable—from one site to another.

Too often errors and delays created upstream have to be corrected on site.

An investigation of human input on site reveals the causes of the mistakes which very often occur long before the project reaches the site—at the design, organization or planning stage.

The real problem lies in the ranks of the designers, clients or contractors who are not sufficiently concerned about what is going on either at the end of the production line (working conditions, poor quality, accidents, etc.) or in areas with which they are not directly concerned (the use to which the structure is to be put). Involving firms and their workers, whether they are builders or users, in the initial stages of the project should make designers more aware of the problems downstream so that they can respond more appropriately to the health and safety requirements of the clients while at the same time ensuring that safe products are used on safe sites.

5 References

Du Roy, O. et al. (1980) Réussir l’investissement productif. **Edition d’organisation,** Paris, France

Lorent, P. and Paoli, P.Du projet au chantier. Conditions de travail, qualité, performances économiques. **Fondation européenne pour l’amélioration des conditions de vie et de travail. Edition P.Mardaga,** Liège, Belgique.

20
Risk behaviour/risk allocation and contract strategy

R.A.McKIM

Abstract
The choice of action selected by construction organizations under risk conditions often do not comply with what the laws of probability suggest as optimal. Many North American construction organizations (primarily contractors) tend to gamble on events that have a negative expected value which probability theory suggests will result in a constant financial loss over a series of gambles.

A construction owner, aware of this irrational behaviour, can use the principles of risk allocation and economic theory to select a contract strategy that will allow the contract to perform at or near the Parieto optimal.

Keywords: Risk, Risk Behaviour, Risk Allocation, Contract Strategy, Claims, Bidding, Tendering

1 Introduction

The nature of the construction industry in North America dictates an adversarial relationship between the owner and the contractor as well as between individual contractors.

This adversarial relationship has its basis in the competitive bidding process commonly used by North American construction owners. In this process competitive bids are publicly requested from contractors with the construction contract awarded to the lowest qualified bidder. This type of competitive bidding process tends to move the bidding results away from the Parieto optimal by turning the process into a negative or zero sum game in which the contractor can only improve his position at the expense of the owner or other bidders.

The negative sum game created by this process dictates that each contractor maintain a competitive advantage over the construction owner and other contractors through:

1- advances in construction methods that reduce construction costs and thereby the bid price and/or

2- the ability to consistently increase the amount of money given to the contractor by the owner above that of the bid price. In North America this is generally achieved through the use of the claims process.

The former approach tends to make the bidding process a positive sum game and move toward a Parieto optimal whereas the latter tends to advance the adversarial process and moves the results of the construction process away from the Parieto optimal.

The end result of this adversarial system for the purchase of construction is that the industry tends to perform at a lower level of productivity than is possible.

2 Organization Risk Behaviour

2.1 Contractor Risk Behaviour in the Bidding Process

A recent study of a small sector of the North American construction industry, McKim (1989), has suggested that the contractor displays a risk seeking behaviour during the bidding process in which the contractor values risk elements in his bid below the expected value.

This research indicates that a typical North American contractor will assess his risk cost, $(r), less than the expected value of the risks, EV(r), thereby making his construction costs, $(cc) less than the sum of his firm costs $(fc) and his expected value of risks.

$$\$(cc)<\$(fc)+EV(r) \qquad [1]$$

The total bid price, $(b), from a typical contractor will consist of his construction costs $(cc) plus his profit (P) as:

$$\$(b)=\$(cc)+P \qquad [2]$$

The bid price of the contractor can have a net negative expected value.

Probability theory, Degarmo, Sullivan and Bontadelli (1989), suggests that if, over a series of gambles (bids), the contractor constantly values his risk costs, $(r), less than the expected value, EV(r), of the risks the contractor will incur risk costs in excess of his construction costs (Cc).

This type of behaviour is often referred to as risk seeking behaviour, Willenbrock (1973), due to the fact that the organization is willing to gamble on an event with a negative expected value. See Figure 1.

An organization displaying risk seeking behaviour by constantly bidding in the negative expected value range must, over a series of bids, lose money. The question then arises as to how a contractor can maintain economic viability over an extended period. One answer to this question can be found by looking at the risk behaviour of the contractor during the negotiation of construction claims.

2.2 Contractor Risk Behaviour in the Claims Process

The contractor displays a conspicuously different risk behaviour after the awarding of the contract. Following the award of a stipulated price construction contract the contractor shifts his risk behaviour so that it is very unlikely the he will accept any risks unless the price for accepting that risk is well in excess of the expected value of the risk.

If, during construction, an unexpected condition arises that changes the requirements of the contract (such as changed soil conditions), Canadian construction contracts allow for a negotiation or rebidding of the price of the changed condition. The contractor will value the cost of the changed condition in excess of the expected value of the cost of completing the work. See Figure 2.

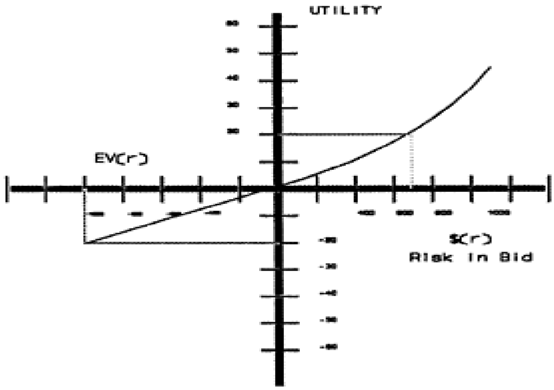


Fig. 1. Contractor Risk Behaviour (bidding)

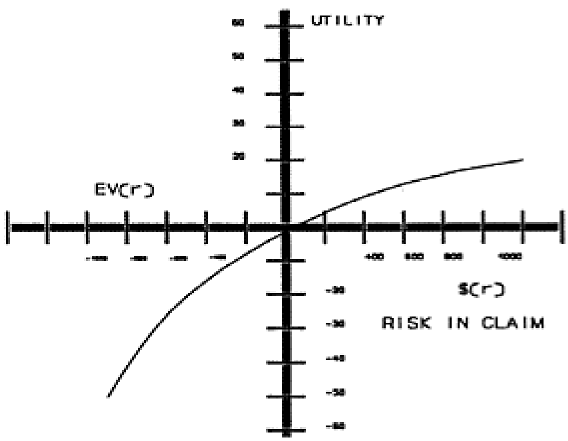


Fig. Contractor Risk Behaviour (claims)

Canadian construction standards allow for the negotiation or retendering of the part of the contract that is materially different. A North American contractor will typically require an amount in excess of the expected value before he will accept the risk of the changed condition.

When the contractor is asked to bid or negotiate the cost of a changed condition he will require an expected value that is positive thereby displaying risk averse behaviour.

The multiple risk behaviour shown by the contractor as the construction project moves from the bidding to the construction phase can partly explain how the contractor can maintain economic viability even though his bids are often economically unsound.

2.3 Construction Owner Risk Behaviour

The North American construction owner tends to display a constant risk averse behaviour throughout the construction process. The owner is generally willing to allow the contractor to assume the risks associated with construction and accept a monetary penalty for this risk allocation. The risk behaviour of the owner is shown in Figure 3.

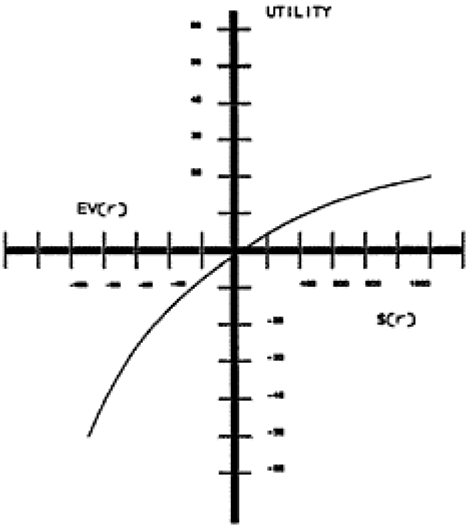


Fig. 3. Owner Risk Behaviour (bidding and claims)

3 Risk Allocation

3.1 The Risk Allocation Model

The multiple risk behaviours demonstrated by the construction contractor and the single risk behaviour displayed by the construction owner make the development of an overall risk allocation model somewhat challenging. The approach taken by this investigator was to create a model that could be applied at the bidding process and again at the claims process. By using the utility functions of each organization the model will determine the efficient risk allocation at each position in the project life cycle. A description of the resulting model follows:

Economic Basis of the Model: A risk allocation model that considers the risk behaviour of the two parties to the construction contract has been developed that uses the basic principles of Input Factor Economics. This allocation model uses the concept of the Isocost and Isoquant to locate economically efficient risk allocations between the two parties at any phase of construction.

The economic principle of Input Factor Economics looks at techniques that will efficiently allocate the proportions of two or more resources (inputs) to produce a single output (product), Fisher (1932). This model utilizes the fact that most construction organizations display either risk seeking or risk averse behaviour at a given phase of the project, McKim (1990), causing the Isoquant of the risk (in this model called the Isorisk) to be concave or convex with respect to the origin. The curved shape of the Isorisk (concave or convex) allows the solution for the most efficient proportions of inputs (in this case the utility value of the risk) to be calculated. The economically efficient location on the Isoquant/Isorisk occurs when the inverse marginal productivity for substituting risk 1 for risk 2 are equal. See Figure 4.

The shapes of the Isocosts and the solutions for efficient risk allocations are shown in Figure 4: "Isorisk Solutions for Risk Allocation". In those phases of the project, where the two contracting organizations have similar risk behaviours (claims), the Isorisk will be convex representing decreasing marginal productivity of risk allocation from party 1 to party 2 (Figure 4A) with the efficient solution between the two endpoints. For the phase of the project, where the organizations display dissimilar risk behaviours

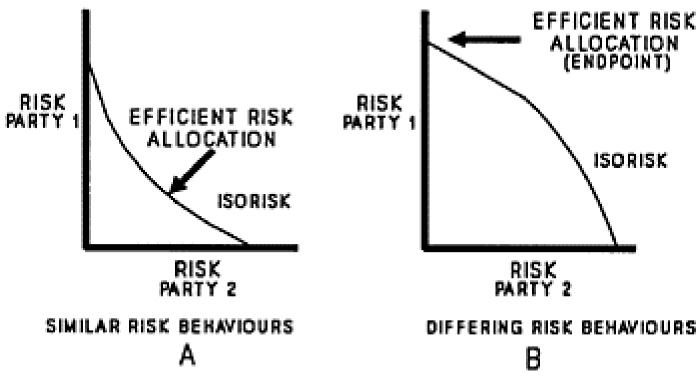


Fig. 4. Isorisk Solutions for Risk Allocations

(bidding), the Isorisk will be concave due to the increasing marginal productivity of the function (Figure 4B) with the efficient solution at one of the endpoints.

Once the risk behaviour of both contracting parties has been empirically derived, the model can determine the most efficient split of the assumed risk such that the risk costs are minimized for the phase of the project under consideration. The model will allow the owner to select the most efficient contract strategy as well as fine tune the contract terms by determining where the optimum risk allocation lies. This is demonstrated in Figure 5 where the total project risk cost is plotted against the risk allocated to the owner. In this example the owner and the contractor each display risk averse behaviours with the efficient risk allocation located between the endpoints.

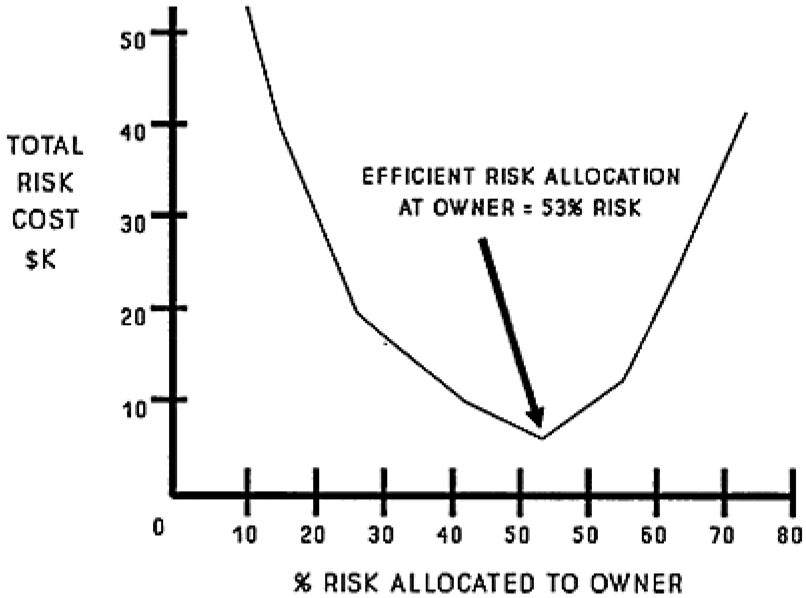


Fig. 5. Risk Allocation and Risk Costs

4 Contract Strategy

4.1 Efficient Risk Allocation using Contract Strategy

The construction contract is the primary instrument for allocating risk in a construction project, Atyiah (1978). The contract should define common construction risks and firmly establish which party is responsible for which risk. A properly defined and executed contract will leave little room for frivolous claims with each party well aware of the risks they must shoulder. When a construction project is plagued with an unreasonable number of claims (in either direction) the contract can be assumed to be inadequate.

The basic elements, Goldsmith and Heintzman (1989), of a North American contract are:

1- An offer, an acceptance of the offer and some form of consideration

2- A firm (unambiguous) assignment of the responsibilities and risks anticipated for the construction

3- An adequately defined mechanism for allocating unanticipated risks.

There exist three basic contract strategies in the North American industry. These being; (1) the stipulated price contract, (2) the unit price contract and (3) the reimbursable cost contract. The basic elements of each of these contracts are listed in Table 1.

Roughly speaking the risk allocation between the owner and the contractor can be determined by the contract strategy selected. A stipulated price contract allocates a large amount of the risk to the contractor; a unit price contract splits the risk between the owner and the contractor; a cost reimbursable contract allocates most of the risk to the owner.

Table 1. Risk Elements of Contract Strategy

Contract Strategy	Stipulated Price	Unit Price	Reimbursable Cost
Risk to Owner	Low	Medium	High
Risk To Contractor	High	Medium	Low
Level of Detail Prior to contracting	High	Low	Low
Owner Risk Behaviour	RA	RA/RN/RS	RS
Contractor Risk Behaviour	RS	RA/RN/RS	RA

RA—Risk Averse
RS—Risk Seeking
Rn—Risk Neutral

The risk allocation model can be used to identify the basic contract strategy used. Without fine tuning the risk allocation model the following general rules can be followed:

1- A risk averse owner and a risk seeking contractor should utilize a stipulate price contract

2- A risk averse owner and a risk averse contractor should utilize a unit price contract

3- A risk seeking owner and a risk averse contractor should employ a cost reimbursable contract.

4.2 General Contract Rules

The fact that the contractor is likely to change his risk behaviour to risk averse during any claims process can best be addressed by the owner by one of two methods.

1- Ensure the contract documentation allows for the retendering of for any significant part of the contract that may be subject to changes beyond the control of the owner

2- The effective use of a contingency clause in the contract to cover risk costs.

The reasoning behind these methods follows:

Retendering Changes: If the owner is contractually permitted to retender portions of the original contract scope due to unforseen changes then he can take advantage of the risk seeking behaviour of contractors while bidding and minimise the impact of the risk averse behaviour experienced during the claims process. It should be noted that the advantages the owner may realize from retendering could be offset by the extra costs associated with mobilizing a new contractor's work force.

Use of a Contingency Clause: Most North American construction contracts have a (mostly ignored) contingency clause that allows the contractor to draw on a specified allocation of money to cover unforseen costs (risks). If this clause is used properly the risks, when they occur, will not cause the contractor to lose money; if the risks do not occur the owner will not have to pay for them. This clause reduces the need for the contractor to include the expected value of risks in his bid and thereby permit the contractor to prepare a bid with a net positive expected value. This author has never seen the contingency clause used and it is his contention that the proper use of this contractual element could greatly increase the efficiency of the construction contract.

5 Conclusion

The understanding of the risk behaviour of the parties to the construction contract is as important as the understanding of the risks. The reaction of organizations to risk is not always rational and contracting strategies and documents that do not consider this aspect of construction and can fail to perform even nominally. Contracts selected and worded with risk behaviour considerations can reduce project risk costs and increase construction productivity.

6 References

Atyiah, P.S., "Contracts, Promises and the Law of Obligations", 94, **Law Quarterly Reports,** 1978, pp. 193–223

Degarmo, E.P., Sullivan, W. and Bontadelli, J.A., Engineering Economy, eight ed., MacMillan Publishing Co., New York, 1989

Fisher, I., Methods of Measuring Utility, first ed., reprinted 1978 by Porcupine Press, Inc., Philadelphia, Pa.

Goldsmith, I. and Heintzman, T.G., Goldsmith on Canadian Contract Law, Carswell, Toronto, 1989

McKim, R.A., "The Measurement of Risk Behaviour of Construction Organizations", Proceedings of the INTERNET International Expert Seminar in the State of the Art in Project Management, In conjunction with **PMI/INTERNET Joint Symposium,** Atlanta, Georgia, 1989

McKim, R.A., **Risk Management for the Construction Owner,** A thesis presented to the Department of Civil Engineering, University of Waterloo, Waterloo, Ontario, Canada, in partial fulfilment of the degree of Doctor of Philosophy

Willenbrock, J.H., "Utility Function Determination for Bidding Models", **Journal of the Construction Division,** Proceedings of the ASC E, Vol. 99, No. C01, July, 1972

21
The use of MRPII-concept in housing

B.MELLES and J.W.F.WAMELINK

Abstract
In this paper the use of MRPII in housing will be discussed. The principles of manufacturing resources planning are presented and translated to the building industry. The first results of pilot projects are given.

Keywords: MRPII, Production Control, Planning

1. Introduction

During recent years research projects on project management and control in the construction industry have become very popular. As a result of the growth of computer facilities a number of software packages have been released. However, in certain parts of the building industry, the developed theories for production control are not able to address all problems in controling projects.

For this reason the Delft University of Technology started a research program to investigate the backgrounds of these problems. If possible new control concepts could be developed. Special attention should be paid to the introduction of control concepts from other industries.

The objective of this paper is to discuss the introduction of one of these industrial concepts (MRPII) in housing.

2. Types of control concepts

The literature (Bertrand and Wortmann (1981), Orlicky (1975), Fox (1983)) presents a large number of different control concepts. Mostly these concepts are developed for one special branch of industry.

The designers of these concepts are often focused on their own branch. The solutions are related to the specific problems of production control in that branch.

In general three types of control concepts can be distinguished:

1. Activity oriented planning concepts

The planning and control processes are considered as being related to activities involved in carrying out orders (projects). Optimising takes place by minimising the project duration. All other planning charts are related to the activity chart. The delivery moment of materials and capacities (labour and equipment) is considered to be variable. This control concept is most common in the building indus try.

2. Material flow oriented planning concepts

The planning and control concepts are considered in relation to the stocks of materials. Optimising takes place by minimising stocks in relation to the expectations concerning orders (projects). The scheduling of production orders does not necessarily give a minimum production duration for one single order. The delivery moment of capacities is considered to be variable.

3. Capacity oriented planning concepts

Here planning and control concepts are related to the capabilities of capacities. In this sense a person (labour capacity) is similar to equipment (equipment capacity). Optimising takes place by seeking the highest return as a result of using a capacity. The time of delivery of materials is considered to be variable. The scheduling of production orders (projects) does not necessarily give a minimum production duration for one single order.

We distinguish two types of capacity oriented planning concepts:

a. the multi-order (multi-project) capacity planning concept

The main issue in this kind of planning problem is to allocate a great number of activities to a small number of capacities.

b. the single order (single project) capacity planning concepts

The main issue here is to optimise the available capacities for one order (project).

As said before in this paper we will discuss a material flow oriented planning concept: MRPII.

3. The theory of MRPII

Manufacturing Resources Planning (MRPII) is a system of decision rules belonging to the MRPI-algorithm (Material Requirements Planning).

The MRPII-concept has been developed for the serial production industry. This means that you produce standard products to stock. The sales organisation sells from this stock to the clients.

The standard products have a steady material structure which can be represented by a Bill of Materials. The production process can be laid down in a Routing file. The MRPII-concept has been used in e.g. the automobile industry.

The working of the MRPII-concept is (according to Bertrand et al.) shown in figure 1.

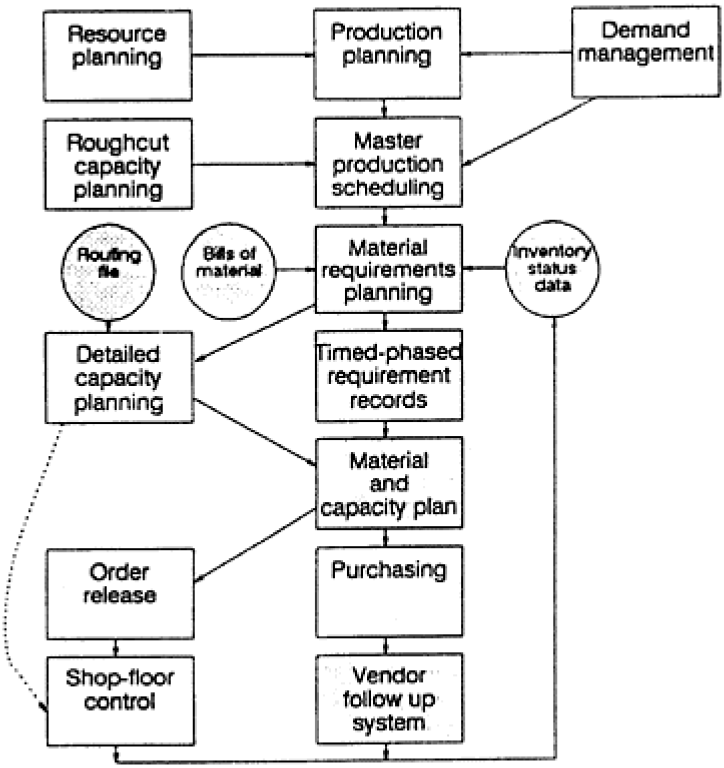


Fig. 1. MRPII (according to Bertrand et al.)

The approach starts with an estimation of the aggregate production planning. This gives a long term (tactical) agreement between production and sales organisation.

On the operational level the start is the production of the Master Production Schedule (MPS). The MPS gives the need of final products during the next months. The possibility of realisation of the MPS is checked by a Rough Cut Capacity Planning.

Based upon the Master Production Schedule, the Bill of Materials and the actual production, stock, purchasing and sales information the MRPI algorithm plans production in discrete time intervals optimising the stock of materials by an explosion of the net materials requirements.

After using the MRPI algorithm detailed capacity planning can be produced using the GANTT chart method and information from the routing file. Specific listings can be made to manage the production, purchasing and vendor administration.

Special attention must be given to the administration systems for production, purchasing and stock control.

Within the production system orders can be released. After that the MRPI algorithm can not change the production scheduling for this order without the permission of the production-site. Similar things happen with regard to inventory control.

Before orders are released the scheduling can be changed after each MRPI run. The results of the MRPI run are nothing more than advice. The production planner still has to decide himself when to release an order.

4. The use of MRPII in housing

Until now we discussed MRPII in general. The concept has been succesful in serial production industries. The biggest advantage of the concept is a better control of the materials flow.

The most important conditions to make MRPII succesful are:

1. Standard Bill of Materials and standard Routing File

You must use standard materials and standard activities with well known specifications which can be filed in bills of material and routing files.

2. Produce and sell standard products to and from stock

Your vendor information system has only to register the sold products from stock.

3. You must have equivalent alternative production orders

The duration time for turning an order into a product is rather short. There is very little relation between different orders for end products.

You do not need overall project planning schemes. Mate-rial and capacity plans are sufficient. You also do not need progress reports about your orders; inventory status data is sufficient.

In the Dutch building industry none of these requirements are fulfilled. The first and second condition are not common in the building industry in our country. The third condition can be fulfilled in theory. In practice the overall planning (which represents the main agreements between building firm, client, government, etc.) is unchangable.

Using MRPII in a similar way as in the automobile industry seems to be impossible.

Nevertheless there are some projects with typical material oriented control problems. For example the housing industry in the Netherlands.

In a special sector of the housing industry the building firms use standard production techniques for the foundation and structural works. The finishing works are standard in a generic way (all houses have a kitchen of the same size) but different in a specific way (all houses have a kitchen of a different color).

This means the finishing works are similar to a typical material oriented control problem. Nevertheless the specific problems of a building project remain. We can not use a standard Bill of Materials, we can not use a standard routing file and we can not produce to stock but we can make a generic Bill of Materials and a generic Routing File for a project. The generic Routing File and the generic Bill of Materials are influenced by technical and non-technical (sometimes political) decisions.

This is why we must extend the MRPII concept if we are to use it in the building industry. An additional procedure is to make a generic Bill of Materials and Routing File specially for the project. The Routing File is based upon an overall planning in which technical and non-technical problems can be solved. The input to the MRPI algorithm is not the MPS but a list of specific orders for specific (different) houses.

This means that the vendor information system must influence the MRPI algorithm on a higher level. It controls the production of the specific Bill of Material to each house. Another reason for replacing the vendor information system to a higher level is that we do not sell houses from stock.

The possible working of the housing MRPII concept is shown in figure 2.

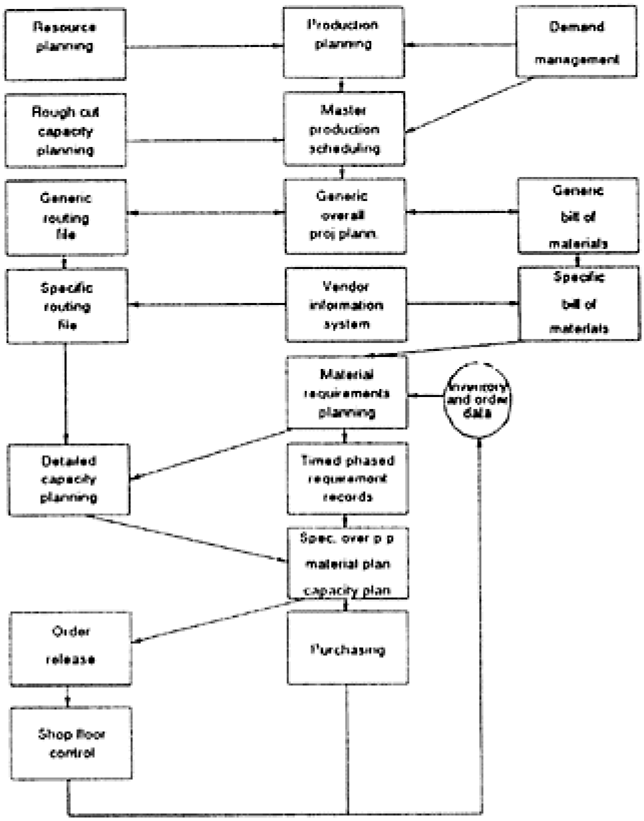


Fig. 2. MRPII in housing

5. The differences between classical project management and MRPII

In the classical way of thinking the finishing works start with the first house and end with the last house. Every disturbance (which mostly depends on delivery problems) increases the project duration time.

In the MRPII way of thinking you split up the project in a great number of independent subprojects. If you have problems at house 1 then you start at house 10 for instance. The total project duration time remains in principle unchanged.

5.1 Some remarks

Until now we expected the delivery problems of materials to be the most important source of disturbance. These problems can be addressed by MRPII.

Another important issue is the availability of capacities (labour and equipment) on site, which is not stringently controlled by MRPII.

In our view it is easier to address the capacity problems because we always use the same capacities (compared to the materials, which are more specific). The capacity problems can be completely eliminated by using general equipment and labour resources. In this case capacity problems are considered to be of less importance to the delivery problems of materials.

5.2 Additional advantages of using MRPII in housing

If we use MRPII we must change our way of thinking regarding logistics. According to this approach we distinguish each house as a separate product within one project. We can not see the materials flow as one flow to the whole project anymore; we must distinguish different materials flows for each house.

Following that idea we must organize the materials flow in another way. Traditionally the same type of materials were transported to the site in one operation. At the site these materials were stocked and divided over the different houses.

When we divide the materials flow into different flows we can use a central stock location (for a few different housing projects) for all types of materials. From this central stock location we can put the materials from one house together and transport them to the specific house on site. This has a lot of advantages:

1. The materials can not be stolen
2. We do not miss materials
3. We do not have to organise the material flow on site
4. We do not have to stock materials on site

6. Using MRPII in practice

The use of MRPII in practice has been evaluated in cooperation with a construction company. In this particular case <u>we did not</u> use general equipment and labour resources.

The first results of the investigations:

1. It is not possible to use MRPII directly in housing. Nevertheless the basic principles are useable. This corresponds with the preceding sections.

2. It is not easy to formulate a Bill of materials.

3. Because of the fact that we did not use general equipment and labour the planning caused major problems.

4. In this experimental project it was not possible to quantify advantages and disadvantages of MRPII.

In autumn 1991 a new research project will start. The results of the first investigations will be taken into account.

7. Acknowledgements

The research described in this paper has been executed within a co-operative project from Delft University of Technology, a Dutch software development company and the Dutch building industry. The research project is being supervised by prof.dr.ir. J. Blaauwendraad, prof.ir. Ch.J.Vos, ir. J.C.B.Robers (Delft University of Technology, Department of Civil Engineering), prof.dr.ir. J.C.Wortmann (Eindhoven University of Technology, Department of Industrial Engineering and Management Science), dr.ir. R.Kwikkers (TNO Institute of Information Technology for Production Automation and Logistics, Eindhoven)

8. References

Bertrand J.W.M., Wortmann J.C. and Wijngaard, J (1990), **Production Control, a structural and design oriented approach,** Elsevier, Amsterdam

Fox R. (1982), OPT—An Answer for America, Part I—Part IV, **Inventories & Production Magazine,** July-August & Nov. Dec. 1982, Jan.-Febr. & March-April, 1983

Melles B. and Wamelink J.W.F. (1990), **Process control in the building industry** (in Dutch), Technische Universiteit Delft

O'Brien J. (1989), Review of Management Information Systems in Construction, **IABSE journal j-38/89,** 1989, pp12–17

Orlicky J. (1975)**, Material Requirements Planning: the new way of life in production and inventory management,** McGraw-Hill, New York

22
Integrated construction management and accounting system—SIGOC

M.E.TELLES de MENEZES and A.A.BEZELGA

Abstract
This paper introduces an integrated construction management and analytical accounting system—SIGOC.

SIGOC integrates the production aspects of construction with those of finance, manpower and supply. It was developed taking into consideration the Official Portuguese Accounting Plan published in 1990.

SIGOC uses as logical support a relational database, known as INFORMIX, and its conversion to PRO-IV is currently taking place.

Keywords: Construction Management, Analytical Accounts, Relational Data Base, Integrated System

1 Introduction

This paper contains a general introduction to the SIGOC system—an Integrated System of Construction Management and Accounting, developed at the Civil Engineering Department of the Instituto Superior Técnico—Technical University of Lisbon.

It is a system which endeavours to link construction management to analytical accountancy and to the other areas of the construction company, in such a way as to obtain an integrated operation, by avoiding redundant information and increasing its respective reliability.

In order to achieve this, the system uses as computerised logical support a relational data base.

The system integrates the financial, manpower, supply and production aspects of construction companies.

The Portuguese accounting system has been used in developing the system, but it can be adapted to any other accounting system.

2 General Description of the Model

The following modules have been taken into account in the overall conception of SIGOC and in linking Analytical Accountancy to Construction Management (Telles de Menezes, 1990):

Module 1 – for “Construction Management and Analytical Accountancy”—constituting the basis of SIGOC

Module 2 – for “Personnel Management”

Module 3 – for “Equipment Management”

Module 4 – for “Stock Management”

Module 5 – for “Body Management”

Figure 1 presents, under Modules 2, 3, 4 and 5, the respective submodules. So as not to affect the reading of Figure 1, details of the subsystems of Module 1 are shown in Figure 2.

The separation into modules, with identification of the objectives involved in the functioning of each module, and the possibility of integrated operation, means that duplication of information can be avoided, and motivates better organization within the company.

The applications corresponding to Modules 2, 3, 4 and 5 were only developed as required so that they could be applied to Module 1. They are therefore open to a number of future developments. The submodules necessary for Module 1 which have already been developed are shown in Figure 1.

Thus the following are shown:

Module 2 – Submodules: units, personnel groups, careers and categories;

Module 3 – Submodules: units, family groups, families and identification of equipment;

Module 4 – Submodules; units, family groups, families and identification of materials;

Module 5 – Submodule: identification of bodies.

Each submodule constitutes a table of the used relational data base.

In Figure 1 the options available for each submodule are not indicated. These can be found in the menus.

In Figure 2 the possible options and various tables for Module 1 are shown, as well as the tables available for each option.

Thus we have the following tables:

Option 1 – Parameters

Option 2 – Financial Timetable for the Work

Option 3 – Budgetary Management

Option 4	–	Analytical Accountancy Plan
Option 5	–	Price Revision
Option 6	–	Periodical Measurement

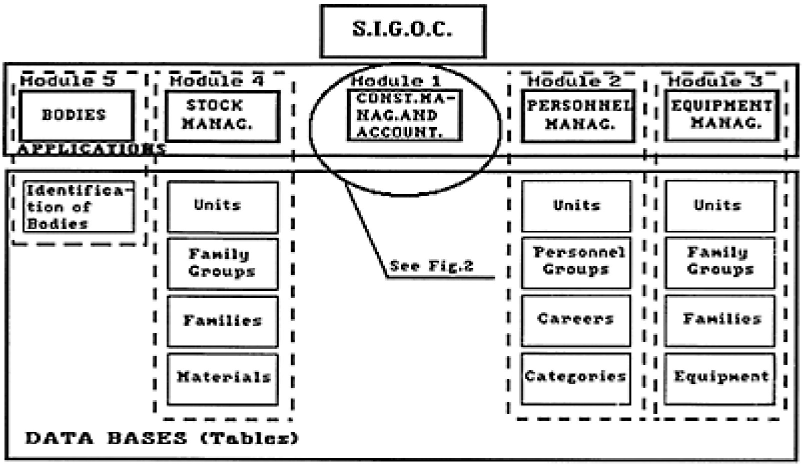


Figure 1. Modules Constituting S.I.G.O.C.

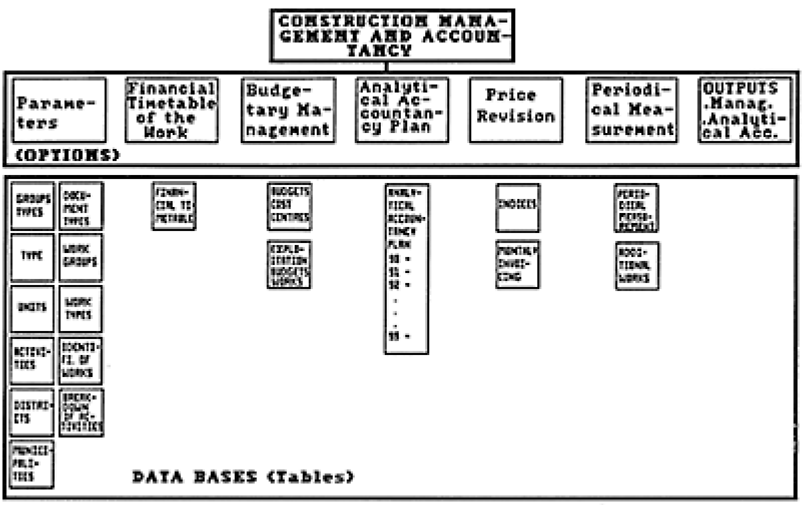


Figure 2. Options and submodules of Module 1—"Construction Management and Accountancy"

Option 7 – “Outputs” for Construction Management and Analytical Accountancy

In conceptual terms, SIGOC demands and carries out the link between the data bases presented, in summary, in Figure 1 and Figure 2.

SIGOC, as a useful computerised relational model, offers a group of “options” on the “Main Menu”, as explained in Figure 2. As it is a logical link system, the decision to use a certain “option” means that the user “enters” 2nd level “menus” or working “screens”, allowing easy and continuous access to anyone operating the system.

3. Construction and Exploitation of the Model

The principal aspects concerning the construction and exploitation of SIGOC are, briefly, as follows:

3.1 -Computerized conception of the model

SIGOC was conceived and developed with a relational data base as logical support.

The “software” chosen for support was INFORMIX (4GL), which, as well as having the inherent advantages of a relational data base, has the advantage of flexibility, as it can be used with two operating systems—MS-DOS and UNIX.

It should be pointed out that SIGOC is currently also being converted to PRO-IV, given the high portability of this language to different operating systems (MS-DOS, Xenix, Unix, AIX, OS 400, MVS, etc.)

3.2 -Analytical accountancy in the model

The top level accounts of the Official Portuguese Accounting Plan are divided into ten classes:

1. Availability
2. Third Parties
3. Stocks
4. Immobilization
5. Capital, Reserves and Transferred Results
6. Costs and Losses
7. Profits and Gains
8. Results
9. Analytical Accountancy
0.

Classes 9 and 0 are reserved respectively for analytical accountancy and for the treatment of other information.

There is no official standardized system in Portugal in the field of analytical accountancy, so it can be developed and structured according to the requirements of each company.

There are three commonly known structure types:

According to the organizational structure of the company.
According to the type of activities developed.
According to the nature of the costs.

With SIGOC it is possible to use any one of the structure types referred to.

The accounts conceived in SIGOC were divided, at the top level, into the following classes:

9	–	Analytical Accountancy
90	–	Connecting Accounts
91	–	Charges and Profits to be Shared
92	–	Reclassification of Costs
93	–	Costs of Goods and Services Produced
94	–	Cost Centres/Sections
95	–	Stocks
96	–	Diversions without Predefined Costs
97	–	Differences of Incorporation
98	–	(free)
99	–	Results of the Exploitation/Analytical

The accounts numbered 93, 94 and 99 are the “main accounts” in the model. The others can be called “auxiliary accounts”.

It should be pointed out that the use of analytical accountancy for construction management purposes is carried out, fundamentally, through a group of accounts under account 93. For correct cost control of each construction project, there has to first exist a budget, again with the same amount of detail as the contract.

3.3 -Codification and account movement

The classification and codification of accounts, at any level, is formed as an open system, able to meet the demands of companies of different sizes and kinds of organization.

The movement of accounts, illustrated briefly in Figure 3, is a linked accounting procedure (debit “versus” credit), operating according to the two column method.

3.4 -Results of SIGOC

The information contained in the SIGOC “outputs” can be very varied, and corresponds to the various modules included in the system.

In Module 1 there are two large output groups in particular:

a) Outputs for overall company management
In particular:

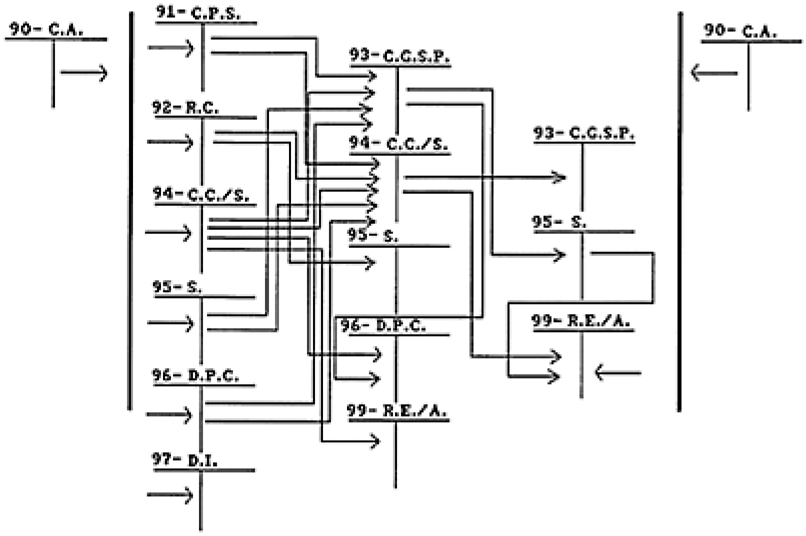


Figure 3. General Plan of Movement of Accounts

Accounting outputs (accounting plan, daily accounts, ledger, analytical balance sheet, synthetic balance sheet, etc.)

Outputs indicating overall management of the company,

b) Outputs for the management of each construction In particular:

Construction budget (synthetic and analytical)

Budgetary control plans

Weekly, monthly, annual

Synthetic, analytical

Production cost plans

By nature of costs, by different and detailed types of resources, etc

Weekly, monthly, annual

Synthetic, analytical

Absolute values, percentage values

Invoicing analysis plans

Plans analysing the construction costs summary

Plans of the results

Plans of the indicators of the overall management of the construction.

4 Conclusions

SIGOC brings together the production function and the other functions of the company, by carrying out the integration of the management of the construction with the analytical accountancy at the company level.

The data base system used and the structure of the tables conceived allows for non-redundancy and the reliability of the information placed in it.

The structuring of the system, particularly of the analytical accounts, is general, but its implantation in the field will obviously have to take into account the size and the form of the organization of each company to which it is applied.

Finally, one can conclude that SIGOC bridges the gap between the financial management of construction companies, integrating the most recent instructions contained in the Official Portuguese Accounting Plan published in 1990, and the production management of constructions.

5 References

Telles de Menezes, E. (1990) Sistema Integrado de Gestão de Obras e Contabilidade, Instituto Superior Técnico, Lisbon

23

The impact of the industry structure on realising an effective utilisation rate for automated equipment in the Australian construction industry

C.C.NEIL, G.SALOMONSSON and R.SHARP

Abstract

The extent to which the potential advantages of robotisation are likely to be realised in any industry will depend very much on the characteristics of that industry. Unless the initial introduction of robots takes into account the existing structure of the industry, advantages are likely not to be realised, and robotisation may be prematurely rejected.

This paper examines the impact of several aspects of the structure of the Australian construction industry on the ability of the industry to realise an efficient utilisation rate for robots. The aspects considered are the tendering process, the fragmentation of the industry, and the supply of labour to the industry. The implications of each for the introduction of robots are considered. In concluding, the paper briefly examines some of the broad strategic implications of these aspects of the structure of the industry for achieving a smooth and successful introduction of robotics.

Keywords: Australian Construction, Robots, Utilisation Rate, Organisational Structure.

1 Introduction

The ill-structured, dusty, noisy, and often hazardous work environment associated with building, the small number of truly repetitive tasks, the need for equipment mobility, and the constantly changing job site, have led to the use of robots in the construction industry lagging well behind their use in manufacturing (Skibniewski, 1988). However, the use of robots on certain construction sites, such as those involving the preparation or processing of large surfaces as on high-rise or large estate housing projects, is, in some contexts, both technically and economically feasible.

The potential advantages of using robots in these sorts of situations have been well documented (Kangari and Halpin, 1989). The extent to which these potential advantages are likely to be realised in an industry, however, will depend very much on the characteristics of that industry. ‘Using robots does not automatically imply certain consequences for organisations, but rather the characteristics of the technology, the manner in which robots are introduced, the organisation’s structure, and the people who work in the organisation determine the impact of robotics’ (Argote and Goodman, 1986:130). The successful introduction of some robots is likely to lead to a degree of restructuring of an industry, which in turn may leave the way open for further automation to be carried out smoothly. However, unless the initial introduction of robots takes into account the existing structure of the industry, advantages are unlikely to be realised, and the whole concept of robotisation may be unnecessarily deemed inappropriate to that industry. The effective introduction of robotics will, for most construction industries, involve a stepwise approach, with very careful selection of the appropriate robots for initial introduction, and very careful provision of support services for those companies who are prepared to adopt innovative technology. Thus, before any attempt is made to introduce robotics into a nation’s construction industry, a careful analysis must be made of the structure of the industry, and a national strategy evolved that takes into account the implications of the industry structure for the realisation of the advantages of robotics.

This paper illustrates this need by examining the impact of several aspects of the structure of the Australian construction industry on the ability of the industry to realise an efficient utilisation rate for robots. (The indirect impact on the utilisation rate that the structure of the industry has through its influence on the acceptance by managers, foremen, and workers of the use of robots to carry out certain tasks, is discussed elsewhere (Neil *et al.,* forthcoming).) In concluding, it briefly examines the implications of the structure of the industry for selecting the most appropriate types of robots for the first stage of a stepwise introduction process, and the type of additional support that the industry will require if robotisation is to be successful.

2 Research design

The paper synthesises recent studies on the Australian construction industry, overseas studies of robotisation, and the opinions of a number of construction managers and workers on the likely impact of robotisation. These opinions were obtained in interviews carried out in person by the authors. In all, 118 construction managers were interviewed, including managers of major contracting companies in Melbourne and Sydney, site managers in the same companies (Melbourne only), and managers of subcontracting and plant hire companies (again only those in Melbourne). The Melbourne sample was drawn from two sources: all companies listed with an annual turnover of $A30 million, and all companies currently undertaking construction in the Melbourne CBD. In Sydney, all companies listed with an annual turnover of $A30 million were approached, and this sample was supplemented by a list of companies selected with the use of random tables from Mahlab’s *Who’s Who in Construction* (1988). Appropriate personnel to participate in the study were ascertained, and interviews sought with one or more managers from each company. (Full details of the sample will be published in Neil *et al.*, forthcoming.)

On conclusion of the interviews, these managers were asked to nominate a number of site managers, and subcontractors and hire plant companies that they used, who were then interviewed. In addition, discussions were held with the unions, and interviews carried out with a small number (approximately 50) employees in three of the above companies. Site circumstances precluded both a random selection of site workers and the interviewing of a larger sample however, and the responses of the latter interviewees cannot be assumed to be necessarily representative of all construction workers.

3 Organisational characteristics of the Australian construction industry relevant to introducing robotics

Three characteristics of the Australian construction industry particularly relevant to the realisation of effective utilisation rates on construction projects are discussed in this section. These are the tendering process, the fragmentation of the industry, and the supply of labour.

In examining these characteristics, it is important to bear in mind the extent to which boom and bust conditions are an inherent feature of the building industry—exacerbated in the Australian context by the degree of foreign investment. It is also important to bear in mind the adversarial nature of industrial relations on Australian construction sites. Some of the industry's worst industrial relations features appear to occur in high-rise buildings in Melbourne and Sydney. Faced with centralised wage fixing system in Australia, it has been a successful tactic of unions attempting to get maximum benefits for their members, to concentrate on prominent building sites and get concessions which are then generalised across the industry.

3.1 The tendering process

Two aspects of the tendering process are of particular relevance to the realisation of the advantages of robotisation in Australian construction: the growing popularity of the fixed-price contract, and the limited amount of input main contractors now have into the design process. Over the last couple of years, most companies have only done work based on a fixed-price or cost-plus contract, with no input at the design stage.

If the advantages of robotisation are to be realised in the face of these trends associated with tendering, then better mechanisms for integrating the design and construction stages of the industry will have to be established. The effective use of robots is in many cases dependent on their use being accommodated at the design stage. The tendering process, however, is seen as reducing the cooperation between different parties involved in the construction process. Once the architect has sold the design to the client for tender, it is usually too late for the construction company to challenge whether differences in design approach could facilitate the use of techniques which could reduce costs. The divided authority over the production process (between owner, designer and contractor) that comes with the tendering process has been recognised as one of the features of construction which has stood in the way of robotisation (Warszawski and Sangrey, 1985).

Further, the fixed-price tendering process also creates barriers to risk-taking, which again limits the likelihood of achieving an effective utilisation rate. With fixed-price contracting in particular, if the incentives provided by a contract do not properly balance the benefits and costs of avoiding loss, there will be adverse impact on the willingness of companies to be innovative; innovation is risky in the sense that better knowledge about possible side-effects or malfunctions is often only obtained from experience (Australia Industry Commission, 1990:21; Halpin, 1988:2).

3.2 The fragmentation of the industry

Work in the Australian construction industry is highly specialised, both at the industry level, and the individual tradesman level.

At the industry level, there are major contractors and developers, specialist subcontractors, and plant hire firms.

The *major contractors and developers* can be classified into two groups on the basis of direct versus indirect employment of labour. The first group tends to employ up to half the workers on their sites. These companies ‘have an established reputation which helps ensure a relatively stable work flow, and are primarily involved in CBD [central business district] building where there is a more continuous stream of work’ (Australia Industry Commission 1990:52). Because they tend to retain their labour force over long periods, these types of companies are believed by some of the interviewees to be more interested than other firms in training and retraining. However, firms in this category have often evolved from family firms owned by families of ethnic origin, and frequently employ new immigrants or first generation Australian-born workers with limited knowledge of the English language.

The second type of major contracting company has a relatively small ‘permanent’ construction labour force—typically about 10 per cent of on-site labour. These companies make heavy use of specialist subcontractors. This approach tends to be the more prevalent approach to employment of construction labour in the Australian construction industry, partly because a firm relying on its own labour force is restricted geographically in the jobs for which it can bid, and partly because an intermittent workload can result in a permanent work force being underemployed in down periods (Australia Industry Commission, 1990:17).

Specialist subcontractors represented 76 per cent of all residential and non-residential construction establishments in the industry in 1989 (Australian Bureau of Statistics, 1990). Most of these specialist subcontractors have an annual turnover of less than half a million dollars (based on 1985 figures, pending release of the 1989 figures) and, in most specialist sectors, have an average employment of less than five people (1989 figures, Australian Bureau of Statistics, 1990).

The major construction companies vary according to whether they regularly used the same set of subcontractors. A minority of general contractors consistently select the lowest bid (Uher and Runeson 1985). With fixed-price tendering, however, losses can be high if estimated productivity is not achieved. Accordingly, a lot of companies from which managers were interviewed tended to use the same set of subcontractors because these subcontractors’ relationships with their work force enabled them to keep a permanent core of skilled workers, and hence increased their perceived reliability.

In boom conditions, the specialist companies have tended to grow in number, rather than size, as measured by either dollar turnover or average number employed. Thus during booms, the increased capital available that might, in the future, facilitate both the willingness of construction businesses to take risks, and their ability to make large capital investments in equipment, was to some extent dispersed into small firms unable to take risks, and unlikely to have the necessary capital outlay or utilisation time.

Plant hire companies have emerged in response to the influence that subcontracting process has had on companies' attitudes to the ownership of equipment. For the most part, construction companies no longer own much construction equipment other than that necessary for lifting materials, and hire equipment from plant hire firms, sometimes complete with crews, and/or use subcontractors who supply their own equipment.

The subcontracting system, in conjunction with the tendering process, is seen by managers to be very efficient, since the tendering process ensures that only the most efficient subcontractors survive, while subcontracting enables builders to select the best mix of specialisations without having to be fully knowledgeable in trade developments themselves. However, subcontracting does mean that 'communications between the members of an increasingly large production team are hard to maintain. The greater number of activities are harder to coordinate and responsibility is elusive' (Marosszeky, 1990:7).

In addition to fragmentation at the organisational level, there is considerable specialisation among workers on a construction site, although individual workers often have multiple skills.

This fragmentation is likely to have a major influence on the ability of the Australian construction industry to realise an effective utilisation rate through its impact on the process through which robotics are likely to come into use in construction. According to managers, changes in the industry tend to be introduced by the larger companies with big projects designed to accommodate technological innovation. On the other hand, there is the growing tendency (discussed above) for major construction companies not to own their own equipment. Given this trend, the feeling among the majority of managers interviewed was that, despite the fact that it is the major construction companies who tend to be more innovative, if robots are introduced onto Australian construction sites, it will be through their purchase by either subcontractors or plant hire companies. Plant hire company managers were definite that their capital resources are such that any acquisition of expensive automated equipment would depend on demand and not be motivated by an interest in innovation. This then places most of the pressure for introducing robots on subcontractors.

In the short term, reliance on subcontractors to introduce robots onto construction sites is likely to have a number of consequences for the ability of the industry to realise the advantages of robotisation. Firstly, robots would be purchased by those least able to carry the risk of high capital outlay, and least able to achieve the utilisation rate necessary for cost effectiveness of a lot of the specialist machines designed for tasks less frequently undertaken. Secondly, the cost of training robot operators would be passed to specialist subcontractors. The specialist subcontractor may, perhaps, be the most willing of different segments of the industry to undertake retraining in order to retain the core permanent work force essential to their continued perceived reliability. For the most part, however, they are least likely to be able to afford the costs of retraining. Thirdly, since subcontractors are smaller, they are, according to union representatives, likely to have a better understanding with their employees, and therefore be more willing to negotiate acceptable arrangements regarding the use of particular robots. On the other hand, even if a subcontractors' workers are willing to use a particular machine, some felt that there could still be problems on sites where the subcontractor worked.

While the introduction of robots through their purchase by specialist subcontractors was seen as the most likely scenario by those interviewed, two possible situations were mentioned in which major contractors might be prepared to purchase robots:

(a) the occasional one-off purchase of a specialised robot, the cost of which could be written off over a single project by a major construction company; and
(b) the purchase of robots by prime contractors who have a relatively large permanent work force, and are interested in innovative approaches.

The introduction of robotics in either situation, however, would need to be carefully managed to avoid inefficient usage. Where a machine was paid for by a single contract, there would be no motivation for its efficient use. Motivation in the second of the two situations discussed above may also present a potential problem. Some, if not all, those companies interested in innovation are interested at least partially because of the importance they attach to being at the leading edge of technological innovation. This creates some problems for the introduction of robotics, in which the collaboration of major companies may be necessary to be able to afford the R&D work necessary for the development of robots appropriate for Australian construction sites.

In the case of the purchase of robots by major contractors with a relatively large permanent work force, there is a further possible constraint on the efficient use of those robots acquired. Firstly, it is the companies with relatively large 'permanent' work forces that are most likely to have relatively large percentages of non-English speaking workers. Secondly, those companies able to retrain a relatively large permanent work force tend to be those companies with a relatively high percentage of CBD work. The type of work carried out on CBD sites is likely to be the type of work that most lends itself to robotisation. However, CBD sites also tend to be the sites that experience most lost time due to industrial disputes, and are most likely to be used by unions to get concessions that can be generalised across the industry (Ireland, 1988:25, 37). If the introduction of robots becomes a weapon in this process of adversarial industrial relations, there is a danger of either bans being placed on particular robots, or of disputes being resolved by restrictive specification of duties *vis-à-vis* the use of robots.

The fragmentation of the industry, moreover, exacerbates the problems that the tendering process presents for realising an effective robotic utilisation rate—that is, the lack of integration between different stages of construction, and the reluctance to be innovative.

3.3 The supply of labour: its availability and characteristics

Two factors influence the supply of labour to the Australian construction industry in ways that have potential consequences for the introduction of robotics.

The first is the pattern of major peaks and troughs in the supply of skilled labour brought about by the boom and bust conditions inherent in the industry. In the past, there have been ‘severe, periodic shortages in the building trades and serious wage pressures coinciding with booms in construction.’ (Department of Employment Education and Training, 1989:6). Partly because of boom and bust conditions, partly because ‘the average period of continuous employment may be as low as eighteen weeks by representatives of the union movement’ (Ireland, 1988:40), and partly because of lack of career paths in the industry, and the associated lack of opportunity for older workers, the industry has an annual wastage rate of around five per cent per annum (Department of Employment Education and Training, 1989).

In 1989, when conditions were still relatively buoyant, ‘the return of skilled workers to the industry, and the practice of upgrading semi-skilled workers to trades level position after a relatively short period of on-the-job training’ (Department of Employment Education and Training, 1989:3) helped ensure that there was only a minor shortage of either new entrants and experienced workers in most construction trades—despite low apprentice completion rates, poor ratios of apprentices in training to employed tradespersons, and a limited contribution from net immigration (Department of Employment Education and Training, 1989:2).

There was agreement among managers interviewed, however, that when the industry came out of its present recession, there would be a shortage of skilled labour in every trade. Firstly, some of the existing skilled labour is likely to be lost to the industry during the period of recession. Secondly, while the high wages associated with the recent building boom have brought a lot of young people into the industry, there has, according to managers, often been a preference on the part of younger workers to do unskilled or semi-skilled work, with the relatively high earnings that can be obtained almost instantly in the construction industry, rather than undertake apprenticeships.

Thus the boom and bust conditions tend to replenish the work force and to keep it fairly young; they also, however, work against the consistent acquisition of skills in the industry. This process is exacerbated by the fact that the construction industry responds to adverse conditions by severely curtailing training expenditure.

In some respects the current process of acquisition of skilled labour to the industry favours the realisation of an effective utilisation rate for robots. The current on-the-job training that has evolved to cope with the labour demands of boom and bust conditions lends itself to training in the use of robots, as does the younger work force. The high wastage rate, moreover, means that to some extent, many of those less able to cope with automation are likely to leave the industry fairly rapidly, quite independently of the process of automation—although the high wastage rate also means that robotics skills acquired by the industry may also be regularly lost.

However, the impact of the boom and bust conditions on the supply of labour also means that if an effective utilisation rate is to be achieved, the timing of introducing robots will be crucial.

In the long term, the likelihood of automation leading to a major loss of jobs in the economy as a whole is debatable—although considerable redistribution of jobs across different sectors of the economy may be necessary. In the short term, however, the influence of new technologies leads to the disappearance of some or all of the tasks that form an integral part of different types of jobs, and, therefore, possibly to some or all of the jobs whose encumbents were previously responsible for performing those tasks. This can lead to job loss for existing workers in a newly automated industry through either an absolute loss of jobs in the industry, or a redistribution of jobs in the industry, with the jobs, for example, of tradesmen or semi-skilled workers being displaced to white collar workers who already have certain prerequisite skills (such as, for example, computing skills).

To reject the use of new technologies in construction, especially in Australia, is likely in the long run to cost more jobs than might have been lost through automation (Steinkähler, 1985, cited in Stihl, 1985). However, faced with ‘sacrificing himself for the long term good of the organisation’, the average worker is likely to have a rather myopic view (Cooke, 1987:81). Thus the introduction of robots in a way that involves rapid loss of jobs, apart from any moral issue, would inevitably lead to a deterioration in industrial relations. Unless fully acceptable to both the unions and the construction workers, therefore, introducing a machine that saved one or two operators on the job, as an end in itself, is considered likely to be counterproductive.

The second factor affecting the supply of labour to the Australian construction industry is the heavy dependence of the industry on the pool of recent migrants as a source of labour. According to the Department of Employment Education and Training (1989:6), ‘the construction industry has had the advantage of immigration to alleviate demand pressures in every construction boom since the 1940s’. ‘It could be argued that our labour supply is [therefore] only assured while we continue an immigration policy that permits a broad socio-economic cross section to enter the country. If we only allow highly qualified entrants we may begin to run short of labour in the building industry’ (Marosszeky, 1990:4).

The dependence on recent migrants to even out the supply of labour, however, leads to major language barriers on construction sites, and, as discussed above, those with language difficulties tend to be concentrated on those major construction sites that are most likely to lend themselves to robotisation. Language problems are likely to create a barrier to retraining, but also to the safe use of robots—unless clear guidelines for their safe handling are laid down and fully understood and accepted by all concerned, robots themselves can be a source of serious injury.

4 Conclusion: implications for the effective introduction of robots

The preceding analysis suggests a number of specific recommendations relating to the introduction of robotics into the Australian construction industry. These will be discussed elsewhere (Neil *et al.,* forthcoming). It does, however, also have certain broad implications relevant to the introduction of robotics into an industry. These are discussed below.

It would be both irresponsible and counterproductive to attempt to introduce robots that involve either major job loss or the displacement of jobs from present construction workers during a period of recession. This does not, however, necessarily preclude the introduction of semi-autonomous robots which operators can use to assist in carrying out a task.

Given the structure of the Australian construction industry, the progressive stepwise introduction of robots, starting with single-purpose robots that assist the worker in carrying out certain tasks but do not lead to major loss of jobs or labour displacement, would have a number of advantages. Firstly, it would enable the steady introduction of robotic handling skills into the construction work force. Secondly, the acquisition of some robotic handling skills by the present work force would help ensure that there was a skill base to draw upon when retraining for the use of more sophisticated machinery was necessary. Perhaps more importantly, this would help to ensure that construction workers are given the opportunity to acquire further vocational training and fill higher grades, rather than these higher grade jobs passing to the present generation of white collar technicians. Thirdly, the preliminary introduction of robots that simply assist a worker to carry out certain tasks, is likely to ensure that people in the industry have realistic perceptions and expectations of robotics before any major use of robotics becomes prevalent on construction sites.

However, given the fact that the purchase of robots and the retraining of workers for their use is likely to fall to the lot of specialist subcontractors—that sector of the industry frequently least able to afford the necessary capital outlay even in boom times—if Australia wishes to reap the benefit of automation in the construction industry, it does not seem feasible to leave innovation in technology to this segment of the industry without the provision of some support services. In Singapore, for example, a government-backed robot leasing company was set up to speed up robotisation and automation: it provides low-cost financing to local firms that want to robotise their production process, and conducts regular seminars and field studies (Meng Hock Pang, 1986). Consideration should be given to Australia adopting the Singaporean approach. This would acknowledge the structural constraints that the fragmentation of the industry presents to the introduction of robotics, and help overcome some of the financial problems confronting subcontractors who might wish to utilise robots.

Above all, analysis of the impact of the structure of an industry on its potential for realising the advantages of robotics, suggests that it is essential that the introduction of robotics does not take place in a piecemeal fashion. Singapore has recently recognised that effective automation requires a coordinated set of national strategies, including strategies relating to manpower development, to technology development, to infrastructure development, and to the development of an automation culture. A similar model must be adopted in any industry if robotisation is to realise its full potential.

5 References

Argote, L. and Goodman, P.S. (1986) The organizational implications of robotics, in **Managing Technological Innovation** (eds D.D.Davis and Associates), Jossey Bass Publishers, San Franscico.

Australian Bureau of Statistics (1990) **Construction Industry Survey: Private Sector Construction Establishments, Details of Operations, Australia, 1988–89.** Australian Bureau of Statistics, Canberra.

Australia Industry Commission (1990) **Draft Report on Construction Costs of Major Projects**. Australia Industry Commission, Canberra.

Cooke, P.N.C (1987) Selling the idea—people in automation. *Proc. Tenth Annual Conference of the British Robot Association,* Birmingham, 1987.

Department of Employment Education and Training (1989) The Building Trades in **NSW: A Labour Market Assessment**. Department of Employment Education and Training, Sydney.

Halpin, D.W. (1988) Impact of international competition on construction technology—a perspective, in **Impact of International Competition on Construction Technology** (ed C.B.Tatum), American Society of Civil Engineers, New York.

Ireland, V. (1988) **Improving Work Practices in the Australian Building Industry: A Comparison with the UK and the USA**. Master Builders' Construction and Housing Association Australia, Turner, ACT.

Kangari, R. and Halpin, D.W. (1989) Potential robotics utilization in construction. **J. of Construction, Engineering and Management,** 115, 126–143.

Mahlab Publishing (1988) **Mahlab's Who's Who in Construction (4th edition)**. Mahlab Publishing, South Melbourne.

Marosszeky, M. (1990) **Planning for Technological Change**. Building Research Centre, School of Building, University of NSW, Sydney.

Meng Hock Pang (1986) Job creation-displacement analysis: the experience of robotisation in Singapore. **Proc. Third International Conference on Human Factors in Manufacturing** (ed T.Lupton), Stratford-upon-Avon, 4–6 November 1986, IFS (Publications), Bedford.

Neil, C.C., Salomonsson, G., and Sharpe, R. (forthcoming) **Introducing Robotics into Building and Construction: Realising Their Advantages**. CSIRO, Melbourne.

Skibniewski, M.J. (1988) **Robotics in Civil Engineering,** van Nostrand Reinhold, New York.

Stihl, P.H. (1985) Trends in technological development and their effects on industry and engineering. **Proc. Second International Conference on Human Factors in Manufacturing,** West Germany, June 1985.

Uher, T.E. and Runeson, G. (1985) **Survey of Tendering Practices in the Australian Building Industry with Reference to General Contractors**. Building Research Centre, School of Building, University of NSWales, Sydney.

Warszawski, A. and Sangrey, D.W. (1985) Robotics in building construction. **J. of Construction, Engineering and Management,** 111, 260–280.

24
Investigation of leading indicators for the prediction of UK contractors' workloads (total new orders)

A.O.OSHOBAJO and R.F.FELLOWS

ABSTRACT
This paper identifies variables that indicate trends of contractors workloads and uses the identified leading indicators to build models for forecasting New Orders.

The sequence of workload flow to contractors' was examined and the underlying characteristics and relationships between the selected quantitive data were evaluated in their original forms and when decomposed into time-series elements. The information so obtained was then applied to formulate suitable models.

The study highlights strong and irregular fluctations in the behaviour of construction variables (such as Investments, RIBA New-commissions, Work at Production Drawing Stage and New Orders) which often distort 'discerned' patterns in past observations. It was found that some of the independent variables are either 'lagging' or 'coincident' indicators of contractors' New Orders while Interest Rate provides significant 'leading' indication of trends in New Orders.

Keywords: Leading Indicators, Contracts' Workload, Multiple Regression, Time Series Analysis.

1. Introduction

Forecasting demands in the UK construction industry generally have involved extrapolation of past trends, amended by 'expert' judgement (based on experience) and 'known' future events. The exceptions to the rule, are a few large organizations which make use of more sophisticated techniques. The predictions of construction workloads published in some of the industry's media (eg 'Building') often have been labelled as 'alarmist' (or pessimistic) particularly when the industry is enjoying a boom in it's workload.

This paper identifies variables which indicate trends of workloads and uses leading indicators to build better models for predicting Contractors' New Orders. It is believed that the use of the Leading Indicator technique, together with the other forecasting methods, will provide more reliable predictions for the industry and consequently minimize the effects of periodic shocks of 'booms'/'busts' that have characterised the Construction Industry.

2. INDICATORS APPROACH

The indicators approach to economic forecasting was pioneered at the U.S. Bureau of Economic Research. The objective was to predict turning points in the economy, thereby forewarning political leaders and business concerns. From their study of economic series three classes of indicators were proposed—Leading (Long & Short), Coincident and Lagging (Long and Short).

In the U.K., four classes (of composite indices) of indicators namely longer leading, shorter leading, coincident and lagging indicators are used to predict and identify turning points in the economy. The different types of indicators are outlined below:

> Leading indicators are economic series which are expected to turn before the aggregate economy, so when some of the series are observed to make a significant turn they suggest that a turning point for the whole economy will follow. In the U.K. government publications such as 'Economic Trends' provide information on the performance of the selected indicator series. Examples of the leading indicators are:

Longer Leading

2.1 Financial surplus/deficit industrial and commercial companies divided by GDP deflator.

2.2 CBI quarterly survey: change in optimism (% Balance).

2.3 Rate of Interest—3 months prime bank bills.

Shorter Leading

2.4 Credit extended by financial houses, retailers, etc, etc.

2.5 CBI quarterly survey: change in new orders (% Balance).

2.6 New car registrations.

Coincident Indicators are series that turn at about the same time as the economy itself. These series are those which are released quickly after the date to which they relate. Examples are:

2.7 Gross Domestic Product (expenditure) factor cost at constant prices.

2.8 Gross Domestic Product (income) factor cost at constant prices.

Lagging indicators are those series that react slowly to a change of direction in the main part of the economy hence when they do turn, it is certain that a turning point for the economy has occured previously. In an ideal system, the lagging indicators are used to confirm what the other series have demonstrated. Examples of these series are:

2.9 Adult Employment Index (at constant prices).

2.10 Investment in Plant and Machinery—manufacturing industries, at constant prices.

APPLICATIONS

The indicators approach is used to make quantitative forecasts only rarely since it does not consider all the factors affecting economic activity.

Primarily, the technique is used to forecast the occurence of turning points, ie to predict the directions of economic changes, a function which Ascher (1978) considers to be of greater importance than the prediction of the magnitude of the change. Sobek (1973) however, argues that 'the purpose of leading indicators is to forecast the turning points of business cycles as well as to assess the magnitude of rising or declining economic activity', Sobek's argument is reinforced by Farnum and Stanton (1989), who sugest methods for calculating the approximate magnitudes of turning points by using percentage changes and multiple regression analysis.

The advantage of being able to predict the direction of economic change as well as the magnitude of the expected change could be very useful for investors, as a mild downturn may not discourage investments in long term projects whereas major recessions encourage the postponement of planned expansion or start-up of new projects.

However, there have been instances of false signals provided by the indicators and there are difficulties of interpreting the indications accurately. Hence, cognizance should be given to the suggestion of Moore & Shiskin (1976) that indicators should be used as 'sensitive guideposts' for monitoring economic tides by analysts who are 'in tune' with the environment of the forecast. Therefore, the approach offers a framework for the application of quantitative techniques while allowing for the use of judgement.

U.K. CONSTRUCTION INDUSTRY: METHODS OF FORECASTING DEMANDS

Literature indicates that the methods of demand prediction in the construction industry are mainly extrapolative (ie usually involving projection of trends) with subjective adjustments Hillebrandt (1974), Fellows (1987). Little use is made of other techniques such as time series analysis (using univariate or multivariate Box-Jenkins), econometrics and the indicator approach.

ADVANTAGES OF INDICATORS

According to Wheelwright and Makridakis (1980) the indicator approach is particularly useful for short term forecasts. Thus, the relationship of the construction industry to the economy (as a capital creating industry) and its susceptibility to economic fluctations makes the fore-knowledge of turning points and the magnitude of the fluctations in economic trends provided by the leading indicators of great significance.

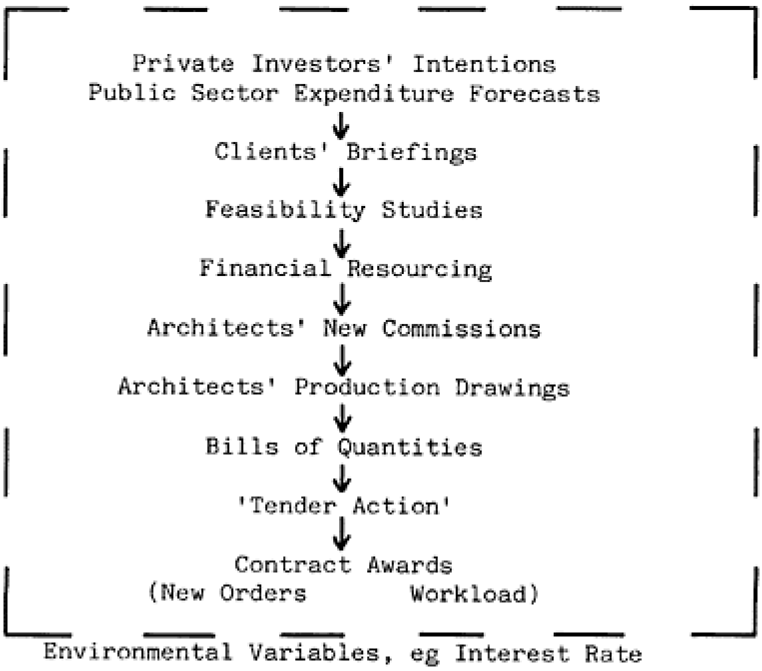


Fig. 1. Potential Leading Indicators of Contractors' Workload

This study used government and professional organizations' published data (quarterly series) of the Dependent Variable, New Orders; and Independent Variables: Investment (GDFCF), RIBA New Commisions, RIBA Work at Production Drawing Stage, and Interest rates (Bank base rates), all at constant prices, 1980=100 (except Interest rate which was in%).

Figure 1 shows potential Leading Indicators which were identified and used to postulate the sequence of workload flow to contractors.

INSPECTION OF TIME SERIES

In order to determine if features such as Seasonal Components, Cycles, Secular Trend and Irregular Components are present in the series, time plots (graphs) for each of the variables were produced. Such graphs facilitate inspections of each series; the following was observed:

Investments

The presence of trend and seasonal fluctuations were indicated. There was an upsurge from Quarter 4 1986 which nearly doubled the level of investments.

RIBA New Commissions

The plot indicated the presence of cycles of irregular periods and an upward trend, it also showed a pronounced upward surge from Quarter 1 1986.

RIBA Work at the Production Drawing Stage

This series indicated the presence of major and minor cycles, the major cycles occurred at about 12 quarterly intervals while the minor cycles often occurred within the major ones particlarly around their peaks. An upward surge from Quarter 1 1986 introduced a positive trend into the series.

Interest Rate

This series showed the presence of an irregular cyclic component, fluctuations and a downward trend from 1980. Further, there was a distinct fluctuating, downward movement after mid 1985.

New Orders

This data also indicated a fairly cyclic pattern and could have been stationary but for the pattern during 1987–88. It should be noted though that this data had been seasonally adjusted at source.

ANALYTIC PROCESS

It was necessary to test if the series were non-stationary in variance (Pankratz, 1983; O’Donovan, 1983; Box and Jenkins, 1979), and thereby to determine the appropriate transformations required. The method suggested by O’Donovan (1983) was adopted which involved dividing each of the series into subsets relating to the size of the seasonal periods. Therefore, each of the five series was divided into ten subsets of 4 quarters. The standard deviation (μ) and the mean (σ) for each series were plotted against each other to highlight the underlying pattern in the respective series.

No evidence of non-stationarity in the variance was indicated in any of the plots, hence appropriate differencing of the respective variables was adequate to yield stationary series.

The procedure—'Identification', 'Estimation' and 'Diagnostic Checking' suggested by Box and Jenkins (1979) was adopted in the evaluation of the data and in the estimation of univariate models.

The evaluation, models' estimation and diagnostic checks for the contractors New Orders series is presented below. The forecast performance of the estimated Univariate models for New Orders served as a 'Control' with which to compare the leading indicator technique.

A second approach involved the application of the classical decomposition technique and cross-correlation analysis to determine the relationship between the dependent variables and independent variables in the original states, when 'detrended' and when 'detrended and deseasonalized'. Multiple regression analysis was used to build regression equations of the leading indicators to predict New Orders.

CLASSICAL DECOMPOSTION METHOD

The original data were subjected to the classical time series decomposition using the multiplicative model—

$A = T \times C \times S \times R$

where:

A=Actual or Original series
T=Trend
C=Cyclical Component
S=Seasonal Component
R=Residual or Random Component

Polynomial trend models were fitted to each series through multiple regression of each variable on different orders of time units. Linear trends had failed to represent the underlying trends adequately. The Plots of the cyclical components showed that U.K. Interest Rate (1978–1987) experienced 2 to 3 years cyclical movements; peaks and troughs led inverse fluctuations in Contractors' New Orders by about 2 quarters. Similar relationships were observed with Investments, RIBA New Commissions and Work at the Production Stage although the lead time with each variable was different. The trend in Interest Rate appeared to lead inverse movements in Contractors New Orders, Investments, New Commissions and Work at the Production Drawing Stage.

CROSS-CORRELATION ANALYSIS

The cross-correlation analysis of the dependant and the independent variables was computed using the original series, the detrended series and the detrended and deseasonalized series. The cross-correlaton functions (ccfs) of the 'raw' series indicated a very strong correlaton between New Orders and RIBA New Commissions, Work at Production Drawing Stage and Interst Rate at coincidence (ie Lag k=0). Investments is also strongly correlated with New Orders and Lags New Orders by 1 Quarter.

The ccfs of the detrended series indicated a significant correlation between New Orders and New Commissions $(r_{xy}(1) = 0.364; > 0.316)$ but at coincidence. Further, a significant but inverse correlation existed between New Orders and Interest Rate, with Interest Rate leading New Orders by up to 2 quarters. No significant correlations were found between New Orders and Investment or between New Orders and RIBA Work at Production Drawing Stage.

The cross-correlation functions of the 'detrended and deseasonalized' series indicated—

a. Significant but inverse correlation between Investments and New Orders with Investments leading New Orders by about 10 quarters
b. Very weak correlation between RIBA New Commissions and New Orders at coincidence.
c. No significant correlation between RIBA Work at Production Drawing Stage and New Orders.
d. Significant but inverse correlation between Interest Rate and New Orders with Interest Rate leading New Orders by up to 2 quarters.

The findings reinforce the observations of the graphs of the cyclical Components from which it was noted that Interest Rate consistently led New Orders downward by 1 to 2 quarters at a significant level $(r_{xy}(1) = 0.417; > 0.316)$. RIBA New Commissions was found to be a coincident indicator of New Orders.

MODEL ESTIMATION

Using Multiple Regression analysis the following model for predicting New Orders from the lagged series of Interest Rate was estimated—

New Orders $(Y_t) = \beta_0 - \beta_1 X_{t-1} - \beta_2 X_{t-2}$ ie NO $(Y_t) = 5229 - 125$ Interest Rate$_{(t-1)}$ $-$ 43 Interest Rate$_{(t-2)}$

where β_0, β_1 and β_2 are regression constants and $X_t =$ Interest Rate at time t

DIAGNOSTIC CHECKING

The estimated auto correlation function (acf) of the residuals indicated significant autocorrelations at lags 1 and 2 ($r_k(1)=0.497$ and $r_k(2)=0.439$) and the estimated partial (pacf) of the residuals indicated the need for an autoregressive term. Further, a plot of the residuals against time did not resemble that of a random series. Thus the model did not fit the data sufficiently, hence a re-estimation of alternative models was computed by regressing the dependent variable New Orders on different lags of both the Interest Rate and of New Orders itself to obtain alternative models.

APPLICATIONS OF THE RE—ESTIMATED MODELS

The alternative models were fitted to the full series (40 quarters). The estimated acfs of the residuals of the fitted models showed random, uncorrelated patterns and their estimated pacfs did not indicate the need for additional variables to be included in the models. The timeplots of the residuals for each model showed random scatter about zero. These diagnostics show that the three models fitted the data sufficiently.

IMPLICATIONS OF THE STUDY

Trends and Cyclical components showed that the fluctuations in those components of Interest Rate appeared to precede inverse movements in the trend and cyclical components of New Orders, RIBA New Commissions, Work at the Production Drawing Stage, and Investments. This reinforces the postulated sequence of workload flow to contractors (figure 1) and suggests that Interest Rate, can influence Contractors' New Orders at any stage of the workload flow (even after the contract has been awarded through the reduction/addition to volume of work). Thus, suggesting an alternative argument to the conventional view that Interest Rate affects construction New Orders sequentially; by which it is implied that high interest rates lead to the erosion of investors' confidence and subsequently lead to reduced demand for construction services typified by RIBA New Commissions, Work at Production Drawing Stage, Tender actions and, consequently, reduction in New Orders. Lower interest rates would have an opposite effect.

The results of this study can provide an important input to the plans of construction businesses, by providing estimates of total value of Contractors' New Orders from which Contractors can predict their share of the workload taking cognizance of the environment and their past performances. The models are more appropriate for short term forecasts of between 3 and 4 quarters In a stable environment, the application of the Box-Jenkins Univariate model may be appropriate as it provides an approximate estimate of the New Orders but in a dynamic environment the leading indicator models were shown to provide much improved Ex Post Forecasts. The performance of the Univariate Box-Jenkins model compared to the Leading Indicator models showed that the leading indicator models improved forecast accuracy by 5 to 12%.

REFERENCES

Ascher, W., (1979), Forecasting and Appraisal for Policy-Makers and Planners, The John Hopkins Press Ltd. (London)

Box, G.E.P. and Jenkins, G.M. (1976) Time Series Analysis, Forecasting and Control. (Revised Edition), Holden-Day Inc. (San Francisco)

Central Statistical Office (1987), Annual Abstract of Statistics, HMSO, London

Central Statistical Office (1988) Gross Domestic Fixed Capital Formation by Sector and by Type of Asset (Total Dwellings and Other New Buildings and Works, Unadjusted, 1980 Prices)—Economic Trends; Annual Supplment No 13, HMSO, London

Central Statistical Office Monthly Digest of Statistics, HMSO, London

Department of the Environment (1987) Housing and Construction Statistics (1977–1987), HMSO, London

Farnum, N.R. and Stanton, L.W. (1989) Quantitative Forecasting Methods, PWS-Kent Publishing Co (Boston)

Fellows, R.F. (1987) Management of Escalation on U.K.Building Projects in Managing Construction Worldwide Vol 1—Systems for Managing Construction (Eds P Lansley and P Harlow) E. and F.N.Spon (London and N.Y.) pp 314–326

Hillebrandt, P.M. (1985) Economic Theory and the Construction Industry (2nd Edition), Macmillan Press Ltd. (London)

Moore, G.H. and Shiskin, J., 1976 "Early Warning Signals for the Economy", Statistics, A Guide to Business Economics, Holden-Day Inc. (San Francisco)

O'Donovan, R.M. (1983) Short Term Forecasting—an Introduction to the Box-Jenkins approach, John Wiley and Sons Inc.

Pankratz, A., (1983) Forecasting with Univariate Box-Jenkins Models—Concepts and cases, John Wiley and Sons Inc

RIBA (1988), RIBA Construction Workload Brief. (Issue 4 October 1988, 2nd Quarter 1988), RIBA Services Ltd (London)

Sobek, R.S. (1973) A Manager's Primer on Forecasting, Harvard Business Review Vol 51 No 3 (May-June)

Wheelwright, S.C. and Makridakis, S. (1980) Forecasting Methods for Management (3rd Edition), John Wiley and Sons (New York)

25
Measurement of safety performance as a tool for managing behaviour on construction sites

R.A.PHILLIPS, A.R.DUFF, I.T.ROBERTSON and M.D.COOPER

Abstract.
The aims of the research were twofold: first, to develop an objective method of measuring a construction site's safety levels; and second to use the results of the measure to test methods of managing safety, using behaviourial techniques. The results indicate that the safety performance measure developed has a reliability of greater than 96%, and that management's commitment to the behaviourial approach seems to be of prime importance, if it is to be effective.
Keywords: Construction, Safety Performance Measurement, Management, Goal-Setting, Performance Feedback.

1 Introduction

The Health and Safety Commission (HSC, 1990), confirms the U.K. construction industry to be the most dangerous occupation in the country. In a typical decade 1500 people are killed, 25,000–30,000 are seriously injured and 300,000–400,000 people suffer injuries which require at least three days away from work. It must be emphasised that these figures are despite 150 years of legislation and safety improvement campaigns.

Attempts to improve the poor accident record by raising operative safety consciousness, through the use of safety poster campaigns such as 'Site Safe '83', have been ineffective (Saarela et al, 1989). One hypothesis suggests that people commit unsafe acts because they have been rewarded in the past for doing so (Peterson, 1982), by financial bonuses for extra production with no compensating reward for behaving safely. This incentive is further reinforced by the low perceived probability of an unsafe act resulting in an injury. Heinrich (1959) empirically determined a ratio of 300–29–1; of which, 300 of 330 unsafe acts do not result in an accident or injury; 29 cause minor injuries and 1 causes a major injury. Perceived conflicts between productivity and safety (Hinze & Parker, 1978) will also affect the successful implementation of safety programmes by impinging upon managerial attitudes (Leather, 1987). However, good safety programmes have been shown to motivate the workforce (Borcherding & Garner, 1981), as well as having considerable potential for increasing productivity (Hubbard & Neil, 1986).

Currently, the majority of contractors use accident indices as a measure of their site safety performance. These, however, are notorious for under-reporting and also indicate the result of a chain of events, rather than the cause. Thus, as a prerequisite to examining the utility of behaviourial techniques designed to improve safety, it was necessary to develop an objective method of measuring site safety performance levels.

2 Psychological Techniques

2.1 Goal-setting

Goal-setting is defined as the systematic setting of specific targets by or for individuals/groups to improve performance. Locke and Latham (1990) observed that 90% of goal-setting studies demonstrated a beneficial effect on performance. The main findings were: (a) difficult goals lead to higher performance than easy goals; (b) specific goals lead to higher performance than vague goals or no goals; (c) goals affect performance in a number of ways, by directing attention and action, by mobilizing effort, by increasing persistence, and by motivating the search for better performance strategies; (d) performance feedback is a necessary condition for goal-setting to work effectively; (e) goal commitment is necessary for goals to affect performance; (f) goal commitment appears to be unaffected by participation in goal-setting; (g) commitment to goals is higher when goals are made public and seen to be supported by management.

2.2 Performance feedback

The importance of feedback in socio-technical systems, Action theory, performance appraisal and Knowledge of Results (of job performance) has been illustrated by Algera (1990). Performance feedback is usually defined as ‘information about the effectiveness of one’s work behaviour’ at both the ‘low’ perceptual-motor skill and ‘high’ organizational levels. It fulfils several functions: motivational, in that it stimulates greater effort to set and achieve higher standards of performance; directive, in that the specific behaviours to be performed are emphasised; and error correcting, in that information is provided about the extent of errors being made.

Previous studies that have been shown to improve safety in various industries have employed a combination of training, goal-setting and performance feedback within a multiple baseline experimental design (Chokkar & Wallin, 1984; Reber & Wallin, 1984; Reber et al, 1984).

3 Experimental design

To test the effectiveness of the most appropriate behaviourial techniques, combinations of training, participative or assigned goal-setting and performance feedback are currently being evaluated on six construction sites in the North West of England.

The evaluation of each combination is carried out by: measuring safety performance for eight weeks, to provide a base-line measure; introducing the intervention for eight weeks and measuring the change in performance; terminating the intervention, to test for a relapse in performance and measuring performance for a further four weeks. The intervention and relapse cycle is then repeated. This entire intervention/measurement process is carried out for three categories of activity: scaffolding, access to heights and general housekeeping (site tidiness); whilst a fourth category, personal protective equipment (P.P.E.), is monitored as a control. The interventions are introduced on each category at different times, to try to discount the effect of external factors from the results (Figure 1).

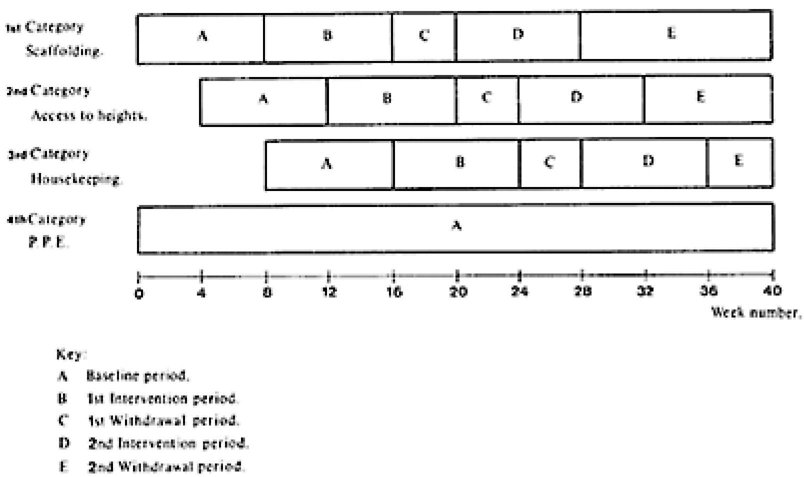


Figure 1. Experimental design.

In addition, all four categories of activity are monitored for the entire period on three other sites in the area, in order to provide a further experimental control dimension.

4. Developing a Safety performance measure.

Developing an objective and quantified method of measurement was achieved by identifying contributory factors in the chain of events which cause accidents. Accidents are caused directly by unsafe behaviour, or indirectly by creating unsafe situations. Conceptually, however, it is recognised that some factors could be construed as both an unsafe act and an unsafe situation. For example, an operative not wearing a safety helmet, is an unsafe behaviourial act, as well as an unsafe situation of an unprotected head.

The criteria for selecting items for inclusion in the measure were that they need to be:

– easily observable, in that items could be observed during a quick safety audit, without specialist equipment;
– clearly defined, in that different observers would record the same for identical situations;
– present throughout the building programme on any site, to reduce the difficulties associated with comparing different types of building project, or different phases of the construction programme.

As far as possible, only situations were included because they are present for a longer time than incidents of unsafe behaviour, which may or may not occur during a safety audit. For example, a ladder not tied securely is a situation. This is different from the equivalent 'snapshot' of behaviour, an operative placing a ladder and not securing it. Using measures containing situations provides a more stable and representative index of site safety performance.

In order to produce a comprehensive list of unsafe items (situations or behaviours), a detailed literature review of construction journals, HSE publications, construction safety manuals and accident records, was undertaken. Initially over two hundred possible items were identified which satisfied our criteria. Seventy-one of these items were then selected as relevant to reported fatal and major injuries (H.S.E., 1988). Seventy-one items were too many to measure at one time, because of cognitive overload for the observers and the excessive time that would be taken to complete each site safety audit. A questionnaire was developed in order to reduce the number of items. For each item the respondents were asked to estimate the frequency of occurrence, the likelihood of an accident occurring as a result, and the probable severity of injury if an accident occurred.

The questionnaire was distributed to 200 operatives undertaking trade courses with the Construction Industry Training Board, 200 site managers undertaking Chartered Institute Of Building site management training courses, and 30 company safety officers from building contractors

One hundred and ninety four questionnaires were completed, a return rate of 47%. The mean values of the three estimates were multiplied to produce the perceived risk level of each item. (Table 1).

Table 1. Perceived risk level formula

example question	frequency× (ex. 10)	likelihood× (ex. 10)	severity= (ex. 6)	total
When operatives are working on scaffolds.				
How often do they work on platforms that are not fully boarded?	6.181			
What is the likelihood that an injury will occur?		5.537		
What would the severity of injury most likely be?			3.963	

TOTAL	135.63

The items were ranked and the 24 highest scoring items incorporated into the safety audit, after field trials indicated that this was the maximum number an observer could measure in an acceptable time. Items were initially categorized under four headings: housekeeping; access to heights; scaffolding; and plant. Minor adjustments were then made to the list so that each category contained six items, and was therefore equally weighted in the overall experimental design. A ‘personal protective equipment’ (P.P.E.) category, was incorporated into the measure when the field trials showed that there were insufficient observations in the plant category to provide a satisfactory measure, despite the high scores from the questionnaire. This suggests that the likelihood and severity of a resulting accident compensates for a low frequency in this category.

A proportional rating scale (Cooper et al, 1991), to record the occurrences of unsafe items, was developed and validated. This scale provides a stable index of site safety performance.

5 Procedure

Independent observers, with no knowledge of the detailed research design, were employed to reduce the likelihood of observer bias. Inter-observer reliability checks were undertaken on a regular basis throughout the duration of the experimental period, and reached a reliability of greater than 96% using the percentage agreement method (Komaki et al, 1978). Observations took approximately 45 minutes on each site and were undertaken three times a week at differing times of the day and week to allow for time of day and week effects.

Site meetings were held prior to the introduction of the interventions to explain to each labour force the research aims and methods. They were also informed of the baseline safety performance level.

A questionnaire containing eight questions aimed at measuring site personnel commitment to the safety goals was devised and administered one week after the introduction of each goal.

6 Results to date

As the research is not yet complete, it has been possible to report only the first experiment of goal-setting and performance feedback. This involved baseline, intervention and withdrawal measures for the first category (scaffolding) on the two experimental sites, on which this intervention was applied.

Site A was a new hospital project, Site B was a medium sized plastics processing plant and conference centre on a greenfield site. Both main contractors provided management control, while all the construction work was by specialist sub-contractors. Goals were assigned to site A and were set participatively for site B at the beginning of each intervention. The results of the subsequent observations were posted on site feedback charts every Monday, except during the withdrawal periods.

The average baseline measure for the previous eight weeks on Site A, for the scaffolding category was 65.0%. A goal of 85.0% was assigned. The commitment to reach this goal measured 67.9% (n=20). After the eight week intervention period the average safety performance level for this category was 68.1%. The average increase, therefore, was 3.1%. The new baseline average during the withdrawal period was 72.5%. Figure 2 shows that the safety performance level increased during the withdrawal period. Analysis of possible reasons will be undertaken when more results are available.

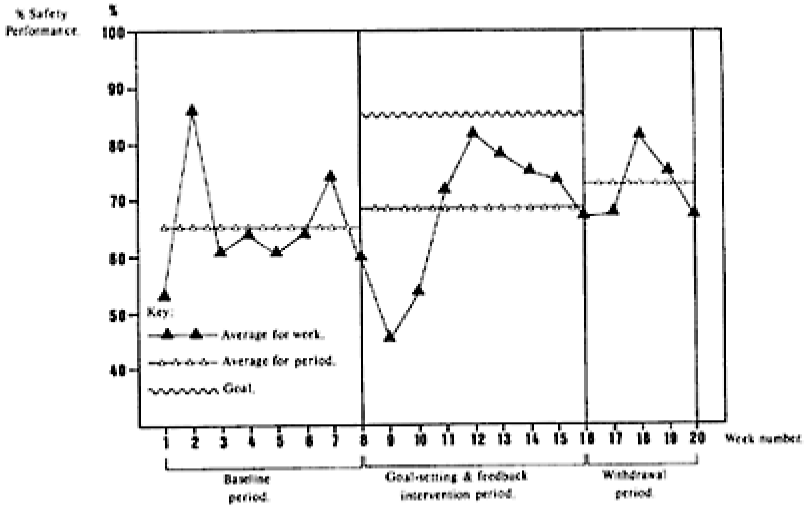


Figure 2. Intervention results of Site A to date.

On this site there has been little commitment from management to the behaviourial programme. This has been demonstrated by: management not attending site meetings when goals have been assigned; the site's Safety Advisor disputing the accuracy of the items measured; the Site Agent refusing to pay for safety work undertaken by the scaffolding sub-contractor who was concerned about the low levels of safety performance being recorded.

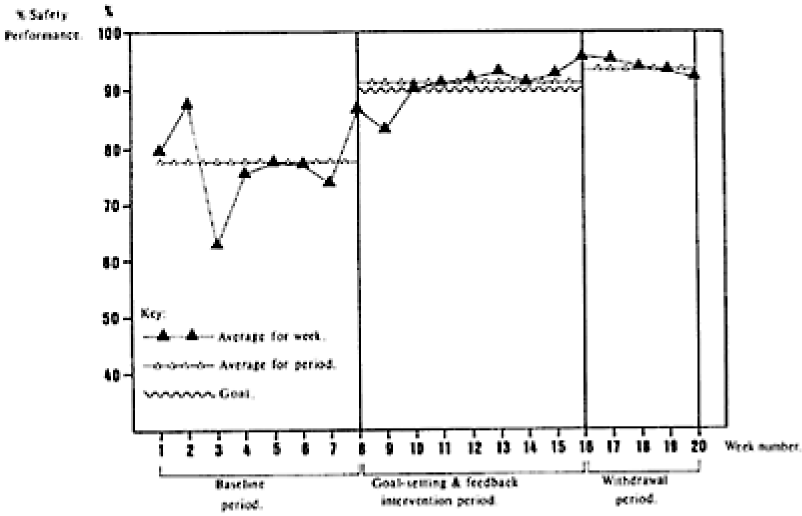


Figure 3. Intervention results of Site B to date.

The average baseline measure for the previous eight weeks on Site B, for the scaffolding category was 77.5%. A target of 90% was participatively set. The commitment to reach this goal measured 87.8% (n=18). After the eight week intervention period the average safety performance level for this category was 91.3%. The average increase, therefore, was 13.8%. The new baseline average during the withdrawal period was 93.6%, and the safety performance level steadily declined during this period (Figure 3).

High commitment of site management to the behaviourial programme was demonstrated by: attending the goal-setting meetings; exhorting the workforce to achieve the goals set; and providing resources to assist the research when requested.

7 Discussion

The safety audit has been demonstrated to be an extremely successful tool in providing objective and reliable measurements of safety performance on construction sites. When this tool is used in conjunction with goal-setting and the posting of performance feedback, safety can be significantly and cheaply improved.

It was expected that site management commitment to implementing this behaviourial approach would be essential for it to be successful (Griffiths, 1985). Some of the observed difference between the two sites may be due to assigning or participatively setting a goal. However, it is likely that much of the difference may be accounted for by managerial commitment.

This research has provided quantitative evidence in support of previous research, showing that positive managerial attitudes are an essential factor in reinforcing safe working practices (Leather, 1987); and that goal-setting is more effective if an authority figure is physically present, supportive and exerts reasonable pressure on subordinates to reach the goals set (Locke & Latham, 1990).

Research is continuing with the introduction of other categories of activity on these and other sites. Much data has yet to be collected, and detailed statistical analyses completed before final conclusions can be determined. Additional results will be available at the conference.

This work is funded by the U.K.'s Health & Safety Executive. The contents of this paper, including any opinions expressed, are those of the authors alone and do not necessarily reflect H.S.E. policy.

8 References

Alegera J.A. (1990). "Feedback system in organizations". In: **International Review of Industrial and Organizational Psychology 1990 vol. 5** (eds C.L.Cooper and I.T.Robertson), John Wiley & Sons Ltd., pp. 169–193.

Borcherding, J.D. & Garner, D.F. (1981), "Work force motivation and productivity on large jobs". **Journal of the Construction Division,** ASCE, Vol. 107, No. C03, pp. 443–453.

Chhokar, J.S. & Wallin, J.A. (1984), "Improving safety through applied behaviour analysis". **Journal of Safety Research,** Vol. 15, pp. 141–151.

Cooper, M.D., Phillips, R.A., Robertson, I.T. & Duff A.R., (1991), "Improving Safety on Construction Sites by the Utilization of Psychologically Based Techniques: Alternative Approaches to the Measurement of Safety Behaviour". Paper given at the 'International work and Psychology Conference, March 1991, Rouen.

Griffiths, D.K. (1985), "Safety Attitudes of Management". **Ergonomics,** Vol. 28(1), pp. 61–67.

Heinrich, H.W. (1959), In: **Industrial Accident Prevention.** 4th ed. New York: McGraw-Hill.

Hinze, J. & Parker, H.W. (1978), "Safety: Productivity and Job Pressures". **Journal of the Construction Division,** ASCE, Vol. 104, No. C01, pp. 27–34.

Hubbard, R.K.B. & Neil, J.T. (1986), "Major-minor Accident Ratios in the Construction Industry". **Journal of Occupational Accidents,** Vol. 7, pp. 225–237.

H.S.E., (1988) "Build Safety", H.M.S.O.

H.S.E., (1990) Annual Report, H.M.S.O.

Komaki, J., Barwick, K.D. & Scott, L.R. (1978), "A behaviourial approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant". **Journal of Applied Psychology,** Vol. 63(4), pp. 434–445.

Leather, P.J. (1987), "Safety and accidents in the construction industry: a work design perspective". **Work & Stress,** Vol. 1(2), pp. 167–174.

Locke, E.A. & Latham, G.P. (1990), **"A Theory of Goal Setting & Task Performance".** Prentice-Hall Int. (UK): London.

McAfee, R.B. & Winn, A.R. (1989) The use of incentives/feedback to enhance work place safety: A critique of the literature. **Journal of Safety Research,** Vol. 20, pp. 7–19.

Peterson, D. (1982), **"Human-error reduction and safety management".** Garland STPM Press.

Reber R.A. & Wallin, J.A. (1984), "The effects of training, goal-setting and knowledge of results on safe behaviour: A component analysis". **Academy of Management Journal,** Vol. 27(3), pp. 544–560.

Reber, R.A., Wallin, J.A. & Chhokar, J.S. (1984) "Reducing industrial accidents: A behaviourial experiment", **Industrial Relations,** Vol. 23, pp. 119–125.

Saarela et al (1989), "The effects of an Information Safety Campaign in the Shipbuilding Industry". **Journal of Occupational Accidents,** Vol. 10, pp. 255–266.

26
The future of construction site robotics in Europe

O.ROLAND

Abstract
A "technical/economic feasibility study of construction site robotics in Europe" funded by the SPRINT Program (ECC-DGXIII) enabled us to determine the assets available in Europe to successfully face international competition, and the perspectives and challenges of R&D and innovation related to them. This paper is intended to specify the results derived from this study in light of strategic and technological challenges.

Keywords: Robotics, Construction, Europe, Research and Development, International Competition.

1 Introduction

At a time when data processing and process automation are penetrating into all economic sectors, building professionals are envisioning the possibilities of construction site robotics. Is it a reliable technology in the near future and compatible with current construction site socio-economic conditions, or is it a research path for uncertain concepts, a carrier of profound changes the impact of which no one can predict?

2 Which robotics?

Several industries have been using robotics for nearly 20 years, but this discipline applied to the construction field is still in the research stage, except for a few rare experimental programs in Japan, the United States, and Europe. They have been covered by media campaigns which are not always scaled to the interest of the innovation: some European construction site machines might more easily be called a "robot" in Japan.

Ethymologically, a robot is a device capable of accomplishing a given function in a totally automatic manner.

It can react to the constraints of its environment without human intervention. Robotization is therefore the ultimate stage of automation, and, in reality, most construction installations under development are only partially automated.

Public works and construction sites are not an ideal environment to robotize elementary tasks at low cost, because they are hardly mechanized compared to other sectors. Construction site robotics are so-called “non-manufacture oriented”: contrary to a manufacturing job in which the robot is used to perform repetitive operations involving precision tasks on perfectly installed objects, the construction field invokes the use of mobile equipment in a badly outlaid and changing environment so that a unique piece of work using elaborated know-how and experience is far from the rule. Therefore, complex robots have been imagined for the construction site. They should be endowed with a high degree of autonomy obtained by resorting either to remote control capability or to analysis and decision-making capability, and have to be equipped with a sophisticated mobility system and sensors.

Diverse studies have defined the functions that these robots could assure in the construction field in the medium term. These functions can be classified into seven principal families:

Handling equipment: advanced telescopic or tower cranes, arms, loaders, dumpers, automated excavators, etc.

Assembly of structures (concrete, wood), building front panels, scaffolding or piping, welding of metal elements, etc.

Bricklaying, tiling, etc.

Finishing work: application of protective coatings, paints, lining, concrete tile polishing, maintenance operations, etc.

Demolition and crushing operations

Drilling of tunnels, canalizations, piles, mines, etc.

Inspection and measurement

3 Two approaches

These potential applications of robotics in the construction field are currently being examined in two different types of studies.

On the one hand, they require a concerted effort on behalf of university researchers and specialists in the robotics field to refine the basic techniques required for the diverse non-manufacturing oriented sectors. Much still has to be done, for example, in data capture technologies on the machine environment, and those problems related to modeling, data processing, and man/machine communication. These problems rapidly augment the complexity of logic and electromechanical devices. They are certainly not insurmountable, but they do require the contribution from a wide range of scientific disciplines and technological transfers between branches. The innovations targeted by these fundamental studies generally concern those sectors in which human intervention is judged impossible: dangerous conditions, polluted atmospheres, hostile environments, submarines, space, etc. The priority of the public works and construction profession in this context has to be organized to facilitate the transfer of technology from the high-technology sectors.

Another approach to implement robotics in the construction field is more pragmatic in scope, and is already yielding encouraging results. Starting from a cooperative effort between construction site materials manufacturers and construction firms, it consists of gradual improving conventional construction equipment. Some process control instrumentation, tele-operation devices, or sensors are already being integrated in traditional equipment to allow the partial automation of certain movements. In the next stage, and in certain cases, the specific “effecters” of construction will be refined and experimented with, that is, the terminal part of the robots performing the task (clamp, hook, nozzle, etc.).

4 R&D policies and actors

4.1 Japan and the United States: the spearheads

Research and experiments conducted in Japan and the United States on the use of robots in the construction field—the structures to be implemented—serve as milestones to pinpoint European potentialities in the research and development of robotics for construction.

In Japan the issue of old age and the lack of a young and skilled work force served as criteria more than a decade ago to initiate an imposing R&D policy that has now moved this country to the forefront of innovation.

In 1979 the Japanese government sponsored a research program worth two million Ecus regarding the use of robots in construction and building maintenance.

Since 1984, the ACT project (Advanced Construction Technology) replaced the 1979 program, and the government allocated 14 million Ecus to fund it. The leading construction firms and materials manufacturers are working in tandem in a tight knit collaborative effort.

In addition, thanks to in-house R&D funding, the public works and construction leaders are investing in remote control projects, and even partial automation of certain equipment linked to:

the manufacture, transport, and implementation of concrete (smoothing, laying, and pouring concrete into forms);

the assembly and welding of metal beams;

the assistance provided by power-driven tools (automatic unslinging capability on tower cranes, to be shortly marketed by Obayashi Gumi);

the drilling of tunnels;

the dismantling of nuclear power plants;

the mobilization of government and private public works and construction corporate funding in a straightforward logic approach is significant of the Japanese commitment to “international excellence based on technological superiority and independence in all the phases of construction”.

Today, Japan is the world’s technological innovative engine in two fields linked to control engineering and robotics:

tunnelers and micro-tunnelers

on-line process control in the manufacturing industry.

And, if Japan wasn’t up to 1985 a great exporting country, the Japanese industry has scored some non-negligible successes: renovating London, engineering a new Turkish city, building smart buildings in Stuttgart, etc.

In the United States, engineering firms and enterprises are using and developing equipment comparable to robots for the laying of roadway pavements and sidewalks or drilling tunnels.

More fundamental research seems to be emerging from U.S. universities. Carnegie-Mellon is spearheading this commitment. Since 1983, it has its own applied robotics institute for construction and a civil engineering robotics laboratory.

In-depth research is currently being conducted on robot mobility problems to take into account the random and variable environment of the construction site.

Like in Japan, dangerous work conditions are being given privileged research status in the development of robots. These particularly dangerous work conditions concern underground or submarine workareas, as well as jobs where toxic materials are involved (cleaning tanks, radioactive products).

For applications closer to public work and construction operations, the principal R&D avenues concern the remote control of “conventional” construction site machines and equipment related to earthwork (excavation, embankment, compaction), drillwork with obstacle detection, identification of buried networks (telephone lines, canalizations) and natural obstacles (tree roots, etc.).

First, major U.S. assets include its formidable industrial power in the manufacture of large-scale equipment in the public works and construction field (John Deere, Caterpillar, Ford, Case), which allow them to develop in an approach adapted to the specific features of the public works and construction field innovative, semiautomatic equipment and machines (remote controlled and/or telemanipulated).

Second, the U.S. has an important intellectual pool in fundamental research inside its major universities. The U.S. university community also is on excellent terms with enterprises and manufacturers.

Finally, although the international community is trying to get its second wind in light of the Japanese offensive, the computer industry is the third U.S. asset. The potential applications of data processing to the construction site are numerous. Already Bechtel Software is marketing “Walkthru”. This “process simulation” software product has the capability of allowing the user, once a building is described, to walk through it, and simulate and display the movements of the men, the equipment, and the machines in order to optimize handling and assembling operations. The interconnection of this type of software to public works and construction equipment on a construction site will open in the medium term the path to Construction Site Computer Aided Production Management (CSCAPM). Already more powerful software packages are being developed in the U.S. and Japan.

4.2 Europe: fragmented riches

Compared to the United States and Japan, Europe has a technological level equivalent in applied and fundamental research, financial and structural resources, and developments in the automation and robotization of the public works and construction sector.

However, this technological wealth is unequally distributed among the different countries of Europe and in a sense is fragmented.

In addition to this inequality, Europe is enveloped in a diversity of approaches corresponding to diverse methods of investigation that have originated and make reference to different local socio-technological contexts, as well as the most specific national organizational and structural logic rationales.

The first European pole, composed of Northern European countries, has developed an ergo-technological research driving force which is based on this group's Scandinavian roots.

Among the different countries composing it, Sweden appears in the public works and construction sector to be both a pioneer and a leader in this commitment to innovation.

Sweden, with a population of 8 million, is the only country (among those surveyed) conducting fundamental research, but even more so applied research, and is making inroads on the four levels of mechanization specifying the work to be done on the construction site:

the human engineering of manual tasks

the ergotechnology of hand-held and electro-portable tools (power-driven aid systems)

partial automation (essentially by remote control) of public works and construction equipment and machines

total automation, robotization of construction site equipment.

The special features of its institutional social system and permanent level of negotiations and interaction between the professional actors derived from it provide assets capable of coping with the competitive world arena.

Germany is the second European country capable of claiming the right to share in the world leadership coveted by the Japanese and the Americans in research resources, that is, the industrial assets linked to construction site (and also shop) production tools. It alone represents the second European pole.

This leadership is based on high-level structural, financial, and technological resources.

Germany's public research organization is based on two large, semi-private, operational institutions:

the Max Planck Gesellschaft (MPG), specialized in fundamental research.

the Fraunhofer Gesellschaft (FHG), specialized in applied research.

But hidden behind this federal research organization are local centers or institutes through which are funneled the majority of research funds. They cover all of Germany.

Then there are the manufacturers who represent the second asset of Germany. Capable of competing with the U.S. and Japan on an industrial and commercial level, the German equipment industry has sourced a wide range of technological applications linked to the automation of construction site machines.

For the rest of the countries, and if globally accounted for, the implemented R&D resources appear to be in Europe at a level comparable to that of the U.S. or Japan. However, these resources are far too dispersed.

As a result, sometimes the same activities are duplicated by two or more member countries of the European Community and then paid for two or more times.

It should be noted that a comparative study of R&D policies reveals that the Northern European approach to a gradual automation and mechanization of construction sites is closer to the reality of public works and construction than certain strong-willed partners intent on having it hurtle an inapplicable industrial technological threshold.

The Northern European countries with the best R&D assets are those with the best levels of synergy between the actors: universities, national research organizations, professional centers, public works and construction tool and equipment manufacturers, construction firms, and unions (professional workers and laborers).

This is the case for Sweden, the Netherlands, Germany, and, to a lesser extent, the United Kingdom.

5 Robotics in perspective

The perspectives of control engineering and robotics appear to be quite different depending on whether they concern the Public Works sector or the Construction sector.

In the Construction field, short-term perspectives are practically concentrated in the concrete sector: concrete manufacture, transport, and delivery to the construction site, and usage on the site.

In the rest of the field, medium-term perspectives look good for most of the applications and should pose no major technical problems (CADAM, shop NCTE, microelectronics onboard construction site equipment and machines).

In contrast, some serious economic problems due to cost overruns averaging 30 percent or more have been reported.

Some systems such as NCTE represent a considerable capital investment (60 000 to 70 000 Ecus) when compared to the investments made by most of the small- and medium-size industries and artisan shops in the public works and construction field.

In the Public Works field, automatic applications or robotics (non-manufacturing oriented applications) already are prevalent in some specific forms: equipment for intervention in hostile environments or those inaccessible to man; tunnelers, laser-based identification and measurement systems, asphalt spreaders, etc.

On a timely basis, and for exceptional sites, public works and construction works (like bridges, viaducts, etc.) offer the possibility of fine tuning the specific equipment and machines corresponding to a unique usage (see “Tunnelers”).

In this framework, financial and economic criteria are of minor importance compared to the technical imperatives of intervention and implementation.

In the medium term, 10–15 years from now, some of the construction site’s heavy-duty equipment and machines should be totally automated. This will be achieved through an ongoing logic process based on the progressive enhancement of these machines by electronic components experiencing a strong expansive trend. On the other hand, mechanical and hydraulic components will drop in relative value as the electronic enhancement advances.

Automation will especially concern public works equipment and machines for highly repetitive activities or those invoking a linear work process. They represent only 10–15 percent of the revenues earned in the public works and construction sector.

Considering the development perspectives in control engineering and robotics applied to public works and construction sites as described above, two avenues of development may be envisioned.

The first avenue passes by way of an active policy encompassing technological, social, and cultural transfers.

The second avenue passes by way of a community policy embodying the management of innovation at the EEC level and more globally for Europe, corresponding to the short- and medium-term R&D objectives (5–10 years).

The perspectives for mechanization, automation, and even the robotization of public works and construction sites offer two new potential avenues in light of transfer dynamics:

either from country to country (see Table 1) within the EEC framework, obviously, but more extensively for Europe as a whole (to take into account the particular interest that Scandinavia represents);

or from sector to sector (see Table 2), according to the centers of interest specific to public works and construction, and taking into account this sector's concrete needs.

The second European development avenue linked to the mechanization, automation, and robotization of public works and construction sites concerns Research & Development and Innovation (RDI).

Under this heading we include the management of innovation projects for the elaboration of new public works and construction equipment, machines, and materials, or the enhancement by a higher degree of technology that may be incorporated in the new machines.

Eight major themes could be defined (see Table 1) as the most promising carriers in the European Plan for the Innovation involving the mechanization, automation, and robotization of public works and construction sites.

What they have in common is that they will be achieved through projects lasting probably 5–10 years, depending on whether the projects are "simple" or "complex" in nature. Based on this distinction, they will not implicate the same Innovation management challenges and constraints. Simple projects should prove helpful from a local and regional viewpoint for independent inventors of small- and medium-sized Public Works and Construction firms, industries and artisan shops to express their ideas and develop their projects. Complex projects will necessarily implicate the mobilization and federation of resources and skills on the European level.

Table 1. Diagram of the desirable actions of technology transfers and innovation partnerships in Europe about perspective of mechanisation and automatisation on construction sites

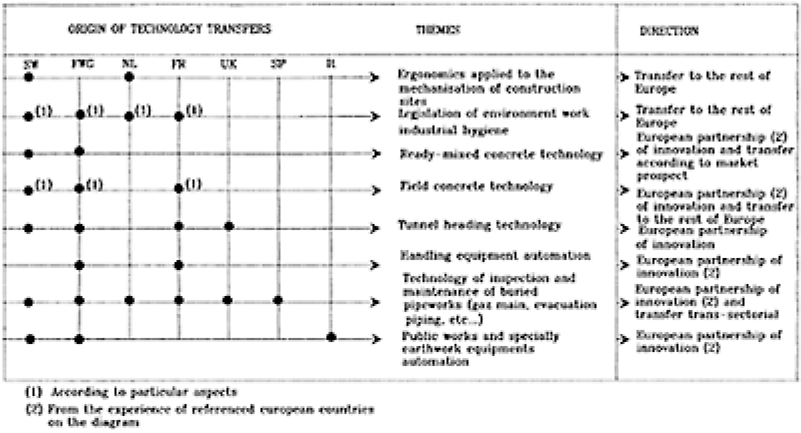
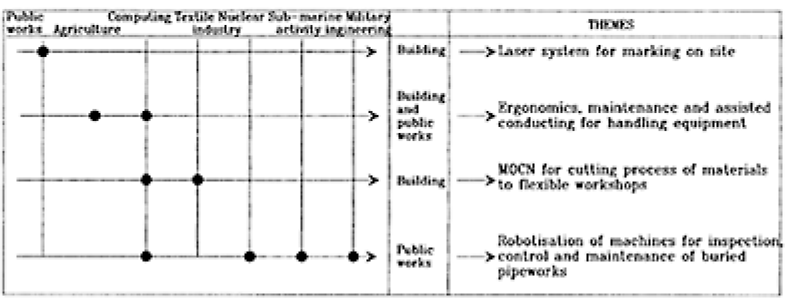


Table 2. Diagram of desirable actions of trans-sectorial transfers of technology to construction



27
Cash flow planning for housing and other building projects

S.SINGH and L.GANESHAN

Abstract
This paper outlines the alternative methods for cash flow projections and situations under which each should be used for accuracy of predictions. It also establishes the need to develop separately, the standard S-curves for each category of building projects. It further illustrates the parameters affecting cash flow from the client's, contractor's and developer's point of view and presents the magnitude of their effect on maximum cash flow and cost of overdraft.

1 Introduction

Efficient management of construction resources is of great importance to clients, contractors and developers in the construction industry. Efforts are therefore made for almost all medium and large sized projects to plan and control the resources even though revisions are made from time to time during the execution of projects.

Amongst all the resources finance (money) is the most important resource since from the contractors' considerations more construction firms appear to fail through lack of liquidity than do so by inadequacy of planning and control of other resources (Cooke Jepson, 1979).

Broadly there are two alternative approaches based on which financial or cash flow projections, for a given project, can be worked out viz. planning techniques and standard S-curves (Cooke & Jepson, 1979; Singh & Phua, 1983). S-curves are empirical relationships between percentage of value and percentage of time, however, in certain countries instead of percentage of value, percentage of cost has been used (Drake, 1978; Hudson, 1978; Peer, 1982; Sidwell & Rumball, 1982). In the application of S-curves for cash flow projections, the need for appropriate curves has been emphasised for better predictions (Singh & Phua, 1983, 1984). Several attempts have been made to develop softwares for cash flow projections owing to the need of their repetitive use. Further, using the software, attempts have been made to study the magnitude of effect of various parameters on maximum cash flow and cost of overdraft (Singh, 1989, 1990).

This paper outlines the alternative methods for cash flow projections and lays down situations under which each should be used for accuracy of predictions. It also establishes the need to develop, separately, the standard S-curves for each category of building projects. It further discusses the parameters affecting cash flow from different view points and presents the magnitude of their effect on maximum cash flow and cost of overdraft.

2 Alternative methodologies

Broadly, there are two alternative methods to plan the financial resource viz: 1) using planning techniques such as bar charts, network techniques etc or 2) using standard S-curves established through historical cost information of past completed projects (Singh, 1990).

Studies have shown that 8–12 percent of projects are completed at or better than the stipulated completion time (Bromilow, 1969; Singh & Sofat, 1977, 1981). In other words, 88–92 percent of the projects have taken more than the stipulated time for their completion. It has been further shown that the magnitude of additional time taken over the stipulated time varies to as high as 160 percent while the average value for the projects considered varies between 10–60 percent, the average for overall being 30 percent. Under this situation, to whatever accuracy a master program is developed, it cannot form a proper basis for projecting cash flow.

Bromilow and Henderson (1974) first published the value-time relationship based on historical records of completed projects. It was republished later in an updated report (Bromilow and Henderson, 1977). In other countries, forms of the cumulative S-curves have also been derived but with cost as a function of time (Drake, 1978; Peer, 1982; Sidwell and Rumball, 1982).

More comprehensive work has subsequently been carried out in the Republic of Singapore (Singh & Phua, 1983, 1984) on S-curves. Some of these results are shown in Tables 1 to 3. These clearly indicate the need to establish S-curves for different categories of buildings and for projects in the public and private sectors.

3 Accuracy of predictions

As far as accuracy is concerned, the comparison made (Singh, 1988) has indicated that both alternative methods can give comparable results. A series of comparison of results between the actual and computer-predicted cash flow has indicated a difference in the range of ±3% to ±12% between the corresponding values of cash flow for the projects considered (Singh, 1989). Overall it has been emphasised that in the case of time-targeted projects, the cash flow projections can be based on the master program developed for the project while in all other cases, appropriate standard S-curves can be used for cash flow projections.

4 Computer Softwares

Microcomputers and mathematical modelling have proved to be an excellent combination in developing programs to simplify cash flow determination. Efforts have therefore been made in different countries to develop programs for cash flow projections (Balkau, 1975; Ashley & Teicholz, 1977; Bromilow, 1978, 1982; Peer, 1982; Puri & Jain, 1984; Singh, 1987; Tarakoli, 1988; Tucker & Rahilly, 1982, 1989; Kenley & Wilson, 1989). Most of these models are based on standard S-curves using historical information of completed projects. In addition, there are also other softwares which are being marketed commercially such as ARTEMIS, TIMELINE, HARVARD PROJECT MANAGER, PMS II, MICROPERT etc. These use a program of activities along with their resources for cash flow projections.

5 Parameters affecting cash flow

The various parameters which affect the cash flow for a given project vary depending upon the need for which the projections are to be made ie whether for a client, a contractor or a developer. The cash flow for a client is affected by contract conditions such as stipulated completion time, frequency of payments, rate of retention etc. For a contractor, in addition to the contract conditions, credit conditions such as frequency of payment to suppliers, subcontractors etc also affect the cash flow. In the case of a developer, the earlier cash inflow from sale of units also need to be considered in the cash flow projections.

5.1 Magnitude of effect

The effect of credit conditions (Table 4) and various rates of profit/overheads (5–20 percent) on maximum cash flow requirement and cost of overdraft at 10% interest for a commercial building project costing $20 million and with completion time 20 months is illustrated in Table 5. The specific month in which the maximum cash flow is required for each credit condition is also shown.

Table 6 gives the effect of different credit conditions and varying completion time on maximum cash flow/cost of overdraft for a commercial building project costing $20 million. The range of variation in time has been restricted to ±20 percent over and above the usual stipulated time for such a sized project.

The effect of different sizes of projects ($5–50 million) on maximum cash flow/cost of overdraft considering a commercial building project is illustrated in Table 7 while Table 8 shows the effect of building types for a specific credit condition.

5.2 Observations

Considering the extreme credit conditions (ie 1 and 8, Table 4) and any specific percentage of profits/overheads for the given project, the maximum cash flow varies substantially and in terms of percentage the variation is in the order of 191 to 298 percent, the higher figure being for greater value of profit/overheads. For example, the maximum cash flow needed for extreme credit conditions varies between $1.985–3.784 million when the profit/overheads is 5 percent while the corresponding figures are $0.645–1.922 million when the latter is 20 percent.

The effect of different credit conditions and completion time (Table 6) for the illustrated project indicate that, considering any specific credit condition and a 20 percent variation in the normal completion time, it can vary the maximum cash flow requirement by about 18–20 percent, the higher value being for a reduced completion time.

The effect of different sized projects on cash flow (Table 7) shows that the maximum cash flow required to execute the project varies between 9.7 to 23.5 percent of the value of the project, the higher percentage being for small sized projects. The trend for the cost of overdraft is however reverse viz. the cost of overdraft, in terms of percentage of the project size, is directly proportional to the value of the project. The effect of building type on maximum cash flow (Table 8) shows an interesting observation viz. for the illustrated project, the maximum cash flow required varies substantially depending upon the building type. The variation in the cash flow requirement can be as high as 36 percent. This emphasises the need to establish 'S' curves for different categories of projects depending upon the type of buildings unlike the present practice of using the same curve for projecting the cash flows of different building, types.

5.3 Sensitivity analysis

Sensitivity analysis was carried out with the object to assess the magnitude of effect of specific change (10%) in the value of variables on cash flow/cost of overdraft for commercial buildings. A medium size project costing $10 million was considered for this analysis and the variables investigated were profit/overheads, completion time, size of project and interest rate. The results are shown in Table 9. The results show that among the variables considered, the variable which has the most severe effect on percentage change in maximum cash flow is size of project. Whereas next in order are completion time and profit/overheads. As far as cost of overdraft is concerned, the order is different viz. size of project, interest rate, profit/overheads and completion time.

6 Concluding remarks

There is a great need to select an appropriate methodology for cash flow projections for a given project. Further the standard S-curves should be established for different categories of projects and separately for projects in the public and private sectors.

Effects of different variables, demonstrated in various tables provide a good appreciation to the construction organisation. However, it is recommended that such organisations should acquire suitable software so that exact information needed can be worked out with ease, speed and accuracy.

Table 1. Percentage value of work done at different stages of contract period for piling work

Type of building	Value of work done (%) in contract period		
	First-third	Middle-third	Last-third
Commercial buildings	37	31	12
Industrial buildings	53	31	16
Residential buildings	60	30	10

Table 2. Percentage value of work done at different stages of contract period for overall project (excluding piling work)

Project type/ features	Contract period		
	First-third	Middle -third	Last-third
Commercial buildings with basements value of work done (%)	11	28	61
Without basements value of work done (%)	35	47	18
Industrial buildings value of work done (%)	27	46	27
Residential buildings value of work done (%)	22	40	38

Table 3. Performance features of housing projects in public and private sectors based on mean value-time curve, overall project

Projects	Public Housing			Private Housing		
	Period			Period		
	First-third	Middle-third	Last-third	First-third	Middle-third	Last-third
Percentage of work executed	40	42	18	22	40	38

Table 4. Credit conditions considered for investigation

Credit condition designation	Percentage of retention (Escrow)	Frequency of payment to	
		Material Suppliers	Subcontractors

1	10% of value of interim payment subject to maximum of 10% of contract value	Once a month	Once in two weeks
2	10% of value of interim payment subject to maximum of 10% of contract value	Once in two months	Once in two weeks
3	10% of value of interim payment subject to maximum of 10% of contract value	Once in three months	Once in two weeks
4	10% of value of interim payment subject to maximum of 10% of contract value	Once in three months	Once a month
5	10% of value of interim payment subject to maximum of 5% of contract value	Once a month	Once in two weeks
6	10% of value of interim payment subject to maximum of 5% of contract value	Once in two months	Once in two weeks
7	10% of value of interim payment subject to maximum of 5% of contract value	Once in three months	Once in two weeks
8	10% of value of interim payment subject to maximum of 5% of contract value	Once in three months	Once a month

Table 5. Effect of credit conditions and profit/overheads on maximum cash flow/cost of overdraft for a commercial building project costing $ 20 million and completion time 20 months

Credit* Condition	Profit/ Overheads (%)	Maximum Cash Flow		Cost of overdraft at 10% interest
		Amount ($million)	Required in month	($million* 10^{-1})
1	5	3.784	19	3.625
2	5	3.272	18	3.240
3	5	2.814	18	2.874
4	5	2.133	18	2.377
5	5	3.550	18	3.416
6	5	3.039	18	3.030
7	5	2.635	17	2.668
8	5	1.985	17	2.172
1	10	3.106	18	3.038
2	10	2.169	18	2.670
3	10	2.181	18	2.325
4	10	1.470	17	1.685

5	10	2.903	17	2.849
6	10	2.464	17	2.481
7	10	2.090	17	2.159
8	10	1.470	17	1.685
1	15	2.489	18	2.521
2	15	2.023	18	2.169
3	15	1.628	17	1.852
4	15	1.035	17	1.400
5	15	2.370	17	2.362
6	15	1.951	17	2.031
7	15	1.593	17	1.736
8	15	1.011	16	1.303
1	20	1.922	18	2.064
2	20	1.514	17	1.748
3	20	1.172	17	1.464
4	20	0.645	16	1.048
5	20	1.882	17	1.947
6	20	1.480	17	1.635
7	20	1.137	17	1.390
8	20	0.645	16	1.007

* Refer Table 4

Table 6. Effect of credit conditions and varying completion time on maximum cash flow/cost of overdraft for a commercial building project costing $ 20 million

Credit* condition	Completion time	Maximum cash flow+		Cost of overdraft at 10% interest
		Amount ($million)	Required in month	($million* 10^{-1})
1	16	3.114	15	2.428
1	18	2.768	16	2.474
1	20	2.489	18	2.521
1	22	2.228	20	2.567

1	24	2.048	21	2.613
2	16	2.522	15	2.075
2	18	2.268	16	2.122
2	20	2.023	18	2.169
2	22	1.825	29	2.125
2	24	1.667	21	2.261
3	16	2.085	14	1.753
3	18	1.835	16	1.804
3	20	1.628	17	1.852
3	22	1.472	19	1.901
3	24	1.332	20	1.948
4	16	1.326	14	1.301
4	18	1.151	15	1.351
4	20	1.035	17	1.400
4	22	0.932	18	1.447
4	24	0.848	20	1.495
5	16	3.019	14	2.284
5	18	2.626	16	2.322
5	20	2.370	17	2.362
5	22	2.105	19	2.397
5	24	1.945	20	2.431
6	16	2.486	14	1.955
6	18	2.136	15	1.995
6	20	1.951	17	2.031
6	22	1.740	18	2.064
6	24	1.599	20	2.096
7	16	2.050	14	1.679
7	18	1.782	15	1.708
7	20	1.593	17	1.736
7	22	1.439	18	1.767
7	24	1.297	20	1.809
8	16	1.291	14	1.227

8	18	1.151	15	1.257
8	20	1.011	16	1.303
8	22	0.932	18	1.343
8	24	0.848	19	1.386

Refer Table 4
Project profit/overheads 15%

Table 7. Effect of different project sizes on maximum cash flow/cost of overdraft considering commercial building project**

Project Size	Credit* Condition	Completion Time	Maximum Cash Flow		Cost of overdraft at 10% interest
($ million)		(Months)	Amount ($ million)	Required in month	($ million* 10^{-1})
5	1	12.5	1.174	12	0.655
10	1	15.0	2.005	14	1.404
15	1	17.5	2.623	16	2.175
20	1	20.0	3.106	18	3.038
25	1	22.5	3.499	20	3.951
30	1	25.0	3.831	22	4.903
35	1	27.5	4.469	24	5.720
40	1	30.0	4.584	27	6.999
45	1	32.5	4.620	29	8.010
50	1	35.0	4.833	31	9.324

**Profit/overheads 10%
*Refer Table 4

Table 8. Effect of building type on maximum cash flow/cost of overdraft for a building project costing $ 10 million and completion time 15 months

Building type	Credit* condition	Maximum cash flow+		Cost of overdraft at 10% interest
		Amount ($million)	Required in month	($ million* 10^{-1})
Commercial	1	1.676	14	1.202
Residential	1	1.130	11	1.063

Industrial	1	1.060	7	0.893
Educational	1	0.896	6	0.881

* Refer Table 4
+Project profit/overheads 15%

Table 9. Sensitivity analysis of the effect of variables on maximum cash flow/cost of overdraft for commercial building project

Variable	Magnitude of change in the value of variable (%)	Effect of change of value of variable on percentage change: in	
		Maximum cash flow ($ million)	Cost of overdraft at 10% interest ($ million* 10^{-1})
Profit/overheads	10	5.55	4.74
Completion time	10	9.13	1.80
Size of project	10	10.00	10.00
Rate of interest	10	Nil	10.00

Note:	The basic project considered for working out the above table had the following features:		
	Estimated cost	–	$ 10 million
	Completion time	–	15 months
	Profit/overheads	–	15%
	Contract/credit condition	–	1 (Refer Table 4)

7 References

Ashley, D.B. and Teicholz, M. (1977) Pre-estimate cash flow analysis. **ASCE Journal-of the Construction Division,** Vol. 103, No. C03, pp. 369–379.

Balkau, B.J. (1975) A financial model for public works programmes. **Proceedings of the National Australian Society for Operations Research Conference, Sydney,** pp. 180–197.

Bromilow, F.J. (1969) Contract time performance—expectations and the reality. **Building Forum,** Vol. 1, No. 3, **pp.** 70–80.

Bromilow, F.J. (1982) The FINPLAN system for planning and controlling programs of capital works. **Proceedings of CSIRO/NCRB National Conference on Programming Capital works for Australian Public Authorities.**

Bromilow, F.J. and Henderson, J.A. (1977) Procedures for reckoning and valuing the performance of building contracts **CSIRO Division of Building Research, Special Report.**

Cooke, B. and Jepson, W.B. (1979) **Cost and financial control for construction firms.** The Macmillan Press.

Drake, B.E. (1978) A mathematical model for expenditure costing post contract. **Proceedings of the CIB W-65 Second International Symposium on Organisation and Management of Construction,** Haifa (Israel), pp. 163–183.

Hardy, J.V. (1970) **Cash flow forecasting in the construction Industry.** M.Sc. Dissertation. Dept of Civil Engineering, Loughborough University of Technology, England.

Hudson, K.W. (1978) DHSS expenditure forecasting model. **Chartered Quantity Surveyor,** No. 5, pp. 42–45.

Kenley, R. (1986) **Construction project cash flow modelling.** Ph.D. Thesis. University of Melbourne Australia.

Kenley, R. and Wilson, O.D. (1989) A construction project net cash flow model. **Construction Management and Economics,** Vol. 7, pp. 3–18.

Mackay, I.E. (1971) **Cash flow forecasting by computer.** M.Sc. Dissertation. Dept. of Civil Engineering, Loughborough University of Technology, England.

Peer, S. (1982) Application of cash flow forecasting models. **ASCE Journal of the Construction Division,** Vol. 108, No. C02, pp. 226–232.

Puri, N. and Jain, M.L. (1984) Project Cash flow forecasting. **Proceedings of the Conference on High Rise Construction Techniques and Management for the 1990's.** CIB 84, Singapore, pp. 198–211.

Sidwell, A. and Rumball, M.A. (1982) The prediction of expenditure profiles for building projects. **Building Cost Techniques: New Directions** (ed P.S.Brandon), E & F.N.Spon, London, pp. 324–328.

Singh S. (1990) Factors affecting the contractor's cash flow and their sensitivity for housing projects. **Proceedings of the XVIII IAHS World Congress—Building the Future,** Rio de Janeiro (Brazil), pp. 431–447.

Singh S. (1989) Sensitivity analysis of the effect of variables on cash flow for construction projects. **Proceedings of the PMI International Conference on Project Management—The International Language,** Atlanta (USA), pp. 21–29.

Singh S. (1989) Developing a computer model for cash flow planning. **Cost Engineering,** Vol. 31, No. 11, pp. 7–11.

Singh S. (1988) **Cash flow planning in the construction industry.** School of Building and Estate Management, National University of Singapore, Singapore, Unpublished report.

Singh S. (1987) Financial resource planning of high rise building projects. **Proceedings of the CIB W-65 International Symposium on Organisation and Management of Construction,** London (England).

Singh S.and Phua, W.W. (1984) Financial planning for high rise housing projects. **Proceedings IAHS Congress on Housing,** Miami (USA), pp. 121–128.

Singh S.and Phua, W.W. (1983) Cash flow trends for high rise building projects. **Proceedings of the International Symposium on Organisation and Management of Construction,** Waterloo (Canada), pp. 841–854.

Singh S.and Sofat, G.C. (1977) Comparative performance study of different building contracts. **Indian Concrete Journal,** Vol. 51, pp. 61–70.

Singh S.and Sofat, G.C. (1981) A quantitative investigation of the comparative performance of building contracts. **Proceedings of the International Symposium on Organisation and Management of Construction,** Dublin (Ireland), pp.431–443.

Tarakoli, A. (1988) Construction project cash flow analysis. **Cost Engineering,** Vol. 30, No. 3, pp. 18–20.

Tucker, S.N. and Rahilly, M. (1982) A single project cash flow model for a microcomputer. **Building Economist,** pp.109–115.

Tucker, S.N. and Rahilly, M. (1988/89) A construction cash flow model. **Australian Institute of Building Papers, 3, 1988/89,** pp. 87–99.

28
A multivariate approach to optimal bidding

R.M.SKITMORE and J.PEMBERTON

Abstract
A multivariate approach to optimal bidding strategy is presented. An optimal formulation is derived and a method of parameter estimation proposed.

Key Words: Bidding Strategy, Multivariate Analysis, Optimal Bidding

1 Introduction

Friedman's (1966) first formulation for optimal bidding has been criticised as demanding unrealistic amounts of data to estimate the model parameters. Hanssmann and Rivett (1959) partially solve this by reducing the number of parameters in the model and thus the data demands, but with loss of predictive power. Multivariate methods offer a means of better utilisation of all available data, depending on the adequacy of certain assumptions concerning the statistical properties of bids. Recent empirical studies (Skitmore, 1991) indicate that, with suitably transformed data, these assumptions may not be unduly violated in construction contract auctions. This paper considers the use of one such multivariate approach for deriving optimal mark up values against both single and multiple competitors.

2 A multivariate approach

Profit depends on the mark up value, v. A low mark up increases the chance of acquiring a contract, but with little profit, while conversely a high mark up gives a larger profit, but with little chance of acquiring the contract. We propose a model for the probability of obtaining a contract as a function of bid, x, or equivalently, v. Since v=x/c where c is the cost estimate, we can choose an additive formulation if we work on a log scale.

If for a particular contract, x_i, i=1, 2…, n are the (log transformed) bids, treated as continuous random variables with joint probability density function $f(x_1,\ldots, x_n)$ then

$P(x_1<x_i, i\neq 1)=$

$$\int_{y_1=-\infty}^{\infty}\int_{y_2=y_1}^{\infty}\int_{y_3=y_1}^{\infty}\cdots\int_{y_n=y_1}^{\infty} f(y_1 y_2 y_3 \ldots y_n)\,dy_n \ldots dy_3\,dy_2\,dy_1 \qquad (1)$$

where f(…) is the joint probability density function of the n bids (n is assumed to be known).

Now assuming the variables are ***independent,*** it follows from (1) that $\Pr(y_1<y_i$ for all i, $i\neq 1)=$

$$\int_{-\infty}^{\infty} f1(y_1)\left\{\prod_{i=2}^{n}\int_{y_i=y_1}^{\infty} f_i(y_i)dy_i\right\}dy_1 \tag{2}$$

In the case of the Normal distribution, $\Pr(y_1<y_i$ for all i, $i\neq 1)=$

$$\int_{-\infty}^{\infty}\frac{e^{-\frac{y_1^2}{2}}}{\sqrt{2\pi}}\left\{\prod_{i=2}^{n}\int_{y_i=\frac{\sigma_1 y_1+\mu_1-\mu_i}{\sigma_i}}^{\infty}\frac{e^{-\frac{y_i^2}{2}}}{\sqrt{2\pi}}dy_i\right\}dy_1 \tag{3}$$

For the special case where $f_1(y_1)=f_2(y_2)=\ldots f_n(y_n)$

$\Pr(y_1<y_i$ for all i, $i\neq 1)=1/n$

(4)

3 Optimal bidding

Empirical analysis (Skitmore, 1991) suggests that bids may be adequately modelled by

$$y_{ij} \sim N(\alpha_i+\beta_j,\sigma_i^2) \tag{5}$$

where yij=1n(xij−mx(1)j) and 0.5<m<0.9 (x(1)j being the value of the lowest bid entered for the contract). The simplifying assumption of independence is still maintained and so all we need do is replace μi in (3) by $\boldsymbol{\alpha_i+\beta_j}$. The probability of bidder 1 entering the lowest bid now becomes

$$\int_{-\infty}^{\infty}\frac{e^{-\frac{z_1^2}{2}}}{\sqrt{2\pi}}\left\{\prod_{i=2}^{n}\int_{z_i=\frac{\sigma_1 z_1+\alpha_1-\alpha_i}{\sigma_i}}^{\infty}\frac{e^{-\frac{z_i^2}{2}}}{\sqrt{2\pi}}dz_i\right\}dz_1 \tag{6}$$

as the $\boldsymbol{\beta}_j$ values cancel.

A further assumption is that applying a mark up multiplier of v to x_1 affects the mean in (5) by an amount of v’. Then the probability of entering the lowest bid becomes

$$P(v)=\int_{-\infty}^{\infty}\frac{e^{-\frac{y_1^2}{2}}}{\sqrt{2\pi}}\left\{\prod_{i=2}^{n}\int_{y_i=\frac{\sigma_1 y_1+\alpha_1+v'-\alpha_i}{\sigma_i}}^{\infty}\frac{e^{-\frac{y_i^2}{2}}}{\sqrt{2\pi}}dy_i\right\}dy_1 \tag{7}$$

where

$$v'=E[\mathbf{ln}(vx_{1j}-mx_{(1)j})]-E[\mathbf{ln}(x_{1j}-mx_{(1)j})] \quad (8)$$

which can be estimated by

$$\frac{1}{n_1}\sum_{j=1}^{c} d_{1j}\{\mathbf{ln}(vx_{1j}-mx_{(1)j})-\mathbf{ln}(x_{1j}-mx_{(1)j})\}$$

where c =total number of contracts

d_{ij} =1 if bidder i bids for contract j 0 otherwise

n_i $= \sum_{j=1}^{c} d_{1j} =$ number of contracts in which bidder i bids

Since we have assumed log-normality, v' is also given by

$$v'=\mathbf{ln}\left\{\frac{E[vx_{1j}-mx_{(1)j}]}{E[x_{1j}-mx_{(1)j}]}\right\}$$

which can be estimated by

$$\mathbf{ln}\left\{\frac{\sum_{j=1}^{c}(vx_{1j}-mx_{(1)j})}{\sum_{j=1}^{c}(x_{1j}-mx_{(1)j})}\right\}$$

if it were true that

$$E[X_1j]=E[X_{(1)}j]$$

then the relationship (still under log-normality) simplifies to

$$v'=\mathbf{ln}\left(\frac{v-m}{1-m}\right)$$

Our objective is to find the mark up v^* to maximise expected profit. Since profit can be taken as zero for those contracts which we do not win, we need to compute

$$E[x_1|win]-A \quad (a)$$

where A is the (unknown, but assumed fixed, actual cost). From Bayes formula, we have the conditional distribution of

$$z_1=\frac{y_{1j}-\mu_1}{\sigma_1}$$

(a standardised, transformed bid), given that the contract is won, given by

$$p(z_1|win)=\frac{p(win|z_1)p(z_1)}{p(iwin)} \qquad \text{(b)}$$

and P(win) is simply the normalisation constant given by (7). Thus we can interpret the integrand in (7) as

$$p(z_1)=\frac{e^{-\frac{z_1^2}{2}}}{\sqrt{2\pi}} \qquad \text{(c)}$$

the density of z_1, and

$$p(win|z_1)=\prod_{j=2}^{n}\left\{\int_{z_j=\frac{\sigma_1 z_1+\alpha_1+v'-\alpha_j}{\sigma_j}}^{\infty}\frac{e^{-\frac{z_j^2}{2}}}{\sqrt{2\pi}}dz_j\right\}dz_1 \qquad \text{(d)}$$

Hence

$E[x_{1j}|win]$

can be computed by writing x in terms of z_1 and averaging over the distribution of (b). Specifically

$$x_{1j}=e^{\sigma_1 z_1+\alpha_1\beta_j+v'}+mx_{(1)j}\,.\,e^{\alpha_1+\beta_j}\,.\,e^{v'}\,.\,E\left[e^{\sigma_1 y_1}|win\right]+m_{(1)}$$

The point of writing the expression in this form is that $\boldsymbol{\alpha}_1$, $\boldsymbol{\beta}_j$ and $mx_{(1)}$ are constants which do not affect the optimisation wrt v. Hence to maximise (a) wrt v, we need only maximise

$$\frac{e^{v'}}{p(v)}\int_{-\infty}^{\infty}\frac{e^{\sigma_1 y_1}}{2\pi}\,.\,e^{-\frac{y_1^2}{2}}\left\{\prod_{j=2}^{n}\int_{y_j=\frac{\sigma_1 y_1+\alpha_1+v'-\alpha_j}{\sigma_j}}^{\infty}e^{-\frac{y_j^2}{2}}dy_j\right\}dy_1$$

The $e^{\alpha 1 y1}$ can be absorbed into

$$e^{\frac{-y_1^2}{2}}$$

resulting in a shift of the lower limits of integration for the Y_j's so that we maximise

$$\frac{e^{v'}}{p(v)}\int_{-\infty}^{\infty}e^{-\frac{y_1^2}{2}}\left\{\prod_{j=2}^{n}\int_{y_j=\frac{\sigma_1 y_1+\sigma_1^2+\alpha_1+v'-\alpha_j}{\sigma_j}}^{\infty}e^{-\frac{y_j^2}{2}}dy_j\right\}dy_1$$

4 Parameter estimation

For the purposes of parameter estimation, we use the model

$$\mathbf{1n}(x_{ij})=y_{ij}\sim N(\boldsymbol{\alpha}_i+\boldsymbol{\beta}_j,\ \boldsymbol{\sigma}_i)^2 \qquad (9)$$

where $\boldsymbol{\alpha}_i$ is a bidder location parameter, $\boldsymbol{\beta}_j$ is a contract datum parameter, and $\boldsymbol{\alpha}_i+\boldsymbol{\beta}_j=\boldsymbol{\mu}_{ij}$. This requires the solution of

$$y_{ij}=\alpha_i+\beta_j+e_{ij} \qquad (10)$$

where e_{ij}if $N(0,\sigma_i^2)$

The log-likelihood is

$$\mathbf{1n}L=-\sum_{i=1}^{r}\frac{n_i\mathbf{1n}\sigma_i^2}{2}-\frac{1}{2}\sum_{i=1}^{r}\frac{1}{\sigma^2}\sum_{j=1}^{c}\delta_{ij}(y_{ij}-\alpha_i-\beta_j)^2 \qquad (11)$$

Where $\boldsymbol{\delta}_{ij}$ =1 if bidder i bids for contract j

=0 if bidder i does not bid for contract j

$$n_i=\sum_{j=1}^{c}\delta_{ij}$$

The MLL over $\boldsymbol{\alpha}$'s, $\boldsymbol{\beta}$'s and $\boldsymbol{\sigma}^2$ is

$$\frac{\delta\mathbf{1n}L}{\delta\beta_j}=\sum_{i=1}^{r}\delta_{ij}\frac{y_{ij}-\alpha_i-\beta_j}{\sigma_1^2}=0$$

$$\rightarrow\beta_j=\sum_{i=1}^{r}\delta_{ij}\frac{y_{ij}-\alpha_i}{n_i} \qquad (12)$$

$$\frac{\delta\mathbf{1n}L}{\delta\alpha_i}=\frac{1}{\sigma_i^2}\sum_{j=1}^{c}\delta_{ij}(y_{ij}-\alpha_i-\beta_j)=0$$

$$\rightarrow\alpha_i=\sum_{j=1}^{c}\delta_{ij}\frac{y_{ij}-\beta_j}{n_i} \qquad (13)$$

$$\frac{\delta\mathbf{1n}L}{\delta\sigma_i^2}=-\frac{n_i}{2\sigma_i^2}+\frac{1}{2\sigma_1^4}\sum_{j=1}^{c}\delta_{ij}(y_{ij}-\alpha_i-\beta_j)^2=0$$

$$\rightarrow\sigma_i^2=\sum_{j=1}^{c}\delta_{ij}\frac{y_{ij}-\alpha_i-\beta_j}{n_i^2} \qquad (14)$$

The procedure involves initialising all $\boldsymbol{\alpha}_i$=0 and iterating (12) and (13) to convergence. The estimates of σ_i^2provided by (14) are adjusted for bias by the approximation

$$\sigma_i^{2'} = \sigma_i^2 \frac{n_i}{(n_i - 1)\left(1 - \frac{c-1}{N-r}\right)} \tag{15}$$

where

$$N = \sum_{j=1}^{c} n_i$$

For computational purposes it is unnecessary to introduce once only bidders, $n_i=1$, until after convergence of the iteration procedure. Convergence is taken to have occurred when the largest change in estimated value of any α_i in consecutive iterations is less than ϵ_* where ϵ_* is small (a value of 10^{-7} is appropriate for most cases).

5 Conclusion

A new method has been described for the extraction of optimal mark up values in contract bidding by means of a multivariate model. Parameter estimates are obtained by method of maximum log likelihood. The method can easily be extended to situations where the contract size, identity or number of bidders are uncertain

The work described is part of research programme, currently funded by the UK Science and Engineering Research Council, to extend the mark up based system described in this paper into a full bidding decision support system tailored to the specific needs of construction companies.

The authors are indebted to Mike Patefield and Ernest Wilde of the University of Salford, Department of Mathematics, and Roy Thomas of the University of Salford, Department of Civil Engineering for their kind help and major contribution to the early theoretical development of the research.

6 References

Friedman, L. (1956) A Competitive Bidding Strategy. **Operations Research,** 1, No 4, 104–12.

Hanssmann, F and Rivett, B H P. (1959) Competitive Bidding. **Operational Research Quarterly,** 10, No 1, 49–55.

Skitmore, R M., (1991) Some Tests on the Contract Bid Homogeneity Assumption. **Construction Management and Economics,** in print.

29
Strategic core changes in Turkish construction firms

Z.SÖZEN

Abstract
The present paper argues that an examination of contractual settings and of the contracting process is necessary to redefine the assumptions about construction firms. The paper briefly focuses on recent work on the theory of the firm, interpreting the strategic core concept for the construction firm. The need to redefine strategic paths within a context of contracts and to analyze the implications of transaction-specific practices is emphasized.
Keywords: Construction Firm, Strategy, Strategic Core.

1 Introduction

The overall thrust of the present paper is that the construction firm is a specific entity, deserving special treatment within the realm of organizational theory.

The construction firm exists in a network of contractual relationships and in a project context. Recently there has been considerable interest in the firm as a “dyad” and the “nexus of contracts” or “treaties” in which the firm operates.

In the treatment of the construction firm, the crucial issue seems to be the contractual context and the formation of contractual links. The crucial issue, defined as such, leads to another one, namely that of formation of policies to deal with uncertainty.

2 Contractual relationships and organization theory

According to Stinchcombe (1985), organization theory is not very well prepared to deal with project administration. Firms operating within a project context are not easy to define with a purely organizational theory outlook. Williamson (1990) remarks that the orthodox approach to the theory of the firm is to describe it as a production function and a monad. The firm, on the other hand, operates in a contractual setting and therefore, in a network of dyadic relationships.

The theory of the firm has recently been modified by transaction costs theory (Williamson, 1975, 1985) and agency theory (Jensen and Meckling, 1976; Fama, 1980; Hart and Holmstrom, 1987). These new theories focus on the contract as a basic construct.

These recent developments have clear implications for the analysis of the construction firm and the explanation of organizational features that matter for organizational outcomes.

The major implication is in terms of boundary definition. It has been suggested that boundaries determine the points at which an organization interacts with the environment (Thompson, 1967). According to Reve (1990), properties of the transaction determine the efficient boundaries of firms.

In the case of the construction industry, subcontracting, is a specific response pertaining to the issue of organizational boundaries. This in turn brings the issues of internal governance, strategic alliances (bilateral governance) and market governance. It has also been suggested that there is an intermediate contracting mode used by construction firms based on a set of stable relatinships between the main and the subcontractor (Eccles, 1981).

3 The construction firm and the strategic core

The strategic core of the firm has been defined as the “raison d’etre” of the firm. The core is represented by “assets of high specificity” (Reve, 1990, p. 140) necessary to attain the firm’s strategic goals. Within this context, organizations focus on defining their strategic core skills, which differentiate the organization from competing organizations and which delineate the firm’s competitive advantages.

The construction firm defines its strategic core and the relevant skills within a network of treaties or contracts. A major issue for the construction firm is how to protect the strategic core to maintain its competitive advantages.

Competition in the building industry is largely dependent on bidding success, which influences the definition of strategic core skills. It is natural that contractual settings should evoke different strategic responses and core skills for the organization. Networks of contracts create a need to focus on contractual core skills, e.g. contract preparation, bidding or contract administration.

As mentioned earlier, the construction firm not only needs to define its core, but to maintain its competitive position. Thompson (1967), has discussed ways of buffering the technological core from environmental threats and disturbances. In the case of the construction firm, buffering mechanisms also reflect the influence of a predominant contractual setting. Subcontracting is a widely used practice in the construction industry and functions as a buffering mechanism protecting the technological core from environmental disturbances. The functions of subcontracting have been extensively discussed elsewhere (Sözen, 1990) and will not be further treated within the scope of the present paper.

What is important is that adaptations are built into contractual relationships and this is one of the major features that characterize the construction firm.

4 Strategic core shifts in Turkish construction firms

But how exactly do contractual settings evoke different strategic responses?

> The major issues in strategy consideration are:
> Choice of products or services.
> Choice of markets (territories and clients).
> Choice of functions.

When the initial choice of products, markets and functions are defined, then, it is possible to talk of strategic alternatives. A firm may choose to change its business definition by expanding or narrowing the scope of its products, markets or functions. It may alternatively decide to maintain its existing definition. These options outline the basic grand strategies, expansion, retrenchment and stabilization.

An expansion strategy is implemented by a redefinition of the firm's business—either by adding markets or functions or by accelerating the current business. There are some difficulties in defining an expansion strategy for a construction firm: First, the construction firm is always faced with a new project that is unique and that has owner determined specifications. It is difficult to predict the nature of future workload and input requirements. The terms of a contractual relationship are renegotiated for every new project (Eccles, 1981).

Expansion strategies of Turkish contractors in the late 70's were accompanied by decisions about functional changes. Entry into the Middle East and North African markets meant changing roles for many main contractors. While the firm expanded by moving into a new market, it narrowed its functional scope by acting as a subcontractor.

On the other hand, entry into a new market meant focusing on strategic core skills, especially those termed "dedicated assets" or "specialized investments" by Reve (1990, p. 140). These particular core skills were transaction-specific, geared to obtain a particular transaction, e.g. bidding skills, contract preparation and contract administration.

The saturation of the Middle East market and legal changes, like the Mass Housing Act, making the home market relatively more attractive were the environmental constraints on strategic changes. In this case, however, what is interesting is that retrenchment strategies were accompanied by functional changes into main contractor roles for some firms. Abandoning a market territory meant a broadening of functional scope.

5 Suggestions for further research

Mechanisms to manage the boundaries of organizational activity are shaped by strategic orientations as well as internal properties.

Specifically, the strategic orientation of a construction firm is also related to contractual settings. Strategic paths are accompanied by changes in the contractual habits of the firm.

A redefinition of grand strategy alternatives within a context of contracts would be significant for the insight it may bring to the issue of organization-environment interface. Transaction-specific devices may serve different functions for different strategic paths. There is a need to analyze the implications of transaction-specific practices for strategic alternatives. This includes redefinition of alternatives, precise operationalization of relevant variables and empirical testing of predictions.

6 References

Eccles, R.G. (1981) The Quasifirm in the construction industry. **Journal of Economic Behavior and Organization,** 2, 335–357.

Fama, E. (1980) Agency problems and the theory of the firm. **Journal of Political Economy,** 88, 288–307.

Hart, O. and Holmstrom, B. (1987) The theory of contracts, in **Advances in Economic Theory** (ed. T.Bowley), Cambridge University Press, Cambridge.

Jensen, M. and Meckling, W. (1976) Theory of the firm: Managerial Behavior, Agency, Costs and Capital Structure, **Journal of Financial Economics,** 3, 305–60.

Reve, T. (1990), The firm as a nexus of internal and external contracts, in **The Firm As a Nexus of Treaties** (eds M.Aoki, B.Gustaffson and O.Williamson), Sage Publications, London, pp. 133–161.

Sözen, Z. (1990) Subcontracting policies and strategies of construction firms, in **Management of the Building Firm** (eds V.Ireland, D.Cheetham, D.Miller, J.Soderberg) University of Technology, Sydney, pp. 510–520.

Stinchcombe, A.L. (1985) Project administration in the North Sea, in **Organization Theory and Project Management** (eds A.L.Stinchcombe and C.A.Heimer), Norwegian University Press, Oslo, pp. 25–120.

Thompson, J.D. (1967) **Organizations in Action,** New York: McGraw-Hill.

Williamson, O. (1975) **Markets and Hierarchies: Analysis and Antitrust Implications,** New York: Free Press.

Williamson, O. (1985) **The Economic Institutions of Capitalism,** New York: Free Press.

Williamson, O. (1990) The firm as a nexus of treaties, an introduction, in **The Firm as a Nexus of Treaties** (eds M.Aoki, B.Gustaffson and O.Williamson), Sage Publications, London, pp. 1–25.

30
Data flow within Portuguese contractors' organizations

J.M.CARDOSO TEIXEIRA, A.A.BEZELGA and A.H.TYLER

Abstract
The importance of construction project management on the behalf of the contractors has been widely recognized. Management Functions should be performed in the scope of a global system thus leading to an integrated approach for project management. However, lack of integration has been reported in the literature and existant solutions for this problem are not fully satisfactory. The paper presents the results of two inquiries made to the Portuguese construction industry. Usual procedures for estimating and planning are reported and reasons for the lack of integration are suggested.

Key-words: Estimating, Bills of Quantities, Planning, Control, Integration, Contractors, Project Management, Inquiries.

1 Introduction

The importance of contractors in construction projects is widely recognized. Construction projects typically pass through the following phases:

The concept/design phase.
The construction phase.
The utilization phase.

Unless for self-construction, the contractors' participation is normally restricted to the construction phase of the projects. For the aims of this study, it is assumed that the construction phase of a project begins when the client requests for an offer to build up a specific facility. Therefore, it is admitted that a contractor becomes involved in a project if he/she decides to submit an offer for it. Subsequently, the tendering stage begins Very often, the participation of a contractor in a project does not go further than the tendering stage. Actually, most of the offers submitted fail. Sometimes, this is an expected result but in other occasions companies were looking forward to carrying out the project but their offers were not selected. However, if the contract is awarded, companies are expected to remain involved in the project as long as its execution lasts. After commitment, companies face a production problem.

Construction project management on the behalf of the contractors includes a great number of activities which should conform to their objectives throughout their participation in the projects. These activities may be organized into managemnet functions.

Project planning, project cost estimating and project control are three commonly accepted management functions. They have a crucial importance from the contractors' perspective because they concern two cornerstone issues, time and costs. They will further be referred to as planning, estimating and control, the project environment being implicit.

Therefore, in what contractors are concerned, the above management functions may be understood as distinct yet evolutionary inter-related processes throughout their participation in the project.

The paper refers to a survey made to the Portuguese construction industry and aims to show contractors perform planning, estimating and control preparation management functions. This is a part of a research programme addressing integration topics among those functions. The programme is being carried in Portugal (Universidade do Minho and Instituto Superior Técnico) and in UK (Loughborough University) and it is supported by INIC. Partial results of this work are used hereafter.

2 Research method

Data was collected from a set of selected construction companies. This was achieved by means of two inquires both supported by questionnaires which were administered directly to each selected company during a set of interviews to their staff [1]. The basic characteristics of the inquires are summarized below.

	Approach	Objectives	Sample
1st INQUIRY	INTERVIEW	DETAILED	5
2nd INQUIRY	INTERVIEW	SPECIFIC	21

2.1 Detailed inquiry to 5 Portuguese construction companies

The following objectives of this inquiry will be discussed:

(1) To survey how companies perform planning and estimating management functions.
(2) To identify data needed to accomplish the tasks included in those functions and data generated.
(3) To survey the degree of integration achieved between those functions and there relations to control.

Ten companies were selected in the first place. Three of them were surveyed during the pre-inquiry stage and other two were later excluded. The remaining five were successively approached and surveyed.

The document used to carry out the inquiry was composed by a set of questions, a set of subjects to be discussed and a set of presentation and connection texts between questions and subjects. The general structure of the document is as follows:

1. FIRST CONTACT WITH THE COMPANY

2. PRODUCTION MANAGEMENT

2.1 General characteristics of the company

2.2 Company organization

2.3 Field of activity

2.4 Management of the construction projects

3.	ESTIMATING	4.	PLANNING5.		5. CONTROL
3.1	General Characteristics	4.1	General Characteristics	5.1	General Characteristics
3.2	The way it is made	4.2	The way it is made	5.2	The way it is made
3.3	Comments	4.3	Comments	5.3	Comments

The questionnaire was mainly composed of open questions thus providing a complete discussion about each subject.

The conclusions of the inquiry are summarized below:

(1) Estimates are generally based on a bill of quantities purchased by the client.
(2) Unit rate estimating is extensively used.
(3) Tender planning is normally made but accuracy is low.
(4) After commitment estimating and planning functions are sometimes refined aiming to prepare production.
(5) Control mostly refers to cost control of the items of the bill of quantities.

Following the above conclusions, it was decided to enlarge the sample and to survey some of the preceding topics more throroughly.

2.2 Specific inquiry to 21 Portuguese construction companies

The following objectives of this inquiry will be discussed:

(1) To survey the methods used to perform planning, estimating and control management functions.
(2) To check the usefulness of an integrated approach.

Companies were selected according to the following rules:

(1) They are either contractors or sub-contractors.
(2) Construction management functions are taken care by of specific staff.

(3) They use to work in the North of the country.
(4) They were interested and willing to participate in the inquiry and they accept further contacts.

Small companies seldom have a sufficiently organized structure in the sense of the second selection criterion above. Therefore, it was decided to select companies from the universe of those with more than 50 employers. This corresponds to a specific class of the Portuguese official statistic data [3]. According to the figures available, 668 of these companies are active in all the country. However, some are not construction companies in the sense of the first selection criterion and probably others do not fit other criteria. Thus, instead of a pure random approach, some direct knowledge of the author was also used to select the sample. About the third selection criterion, it is related to the need to limitate geographically the scope of the inquiry. Initially, thirty companies were selected but only 21 were eventually surveyed.

The general structure of the document used to carry out the inquiry is as follows:

1. CONTACT WITH THE COMPANY AND GENERAL CHARACTERISTICS.
2. ESTIMATING, PLANNING AND CONTROL PROCEDURES.
3. INTEGRATION APPROACH.

In a way, the inquiry reported in section 2.1 was used as a pre-inquiry for this one.

The conclusions of this inquiry reasonably agree with those from the previous one. Moreover, the following findings should be referred to:

(1) Bills of quantities are heavily utilized by the industry.
(2) Unit rate estimating is generally used to support building projects cost calculations whereas operational estimating is most common for civil engineering projects.
(3) Construction activities bear a closer relation to the items of the bills of quantities for civil engineering projects than for building projects.
(4) Detailed planning usually includes labour requirements for each activity; major plant requirements are generally included by civil engineering contractors and to a lesser extent by building contractors; materials purchase is however less common.
(5) Integration among management functions is harder to achieve in building projects than in civil engineering projects.
(6) Unit rate estimating and scheduling are currently supported by computer packages.

3 Summary and conclusions

The results of two inquiries made to Portuguese construction companies were presented. The small number of companies selected for the first inquiry allowed for a detailed study of estimating, planning and control management functions. Afterwards, that study was used in a specific inquiry to a larger number of companies. The dimension of the sample when compared with the universe from which it was extracted shows that a significant number of companies was surveyed (over 3%).

The findings shows that companies use a traditional approach for construction project management functions [4]. However, integration is not satisfactorily achieved, although it is closer for civil engineering projects than for building projects. It seems that the following obstacles to integration apply to building projects:

(1) The form and complexity of the bill of quantities.
(2) The nature of unit rate estimating.

An effort should be made to achieve integration between estimating and planning but modifying usual procedures could possibly be unacceptable for the industry. Therefore, usual methods should be improved and solutions for integration should be found within the traditional procedures.

References

[1] JAVEAU, C. (1978) **L'enquête par questionnaire. Manuel a l'usage du practicien.** Editions de l'Université de Bruxelles.
[2] SANTOS, F. (1988) **Entrevistar. A teoria e a prática.** Livros Plátano de Formação Profissional, Lisboa.
[3] INE (1988) Instituto Nacional de Estatística **Estatísticas da Construcão e da Habitação.**
[4] McCAFFER, R. and PASQUIRE, C. (1988) **The interchange and Use of Data by contractor's management functions.** International Journal of Construction Management & Technology 2.4.

31
An integrated data management system for house builders

A.THORPE and R.McCAFFER

Abstract
This paper describes an operational integrated data management system for a house building organisation. The system was designed to aid the estimating, purchasing, valuations and cost monitoring functions of the company, The system details, and the advantages offered by the system are discussed.

Keywords: Data Management System, Estimating, Purchasing, Valuations, Cost Monitoring.

1 Introduction

It has been argued that the profitability of a construction project is ultimately determined by the management of the site. Site management involves many activities including managing the domestic labour, managing the sub-contract labour, liaising with the clients' representatives, organising the materials and plant required for the project and numerous associated activities.

In this context the late ordering (and subsequent late delivery) or the double-handling of materials are regarded as bad management practices which waste time and result in a loss of profit. However in the contractors' head-office the double-handling of data is commonplace and the same information, in different guises, may be created or captured many times by several separate departments. This may be due to departments being insular and unaware of the data available in other departments, but more usually results from a mistrust of data which they have not created or captured themselves, or the fact that the data may not be in the form which they can readily use.

If the information flows can be streamlined by integrating the various management functions, thus increasing the exchange of common data, more efficient management could be achieved.

This gain in efficiency would be evident in terms of:

faster throughput of information;

greater consistency of information; and
better communication (at all levels) between the various members of the functional departments.

The obvious method of streamlining and integrating data transfer between the various departments is by means of a computerised or computer-aided system.

The use of a computer-aided system also allows greater analysis of the available data, thus giving better quality management information.

This paper describes the development of such a system for a housing development company. The system was designed to support the estimating, purchasing, valuations and cost monitoring functions of the company The system details and the benefits offered by the system are briefly outlined in the following sections.

2 The Basic Requirements

The basic requirements were that the system should support the four key functions as follows:

ESTIMATING—should allow the estimator to price a phase, plot by plot and produce a summary for each phase.

PURCHASING—the buyer should be able to extract aggregated quantities for purchasing from the estimate and maintain purchasing records.

VALUATIONS—the surveyor's monthly progress figures should be captured on a tick sheet and using data from the estimate, monthly valuations produced which could be compared to the invoiced accounts.

COST COMPARISONS—the purchasers' rates should be compared to the amounts allowed in the estimate.

While the user sees these four functions as representing 'the system' there is implicitly another element which is the software to create, edit and maintain a set of company files containing data on: SPECIFICATIONS; MATERIALS SUPPLIERS and SUB-CONTRACTORS; MATERIALS PRELIMINARIES and SUB-CONTRACT ITEMS; DETAILS OF STANDARD DWELLINGS; DETAILS OF ADDENDUMS TO DWELLINGS; PHASE DETAILS and VALUATION STAGES. These files and the supporting software were named the COMPANY DATA SUB-SYSTEM.

Figure 1 shows the relationship between the company data and the phase data.

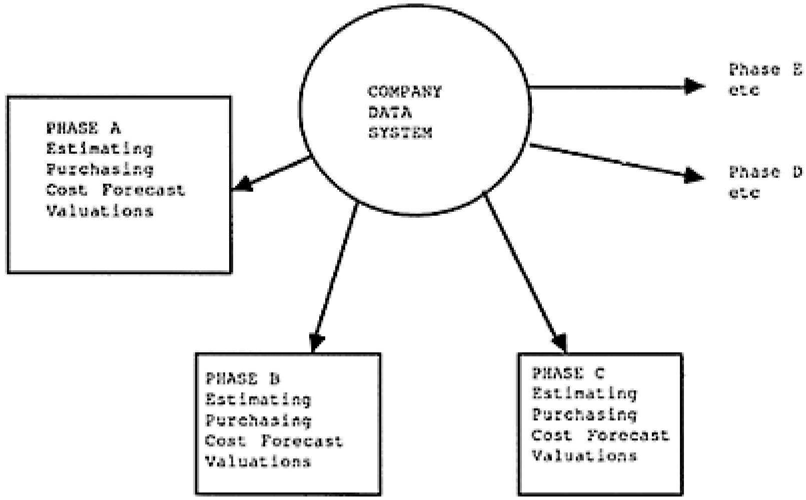


Figure 1: The Company Data and Phase Data

2.1 The company data sub-system

This is a suite of programs which creates, edits and manages the following company data files:

The Specification File which contains specifications for each item contains specifications for each item contained in a house (eg work below DPC; drainage services; load bearing walls; sanitary fixtures and fittings etc). A total of 99 main categories with up to 300 sub-headings are available. The following example is typical of an entry from the company's main specification file:

Specification: S04.01

LOAD BEARING WALLS

Cavity Walls: 265mm facings and Hemelite U1 blocks or 250mm of two block skins. Tile hung walls always cavity construction. Plus 50mm Rockwool batts in cavity.

SCHEDULE REF. 01.000 BRICKS, BLOCKS ETC

Item Code	Description	Units
01.001/S04.01/C04.00	FACINGS IN HB SKIN	TH
01.002/S04.01/C04.00	FACINGS IN HB GARAGE PROJECTION	TH
01.003/S04.01/C04.00	FACINGS IN 225×225 ISOLATED PIERS	TH

01.004/S04.01/C04.00	FACINGS IN 225×328 ISOLATED PIERS	TH
01.005/S04.01/C04.00	FACINGS IN 328×328 ISOLATED PIERS	TH

Figure 2: Extract from Typical Item Schedule

The Suppliers File which contains names, addresses and telephone numbers of materials suppliers and subcontractors. This is split into three groups: labour only; labour and material; and material only suppliers with up to 400 of each contained in the file.

The Items File which contains a library of 80 schedules with up to 600 items each. Examples of schedules are: bricks and blocks; stressline lintels; main roof construction; external doors; etc. Examples of items within the schedule ‘Bricks and Blocks’ are: facings in half brick skin; 100mm blocks and internal walls; 225×225 air grills; etc. Each item code has an associated specification and cost code. An extract from the items file is given in Figure 2.

The Standard Dwellings File contains details of the standard dwellings which are represented by a group of item codes together with the quantities of each item. A total of 99 house types can be accommodated.

The Dwellings Addenda File contains details of amendments in the form of additions to standard house types. These comprise extra or replacement items and quantities.

The Phase Details File contains details for each active development phase. The details comprise general phase details such as: site address; start and finish dates; agents name; etc together with a list of plot numbers, their associated dwelling types and purchaser’s name. The Valuation Stages File. There are 30 cost headings such as: ready mix concreting; bricks; frames; etc. Within each cost heading there are up to 30 sub-divisions, eg within the heading ‘Frames’ example sub-divisions are: ‘ground floor’; ‘first floor’; ‘linings (G.F.)’; ‘trusses’; etc. The stages and sub-divisions form the cost code to which each item is allocated. This allows the formation of the valuation details.

The link between these data is achieved through the codes used to identify each element. The following example is typical of an entry form from the items file:

Item Code	Description	Units
01.003/S04.01/C04.00	Facings in 225×225 Isolated Piers	TH

The first pair of digits in the code refers to the ‘schedule’ into which the item is classified. There are 80 schedules covering all aspects of building undertaken by the company. The three additional figures following the decimal point identify the individual item within the specified schedule.

In the above example, the schedule reference is 01—BRICKS, BLOCKS; the item is .003—FACINGS IN 225×225 ISOLATED PIERS.

Against each item code in the file is stored the relevant specification code for the item and the relevant valuations cost code. In the above example these are S04.01 and C04.00 respectively.

The details of a dwelling are held in the STANDARD DWELLINGS FILE against a dwelling code as follows:

374/H/FF

Linked to the dwelling code are a sub-set of item codes which together comprise this specific house type.

2.2 Estimating

The purpose of the ESTIMATING sub-system is to produce a budget estimate for a phase using data from the Company Data Files and price inputs from the estimator. The estimator is required to price each item in the dwelling, a price given to an item in a dwelling is subsequently applied to the same item in all other dwellings in the phase. The estimator is also required to enter data for overheads, inflation and profit.

The estimator may add, change or delete any of the data relating to items, specifications, or dwelling details for his particular phase without disturbing the data in the Company Data Files.

The system produces a budget summary containing summaries of all costs and quantities for each plot in the phase.

2.3 Purchasing

The purposes of the purchasing sub-system are to calculate the aggregate quantities for purchasing and keeping purchasing records.

The purchasing system for each phase will aggregate the item quantities from the estimate to produce the totals to be ordered together with the purchasing specification. This provides the basis for sending out enquiries.

The buyer is required to enter against each purchased item the amount to order, the purchase price or rate, the discount, the order date and the supplier or subcontractor reference.

The buyer has facilities for amending the specification and item details. The output the buyer can obtain is:

> aggregated quantities for all items within a phase; aggregated quantities for all items within selected combinations of dwelling types within a phase; and the purchase record comprising:

– a list of all items in a phase;
– the associated aggregated quantities;
– the amount of each item the buyer will order (and hence the item wastage);
– the latest purchase rate for the item;
– the date of last order/rate;
– the amount ordered to date;

– the item discount allowed by the supplier;
– the cumulative item cost;
– the supplier code for the item.

An example of this record is shown in Figure 3.

PURCHASING—SCHEDULE PRICING								
SCHEDULE 01 BRICKS, BLOCKS ETC								
Item Code 01.021 100 BLOCKS IN INTERNAL WALLS Units: M2 Wastage: 13. 6%								
Code	Ag. Quan.	Tot .Ord	Rate	Ordered	Date	Disc	Cum. Tot.	Supplier
01.001	128.3	130.0	115.00	130.0	02.03.88	0.0	14650.0	MA12355
01.002	20.5	20.0	112.00	20.0	02.03.88	0.0	2240.0	
01.003	22.1	22.0	112.00	22.0	02.03.88	0.0	2464.0	
01.004	10.8	0.0	0.00	0.0		0.0	0.0	

Figure 3: Extract from the Purchasing Record

DEVELOPMENT:		VALUATION			TYPE:		365/G/GG/		
PHASE: LOUGHBOROUGH		MONTH:		MAY 88		NO OF UNITS			4
04.00 BRICKS:		Plot Nos							
Cost	Code+Detail	Value	100	106	107	109	VWD	MoS	VMoS
01	fndn	846	100	100	100	100	4653	0	0
02	1st lift	1553	60	20	10	100	2951	0	0
03	2nd lift	1376	0	10	0	100	1514	0	0
04	3rd lift	1574	0	20	30	20	1102	0	0
05	4th lift	1311	0	0	0	0	0	0	0

Figure 4: Extract from Monthly Valuation Sheet

2.4 Valuations

The valuation sub-system aggregates the value (ie the estimator's costs, overheads and profit) of the items within each cost division, using the third element of the item code. This produces a table of plot numbers against the cost codes showing the value of each cost code within the estimate.

A tick sheet is printed on which the surveyor can use on site to record monthly progress. When the data from the surveyor's tick sheet are entered the monthly valuations are produced.

Figure 4 shows an example of a monthly valuation sheet as produced by the system. This forms the tick sheet for next monthly valuation.

The valuation sub-system using data on invoices from accounts also compares the monthly valuations with the invoiced amounts.

2.5 Cost monitoring

The purpose of the cost monitoring sub-system is to compare estimated costs with actual cost and to produce an analyses of the difference. The comparison produced, on an item by item basis, is the purchase rate with the estimated rate.

The data for each of these comparisons are derived from the 'estimate' and the 'purchaser's records'.

Figure 5 shows a cost comparison sheet.

COST FORECAST/COMPARISON					LOUGHBOROUGH Inflation=3.%		
ITEM CODE	CURRENT PURCHASE RATE	CURRENT PURC HASE FORE CAST	ESTIM ATED RATE	ESTI MATE FORE CAST	ESTI MATE FORECAST & INFL	DIFF ERENCE EST-FOR	DIFF ERENCE +INF
01.001	115.00	14650.	125.00	17640.	18240.	2990.	3590.
01.002	112.00	2240.	120.00	2701.	2793.	461.	553.
01.003	112.00	2464.	120.00	2912.	3011.	448.	547.
01.004	0.00	0.	120.00	1426.	1474.	1426.	1474.

Figure 5: An Extract from the Cost Comparison Sheet

3. Benefits of the System in Use

3.1 Estimating sub-system

The estimating sub-system is the greatest source of data for the other functions after the company data library. It is therefore central to the whole system and vital for data integration between the functions.

However its prime purpose is to produce accurate and timely phase budget estimates. In addition, it allows much greater flexibility in tailoring the company standard data to suit a particular development and reworking the budget at the adjudication stage. This is because of the ability to quickly change unit rates, overhead allocations, dwelling details or even the dwelling mix to achieve the target figure required.

3.2 Purchasing sub-system

The purchasing sub-system offers three advantages over the manual methods. Firstly, it allows the creation and maintenance of a file of material suppliers and subcontractors. This enables the rapid retrieval of suppliers and sub-contractors' details either by supplier type (ie labour only, materials only or labour and materials) or by geographical area.

Secondly, it enables a purchasing record to be maintained. Whilst this involves the same amount of time and effort on behalf of the buyer as the manual purchasing record, it is available on-line to the estimators and therefore reduces the amount of queries regarding current item rates.

Finally, and in terms of time saving, most significantly, the aggregation of the quantities from a typical development of 30 dwellings is reduced from approximately three man days to one hour.

3.3 Valuation sub-system

The valuations sub-system provides advantages over the manual methods in three areas. Firstly, the aggregation of the item estimates into cost centres for a typical development of 30 dwellings has been reduced from approximately three man days to one hour.

Secondly it enables monthly valuations to be produced more quickly. This is due to the surveyor's tick sheet, on which the monthly progress figures are recorded, being used directly as the input sheet for the monthly valuations program, thus reducing clerical time in transposing the figures into a form from which the monthly valuation totals can be calculated. The tick sheet also contains more information (such as cost centre totals) than previously.

Thirdly, the valuation sub-system allows the data to be presented and analysed in a different format than was previously attempted.

3.4 Cost comparison sub-system

The cost comparison sub-system enable comparisons for all material and labour items whereas it had previously only been possible to compare the most cost significant labour items due to the time-consuming nature of the task. A complete analysis is therefore now possible.

It is also now possible to perform the analysis at any time after the completion of the estimate, thus enabling cost forecasts to be produced as there are no additional inputs required other than the budget estimate and the purchasing record.

4. Conclusions

One of the major benefits of the system development was the formalisation and structuring of the company's management information. This resulted from the rationalisation which occurred as part of the systems analysis phase of the development. By examining the company's data flow and the forms that were used to capture, record and transmit the data, anomalies, duplications and redundancies were identified and eliminated. This produced much more streamlined and efficient procedures which reduced time and effort in manipulating the data. This process would have had benefits to the company even if a computer-aided system had not been developed.

By creating a common company-specific library of information, by enabling access to functional data from other functions and by streamlining the transfer of data from one function to another, an improved integration of the functional departments of estimating, purchasing and surveying together with senior project management staff was achieved. This integration enabled a faster throughput of management information and ensured a greater consistency than had been possible with the manual methods, thus providing management with better quality information. However, the computer system not only achieved the integration of the data flow between departments but also promoted greater informal communication between the company staff and highlighted their interdependence.

32
Risk evaluation and decision support system for tendering and bidding in refurbishment contracts

D.H.P.TEO, L.K.QUAH, V.B.TORRANCE and M.I.OKORO

Introduction

This paper reports on the progress of a six year study into tendering and bidding processes for building refurbishment contracts. The results have, to date, remained largely unpublished as a result of strict confidentiality constraints placed upon the researchers.

The research has been carried out in three phases, the first two of which have been completed and the third is now underway. The following focuses on the second phase of the work, preceded by a summary of the first phase and is concluded with a short summary of the third phase.

Phase I Of The Project

This study has been motivated by the lack of research in the substantial and growing refurbishment sector of the United Kingdom construction industry. The reasons for inexplicably higher variability in tender bids for refurbishment work when compared to new work were investigated. This phenomenon had led to a claim by a large body of contractors that they were exposed to higher risks in such projects.

The research involved the joint support of a confederation of contractors and a large number of individual contractors. In all, 47 contractors participated and a total of 2,261 contract documents were analysed. The methodology adopted consisted of structured interviews with individual contractors as a means of obtaining basic information on the refurbishment industry and the particular problems that contractors have in tendering for such work. This qualitative information was augmented by quantitative information derived from measuring the bidding performance of contractors utilising two unique interactive data bases created from primary data obtained from both sets of collaborators. The first data base, consisting of tender bids for a very large sample of refurbishment projects, provided global variability measures which served as indicators of the risk and uncertainty in the price prediction process. The second data base consisted of detailed tender buildups of competing contractors for a smaller sample of refurbishment projects drawn from the main sample; variability measures in this case isolated the main components of risk in the tender bid.

The most variable main cost component in the tender was the Priceable Building Work, followed by Preliminaries, Mark-up, Dayworks and Fixed Price Allowances. The variability in Priceable Building Work and Preliminaries is founded in poor and unsuitable tender documentation and the high reliance upon domestic subcontractors' quotations included in the tender. Variability in mark-up has its origins in the different perceptions of risk and in the competitive mix in tendering, in terms of specialism and size of competitors.

The investigation into the confidential cost and price information within this study has also provided insights into comparative pricing methods and bidding strategies which have never previously been obtainable. It has, at the same time, provided answers to many of the unresolved questions overhanging past research studies in estimating and tendering.

The first stage of the study concludes with a proposal for an optimal method of allocating or sharing the risk associated with the uncertain nature and unpredictable costs of refurbishment works. It also draws attention to the fact that objective statistical measurements of variability for the purposes of determining risk and uncertainty can only provide part of the information. The need to conduct behavioural studies on the perceptions and evaluation of the risks in estimating and tendering for construction work was identified.

Research Methodology

Research methodology incorporating both quantitative and qualitative features was developed. The qualitative approach consisted of a structured questionnaire survey on a selected group of contractors with the object of securing relevant information on the refurbishment industry and, in particular, tendering methods in current use. At the same time, perceptions of risk in estimating and tendering for such work were surveyed. The quantitative approach comprised the creation of a very large primary data base of refurbishment tender bids and a smaller unique secondary interactive base of tender bid components. The principle objective being to measure the dispersion in tender bids and bid components and to study the patterns of competition from these two data bases. The exercise to determine the variability in tender bids, and bid components, as a means of providing indications of risk in the estimating and tendering process, also revealed information on the different pricing and tendering methods used by contractors.

Variability in Tender Bids for Refurbishment Work

The dispersion in refurbishment tender bids was found to be higher than in new work. The implication being that there are higher risks in estimating and tendering for refurbishment work when compared with new work.

There was a significant but weak negative correlation between the R.D. of the refurbishment bids and the project size, as well as the number of bidders. This phenomenon has not been detected by other researchers. The negative correlation between R.D. of the bids and project size could have been caused by the unique competitive mix in refurbishment work, with widely unequally sized firms competing for the smaller value projects but not for the larger value projects. The negative correlation between R.D. of the bids and number of bidders could have been caused by the effect of intensity of competition which increases with the number in competition, and/or the compound effect of size of project as there were smaller numbers of bidders in the smaller sized projects.

The negative correlation between the R.D. of the tender bids and the PPCPCS is similar to that detected by other researchers. However, the positive correlation between the true R.D. of the tender bids and the PPCPCS implies that as the risk in determining the cost of Priceable Building Work reduces, as a result of increase in the PPCPCS, a higher variability and possible risk occurs in the variable costs in the tender. Three possible reasons are offered for this relationship. As the PPCPCS increases, the residual Priceable Building Work will be small and would probably consist of relatively insignificant items of work such as Spot Items and Builder's work in Connection with Services. The variability in costs of these insignificant items is higher as is evidenced in the analysis of variability in tender bid components. The true R.D. will progressively serve as a measure of the relative efficiencies of widely different sized firms as the PPCPCS increases the relative efficiencies being reflected in the mark-up and preliminaries, which form the main proportion of the variable costs in the tender. The higher PPCPCS will also positively encourage the use of bidding strategies, such as netting of discounts from nominated work, and scope deductions in anticipation of enhanced profits through the conversion of Provisional Sums into Builder's Work as a result of Architect's Instructions.

Methods of Estimating and Tendering

The major differences discerned in estimating and tendering methods were associated with the pricing of profit and attendance on nominated work; in the allocation of general overheads; in the provision of risk allowance in the tender; in the bidding strategies of scope deductions; and in the netting of discounts in respect of nominated and own contractor's work. A methodology was devised to rationalise these different methods in such a manner that the measures of dispersion in tender bid components would reflect the true differences in the cost of the components. The Anticipated Return element of the tender was the result of this rationalisation process and was used to accommodate the bidding strategies adopted by different firms which could not be discerned just by observing the mark-up applied.

Variability in Cost Components of a Refurbishment Tender

The most variable main cost component in the tender was the Priceable Building Work, followed by Preliminaries, Mark-up, Dayworks and Fixed Price Allowance. The Demolition Trade considered separately, emerged as the most variable component in the tender, with Mark-up closely second. The Anticipated Return element, when considered as a component of the tender, would become the most variable component.

The variable in the Priceable Building Work and Preliminaries is founded in tender documentation which often fails to describe adequately the extent and complexity of the work, thereby giving rise to risk. It is also founded on a high reliance upon domestic sub-contractor's quotations included in the tender. The variability in the mark-up component has its origins in the different perceptions of risk in the work, and/or in unequally sized competitors meeting in a project, and/or the varying degrees of need for the project. On the other hand, the variability in the Anticipated Return indicates the very significant contribution of bidding strategies as a means of securing a project in competition.

Patterns of Competition

The patterns of competition revealed that refurbishment specialists performed significantly better than general contractors measured in terms of the success rates in tendering, bid spreads in tenders won, and in the margin of failure in unsuccessful tenders. General contractors inevitably met up with at least one specialist in competition, subjecting them to a higher probability of losing the tender. Although there was no significant difference discerned between the competitive performance of different sized firms, the significant but weak positive correlation between the true spread of bids and the PPCPCS implies that the competitive performance could be significantly different when widely different sized firms compete because of relative competitive advantages.

Evaluation of the Risks in Estimating and Tendering for Refurbishment Work

The variability in tender bids for refurbishment work has its origins in a number of factors.

The primary factor lies in the unsuitability of the tender documentation, which often fails to convey the scope and extent of the work. This leads risk averse contractors to include hidden contingency sums in their tenders to allow for risk. Risk seeking contractors, on the other hand, seize the opportunity to reduce their tenders by the scope of potential for claims within the tender documents. The confirmation of higher incidence of variation orders and resulting profitability in refurbishment projects suggests that the client is ultimately carrying the risk of uncertain construction costs through increased final accounts.

The technical and managerial uncertainties of directing small multi-trade construction operations in an existing congested building, which is often occupied, is reflected in the high variability in the Preliminaries cost component of the tender.

The high reliance on domestic sub-contractors quotations also has a marked influence on variability detected in the tender bids.

An assortment of different sized contractors ranged in competition, will exert a positive influence on variability, particularly in projects where the PPCPCS is high.

Phase II of the Project

This phase was concerned with the management of risks in competitive bidding for refurbishment work (lump sum contracts). It investigated the main difficulties and risks faced by contractors when they were making decisions in competitive bidding as a result of the general lack of information both inside and outside a contractor's organisation.

A decision support and risk management system model was developed which provides a systematic and objective approach to risk management in competitive bidding for refurbishment work. The model provides a framework whereby both quantitative (tender bid records) and qualitative (risk perception of contractors) information may be obtained to support the decisions of contractors during tendering.

The research adopted a combination of both Archival and Opinion research methodologies to build up two main databases consisting of tender bid records and information on the risk perception of contractors during tendering.

From the analysis, a decision support and risk management system was developed consisting of six modules namely: (i) Module 1—Databases of tender bid and Repertory grid data, (ii) Module 2—General information of bidding characteristics, (iii) Module 3—Contractor's analysis, (iv) Module 4—Competitor's analysis, (v) Module 5—Bidding model, and (vi) Module 6—Risk management system. (See Table Attached)

This study has demonstrated that past tender bid records of contractors may be organised in a systematic way to provide valuable information to enhance the understanding of contractors with respect to their competitive bidding environments, their own bidding performance and the bidding behaviour of their competitors, thereby enabling contractors to manage risks more effectively and efficiently.

Main Findings of Second Phase of the Research

The following state the main objectives of the second phase of the research and discusses the strengths and weakness of the adopted research methodology in fulfilling the objectives. The results of the findings are organised according to the modules of the decision support and risk management system.

A) Module 1—Databases of tender bid records and repertory grid data

The decision support and risk management system has two main databases namely: (i) tender bid records and (ii) repertory grid data. The tender bid database consists of 2261 cases of refurbishment contracts (lump sum contracts) and was set up in the mainframe computer (DEC VAX 8700) at Heriot-Watt University. The repertory grid data consists of a fully rated grid obtained through the interviews of twenty-two refurbishment contractors (directors and estimators). It contains information on the risk perception constructs of contractors (directors and estimators) in competitive tendering. This information is stored in a micro-computer which uses a specially developed program named Flexigrid for analysis.

B) Module 2—General information of bidding characteristics

i) Descriptive Statistics of Tender Bids (Population Analysis)

1 The distribution of the number of bidders per contract is positively skewed with more contracts having four to five bidders (49.3% of all contracts). The mean number of bidders for the refurbishment work studied is 4.80 and has a standard deviation of 1.42. A comparison of mean number of bidders between new-build and refurbishment contracts shows that refurbishment work had relatively fewer bidders in competition per contract. This implies that refurbishment contracts are generally less competitive as compared to new-build work.

2 A large proportion of refurbishment contracts (52.6%) was within the £100,000 to £500,000 value range. While only 2.2% of all refurbishment contracts in the sample (2261 contracts) had contract values exceeding £3m.

3 The refurbishment of office (28.3%) and residential (37.3%) building constituted a large proportion of all refurbishment work in London (from 1984 to 1989). While the refurbishment of religious buildings accounted for only 1.26% of all contracts. The remaining contracts were for education, industrial, health and transport buildings.

4 Most refurbishment contracts (73.6%) of the sample were concentrated in London and Greater London. The remaining 26.4% were located around the periphery of London.

5 There was an almost equal distribution of jobs between the public (46.6%) and private (54.4%) sectors in the sample of refurbishment contracts.

6 The distribution of bid range of tender bids indicates that bid range varied considerably between 1.0% and 88.8% in refurbishment work. The mean bid range was 20.6% and thus indicates that the risk perception of contractors varied quite differently when tendering for refurbishment contracts.

7 The distribution of bid RD is positively skewed and has a mean of 11.0%. It ranges from 0.4% to 62.2% and thus confirms that tender bids were widely spread in refurbishment work. This could be attributed to the inherently precarious nature of refurbishment work.

8 The distribution of bid spread is significantly positively skewed with a mean of 6.2% and standard deviation of 6.8%. The median bid spread is 4.1% which implies that 50% of all refurbishment contracts were secured by contractors with at least 4% of contract value being “left on the table”. The comparison of jobs with bid spread greater than, or equal to, any given amount between new-build and refurbishment work displays similar trends. This suggests that the proportion of jobs with various bid spread were equal for both new-build and refurbishment work.

9 The skewness of tender bids refurbishment work has a mean of 0.1 and standard deviation of 0.6. This clearly shows that refurbishment contracts are approximately symmetrically distributed and thus are less competitive in nature.

10 The kurtosis of bids varies considerably between −2.9 and 3.0. The mean kurtosis is −1.1 and has a standard deviation of 0.6. This result indicates that the peakedness of tender bids for each contract varies quite considerably.

ii) Competitive Pattern of Tender Bids

1 Number of bidders and job size—Contracts which are less than £250,000 tended to attract 3 to 4 bidders (about 60–70% of all contracts) and thus are generally less competitive in nature. However, as project size increases, the number of bidders in competition also increases. This pattern is more discernible in jobs of value between £250,000 and £1.75m. This range of contracts usually attracted 3 to 10 bidders in competition indicating more intense competition. On the other extreme, large contracts which were over £3m tended to have relatively fewer bidders (5 to 6) in competition.
2 Number of bidders and job type—The refurbishment of industrial, recreation and entertainment, and religious buildings had generally fewer bidders (usually less than 7 bidders) in competition as compared to educational, scientific, office and residential buildings.
3 Number of bidders and year of tender—The analysis of number of bidders shows that in all years (1984 to 1989) most refurbishment contracts tended to attract between 3 and 6 bidders. However, there were relatively more jobs with 5 or more bidders in 1986 and 1989 indicating higher competition in those years.
4 Bid spread and job size—The bid spread varied considerably particulary for jobs below £750,000. It was found that a large proportion of small contracts (less than £500,000) had bid spread over 14%. This is mainly attributed to the mix of competition (contractors of different firm sizes and capabilities) for these small contracts. On the other hand, large jobs of over £2m had relatively lower bid spread (about 2% to 4%). This is mainly due to the comparability of bidders competing for such contracts.
5Bid spread and job type—Most job types had a large proportion of contracts (60% to 70%) with bid spread between 0% and 6%. However, industrial buildings tended to have relatively more contracts with lower bid spread (less than 3%) while residential buildings had comparatively more contracts with bid spread over 14%.
6 Bid spread and year of tender—There is no discernible pattern observed in the distribution of jobs with various bid spread for different years of tender.
7 Bid RD and job size—It was found that there were more contracts in the lower job range (less than £500,000) with high RD (over 18%) as compared to those jobs over £2m. The bid RD of tender bids tended to decrease as job size increased.
8 Bid RD and job type—Industrial buildings had more contracts with lower bid RD (less than 3%) while a large proportion of residential buildings had bid RD over 18%. This suggests that the refurbishment of industrial buildings was less risky in nature than residential premises.
9 Bid spread and year of tender—There is no discernible difference in the distribution of jobs with various bid RD for different years of tender. In most years (1984 to 1989), a large proportion of contracts had bid RD between 3% and 9%.

iii) Correlation analysis of bidding variables

The correlation analysis of various bidding variables shows that both the dispersion of tender bids (bid range and bid RD) and level of competitiveness (bid spread) are influenced by job size and number of bidders. Generally, both bid dispersions and level of competitiveness tended to decrease as job size and number of bidders increased.

C Module 3—Contractor's analysis

A simple information search framework has been developed whereby tender bid information of past contracts of contractors may be retrieved in an understandable form to assist contractors to monitor their bidding performance and that of their competitors. The main measures adopted for evaluating and monitoring bidding performance include tender success rate, tender success value, win/lose margin distribution and contractor's bid to mean bid ratio.

D Module 4—Competitors' analysis

Using the same approach as discussed above, this module provides a framework which enables a contractor to monitor the bidding performance of his competitors. Besides this, it also identifies the strengths and weaknesses of the competitors with respect to different bidding situations.

E Module 5—Bidding models

Two bidding models were developed by fitting past tender records of refurbishment contracts into either a Normal distribution or an Edgeworth distribution. The distribution of tender bids and the test of normality (using skewness and kurtosis test) indicates that the distribution of tender bids in refurbishment work (lump sum contracts) is approximately normal. Thus, it is reasonable to assume normality in the distribution of bids or to fit the bids into an Edgeworth distribution using the principles of the Central Limit Theorem.
From the fitted distributions (Normal or Edgeworth), it is possible to predict the distribution of the lowest bid of each contract using Order statistics. As such, it enables a contractor to predict the probability of success when submitting a bid in various bidding situations. The main parameters required for both models are as follows:-

(i) Number of bidders against whom the contractor is competing
(ii) True skewness and true kurtosis of tender bids
(iii) Reciprocal of true coefficient of variation of tender bids
(iv) Cost estimate of proposed job
(v) The predicted bid mean of the proposed job

Both bidding models have been tested on five refurbishment contractors with reasonable success. The predictions obtained from both models (Normal and Edgeworth distribution models) are very similar. However, it must be noted that these models have been tested on a relatively small sample of contractors and thus must be applied with caution in practice bearing in mind the assumptions made in the models.

F Module 6—Risk Management

i) Questionnaire Survey of Contractors

1 From the questionnaire survey of 47 refurbishment contractors, the most significant factors affecting the pricing decisions of contractors during tender adjudication are identified as follows:-

a) Accuracy of contractor's cost estimate
b) Credit worthiness of client
c) Contractual liabilities
d) Type of job
e) Relationship with consultants
f) Relationship with clients
g) Workload commitment of contractor
h) Complexity of work
i) Size of job
j) Amendments to standard contract form

2 A closer examination of the ratings which have been assigned to various tender adjudication factors shows that most contractors tended to place more emphasis on personal relationships when adjudicating their tenders. While factors relating to the general market and political conditions were of least importance when adjudicating a tender.

3 The frequency analysis of the rating responses of various tender adjudication factors reveals five distinct types of distribution of the rating as follows:-

a) Significantly negatively skewed factors
b) Slightly negatively skewed factors
c) Normally distributed factors
d) Significantly positively skewed factors
e) Uniformly/Bi-modally distributed factors

4 The two-way analysis of variance test provides strong statistical evidence that the mean score rating varies both between tender adjudication factors and different sizes of firm (small, medium and large firms). The test also confirms that there is no discernable difference in the mean score between refurbishment specialists and general contractors. Statistical evidence has also been shown that the mean score of rating does not vary between directors and estimators. Thus, the above results indicate that differences in judgement among contractors on the importance of various tender adjudication factors is influenced by the size of the firm

5 The Kendall's Coefficient of Concordance test shows that all contractors were in agreement that the order of pricing difficulty (in terms of assessing the financial risks involved) for different job types are as follows:-

a) Health and Welfare (most difficult in pricing)
b) Religious
c)Refreshment, Recreation and Entertainment
d) Education, Scientific and Information
e) Transport and Utility
f) Administration and Office
g) Residential

h) Industrial (least difficult in pricing)

6 Most refurbishment contractors (78.8%) adopt a group decision-making strategy when adjudicating a tender. There is no discernible differentiating pattern observed between small, medium and large sized firms

7 The main construction risks faced by contractors in refurbishment work are (i) accessibility of work (mean rating score=5.2) and (ii) productivity of work force and plant (mean rating score=5.0).

8 The most commonly adopted risk management strategy in competitive bidding is a risk reduction strategy. Most refurbishment contractors attempt to reduce risk by obtaining information from various sources such as clients, consultants, subcontractors, suppliers, independent organisations (for example Builders' Conference) and their own records.

ii) Risk perception of contractors (Repertory Grid Interview)

1 From the frequency analysis of the personal constructs (both free response and predetermined constructs) of the twenty-two refurbishment contractors (directors and estimators) interviewed, the most frequent constructs which were adopted by refurbishment contractors in discriminating between high or low risk bidding situations are as follows:-

a) Degree of difficulty in pricing cost estimate
b) Client relationship
c) Restricted access
d) Degree of complexity of work
e) Consultant relationship
f) Workload of contractor
g) Number of bidders
h) Size of job
i) Identity of bidders

2 The Chi-square tests on the frequency of different job characteristics (client type, job type, job size and job location) indicate that high and low risk bidding situations are distributed in similar proportions in different job characteristic categories.

3 From the Content analysis of the elicited constructs, it is possible to group the risk perception constructs of refurbishment contractors into six main categories:-

a) Contract related constructs
b) Information related constructs
c) Protection related constructs
d) Personnel related constructs
e) Work content related constructs
f) Work nature related constructs

4 The Contingency Table test reveals that the distribution of various categories of constructs are in the same proportion for different firm size, different firm specialism and different respondent type.

5 The most variable constructs as determined by the Principle Component analysis are different for all contractors. However, the more variable constructs among the contractors were as follows:-

a) Degree of difficulty in pricing cost estimates
b) Relationship with client
c) Tender documentation

6 The Principal Component analysis identifies that most contractors' risk perception constructs may be explained by two or three major dimensions. The key dimensions for each contractor are unique and different from other contractors. The analysis shows that between 84% and 98% of the total variance of all constructs for each individual contractor is attributable to two or three key dimensions. The highly correlated constructs of each dimension of individual contractors are also different among individual contractors.

7 The most frequent constructs that are related to the risk construct of all contractors are as follows:-

a) Degree of difficulty in pricing cost estimate
b) Restriction of access
c) Degree of complexity of work

8 The construct poles related to the worst bidding situation of individual contractors also vary considerably. This is mainly attributed to the respective strengths and weaknesses of individual contractors and their past experiences.

9 The common characteristics present in the various respective ideal bidding situations of contractors are as follows:-

a) High intensity of work
b) Good client relationship
c) Prime location

10 The Cluster analysis shows that the risk perception constructs of most contractors may be grouped into two or three clusters. These clusters differ between contractors but do correspond very closely to those highly correlated constructs obtained in the Principal Component analysis.

Conclusion, Summary and Discussion

This second phase provided a systematic and objective approach to risk management in competitive tendering for refurbishment work. It developed a framework whereby both quantitative (tender bid information) and qualitative (risk perception of bidders) information may be organised so as to provide strategic information to support the decision-making processes of contractors in competitive bidding.

From analysis of 2261 tender bid records (lump sum refurbishment contracts), a questionnaire survey of forty-seven refurbishment contractors, and personal interviews of twenty-two estimators/directors of construction firms, a decision support and risk management system was developed. This system consists of six main modules namely (i) Databases of tender bid records and repertory grid data, (ii) General information of bidding characteristics, (iii) Contractor's analysis, (iv) Competitors' analysis, (v) Bidding models, and (vi) Risk management system.

The research adopted both quantitative and qualitative approaches to risk management in competitive tendering. Using a combination of both archival and opinion research methodologies, two main databases comprising tender bid records and information on the risk perception of contractors (directors and estimators) are set up in the decision support and risk management system. The main advantages of the archival research method is that it provides a flexible and versatile approach to collecting a relatively large sample of data and also provides the means for accessing and manipulating the data. As such, this approach has been adopted to collect and analyse the 2261 tender bid records which were obtained through the Builders' Conference in London. However, this method does suffer from some limitations such as selective deficiencies, selective suicidal, selective retrieval, "filling the gap", and biases from the researcher.

With regard to the collection of information on risk perception of contractors, the opinion research methodology is considered to be appropriate as the required information is highly subjective and sensitive. Two principal techniques, namely: (i) questionnaire survey, and (ii) Repertory Grid interview, were utilised to elicit information on the risk management strategies and risk perception of contractors. There are numerous benefits which accrue from the use of the opinion research methodology. It provides a simple, direct, inexpensive, effective and consistent means of obtaining qualitative information. However, this approach also suffers form certain deficiencies, particulary in the use of the questionnaire survey which is often criticised for failing to obtain an adequate response rate and response bias. In this study, attempts were made to overcome such weaknesses through the use of various follow-up techniques.

Thus, despite the above limitations, this study has made a significant contribution to the management of risks in competitive bidding. It has provided a new dimension and approach which can enable contractors to identify and manage risks more effectively. Common problems faced by contractors as a result of lack of information have been identified and the proposed decision support and risk management system has proved to be an effective risk management tool. The system enables contractors to obtain strategic information about their competitive environment and the bidding behaviour of their firms and their respective competitors. It can also enhance the understanding of contractors with respect to risk management in competitive tendering and thus can improve the quality of their decisions in competitive tendering.

Besides this, pertinent risk factors which affect the risk assessment of contractors under different tendering situations were also identified. This should increase the knowledge and understanding of contractors and also provide useful guidelines for contractors to focus their efforts on managing these risks more effectively.

However, it must be noted that the results of this research are based upon 2261 tender bid records, a questionnaire survey of 47 contractors and personal interviews of 22 contractors. Although the sample is statistically representative of refurbishment contracts in the London area, it does not represent all refurbishment contractors in the United Kingdom construction industry. Furthermore, due to constraints imposed by the availability of tender bid information, only significant bidding variables such as bid dispersion, level of competitiveness, and various job characteristics (year of tender, job type, job size, client type, job location and number of bidders) were considered in the analysis. This study did not specifically consider the impact of market forces such as political, social, technological and economic factors on the bidding characteristics of refurbishment contractors, although the questionnaire survey and repertory grid interview did provide indications of how contractors perceive such factors in tendering.

Another factor to be considered is that the analysis of the tender bids was based upon past tender data under market conditions and the tendering policies of various firms at the time of the investigation (1984 to 1989). As a result, such information could only be used as a guide for predicting the future behaviour of competitors (as bidding behaviours and policies of competitors will probably change). However, the decision support and risk management system does provide the flexibility for updating its databases so as to provide more updated information on the bidding characteristics of refurbishment work and the behaviour of contractors and competitors.

In conclusion, a knowledge base may also be incorporated into the proposed decision support and risk management system to develop an expert system for the management of risks in competitive bidding for refurbishment work.

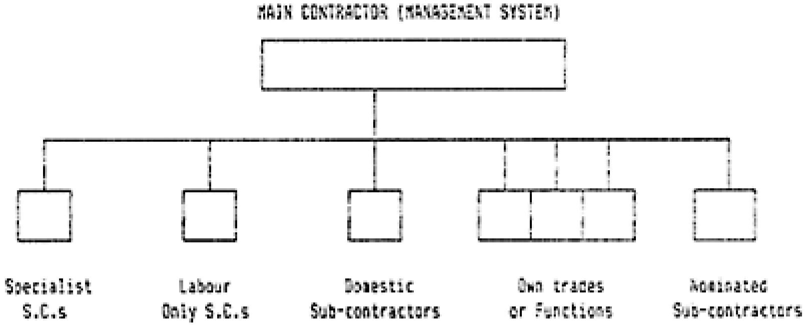
Phase 3 of the Project

Developing the K.B.S.

The third phase of the research programme is currently underway, in which such a knowledge based expert system (K.B.S.) is being developed. The first stage of the work has been concerned with identifying the most suitable system "shell".

Currently, collaboration has been arranged with a suitable senior estimator form a large construction company. This work is developing the knowledge base and expert decision making processes upon which the K.B.S. will be developed.

Due to the present trend in which refurbishment (and other general) contractors are making ever increasing use of subcontractors, the sub-contractor selection process is being modelled. The starting point has been to treat each contract as a series of functions, either in-house or domestic or nominated sub-contracted or otherwise sub-contracted as in the following diagram.



When this stage has been developed and tested, using selected refurbishment contractors from the collaborating group, the work will move on to developing other features of the K.B.S.

The background research within the current phase of the programme is identifying interesting trends in the use of sub-contractors with UK construction companies. In the companies currently being studied, many are considering internal reorganisation to improve effectiveness. Part of the reason appears to be to resolve potential conflicts between their Estimating and Buying departments and to develop better co-ordination between the Estimating, Planning and Buying functions in the companies. Another, more clearly definable set of reasons arises from marked change in subcontracting practices. There are now few companies who carry their own specialised trades. Also, there is very little use now of labour only sub-contractors. Even more interestingly, there is a rapid disappearance of nominated sub-contractors, consequently, there has been a correspondingly great increase in the use of specialist sub-contractors. In place of nominated sub-contractors, bidding contractors are currently being offered lists of recommended specialist sub-contractors to choose from and incorporate into their contract bids.

References (Unpublished)

Okoro, Michael "Tendering Strategies in the Construction Industry" M.Sc. Thesis, Heriot-Watt University, 1985

Quah, Lee Kiang, "An Evaluation of the Risks in Estimating and Tendering for Refurbishment Contracts", Ph.D. Thesis, Heriot-Watt University, 1988

Teo, Daniel Ho Pin, "Decision Support and Risk Management System for Competitive Bidding in Refurbishment Contracts", Ph.D. Thesis, Heriot-Watt University, 1990

Figure 1: Histogram of tender bids by number of bidders per contract

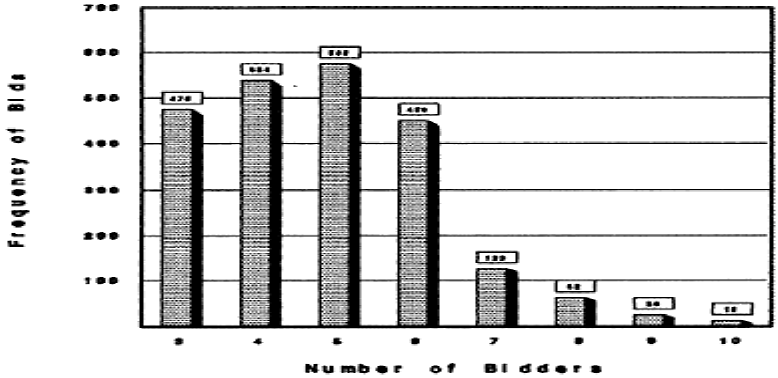


Figure 2: Histogram of tender bids by job size

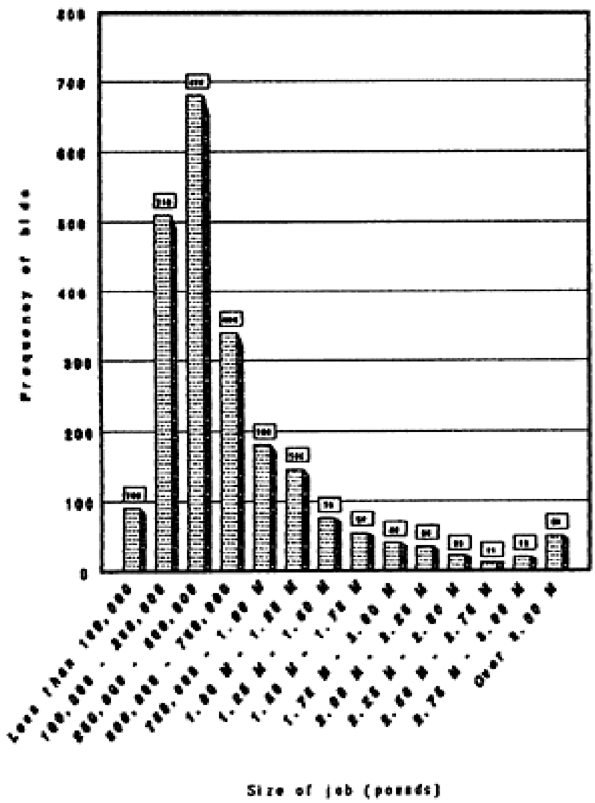
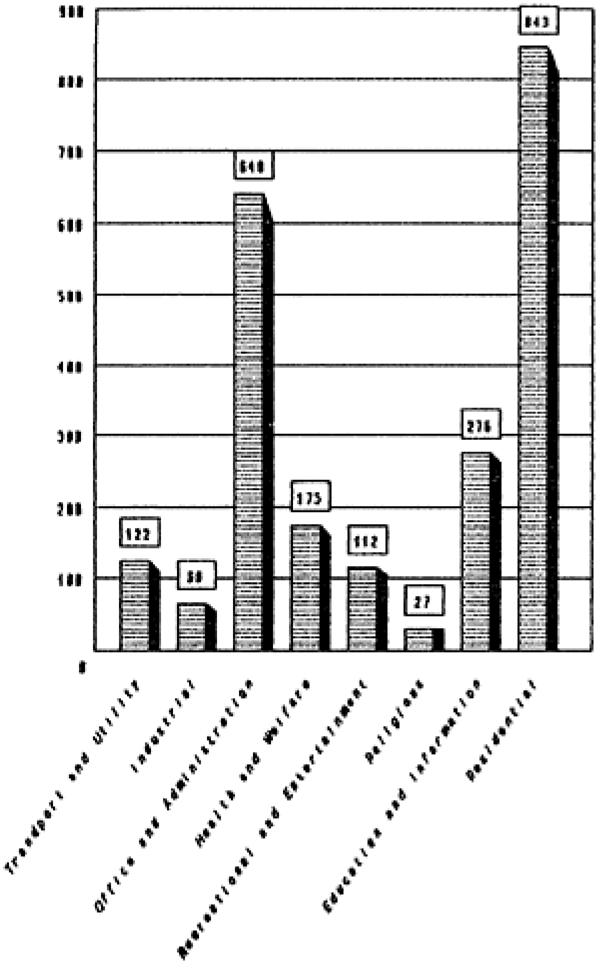
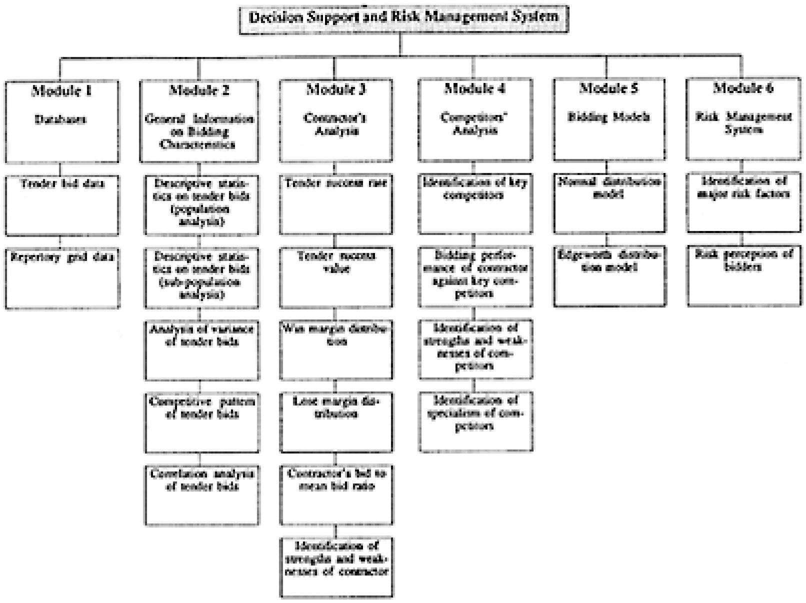


Figure 3: Histogram of tender bids by job type


122
640
175
112
27
276
843
Transport and Utility
Industrial
Office and Administration
Health and Welfare
Recreational and Entertainment
Religious
Education and Information
Residential

Type of job

Figure 4


Decision Support and Risk Management System
Module 1
Databases
Tender bid data
Repertory grid data
Module 2
General Information on Bidding Characteristics
Descriptive statistics on tender bids (population analysis)
Descriptive statistics on tender bids (sub-population analysis)
Analysis of variance of tender bids
Competitive pattern of tender bids
Correlation analysis of tender bids
Module 3
Contractor's Analysis
Tender success rate
Tender success value
Win margin distribution
Lose margin distribution
Contractor's bid to mean bid ratio
Identification of strengths and weaknesses of contractor
Module 4
Competitors' Analysis
Identification of key competitors
Bidding performance of contractor against key competitors
Identification of strengths and weaknesses of competitors
Identification of specialism of competitors
Module 5
Bidding Models
Normal distribution model
Edgeworth distribution model
Module 6
Risk Management System
Identification of major risk factors
Risk perception of bidders

33
Civil engineering project support systems

P.van der VEER

Abstract
One of the most relevant difficulties in designing decision support systems for civil engineering projects is the structuring and analysis of the information that actually contribute to the realisation of a product of civil engineering in its surroundings, defined in a way that it is realisable within budget and maintainable in the period of use.

This paper shows an information structure that can be used for designing decision support systems for civil engineering projects. It may help to overcome the complexity caused by interacting of many disciplines and by the necessity of overviewing consequences of decisions in early phases of the project. Using this information structure model a more consistent way of developing civil engineering projects may be supported.

Keywords: Decision support, Integrated disciplines, Civil engineering.

1 Introduction

Civil engineering projects require grip on information from the first initiation activities onto the phase of use and maintanace, see e.g. Beheshti and Van der Veer (1988) and Booij et.al. (1988). For many tasks in civil engineering projects there are already suitable supporting tools available, e.g. models for calculation of physical dimensions of constructions, CAD-programs for designing activities, information systems for project management, etc..

One of the problems that are encountered in practise is the communication of the results that have been obtained from the different supporting tools. A consequence of this lack of communicating aibility of different tools is doing manual translation work of these results towards in order to integrate the results in decision making about the project. For example: a crusial moment in a project is the moment where information about feasibilty, physics and economics meet. Let us imagine a project about crossing a canal or river. The project is in its initiation phases.

– A feasibility study shows the relationship between realising one the alternatives and the aims that are set for the project. Alternatives like bridges, tunnels and dams may have been evaluated. The study may result in quantitive parameters about effects on policy, infrastructure, traffic, water management, etc..

– A study about physical boundary conditions shows the parameters that are relevant for the actual design of the construction. An, of course, limitation parameters for the various alternatives. For example realising a dam in a river needs to develop additional constructions to let the water pass. The study is in such a detail that further study can be done about the realisibilty and the design can be made. Carefully choosing the parameters that define technical characteristics is important for being able to decide the alternative has to be worked out in a next phase of the project.
– A study about the financibility of the various alternatives. Especially relevant are the relationships between the required finances, the aims that will be made, the benefits after realisation the project, costs or benefits of extra effects (e.g. the necessary construction for letting pass the water if a dam is choosen to cross the river). This study has the character of a combined financial and technical evaluation.

Here we see that already in an early phase of the project several disciplines meet: disciplines like policy, finance, traffic, infrastructure, constructive disciplines, water management, etc..

Using a supporting environment for generating information about the alternatives for the project may result in two important benefits:

– Decreasing the waiste of human energy, time and money used for iterations in the project that otherwise should be caused by the lack of information in this early phase of project progress. In practise sometimes we see that many effort is used for designing while elementary evaluation of alternatives still have to be made. Consequently some work hase to be done again for other alternatives.
– Improving the efficiency of the process by the availability of tools that can show consequences of decisions in good mutual consistence. This is especially of interest if many aspects and many alternatives have to be evaluated.
– Improving the quality of the product by being able to carefully integrate the aspects of different disciplines. The availabilty of tools for integrately evaluating technical, policy, financial, and other aspect may lead to more optimised decisions about the alternatives.

For the design of decision support systems it is essential to pay special attention to the struture of all information that has to be taken into account during the decision making, see e.g. Keen and Scott Morton (1978) and Andriole (1989). The next section of this paper describes an information structure that may be used for designing decision support systems for civil engineering sciences.

2 Analysis of project characteristics

In a civil engineering project there are two main items of information to focus on:

– The object point of view: all information about functionctional and technical aspects of the object.

– The process point of view: all information about the process that leads toward a realised object. In addition, to bring more structure in the information that is used for decision making, there aspects on three levels that must be considered:
– Firstly the strategic level. Strategic aspects concern questions about “why” and “what”. For example, if we consider a project consisting of all activities from evaluating alternatives up to the realisation of the object, aspects about feasibility of solutions has a strategic character because it concerns principly questions about meeting aims and proposed solutions.
– Secondly the control or management level. Questions are met that concern the way objects have to be realised and the boudary conditions for realistion. For example, information about available budgets is managament information.
– Thirdly the level of operation. Of course, information about the realisation of an object is part of the information on operation level.

An analysis of these two points of view and three levels of information may give us an insight in the consistency in the various kinds of information and in the interference of the many decisions that are made during the project.

Combining the two points of view and the three levels of informations there are nine items that deserve our special attention:

Feasibility of solutions. The item concerns with information with respect to questions about the principles of the project. From object point of view as well as from process point of view the information about the relationships between aims and functional aspects of alternative solutions.

Financibility. The item concerns with information about the relationships between the required finances, the aims that will be made, the benefits after realisation the project, costs or benefits of extra effects, etc.. From an object point of view these aspects are of strategic level because essential questions are answered about possibilities for realising the object. From a process point of view however this information is of control level because it is management information about financial boundary conditions.

Realisibility. The item concerns with information about the technical realisibility of the object. From an object point of view of course this is of strategic level. It concerns technical questions about about possibilities for realising the object.. From a process point of view it is information operation level that aware questions about technical constraints for starting the process.

Physicalal boundary conditions. The item concerns with information with respect to the parameters that have to be taken into account for the designing of an object. From object point of view this infomation is of control level because it involves conditions for actual elaborating details of the object in an design. From process point of view however the information is of strategic type: physical conditions that may determine whether a process can be started or not.

Budget boundary conditions. The item concerns with information about the available budgets for various parts of object and process at various moments. The information is control information from an object point of view as well as from an process point of view.

Logistic boundary conditions. The item concerns with information with respect to technical conditions for operational activities. From object point of view this information may control some characteristics of the object that is to be designed. From process point of view it is operational information that has to be taken into account during the realisation.

Design. The item concerns with information about the definition of the object in details. From object point of view this is of course information of operation level. From process point of view however it involves essential information for the process: the definition of the result of the process.

Planning. The item concerns with information about the planning of the realisation of an object. From process pont of view it is of course management information and thus of control level. From object view it is information of operation level because it concerns with aspects of actual realisation.

Realisation. The item concerns with information about the actual realisation of the object. This is information of operation level from object point of view as well as from process point of view.

3 Supporting systems

3.1 Project point of view

Information at various levels and from various disciplines that meet in a project were structured in the previous section. In the present section the use of the information in decision supporting systems is elaborated.

From a user point of view a supporting system should manage the information in a way that shows to be:

– simple to use and consistent in structuring the information
– usefull for each phase in the project and for a wide spectrum of activities
– and, of course, showing information that is relevant for the decision that has to be taken.

The simplicity in use is mainly a question of software design. For the underlying information structure the previous section may be used. That information structure has recursive properties: in the figure it is worked out for a project that begins with feasibility studies and ends with the realisation of an object. A similar structure, using the same overall concept may be used for the various parts of the project because always there are two views that may be used, object view and process view, and for each part of the project there are goals, control aspects and operational activities. Therefore, a system that uses the outlined information structure may be used for each phase in the project end for a wide spectrum of activities.

In addition, because of the recursive properties of the information structure, it has the potention of integrating in a consistent way information from various levels of abstraction, going from the overall project up to small details.

The interaction of the discussed nine items in a system is briefly shown:

Starting with feasibility studies, where aims and concepts for solutions meet, we follow some top-down way towards the final realisation. During the project the scope firstly broadens to overview the financibility an physical boundary conditions. Then it broadens more to study the realisibilty, budget boudary conditions and design. It has a more narrow scope again when studying logistic boundary conditions and planning. And finally only the realisation has to be focussed on.

Using the information structure in a project, it is beneficial to see that there are three main phases in a project: initiation, development and realisation. In the inititiating phases of the project only strategic aspects are studied. After having got an insight in feasibilty, financibility an physical boundary conditions there is a decision moment about continuation of the project. It is because next steps will require more effort, espescially studies with respect to the technical realisibility and the design. Here we see that two stategic items, realisibilty and design, have still to be discussed in de development phase of the project. (Realisibilty is a strategic item from object point of view and design is a strategic item from a process point of view). Having discussed the results of the development phase we again meet a crusial moment: a decion about the final realisation of the project. All strategic questions have been answered now. Continuation is from now on only focussed on the actual realisation of the object.

3.2 Design point of view

The concept that was presented can be used for overall-support in decision making; however it is probably not the right way to set up one large system at once. It is much more attractive to used the ideas that have been developed in a top-down way as a frame for actual development with a bottom-upo approach.

In practise it means that systems can be build for parts of the process, while keeping in mind what the overall structure of information is. And regarding what kind of coupling of modules will be necessary later on.

This is in some regards advantageous:

– During the development of systems we get experience that is necessary for being able to work at greater systems,
– By beginning small there are benefits within rather short time: we are able to make systems that can be used for selected areas of civil engineering science. Users see directly result from the approach in rather small projects. Consequently they are more willing to actally support developments of greater systems.

For example one could start with developing information systems for the realistion phases of projects. This is a cost and time expensive phase. Consequently tools that can help to increase the efficiency may actually add benefits to the projects. In addition more experience will be buit up about the information that is necessary for activities in these phases. A next step can be the development of decision support tools for the development phases. During this development one can use the knowledge about information items of the realisation phases. So the product of this development may be optimal suitable for the phases that follow.

Having built and used tools for the development phase of projects a lot of experience has built up of information of all phases after the initiation activities of projects. Now we are able to overview the whole field and develop tools for the initiation phases in such a way that the results will be suitable for next phases is the project. The way of realisation decision support systems that is outlined here is a bottum up way using an overall top down concept. It is based on the idea that benefits has to be shown during the making the system. And of course practical implementation should go gradually, beginning at operational level. Otherwise, beginning with tools for the initiation phases of projets, we might develop tools that finally are not suitable for operational activities. Then one two situations may occur: a substantial reorganisation of present operational activities or not using the tools that we have made. Both situations are disadvantaguous and cost expensive.

4 Example of research on this topic

One of the projects of the program concerns decision support systems for water management that is oulined in this section.

So far much attention has been paid to the development of informatic tools in water management. Espescially in the field of mathematic modeling of physic processes, like groundwater flow, there has been a substantial progress in the past decades. A wide spectrum of computer programs is available now for selected areas of computatinal sciences in water management.

From the second half of the ′70 one has gradually more focussed on the interest of policy sciences in water management. However the tools that are available are up to now mainly restricted to computation of isolated aspects of the whole field such as surface run-off models and one or two dimensional groundwater flow. The development of integrated models that can be used for computation and evaluation of several aspects of the watermanagement has not reached much practical applicability. Still farther away from present applicability are decision support systems for initiating phases in projects that can integrately evaluate technical as well as economic and institutional aspects.

In the research project about water management attention is paid to the integration of models for evaluation of institutional aspects and mathematical models for simulation physical processes. Subjects like knowledge representation, user interfacing, decision processes, computational modeling ande databases play an important role in the project.

When gradually more aspects have to be integrated in decision making the chance increases that information that has to be processed involves uncertainties or even inconsistencies. In the project also attention wil be paid to handle with these uncertainties and eventual inconsistencies.

Availability of the foreseen integrated tools may increase efficiency as well as effectiveness of decision making. Using the information structure of this paper a situation may be arrived where already in early phases of projects the right alternative can be chosen and the number of iterations in the project can be diminished. So benefits of using realised decision support systems in this area may have benefits in term of costs, quality and time.

In water management we especially meet the integration of water quantity and water quality aspects. For example in river flow the run of and the water quality may be directly related in cases of dumping a fixed amaount of wate water on the river. In more complicated situations we meet a wide range of parameters that influence quality as well as quantity aspects. However the subjects quality and quantity are covered by partly different disciplines. In practise the integration of these aspects in preparing water management measures plays an important role in decision making. A practical problem occurs when specialists of these disciplines do not understand each others language quite enough. Decision support systems may help to overcome some of the problems that may appear then.

From a users point of view decision support systems should meet three requirements:

– The system should be able to handle information about policy. It means that procedural information as well as information about interests can be evaluated by such a system. This is important for the initiation phases of projects.
– The system should cover models that are used by different disciplines in a consistent way, e.g. groundwater flow, water quality modeling, law sciences, etc.. Especially the integration of various existing models and databses that are already being used has to focussed on. This is important for the development phase of a project.
– The system should show direct operational benefits for the operational phase in order get people interested in further work on integrated systems. And it should have such a practical elaboration with sophisticated userinterfaces that actual use is attractive and advantageous over currently used methods.

Before being able to design and elaborate decision support systems for some area's in water management a number of questions has to be answered. Primarily investigations that give us an answer to that questions have to be done before starting further research on the subject. The main questions are:

– Wich interests and user aspects play major roles in management of surface water and groundwater, e.g. agriculture, drinkingwater authoroties, traffic, industry, etc.
– What are the current tools from policy, management and technical point of view, e.g. law, procedures and mathematical models.
– What are the characteristics of the current decision making process. What aspects are actors for efficiency and wich aspects are relevant for the quality of decision making.
– What (types of) models contribute to policy. What is the relationship between information generated by the model and the decision making in policy,
– What problems exist in comunication between models of different disciplines. These problems may be of information structure character or may concern technical aspects or both.
– What methods have to be developed for integrated use of these models.
– In what respect, e.g. efficiency, quality, etc. may supporting systems contibute to decision making,
– What types of knowledge have to be implemented in such systems; this question is focussed on implemattion in databases and software,
– What reasoning methods have to implemented in such systems.

The results of these primary investigations give us a good starting point for further research on decision support systems that actually may contribute to efficiency as well as effectiveness of decision making in water management.

5 References

Beheshti, R. and Van der Veer, P., Decision support environment for civil engineering design. **Proc. EuropAI,** (1988)

Booij, N. et al., Decision Support Systems for Water Management, **International Conference on Designing Support Systems,** (1988)

Keen, G.W., and Scott Morton, M.S., Decision Support systems, an organisational perspective. **Addison Wesley** (1978)

Andriole, S.J., Handbook of decision support systems. **TAB Books** (1989).

34
Work time modelling in construction processes

S.L.VUKOVIĆ

Abstract
This paper gives a short review of the methods of recording work and time standards in construction, as seen in international practice (especially in Eastern and Western Europe as well as Yugoslavia). Special emphasis is placed on the methods which the author used in her own research and measurements of work.

The paper outlines the characteristics of standard methods for recording work from which the most suitable data for modeling are obtained. The statistical modeling of work time for construction processes is shown on the basis of theoretical observations, research and an enormous amount of measured work time which were carried out by the author. Some suppositions about developments in this field are also given.

Keywords: Construction Processes, Modeling, Work Time Measurements, Time Standards.

1 Introduction

The study of construction processes begins with the gathering of preliminary information, the study of work, and the measuring of work time and time losses, along with other relevant data. Over a period of several years of research, the author of this paper carried out an enormous amount of work measurement in modern construction processes, especially processes which are organized on industrial principles, in the prefabrication of concrete panels for residential buildings and on a number of building sites.

The methods of mathematical statistics stand at the basis of modeling work time in modern construction processes. Quantitative and qualitative analysis of the character, flow and quality of construction processes is made possible by the statistical modeling of these processes. Such modeling has been successfully applied in the study of organization and productivity (Flašar, 1991).

In this paper, some of the possible methods for modeling the work process in the construction industry are given, as well as a proposal concerning developments in this field.

2 The historical development of the study of work

Human attempts at improving and advancing invested work, and thus the study of work (conditionally understood) is as old as humankind itself. We can only guess as to when humankind began to critically evaluate methods for carrying out certain jobs. The very beginnings of history lucidly speak of the great architectural undertakings of humankind, although we can only assume that man's ingeniousness was directed at finding easier and more efficient methods for doing jobs of all sorts.

The field of work study has been stormily and erratically recorded over the last two hundred years. Individual thinkers, as early as Leonardo da Vinci and later Perronet, Mason and others offered great contributions, studying the problem of labor division, the study of elementary operations and the perfection of work methods as well as the increase of output (efficiency).

Although the study of work, in an almost scientific manner, was first carried out in Europe much earlier, the modern study of work starts with the American engineer Taylor (1856–1915). The pioneers of the study of work (Taylor, the Gilbreths, Emerson, H.Ford, Bedaux, and later Mayo, Maynard, Barnes, and others) created the modern science of the study and organization of work. This development was especially shaped by the development of industrial engineering in America. The development of systems theory, discoveries in the fields of mathematics and statistics, the application of operational research and the theory of information all played a significant role in the modern development of the science of work study and organization.

Although the principles of work study were defined and known before Taylor, it was he who laid the foundation for the study of work as a science, clearly solving production problems in a scientific way. Taylor introduced a new understanding of the means of industrial management, trying to make the work easier and faster, with an accompanying increase in productivity. He consolidated the study of work methods, which later formed the basis of the development of work time measurement.

American engineer F.B Gilbreth and his wife Lillian, developed the study of motion during work, using the study of movement during bricklaying as a basis. They paid special attention to methods of recording and following work movements. They defined the micro-movement and in that way they broke ground for the study of work.

Time measurement on today's level was introduced by the American C.Bedaux, who brought in the element of “normal” work time, observing and defining the intensity of work of an average worker, as well as the notion of allowed breaks during work time as an integral part of work time.

H.B.Maynard, G.J.Stegemerten and J.L.Schwab developed the method of defined motion times during work, known as MTM (Methods Time Measurement).

The methods of work study and work time measurement developed mostly in the USA. In western Europe, great attention has been paid to work study especially since the Second World War. However, some of the European achievements are equal to those gained in America. Yet, the theoretical basis and further development of practice is still advancing primarily in the USA.

In the USSR and other socialistic countries, the study of work and the formation of standards has received special attention since World War II. The recording of standards (norms) includes many areas of production, especially in the form of synthetic time (standards). Standardization in the machine and construction industries has been especially developed.

2.1 Work study in construction and standardization

In construction the development of work study has developed rather specifically, mostly because mechanized production was introduced relatively late into the construction industry. The construction product—building, is quite specific when related to other industrial products. Each of them is usually unique. They are connected to the location on which they are built, which makes the conditions for rational and advanced production quite difficult to a large extent. In the framework of construction, a series of other kinds of work is involved, which makes the problem even more complex. The application of modern work study to construction occurred relatively late, although the first sources originated in conjunction with this field of human activity. In the first decades of the twentieth century, manual labor, organized on the principle of the work of craftsmen, as well as a low degree of mechanization was still quite characteristic. The world had already begun the development of sciences dealing with the organization of work, but industrial methods still could not be applied to the construction industry.

In the period 1935–1945, a trend toward prefabrication started. Several important discoveries were made during that period: fast-setting cement was discovered, and high strength concretes were produced for the first time. The pre-stressing of prefabricated constructions was introduced. Industrialized construction was under full steam after the Second World War, especially in the field of residential construction.

The most recent development in the construction industry is directed at the introduction of mechanization and industrialized processes, along with the application of new organizational methods, production planning and management (methods of operational research, mathematics and statistics), with the aid of electronic computers.

The development of work study and normative activities in construction is in direct contact with the described development. The study and measurement of work is mostly related to the testing of work time standards. Work study still hardly and only occasionally penetrates into construction.

2.2 Standardization and work study in Yugoslav construction

The development of normative activities and work study in the Yugoslav construction industry has followed world trends, in spite of the objective and subjective difficulties which generally existed in production and which thus also existed in construction. In the years immediately after World War II, development was especially intensive. The first construction time standards endorsed by the government were already initiated in 1947. With the usage of foreign experience (Russian and other), in conjunction with the significant efforts of domestic engineers and their experience, these time standards obtained their definite form in 1955. Since the 1970’s, there has been significant growth in the production forces in the construction industry and important changes in the technology of construction have been taking place. Manual labor is being replaced by machines wherever possible. Prefabricated construction systems are being applied, especially in residential construction. Existing work norms are no longer applicable to this new technology.

In this period, without government influence, construction companies are more and more often defining their own “internal” time standards. The significant efforts of the KOMGRAP company in Belgrade has led to the formation of books of internal (experiential) time standards which are then published. However, beside the individual attempts and a few research studies, organized efforts to form unique norms, based on the methods of technical standardization, do not exist.

It should be emphasized that the existing standards (of 1955) are still in use, but that companies use them and complement them according to their own needs.

3 The most common methods for recording work in construction processes

In the construction industry, and especially in industrialized construction processes, highly mechanized technology is used more and more often. The application of these modern technologies requires a more complete study of work, as well as the measuring of work time.

The following methods are most often applied for record ing work in modern construction: the stop-watch method, the sampling method, photo-surveys, work day records, and some other especially developed methods. The choice of time measurement methods for studying work in construction processes is directly related to the reasons for the recording and the type of technological process. Production processes in construction may be manual, mechanized and partially mechanized or partially manual. It is also possible to study the work of construction machines and equipment. In Table 1, a selection of the most suitable methods for recording work time is offered according to the actual goal of the recording—the study of work for manual, machinemanual processes and machines. The most common time study equipment is listed. The explanation of method choice will not be discussed here, because it is laid out in detail in the accompanying literature.

However, it is interesting to mention something about the methods for recording work time in construction processes, which are recommended or used for the formation of individual normative times, and for work study as well.

The basic methods of technical standardization which are recommended by the REFA (Verband für Arbeitsstudien und Betriebsorganisation), for example, are: the stop-watch method and the sampling method, but for an individual crew they recommend photo-surveys (Künstner, 1984).

Technical normatives in Soviet construction recommend three methods: the photo-survey, the stop-watch method, and the work day record. These norms differentiate time standards and standards for task completion, where the standards for task completion are inversely proportional to the time standards (Petrov, 1948; Zaharov, 1964). Here the time standards are founded on the methods of statistical modeling. The remaining countries of eastern Europe have followed this practice, and formed their own time standards on the same or similar principles. Czecho-Slovakia and East Germany went the farthest in this direction. Special synthetic time norms for the work of machines were formed.

Yugoslav practice is also based on the stop-watch and photo-survey methods, where an especially mixed photosurvey (graphic and numerical) is used.

However, in order to decrease the cost of work time recording, there is a tendency to use other methods (for certain special goals such as productivity studies, research on machine reliability and so on), such as the MOST technique which is based on synthetic normatives of object movement or specially adapted for construction industry MTM techniques (created by the Swedish MTM association).

For recording and analyzing the productivity of masonry work, a data recording technique which emphasizes the occasional presence of the recorder on the construction site has recently been developed on the international level

Table 1. Methods of time measurement for work study according to the goals of the recording and the type of technological process in construction

Goal of the recording	Type of technological process	Suitable method for recording work time	Most common time study equipment
1 Testing effective work time (without recording stoppages)	manual	stop-watch method	– forms – stop-watch
	manual-machine		– time recording machines – computer (micro) – portable computers
	machine*		– video equipment
2 Testing work time standards	manual*	photo surveys work day records stop-watch method sampling method (MTM), (MOST)	Same as 1. Future development:
	manual-* machine machine		– time-lapse video equipment
3 Organization of work process (time losses in the work process) – productivity analysis	manual	photo-surveys work day records	Same as 1 and 2.
	manual-* machine	special methods photo-surveys work day records	
	machine		
4 Measuring usable	manual	sampling method	– forms

	capacity – daily % of work time and stoppages			– computers (micro)
	– average worker dedication	manual-machine*		– portable computers
	– causes of stoppages	machine*		– video equipment

*Method is especially suitable to the type of technological process.

(Handa, Thomas, Horner, 1990). This technique is adapted to the goal of recording and analyzing productivity.

On the basis of the voluminous study and measurement of work, especially in the industrialized construction processes for prefabricating concrete panel intended for residential construction and certain other construction sites which use prefabricated concrete elements, the experiences of the author follow here:

Work day records Photo-survey (graphic)	For processes which are well placed in relation to technology and organization, when one wishes to obtain reliable data about time norms and usable capacity, the work day record (graphic photo-survey) should be used.
Sampling method	When one wishes to quickly obtain data with which to intervene in the work process, efficiently, quickly and without a large investment, the sampling method gives maximal results.
Work day record Sampling method	For measuring transport machines in the prefabrication process, both of the suggested methods can be used, depending on the effect one wishes to achieve with the work record.
Stop-watch method	Cyclical work time operations of construction machines.

When choosing a method, one should utilize the criteria of observation (Vuković, 1990) for individual methods, and then decide on the most appropriate method.

4 Treatment of the statistical modeling of work time in construction processes

Construction production processes can be described as being repetitive processes of the man-machine type. In the process flow, it is possible to register a large number of technological and organizational factors which influence the process, and which have a deterministic or stochastic character. Among the deterministic factors one can fairly precisely define the effects of activities, while among accidental factors, one can hardly define the effects of the activities whatsoever. Most often, construction production processes are weakly structured processes, because there are fewer deterministic than stochastic factors which effect the production process. All stochastic variables carry uncertainty in themselves, changing over time. That uncertainty is related to the appearance of factors on some of the characteristics of the process and on its results (according to Flašar, 1991).

Weakly structured repetitive processes can best be presented with statistical models. Various methods can be used for measuring work time, but the most complete results are obtained by means of the photo survey, where sets of measured values expressed variably are obtained. Such data sets of measured time are most suitable for the modeling of processes.

On the basis of completed experimental research done by the author (Vuković, 1990), it was determined that the statistical modeling of construction processes (that is, measured work time) can be done by the process which will be described further on in this paper.

The research of an empirical data set is presented as the starting point for the statistical modeling of the process: data analysis, testing of the statistical set's size with a reliability evaluation of 0.95, the exclusion of rough measurement and process errors, testing the homogeneity of the set. Here, it should be noted that only stable production processes can be reliably modeled, meaning those production processes from which unallowable factors have been removed (the use of raw materials whose quality is changeable, changes in machine adjustment, changes in the production order, inadequate worker training, systematic errors in the process). The stability of the process is tested in a known way, by means of control charts.

The statistical model encompasses the calculation of statistical parameters, as well as the definition of empirical functions of probability density and distribution functions.

The state of a technological system in construction (both as a whole and element by element), can be described by means of a distribution model. Even though work measurement deals with discrete data, it is possible to approximate by continual theoretical distributions. For researching a prefabrication production process and certain assembly processes on the construction site, it has been concluded that the following model for the approximation of empirical data can be proposed:

Effective work	Log normal distribution, Weibull's, Gamma, Pearson Type III, and normal distribution.
Preparatory-finishing work	Log-normal distribution, Weibull's, Gamma, Pearson Type III and normal distribution.
Total work Work process (work tact)	Same as effective work. Log-normal distribution, Weibull's, Gamma, and Pearson Type III distribution.

In each case, the quality of the approximation should be tested with statistical tests (Pearson's χ^2-test and the Kolmogorov-Smirnov test).

On the basis of these statistical distribution models the character and flow of the process can be defined, its stability and natural precision, and then it will be possible to make decisions about the process and confirm the time norms for the work with a certain reliability.

Two or more variables must often be observed during the analyses of the production process. In that case, variance analysis can be used, simple and multiple linear regression analysis. Simple and multiple correlation analysis and analysis by means of Spearman's coefficient ranking can be used in the analyses of the interdependence of production factors. These analyses of dependence and interdependence make the testing of the significance of individual factors possible, which effect the process and productivity. Multiple regression analysis as a model was best applied in the author's research of work time for processes in which the complex effect of factors was ascertained. It was also concluded that all relations in that analysis are not linear.

The proposed models of theoretical distributions can be used to model work processes in the construction industry. It is also possible to model the common influence of factors which effect the work process by means of regression models, the multiple regression models being the best.

5 Conclusions

The complexity of construction processes, as well as the influence of numerous factors which effect them, often require valuable and long lasting work records. Such data bases are thus highly valued, and should be used for the formation of universal (broadly used) work time standards. In that sense, they can be of great usefulness in the modeling of processes and work time, on the basis of experimentally gained measurements.

However, the author has concluded, by doing experimental research and work measurements in prefabrication plants and on numerous construction sites, that it is not possible to successfully model a process which is not stable. The process should thus be made stable first, and then it may be modeled.

Likewise, it should be emphasized that conditions on the construction site are truly varied and that a universal solution, without proper analyses of the factors which effect the specific processes, is impossible. This is true both for work time norms and the process itself. Well placed correctional factors can be a solution for some intended goals (productivity studies). Further research will probably offer answers to these questions.

6 References

Barnes, M.R. (1958) Motion and Time Study. 4th Edition, John Wiley and Sons, Inc., New York.

Flašar, A. Vuković, S. and Brana, P. (1987) Recording and defining work time norms. Gradevinski kalendar 1988, Belgrade, pp. 455–545. (in Serbo-Croatian)

Flašar, A. (1991) The statistical modeling of repetitive building production processes. Proceedings of the International Conference on Construction Project Modeling and Productivity, Dubrovnik-Cavtat.

Gilchrist, W. (1984) Statistical Modelling. John Wiley and Sons, Chichester.

Handa, V.K., Thomas, R.H. and Horner, R.M.W. (1990) International collaborative field study of masonry productivity. CIB '90 Proceedings, Building economics and construction management, Management of the building firm, Vol. 6, Sydney, p. 230.

Horner, M.W., Talhouni, B.T. and Whitehead, R.C. (1987) Measurement of factors affecting labour productivity on construction sites. Managing Construction Worldwide, Vol. 3, E. and F.N.Spon Ltd., London, p. 669.

Klepac, J. (1982) Work Study in Construction. Faculty of Construction Sciences, University of Zagreb, Institute of Civil Engineering, Zagreb, (in Croato-Serbian)

Künstner, G. (1984) REFA in der Baupraxis—Datenermittlung. Teil 2, ZTV—Verlag, Frankfurt/Main.

Lehrer, N.R. (1957) Work Simplification. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
Maynard, H.B. (1972) Industrial Engineering Handbook. 3rd Edition, McGraw-Hill Book Company, New York.
Petrov, I.A. (1948) Tehničko normiranje i predračuni. Rad, Belgrade. (Serbo-Croation translation of the Russian)
Petrovic, M.B. (1986) Work Standards. Yugoslav Institute for Work Productivity, Belgrade, (in Serbo-Croatian)
Silanteva, N.A. (1966) Matematicheskie metodi v tehnichejskom normirovnii truda—na mashinostroitelnom predprijatii. Izdatelsvo Mashinostroenie, Moscow.
Taboršak, D. (1987) Work Study. Tehnička knjiga, Zagreb, (in Croato-Serbian)
Vuković, S. (1985) Recording work processes in prefabrication—the work day recording. Organizacija rada, 10, pp. 13–19. (in Serbo-Croatian)
Vuković, S. (1990) The productivity of lines for the prefabrication of reinforced concrete panels. Special Edition 15, Faculty of Technical Sciences, Institute for Industrialized Building, Novi Sad. (in Serbo-Croatian)
Zaharov, N.N. (1959) Tehnicheskoe normirovanie truda v mashinostojenij. MASGIZ, Moscow.

35
Comparison of control concepts and information systems in different parts of the Dutch construction industry

J.W.F.WAMELINK, B.MELLES and J.BLAAUWENDRAAD

Abstract
In this paper an overview of differences in control concepts in different parts of the Dutch construction industry is presented. A description method for control concepts is given. Finally the consequences for supporting information systems will be discussed.
Keywords: Classification of Production Control, Management Information Systems, Supporting Information Systems

1. Introduction

During recent years research projects on project management and control in the construction industry have become very popular. As a result of the growth of computer facilities a number of software packages have been released. However, in certain parts of the building industry, the developed software for production control is not able to address all problems in controlling projects.

For this reason the Delft University of Technology started a research program to investigate the backgrounds of these problems. Controlling projects consists of making decisions based on available information. To describe the differences in decisions and information needs a description method has been developed.

The objective of these paper is to discuss some remarkable results of the investigations and to evaluate the consequences for the development of new software packages.

2. How to model production control

The production process in the building industry aims to deliver building objects of high quality at an acceptable price and building time. In other words: “the production process must be executed under certain conditions”.

To achieve the conditions the production process has to be controlled. This results in the systems theory approach (figure 1).

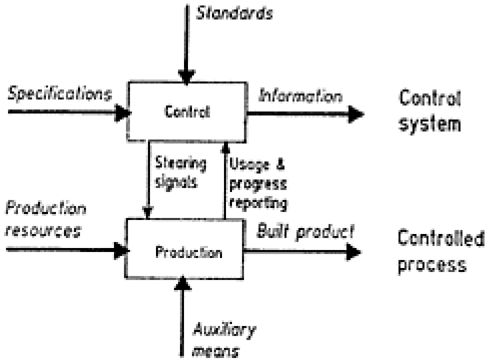


Fig. 1. systems theory approach

The objective is to compare the different control situations. For this reason a basic model of the working of the control system has been developed (figure 2)

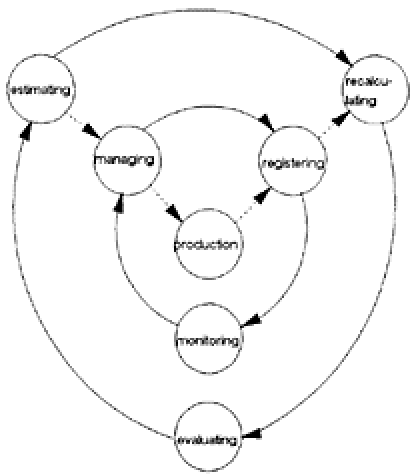


Fig. 2. The basic control system

The control system receives data about resource usage and the progress of the production process. After processing (interpretating) this data it may necessary to adjust the production process.

The control system consists of several control activities: managing, registering, monitoring, estimating, recalculating and evaluating.

The control activity "estimating" sets the required value of different attributes of the production process and product such as quantity and quality. Monitoring the system consists of comparing these requirements with the registe-red value. In case of a difference between these two values, the system can re-adjust the production process or set new requirements. The decision between these two possibilities is made by the control activity “managing”. Collecting and processing data is done in the control activity “recalculating”. The control activity “evaluating” compares project estimates with real usage of resources.

The control cycle must be run for several aspects. Table 1 shows which aspects must be managed.

Table 1. Aspects and Attributes

aspects	attributes
materials	quantity (Q)
equipment	point of time (Pt)
labour	price (Pr)
activity	location (L)
	specification (S)

Varying the combinations of aspects and attributes allows us to model a change in production control.

After examining process control in several building firms we discovered various control cycles within a single project. The control system within one project consists of four control levels connected with each other. The control activities as discussed before (estimating, etc.) can be distinguished on each control level.

Every control system has its own specific task which can be summarized in a specific objective.

Regulation (Firm coordination): The regulation system formulates the conditions under which a building object must be realized. Labour and equipment from the building firm must be allocated over the different current projects. The interests of the building firm as a whole come first. This is reflected in the priority given to different projects.

Coordination (project coordination): The coordination system coordinates the different activities in one project. Duration time of the project is the primary concern. Within the conditions of the controlling system in this system, different production schemes are made. For every activity the required material, labour and equipment is globally determined.

Mobilisation: The objective of this system is to determine the exact needs of materials, labour and equipment. Not only the attribute quantity should be determined, but also the different points in time at which materials, labour and equipment must be delivered to the building site.

Allocation: The allocation system is most directly involved with the production on site. In this system different tasks are allocated to the available gangs or equipment. The objective of this system is to optimize the available equipment and gangs on the site. In other words: loss of available capacity must be avoided.

The main characteristics of the used model of production control can be summarized:

1. The model has a cyclic character. This aspect underscores the dynamic character of production control
2. The model has been divided into specific levels. Each level has its own objective. The different objectives result in different goal variables for each level. This aspect underscores the different subgoals within the total production control system.
3. The model contains variables to control the production process. These variables are made up to a combination of an aspect and an attribute. The possibility of varying different variables affects the control activities.

3. Production control in practice

After modelling the production control process the model has been used to investigate production control in practice.

The activities of different employees in a large number of construction companies have been investigated. The activities of these employees have been described using the IDEFO technique. This method is also being used by the research group of V.Sanvido (Sanvido et al. 1990) who made comparable models for the US-building industry.

The cyclic model as explained in the preceding section has been used to analyse the activities of the employees. The activities have been linked with the control-levels, the aspects, attributes and controlactivities.

To facilitate understanding, the results of the investigations can be summarized in one figure (figure 3).

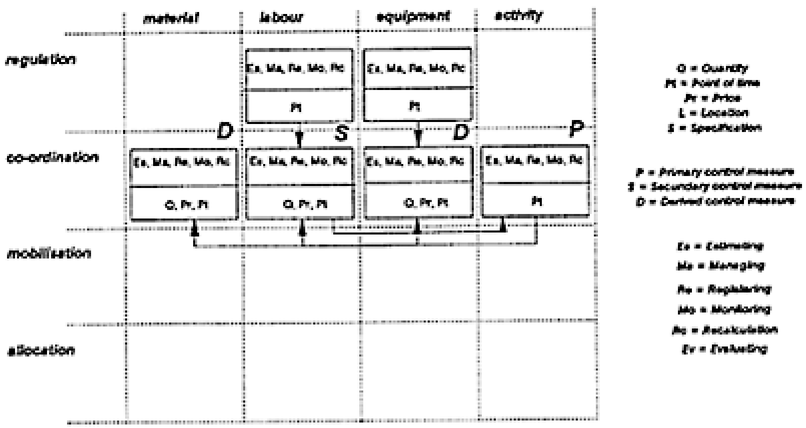


Fig. 3. Principle of the description method

For this specific case much attention is paid to the regulation control level. This means that the designer of this control system thinks that the control of equipment and labour use in time is very important on the multi-project level: the attribute “point in time” is being estimated, registered, etc.

The coordination level is also very important. The control of the aspect “activity” is chosen as the most important (indicated by P above the rectangle). The control of the other aspects is being derived (materials and equipment) or secondary (labour). A secondary control measure means that feedback takes place. In the example of figure 4, the control of activities is the primary control measure on the co-ordination level. The activity scheme is made first. All other schemes are derived from the activity schedule except the control of labour: the result of scheduling the aspect “labour” is fed back to the scheduling of activities e.g. in case of leveling labour resources. No attention is paid to the control tasks from the mobilisation- and allocation level. This means that people pay less attention to the deliveries on the building site or the allocation of gangs of workmen to tasks on the building site. In practice this means that control of tasks on the building site with a very short horizon (one week) is done informally.

4. Classification of production control situations in the Dutch construction industry

The description method as explained in the preceding section can be used to summarize the controlconcept of production situations in the Dutch building industry. In doing so, our research group investigated the control processes which can be recognised in different production situations in the Dutch building industry.

A distinction has been made between seven classes of production situations (building works, housing, renovation, small civil works, civil works, road construction, dredging). We will discuss the main conclusions for three classes.

4.1 Housing

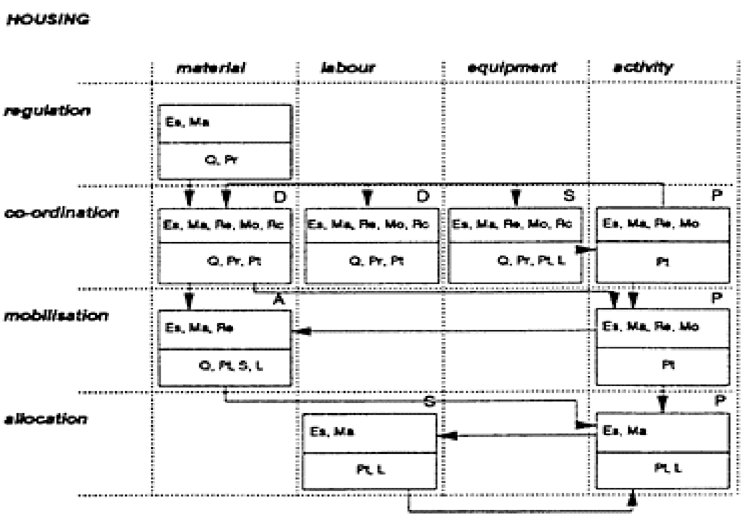


Fig. 4. Control concept in housing

Figure 4 shows only the formal decisions. In the case of housing the formal decisions are focused on the coordination level. Little attention is paid to the regulation level. The mobilisation of labour and equipment is not very formal organized. Not much attention is paid to the allocation of materials and equipment on site (allocation level). The investigations made clear that most of the theoretical expected decisions were made informally. It is very popular to improvise. This is remarkable when considering such large projects.

4.2 Road construction

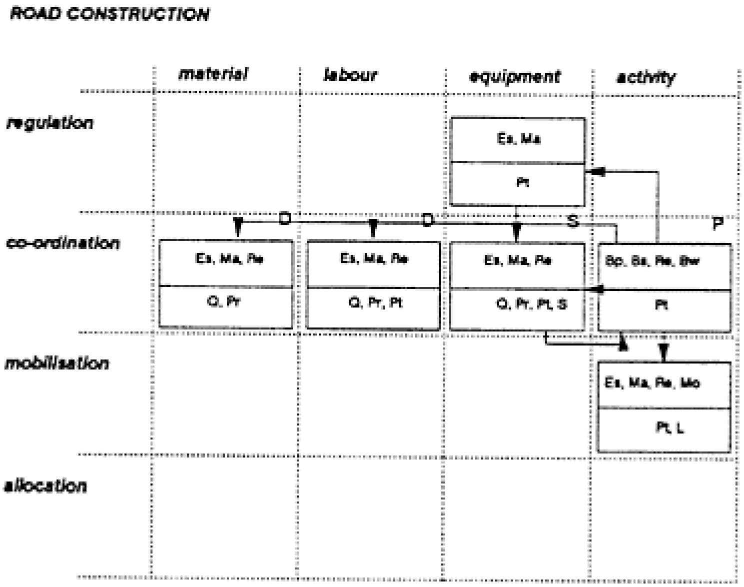


Fig. 5. Control concept in road construction

Comparing figure 4 to figure 5 we recognize that in road construction projects even less formal decisions are taken.

Further investigations make clear that there are also no formal decisions about labour on the regulation, mobilisation and allocation level. The explanation is that in road construction labour is related to the equipment.

It is also remarkable that on the mobilisation and allocation levels all theoretical expected decisions on equipment and materials are made informally. Investigations showed that there were large inefficiency losses wich were directly related to the informal way of deciding.

4.3 Small civil works

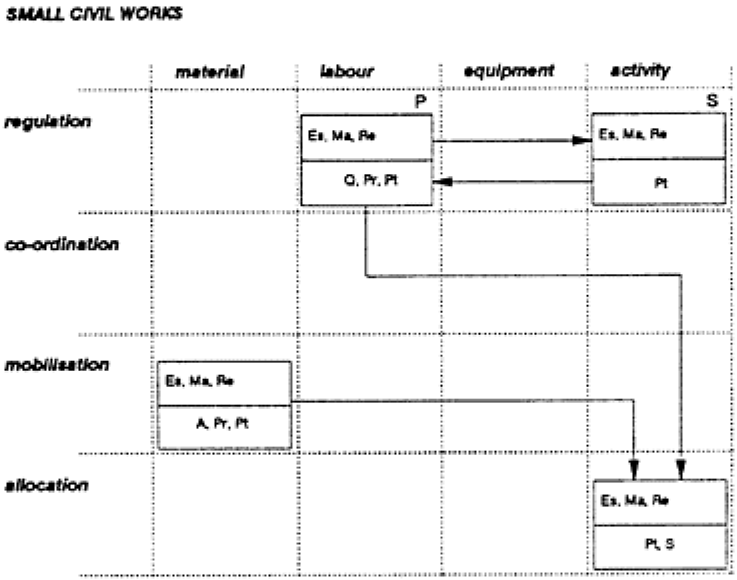


Fig. 6. Control concept in small civil works

Figure 6 shows us that there are no decisions about equipment. In fact this is the same problem as we recognized in the case of road construction. Now (small) equipment is directly related to labour. If we schedule workmen, equipment is also scheduled.

Another remarkable issue is the total absence of the coordination level. Investigations made clear that there are not even informal decisions. The explanation is simple. The projects are very small. Overall-project coordination is not useful. The production control (formaly and informaly) is concentrated on the (multi-project) regulation level. The real start of the production process is directly related to the mobilisation of materials. The mobilisation of materials is, in this case, the same as allocation of materials. The quantity of materials is very small thus further allocation is not necessary. In the same way mobilisation and allocation of labour are (in this case) more or less the same.

4.4 Some remarkable conclusions

—The formal production control decisions are different within different areas of the construction industry. The main issue to characterizing these areas is the specific product.

—In some cases decisions about labour and equipment are put together because the are directly related. In that case the theoretical production control model changes.

—Formal production control on regulation, mobilisation and allocation level is mostly replaced by improvisation. Investigations made clear that inefficiency losses are high. These are directly related to the use of too much improvisation.

5. Production control and automated information systems

Making decisions about production control, within the control system, needs a lot of information. This information is provided by an (automated) information system (figure 7, according to Bertrand and Wortmann (1981)).

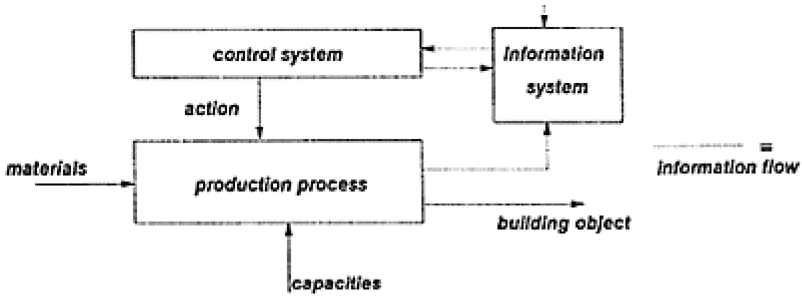


Figure 7: Relation between production process, control system and information system

It is clear that the design of both systems (the production control system and the information system) can not be separated. The information system should support the production control system in a proper way.

If we look to the automated information systems used in the Dutch construction industry we see that they are based on standard software packages. The software packages are developed by specialised software houses.

Analysing the control concept of different projects in the building industry shows us that control concepts can be different for various production situations. However the standard software packages do not differ.

There are large differences between real control concepts and the control concept of supporting information systems. The multi-project situation in road-construction can not be supported with available software. Also the typical control concept of small civil works can not be supported. Future development of software has to take into account more differences between the control concepts. Only then can an appropriate support of the control system in various production situations be provided.

6. Final conclusions

We recognise a great number of differences in production control in production situations in the Dutch construction industry. These differences are partly introduced by too much confidence in improvisation. These differences are also partly related to the specific product (e.g. production time). The standard software packages do not account for these differences. Mostly, the standard software packages are developed for building projects.

This is one reason that the introduction of automated information systems in some areas of construction (e.g. road construction and small civil works) goes very slow.

7. Acknowledgements

The research described in this paper has been executed within a co-operative project from Delft University of Technology, a Dutch software development company and the Dutch building industry. Prof.ir. Ch.J.Vos, ir. J.C.B.Robers (Delft University of Technology, Faculty of Civil Engineering), prof.dr.ir. J.C.Wortmann (Eindhoven University of Technology, Faculty of Industrial Engineering and Management Science), dr.ir. R.Kwikkers (TNO Institute of Information Technology for Production Automation and Logistics, Eindhoven) contribute in the supervision of the project.

8. References

Bertrand, J.W.M., Wortmann, J.C. (1981), **Production control and information systems for component-manufacturing shops,** Elsevier, Amsterdam

Gunning J.G., Site management Information and control systems, **CIB Waterloo Vol 1,** pp 169–179

Melles, B., Wamelink J.W.F. (1990), **Process control in the building industry (in Dutch),** TU-Delft, Faculty of Civil Engineering, Delft

O'Brien J., Review of Management Information Systems in Construction, **IABSE journal j-38/89,** 1989, pp12–17

Sanvido, V., Khayyal, S., Guvenis, M., Norton, K., Hetrick, M., Chung, E., Al-Muallem, M., (1990) Information requirements for an integrated building process model, **CIB Sydney Vol 4**

Veld in 't, J. (1981)**, Analysis of organisation problems** (in Dutch), Elsevier, Amsterdam

36
Corporate failure in the construction industry

B.A.YOUNG

Abstract
This paper presents the findings of information contained in the reports of the Official Receiver on involuntary liquidations which took place between 1973 and 1983. The 375 limited companies under investigation comprised of Building and/or Civil Engineering Contractors and Specialist Trade Contractors. Most liquidations were confined to small firms. The reasons for corporate failure may well explain the more recent bout of business collapse inflicted on the construction industry.

Keywords: Building/Civil Engineering Contractors, Specialist Trade Contractors, Involuntary Insolvency.

1. Introduction

The literature on corporate failure rather than identifying the causes of failure, with the notable exception of the London Business School (1987), tends to concentrate on providing a set of symptoms. Additionally, reliance on data from quoted companies is often the case, discriminating between the probability of ‘likely’ failure and ‘likely’ survivor with the explicit objective of improving the capital market, Altman (1968). Though Storey et al (1987) attempt to break the mould, not only by focusing on the unquoted sector but including non-financial variables, they do not address whatever factors lead to failure, only the symptoms.

More alarmingly is the absence of a body of knowledge which would serve to explain the factors associated with failure of firms, particularly those having operated in the construction industry. Given the reportedly relatively high incidence of construction firm fatalities compared to other industrial and service sectors (Hall & Young 1988), the analysis that follows attempts to ameliorate this deficiency.

2. Methodology

For the purpose of this paper 375 cases were selected from a sample of 1064 involuntary insolvencies which took place between 1973 and 1983. Of the 375 cases, 264 were categorised as Building and/or Civil Engineering Contractors, the remaining 111 insolvents represented the Specialist Trade sector. Combined, these two categories represent 35% of limited companies failing over that ten year period. Reported elsewhere are inter-sectorial comparisons (Hall & Young 1991). The manufacturing sector was second to construction with significantly less reported failures; only 10% in all. The overwhelming evidence suggests that the construction industry was the most vulnerable sector during that 10 year period and that the same is true in the early 1990s, given current business collapses (New Builder 1991).

The legal requirement is for the Official Receiver (OR) to provide a comprehensive report on each case of involuntary insolvency. The OR reports contain a mixture of factual and subjective information including:

- year of insolvency
- period of trading
- nature of business
- value of assets at time of insolvency
- total estimated deficiency at insolvency
- reasons for failure as perceived by the owner
- reasons for failure as perceived by the OR.

Occasionally, OR reports give details of historical data, for instance, owners' remuneration, gross and net profits, which in sufficient volume, would have been of immense value. Since the enforcement of the 1985 Companies Act, the OR reports contain considerably less information and therefore comparisons are not possible with more recent years.

All money values have been inflated to their equivalent at 1988 prices.

3. Corporate failure

3.1 Size and insolvency

The mean value of assets in 1988 prices in the 375 cases that provided this information was £58,873. Only 4 contractors exceeded £100,000 and the maximum value was £1,652,266. The owners of failing companies may be expected to dispose of whatever assets they can prior to the beginning of formal insolvency proceedings. Turnover in years prior to failure would be a more reliable measure of size, but few companies were able to supply this information, even though a legal requirement.

A more comprehensive but surrogate indication of size, that is estimated total deficiency, is the amount owed at the time of winding up the business. The mean was £627,305 and the standard deviation £3,328,044 reflecting the outliner £9 million maximum. Only 5 contractors owed more that £1 million, whereas 199 contractors were in debt for less than £50,000. Although, by definition, the burden of debt is shared by the larger contractors, failure is almost confined to relatively small firms.

3.2 Number of years traded

The mean life span of the insolvents was 6.75 years and the standard deviation 8.25 years. Fifty six per cent of the sample firms survived less that 5 years and only 18% traded beyond 10 years.

If firms are to fail, it will almost certainly be in their infancy. The incidence of post-natal mortality would appear, however, to be lower for contractors than Gangullys (1975) more general study suggested. He estimated that 54% of firms, VAT registered, failed within the first two years. This is not borne out by the contractors. Within the first two years of operation only 20% Builders and/or Civil Engineering Contractors had ceased trading and less than 15% Specialist Contractors. The critical development stage occurred between 2–5 years and the likelihood of failure it would appear diminishes thereafter. Gangully estimated the average life expectancy of firms doomed to fail was 2–3 years, just less than a third reported here. As Gangully conceded, VAT registration is only an approximate surrogate for corporate existence, not all firms hit the threshold for VAT and become registered.

When the data is banded into <5 years, 5–9 years and 10 years and over, and cross tabulated with nature of business, differences are not significant at 0.05% on a X^2 distribution. No association between lifespan and the type of contractor can be claimed on the evidence obtained from these data (Appendix I). The early development period when contractors were attempting to build up their business was when they were most vulnerable. Both sectors, Building and/or Civil Engineering Contractors and Specialists became subject to the vagaries of the market in which they operate.

4. Reasons for failure

The majority of OR reports contain the reasons for failure as perceived by owners and OR's. Both views are worthy of reporting, even though owners may lack the objectivity or expertise to correctly interpret the facts and OR's are disciplined by their training, which is biased towards accountancy.

Nevertheless, owners are most closely associated with the history of their companies, albeit relatively short lived. OR's may draw advice from employees, creditors, solicitors and bankers, widening the investigation. However as the LBS study implies a question-mark hangs over the competence of bank managers to make a balanced assessment of why businesses with which they had dealings had proved unsuccessful. A bias towards financial factors would appear inevitable. Because of the necessity for brevity only the opinions of owners are reported below.

Table 1. Reasons for Failure—Owner's Perceptions

	N=300
Operational Management	
Undercapitalisation	89
Poor management of debt	58
Inaccurate costing and estimating	27
Poor management accounting	8
Poor supervision of staff	4
Skill shortages	2
	188
Strategic	
Lack of demand	18
Funding associated companies	12
Reliance on a few clients	10
Competitor behaviour	2
Reliance on a few suppliers	2
	44
Personal	
Disagreement with partners	8
Ill health	8
Excessive remuneration	7
	24
Technological	
Inferior product	11
No previous knowledge or experience	4
Use of inferior materials	1
Inferior plant	1
	17
Environmental	
High interest rate	6
Fire	2
Theft	4

Exchange rates	1
	13
Marketing	
Under pricing	8
	8
Rises In Costs	
Overhead	1
Labour	1
Material	4
	6

4.1 Owners' perceptions

Those factors which may be construed as beyond owner's control, labelled 'environmental' were not commonly cited reasons for failure. Nor were rises in costs, only 2% of the sample attributed failure to increased overheads, and variable costs (Table 1).

Overwhelmingly, owners ascribe their failure to problems in operational management and, of these, under capitalization—a shortage of working capital, ranked the most important reason followed by poor management of debt. Clearly, a cash-rich business can more readily ride the tough times and buy time to change course when market forces dictate. But by the very nature of business survival, especially a new business without a track record, attracting finance is an unrelenting task. As McQueen (1989) claims, banks loathe to risk capital in a new business when there are plenty of much safer investments around.

Strategic Issues featured relatively importantly with 15% of contractors claiming to apportion failure to lack of market demand, the costs of funding associated companies, the reliance on few suppliers and behaviour of competitors.

Of the 17 contractors who attributed failure to technological factors, 11 conceded that quality was inferior to those of their competitors. In comparison, inferior plant and materials received low weighting. Only 2 cases are reported.

Most striking is the virtual absence of marketing skills, which are regarded as often lacking by managers in the construction industry. Rather than refute this wisdom, it more than likely vindicates the low priority attached to marketing.

It is not possible to state with any certainty whether there are statistically significant differences in the distribution of reasons across contractors (Appendix II).

There are too many cells with expected values of <5 to allow inference. However, there are differences, Specialist Trade Contractors cited problems in Strategic Management more than expected and Building and/or Civil Engineering contractors much less. Conversely, main stream contracting placed more emphasis on Operational Management than did Specialist Contractors.

5. Conclusions

This paper is based on a study which drew on a previously untapped source to add to the meagre state of knowledge of the factors associated with corporate failure, especially amongst small firms in the construction industry.

Firstly, it would appear that contractors operating at the smaller end of the construction industry irrespective of the nature of the business became insolvent for relatively small amounts.

Secondly, contractors regardless of the type of business experienced difficulties in keeping their business solvent particulary during the critical, early development stages, within 5 years of business start-up. Since the initial years of trading are the most vulnerable in the life span of contractors, assistance by various bodies, tailored to suit the needs of contractors at stages in their development, may reduce the incidence of insolvency in the construction industry.

Moreover, the factors associated with failure, namely Operational Management and Strategic Issues which are common to Specialist and Building and/or Civil Engineering Contractors alike deserve immediate attention.

With high probability, the reasons for failure could be extended to the recent wave of corporate failure that is blighting the construction industry.

Finally, the adequacy of the capital market, a commonly voiced criticism is further underscored by the results of this study. Contractors may well question the rationale behind the banks' decision to lend finance and lay the blame for failure on the lack of adequate capital.

References

Altman, E.I. (1968) Financial Radios, Discriminant Analysis and the Prediction of Corporate Bankruptcy in **Journal of Finance,** Vol. 23, No. 4, September, pp. 589–609.

Ganguly, P. (1983) Lifespan Analysis of Business In The UK 1973–82 in **British Business**. August.

Hall, G. and Young, B.A. (1988) Factors Associated with Insolvency amongst Small Firms in the London Area, **MBS Working Paper** No. 181.

Hall, G and Young B.A. (1991) Factors Associated With Small Firm Insolvency, in **International Small Business Journal,** No. 2, February.

London Business School. (1987) **A Study To Determine The Reasons For Failure of Small Businesses In The UK.**

McQueen, J. (1989) The Causes Of Business Failure in **Management Accounting,** June.

New Builder (1991) Business in Brief, 14 February.

Storey, D. Keasey, K. Watson.R, and Wynarczyk, P. (1987) **The Performance of Small Firms**. Croom Helm.

Appendix I Number of Years Traded By Nature Of Business

Years	Specialist Trade	Building/Civil Engineering
<5	56	156
	(62.8)	(149.2)

5–9	30	66
	(28.4)	(67.6)
10 and over	25	42
	(19.8)	(47.2)
X^2=3.0		N=375

Appendix II Owners' Reasons By Nature Of Business

	Specialist Trade	Building/Civil Engineering
Costs of Production	1 (1.7)	5 (4.3)
Technogical	3 (4.8)	14 (12.2)
Operational Management	42 (56.6)	146 (135.4)
Marketing	3 (2.2)	5 (5.8)
Personal	10 (6.7)	14 (17.3)
Strategic	20 (12.3)	24 (17.3)
Environmental	5 (3.6)	8 (9.4)
X^2=14.2		N=300

PART TWO
QUALITY

37
Quality housing in the context of a developing country

A.K.ABIKO

Abstract
The shortage of residential buildings in developing countries can be minimized if we comprehensively understand the phenomena and establish the correct role of technology among other means.

This paper discusses the main instruments that have been introduced to improve quality brazilian housing in the areas of standardization, performance concepts, quality control, and also discusses how these instruments could be most effective.

Keywords: Housing, Quality, Low-income people, Developing country.

1 Introduction

Recent statistics point out that a 10 million house shortage exists in Brazil. For a country of 150 million habitants, that represents roughly a third of its population, 50 million people having precarious habitations.

The brazilian housing problem, as well as that of many other developing countries, should be understood as a result of several structural and conjunture factors that have their roots in the uneven growing and the accelerated urbanization process which have involved the country in the last decades. This has made a dramatic picture of living conditions in the rural and urban areas.

The urbanization rate has grown from 30% in the 1940's to 70% in the 1980's in a chaotic process of metropolis build-up and in an increasing reduction of the quality of living conditions in population in towns.

In adition, the cost of a housing unit has become considerably farther from the population income. This is duo to an uneven growing process.

In 1981, the poorest half of the brazilian population made up 13.4% of the national income and in 1989 they only earned 10.4%. In the beginning of this decade, the wealthiest 5% of the population held 33.4% of the country's income and that amount had grown to 39.4% untill the end of the decade.

The income in 1988 was $ 2,437 dollars per capita.

In 1975, each square meter of a habitation unit had cost $ 100 dollars and in 1988 this value has risen to $ 350 dollars. In 1988 a Brazilian family should have a yearly income of $ 4,400 dollars to get a 25 year loan for a 35 sq mt house.

This disparity between housing price and purchasing capacity had happened due to the increase of land and infrastructure costs as well as material, labor and management costs.

2 Quality

By the brief panorama pictured above, one could see that the housing problem is complex, still growing and involves a lot of factors for a variety of institution for various interests.

It is the concern of technical staffs to find a solution to this problem in the range of their actions, or at least to find some relief to the problems. There is a need to become prepared with solutions without discouragement confronting such difficulties.

The matter of quality emerges from this context.

This subject has long been a concern in the industry sector and involved concepts such as productivity, competitivity and rationalization. The quality concept plays more and more a fundamental role in this sector. Lately this concept has been changed to a position, an attitude to the production and the product.

Civil construction in developing countries has not had that happen so far due to several reasons: scattered and disorientated customers, lack of technical documentation of quality evaluation, lack of interest of the companies, lack of a technical institution prepared to face the problem and to propose quality improvement.

Undoubtly nobody is against quality. Moreover quality contributes to:

- final cost reduction of the product: in civil construction, durability (an important item) is improved and thus maintenance expenses are reduced;
- improvement of the productive process through rationalization (in civil construction, the productive process is mostly primitive and becomes necessary to train labor and utilize equipments in order to ease the job);
- standardization and modulation that allow component matching and waste reduction.

Five instruments were implanted in Brazil intended to converge means of improvement of quality housing construction: technical standardization, quality control, conformity certification, homologation and quality warranty.

2.1 Technical Standardization

The ABNT—Associação Brasileira de Normas Técnicas—has been coordinating the actions of technical standardization in the country with the purpose of modernizing the normative body by reviewing obsolete standards and elaborating new texts for sectors lacking standardization.

These actions have sought to develop technical standards designated to: steps of design, material and component fabrication, building construction and housing use and maintenance, in the hope to get an articulated normative action and to reward all productive processes and housing utilization. The types of standards elaborated by ABNT involve: specification, test methods, standardization, procedure, symbolization, classification and terminology.

A brief assessment of the brazilian process of technical standardization of the past 4 years shows a reasonable increase of standards reviewed as well as development of new texts in progress. An updated review points to the existence of 85 study commissions at COBRACON (Comitê Brasileiro da Construção Civil) which are analysing approximately 300 texts (reviews and new texts) and the existence of 615 standards within the range of this Commitee.

It should be stressed that this intensification of the technical standardization process is attributed to the increasing participation from universities, research institutes, syndicates, class associations, and public and private companies.

Although technical standardization is going fairly well, there are several gaps to be filled. The standardization process still needs to form a more professional structure, as it has occured in many developed countries where the subject of quality has received more and more importance.

Technical standardization supports the development of systems of quality control, conformity certification, product and innovative process homologation, and quality warranty.

2.2 Quality Control

The quality control actions of housing construction in Brazil have been very incipient so far. They exist in isolated areas, on iniative from promoter agents, some material manufacturers and some building contractors which have tried to establish a differentiated market image. The controls adopted have been mostly technological material controls (specificaly for concrete) and more recently some design and construction task controls have appeared. The results from these quality control housing construction actions have been very limited countrywide. There is still a gap for implementation of production control systems and reception control systems, involving design steps as well as material manufacturing and building construction.

2.3 Conformity Certification

Conformity Certification is a system suitable to already acclaimed standardized products. It proves the conformity of materials and components to a certain standard by carrying out tests of samples collected from the market and factory, and by auditing through specific technical regulations the production quality control system adopted by the manufacturer.

The conformity certification system has its basis on prescriptive technical standards, chiefly specifications and test methods, and grants a ‘Conformity Seal’ to an approved product.

There are still few moves on this matter in Brazil, with exeption of the ABNT Conformity Seal to portland cement, fire extinguishers and fire-resisting doors.

The actions on conformity certification should expand significantly in Brazil with the implication of the Customer Protection Code, increasing the number of certifying institutions, laboratories and private companies involved in the certification process.

2.4 Homologation

The homologation system is suitable for prescriptive standardless products and inovative process in building construction. The system aims to certify the suitability of a component or constructive system by subjecting it to a performance judgement before market release. The homologation system has its basis on performance standards or directions on performance evaluation. It grants to a approved product or process a Homologation Certificate valid within a period of time and conditions of production, control and use.

In Brazil there is no homologation system in course so far.

During 1985 to 1989 a series of studies and research had been developed by universities, research institutes and companies where the performance evaluation policy had progressively been diffused and brought to effect its practical implement. This policy was first introduced into the elaboration of performance standards for housing components (doors, windows, partitions, floors, etc.) and into submission of performance concept to specific subjets as acoustic, thermal comfort, fire safety, watertighness, structural safety, and durability.

Some institutes and private laboratories have improved their equipment and technical capacity in order to be able to evaluate housing construction performance. Nowadays laboratories and technical background existing in the country is at minimum level to head a performance evaluation and later the homologation of components and construtive systems.

2.5 Quality Warranty

In Brazil the actions of quality affairs have been done in an isolated form. Although they have been dealted with a wide form worldwide through quality warranty systems (understood as the action-rig during all the process of production and use, involving many factors such as technical, labor, organization and company management).

Some building contractors of medium to high income housing have shown little moves toward quality warranty, guided by the serie of standards from ISO/NB-9000 (guidelines to implantation of quality warranty systems) and they have started their efforts by creating internal standards and establishing quality control procedure for steps of design, selection, material, reception and building construction.

It is still impossible to evaluate the results of those actions because they are very recent and isolated. However the future tendency is the adoption and implantation of quality warranty systems, particularly when markets become more competitive and customers demanding higher quality.

3 Conclusion

Due to the magnitude and complexity of housing matter in Brazil and other developing countries, civil construction requires a technological and organizational modernization process.

Such a modernization process aims fundamentaly to improve the quality of final products available in the market, decrease of materials wasted, productivity increase implemented in the processes and expansion of the range of technological inovations at stages of design, material and constructive systems.

We believe that we have been on the right path by implanting several instruments mentioned in this paper. Those instruments belong to a National Technological Housing Policy that is now being discussed in this country.

We would appreciate having these instruments discussed in a wider perspective with the participation of industrialized countries which have already overcome many times the problems pointed above. New ideas might arise and from the discussion of these ideas may exist the solution to these problems.

4 References

Meseguer, A.G. (1989) **Garantia de Calidad en Construction**. Madrid, Agrupacción Nacional de Constructores de Obras.

Helene, P..L. and Souza, R. (1986) Controle de qualidade na indústria da construção. **A Construção São Paulo,** 1981, 27–01–86 (Tecnologia de Edificaçðes n° 72)

Instituto de Pesquisas Tecnológicas do Estado de São Paulo—IPT (1984) **A Avaliação de Desempenho de Sistemas construtivos Empregados em Canteiro Experimental da COHAB-SP**. Relatório n° 19.816, IPT, São Paulo.

38
Quality control in the design process

V.ABRANTES and J.M.da COSTA

Abstract
Designing a building is a very complex matter. Several people are involved and good co-ordination among them is essential for a satisfatory outcome. In this paper are stressed some management procedures which may contribute to a better evolution of all design phases and avoid conflicts between team members. The outline of a evaluation method applied to the final design result, which encloses both technical and economical points of vue is also presented.
Keywords: Design Quality Evaluation, Design Team, Cost-Performance Ratios, Construction Elements.

1 INTRODUCTION

To ensure the good quality of the final product is the main objective of quality management procedures. This philosophy has been traditionally associated to industrial production of goods but the production of buildings (dwellings or other) is no exception.

Nevertheless, if one looks more closely at the production process of the base element of a building—the design—the scope of this problem widens and deserves a more detailed analysis.

2 QUALITY CONTROL IN THE DESIGN TEAM

First of all, a design is the result of a team of different people each one with specific technical background and experience and looking at his role in the team differently.

In a broad perspective we can identify the following intervening elements in the design phase of a development:

Client	**CLIENT**
Architect/Management and Team Co-ordinator	**ARCH/Co**
Architect/Designer	**ARCH/Ds**

Civil Engineer	**CIV.ENG**
Electrical and Mechanical Engineers	**E/MEC.ENG**
Quantity Surveyor	**QTYSURV**

During the development of a design few situations will arise where a decision, might it be architectural, structural, of services or other, will not have effects through all the specific designs.

In this way one of the main aspects to be looked after in pursuing a high quality level of a design is, before anything else, to establish a very strict definition of the various design phases, to define the needed contributions of every team member to each phase and, perhaps even more important, by the compromise of each member in developing their fundamental design decisions in due time.

The inability of doing so will probably lead the team to a situation where the final result, instead of being the possible sum, under the circumstances, of the best individual contributions becomes a trial-and-error exercise where each member essentially trying to limit losses and saving as much as possible of the work already done. Dialogue and compromise between parties, essential in this process, becomes virtually inexistent.

The importance of this methodology is recognized by several organisations. Among of them the Royal Institute of British Architects (RIBA) has established a very detailed Plan of Work in which the actions of each team member in every design and construction stage are carefully defined. Some highlights of this Plan restricted to the design phases are presented in Tables 1 to 5.

Table 1. INCEPTION

Member	Action to be undertaken
CLIENT	Consider the necessity to build. Contact ARCH/Co and present ideas. Receive and analyse reply. Undertake following contacts and actions or appoint delegate. Exchange with ARCH/Co and define preliminary details of project including deadlines and cost.
ARCH/Co	Accept appointment from CLIENT. Inform of job responsabilities, fees, contracts and professional practice. Obtain general information about possible conditioning parameters and appoint other members in the team. Prepare reunion with CLIENT with every relevant aspect. Prepare general directive to other members regarding all relevant details to be met.
ARCH/Ds	Assimilate preliminary details.
CIV.ENG	Inform of fees and professional practice. Assimilate preliminary details.
E/MEC.ENG	Inform of fees and professional practice. Assimilate preliminary details.
QTYSURV	Inform of fees and professional practice. Assimilate preliminary details.

Table 2. FEASABILITY

Member	Action to be undertaken

CLIENT	Provide all information required by ARCH/Co. Analyse feasability report and decide on evolution of the project. Decide, with team, on deadlines for design phase and carry out any additional procedures recommended by ARCH/Co.
ARCH/Co	Organise team and define contact procedures. Review all data and studies gathered by other team members and assure every relevant information is issued to concerned members. Prepare feasability report to CLIENT assisted by other team members.
ARCH/Ds	Carry out studies on site conditions. Enquire local authorities and gather necessary data. Collaborate with other members in the team to decide on presentation to CLIENT to show feasability including needed design work. Include all relevant aspects stressed by team members which may influence architectural solution.
CIV.ENG	Carry out studies on site conditions, geological records, drainage and water supply, etc. Preliminary definition of probable construction solutions. Provide information to QTYSURV and ARCH/Ds, if possible with sketches. Assist ARCH/Co in report to CLIENT.
E/MEC.ENG	Carry out studies on site conditions, electric supply, climatic conditions, air pollution, special code specifications if any, etc. Preliminary definition of possible construction constraints. Provide information to QTYSURV and ARCH/Ds. Assist ARCH/Co in report to CLIENT.
QTYSURV	Carry out studies on special site conditions, probable price trends, level of local building costs, cost information on similar projects. Assist ARCH/Co in report with emphasis on cost ranges to be expected.

Table 3. OUTLINE PROPOSALS

Member	Action to be undertaken
CLIENT	Provide information required by ARCH/Co. Assist as required in studies by any team member. Decide on all matters submitted. Receive ARCH/Co's report, check consistency with project objectives and make final decisions to enable carrying of next design phase.
ARCH/Co	Assure every design team member understands final decisions of previous phase. Define timetables to enable co-ordination between team members in respect to conflicting issues. Receive individual contributions and analyse its consistency. Check cost plan with QTYSURV and prepare final presentation dossier to CLIENT and authorities.
ARCH/Ds	Carry out studies for this stage: similar projects, circulations, space arrangement, building image, etc. Provide engineers with every relevant aspect which should regulate their proposed solutions. Receive replies, discuss and decide on compatible design solutions to be carried out. Confirm costs with QTYSURV. Prepare final documents to be presented to CLIENT and assist ARCH/Co in this matter.
CIV.ENG	Carry out studies for this stage: define type of structure, methods of building, type of foundation, roads, water supply, drainage. Confirm with ARCH/Ds proposed solutions and adjust accordingly. Check with QTYSURV. Prepare final documents to be presented to CLIENT and assist ARCH/Co in this matter.
E/MEC.ENG	Carry out studies for this stage: environmental conditions, user and services

	requirements, define types of installations, services supply, size and effects on the building. Confirm with ARCH/Ds and CIV.ENG proposed solutions and adjust accordingly. Check with QTYSURV. Prepare final documents to be presented to CLIENT and assist ARCH/Co in this matter.
QTYSURV	Carry out studies for this stage: obtain all relevant information from C regarding possible contract or cost constraints. Review outline proposals from designers. Check cost estimates with ARCH/Ds, CIV.ENG and E/MEC.ENG and propose corrections if necessary. Prepare cost report to CLIENT with ARCH/Co.

Table 4. SCHEME DESIGN

Member	Action to be undertaken
CLIENT	Provide information required by ARCH/Co. Assist as required in studies by any team member. Decide on all matters submitted. Receive ARCH/Co's report, check consistency with outline proposals and make final decisions to enable carrying of next design phase. Begin considering actions relevant to tendering.
ARCH/Co	Inform design team members on final decisions of previous phase. Define timetables for the development of the various parts of each members work and ensure good communication among them. Receive final drawings and specifications and verify consistency with outline proposals and cost plan. Discuss any divergencies and check with QTYSURV. Prepare final report to CLIENT and presentation dossier both to CLIENT and authorities.
ARCH/Ds	Complete every study and develop full scheme design. Pass these to QTYSURV and engineers. Receive comments, discuss proposals and decide on design solutions. Foresee adjustment of detailing to proposed scheme design. Consult with QTYSURV and provide every information for final cost plan. Assist ARCH/Co in preparation of report to CLIENT and final presentation drawings.
CIV.ENG	Complete every study under way and clear all outstanding problems with authorities. Inform ARCH/Co on this matter. Receive scheme design from ARCH/Ds and carry out design for structural, watering and drainage solutions. Check consistency with proposed architectural solutions and electrical/mechanical requirements. Discuss and adjust solutions for found divergencies. Consult with QTYSURV and provide every information for final cost plan. Prepare final drawings and documents and assist ARCH/Co in report to CLIENT.
E/MEC.ENG	Complete every study under way and clear all outstanding problems with authorities. Inform ARCH/Co on this matter. Receive scheme design from ARCH/Ds and carry out design for routing, location and overall dimensions of major services elements. Check consistency with proposed architectural solutions. Present proposed design to CIV.ENG, discuss and adjust solutions for found divergencies. Consult with QTYSURV and provide every information for final cost plan. Prepare final drawings and documents and assist ARCH/Co in report to CLIENT.
QTYSURV	Prepare all updated cost studies and advise team members on any new conditions relevant to their work. Receive scheme designs, analyse and verify accordance to cost plan. Propose adjustments. Receive final drawings and specifications and prepare final cost report. Assist ARCH/Co in report to CLIENT.

Table 5. DETAIL DESIGN

Member	Action to be undertaken
CLIENT	Provide any final details required by ARCH/Co and decide on all matters still pending. Attend meeting with design team in order to fully understand the final result of the design and how the various recommendations have been integrated. Decide on tendering actions and assistance to be expected from the design team.
ARCH/Co	Maintain co-ordination among team members. Investigate any detail specifications which may require adjustment by other team designers and concede only in new solutions which provoke only limited revisions of work already performed. Call meeting of design team and conciliate any disagreement. Obtain confirmation of final specifications and cost. Call meeting with CLIENT and prepare all information required by QTYSURV to organise bills of quantities and tendering documents. Prepare dossier of final version of design elements for CLIENT.
ARCH/Ds	Carry out detail design according to programed timetable, constantly checking with engineers and QTYSURV for design and cost control. Receive all relevant details from engineers and incorporate all necessary specifications in drawings or other design documents. Review results in meeting with all team members and agree on final design solution. Check with QTYSURV for final cost. Assist ARCH/Co in preparing dossier and contribute in meeting with CLIENT.
CIV.ENG	Confirm all design conditions and constraints and carry out all additional details. Check with other designers for consistency of conflicting situations. Consult with QTYSURV for cost checking. Develop final design elements for dossier according to instructions by ARCH/Co. Contribute to meeting with CLIENT.
E/MEC.ENG	Confirm all design conditions and constraints and carry out all additional details. Check with other designers for consistency of conflicting situations. Consult with QTYSURV for cost checking. Develop final design elements for dossier according to instructions by ARCH/Co. Contribute to meeting with CLIENT.
QTYSURV	Perform cost checking on all elements provided by designers and immediately inform of any disagreement in respect to cost plan. Give advice accordingly. Produce complete cost report and assist ARCH/Co in dossier and meeting to CLIENT. Check posession of all needed data for production of bills of quantities and tendering.

3 QUALITY CONTROL OF THE DESIGN

Having mentioned above the optimal result of the work of a design team—the POSSIBLE sum of the best individual contributions of every member—it is important in the end to evaluate the quality level of the final outcome.

Several methods have been used to this purpose in various countries. Generally associated with financing schemes for housing purchase, the quality evaluation performed consists in the comparison between values derived from the design solutions used (for instance room areas, thermal and acoustic coefficients, specified finishes) and graded scales referred to marks. An example is presented in Fig. 1.

It is observed, though, that the evaluation methods with wider use assume a general perspective while evaluating the proposed solutions under the light of absolute performance and not under the look of a cost/performance ratio.

A quality analysis which might enclose in the same parameter the technical and economical points of vue seems therefore to answer both to the parametric needs of credit institutions and to commercial objectives of promoters.

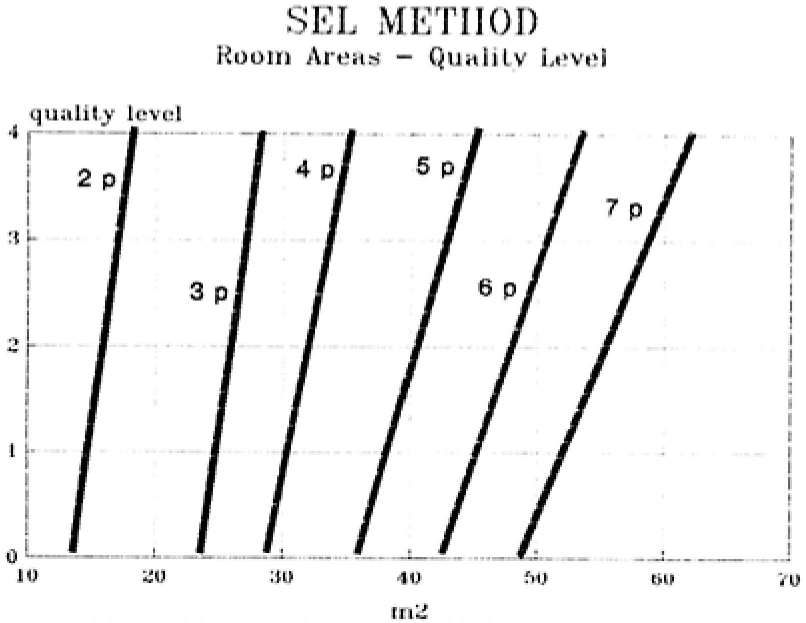


Fig. 1. SEL Method—Evaluation for Room Areas.

A possible development procedure of such a methodology might be the quantification of elementary costs of traditional building solutions which guarantee minimum performance levels (code established or, in its absence, simply specified), to which descriptive point in a XY grid a mark will be attributed.

The establishment of a evaluation matrix could be made as follows: design solutions which provide the same performance level with higher costs will obtain lower marks while the inverse situation will be rewarded with higher marks.

An example of evaluation procedure based on these principles are presented in Fig. 2. This chart presents an evaluation of external wall performance in Winter introducing in the X-axis the thermal transmission factor of a wall K. The Cost Factor on the vertical axis represents the ratio between the cost of a specific solution and the cost of a specified standard-traditional solution for the same construction element (for instance, the ratio between the cost of a externally insulated single-panel lightweight concrete brick wall and the cost of a non-insulated double-panel clay brick one).

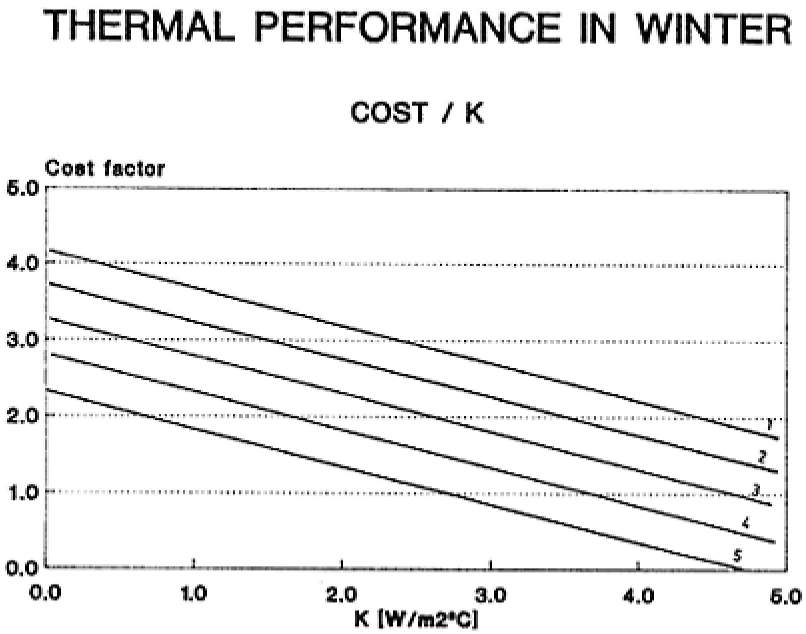


Fig. 2. External Wall Thermal Evaluation (Winter)

4 REFERENCES

Abrantes, V. (1977) Apreciação da Qualidade Térmica de Projectos de Habitação. **Bulettin of the GCC.** Faculty of Engineering, University of Porto, Porto, Portugal.

Aellen, K., Keller, T., Meyer, P. and Wiegand, J. (1978) **Système d'Evaluation de Logements SEL**. Office Federal du Logement, Berne, Switzerland.

Association Qualitel (1980) **Guide Qualitel**. AQ, Paris, France.

RIBA—Royal Institute of British Architects (1983) **Handbook of Architectural Practice and Management**. RIBA Publications Ltd., London, United Kingdom.

Moreira da Costa, J. (1986) **Métodos de Avaliação da Qualidade de Projectos**. Faculty of Engineering, University of Porto, Porto, Portugal.

Bezelga, A., Abrantes, V. and Macedo, J.P. (1987) **Establishing a Method of Quality Evaluation of Housing Building Projects—An experiment in progress**. Paper to the 5th Seminar on Construction Quality Management. British Quality Association, London, United Kingdom.

Moreira da Costa, J. (1989) The Use of Generic Cost-Performance Ratios in the Financing of Housing, in **Innovative Housing Practices** (eds. Vitor Abrantes and Oktay Ural), Pergamon Press, Oxford, United Kingdom, pp. 349–356.

Moreira da Costa, J. (1989) Financing of Housing Through Limited Quality Analysis. **International Journal for Housing Sciences and its Applications,** vol.13 n.4, pp. 267–275, IAHS, Miami, USA.

39
The impact of quality management on overall company management

J.P.ANQUETIL

C3B, a subsidiary of Compagnie Generale de Batiment et de Construction (CBC) has a work force of 120 persons (60 workers, 30 managers and 30 supervisors and administrative personnel). The company generates net sales of approximately FFr150 million.

As contractor for mid-size construction projects in France's Burgundy and Franche-Comte regions, C3B handles shell construction, covered enclosures and general contracting. These projects are primarily mid-sized sites—FFr1 million to FFr20 million—which span the diffuse structure of this regional market.

In the early 1980's C3B launched a Quality program, making the customer and Customer Satisfaction the focus of all actions, and consequently our number one commitment. A broad range of quality-oriented efforts were implemented during this period, but results often fell short of hoped-for performance.

The underlying problem has been that while the customer must become the company's main benchmark for evaluating actions and performance, this does not mean that all customers are the same. To avoid such stereotyping, it is important to keep in mind that:

> Each construction site constitutes a "prototype",
> Each contract is designed to satisfy specific needs,
> And each set of architect's plans calls for execution of a unique project in a unique place, using unique methods.

All the parameters involved therefore vary with each new project. What's more, the chain that begins with market needs (as evaluated by the prime contractor) and ends with customer satisfaction encompasses a considerable number of players. These participants successivelswing into action in the pursuit of specific goals, and the chain evolves in unique fashion with each new project.

The challenge thus facing the company is how to ensure that **quality is a constant, everyday concern,** while integrating it within a committed global strategy and adapting to the specific needs of each new customer "prototype".

The quest for a solution initially shows that this challenge cannot be met simply by imposing certain technical solutions or pre-existing building techniques. Rather, the company must adapt a **quality-oriented state of mind** to each new contracting challenge and each phase in the construction process.

Experience and subsequent analysis have brought to light two progress factors:

The first concerns the right state of mind, without which nothing can be achieved. We call this the Foundations of Quality.

The second factor concerns the satisfaction of all the participants in the construction project and goes much deeper than customer satisfaction alone. This we call the quality objective, or Quality Challenge.

1 The foundations of quality

Before a quality program can be put into action, a number of upstream requirements must be satisfied:

Company management must express a clear commitment to quality that must be shared by the great majority of the work force. This must lead to definition of a Quality Charter that underscores the key issue: Quality is a constant, everyday concern.

Personnel, including labor, must develop an attitude that is open to criticism, willing to re-evaluate past habits and ready to participate team analysis of problems. The goal of such actions is to institute a dynamic which will foster ongoing progress.

The company's organization must nurture increased responsibility at all levels, backed by effective internal communications (which in turn calls into question the pyramid-shaped organization chart).

The work resources and methods deployed must encourage people to take responsibility. In particular, the project must be carefully examined before work begins to provide those in charge of work with a global overview.

Measurement yardsticks must be developed. These metrics must be based on a simple quality criteria scale that enables every member of the team to make improvement a personnel goal and evaluate his or her performance. It is also important that results be publicized.

Laying these foundations for quality is integral to the way the company operates, from its organization and expertise to its resources and procedures.

The three key areas in laying the foundations for quality are:

Training

Internal organization

Work procedures and project management

1.1 Training

The objective of training is to create opportunities for employees to develop critical perspective, to re-evaluate habits and to replace “obeying orders” and seeking assistance with action-oriented initiative and responsibility.

Such opportunities are fostered by progress efforts which mobilize the entire company, such as:

> Learning new skills applicable to the company’s business (exterior carpentry, external insulation, roofing, partitions, etc.), Integration of information technologies in everyday operations and the introduction of computer-aided design.

Creating these opportunities, however, supposes a carefully defined training plan to support this strategy. The training not only provides a context for conventional individual programs, it also seeks to give the company a common language, work procedures—and spirit. As such, it encompasses all categories of personnel. Two specific training actions have been launched to date:

> Intensive training in written and oral communications for all managers and supervisors.
> Training in problem solving (for the same personnel categories).

The results of training efforts have so far proved extremely positive. However, this program requires that the company provide the same training for all new employees, because only by ensuring a common culture will we guarantee that our entire work force has “Quality Reflexes”.

C3B is also preparing a third phase which will involve all workers and site supervisors: training in fundamental economics, based on economic problems encountered in employees’ daily lives.

In short, we train to achieve excellence inside the company in order to guarantee excellence in our work with outside partners.

1.2 Internal organization

Re-evaluation of the company’s internal organization was spurred by the realization that “nobody will supply Quality over the long term only for his direct superior”.

C3B therefore changed its organization chart to reflect the way jobs and responsibilities are assigned within the company. Each unit is responsible for specific jobs which are in turn part of the company’s “job”, or general objective. A unit is thus responsible directly to the entire company for successfully doing the job assigned to it.

During the past two years, twenty key C3B managers have met monthly to jointly define their personal assignments within the company. These “job descriptions” are flexible, to enable the company to constantly adapt to changes in its market. They are written by the individual managers and then subjected to constructive criticism from the group.

Each assignment description details three areas:

The manager's contribution to meeting company goals
The resulting responsibilities, expressed in terms of action
Intermediate goals (accompanied by "achievement deadline" dates), meaning the intermediate steps the manager must accomplish to move towards completion of his assignment.

These meetings have augmented individual efficiency, done away with unnecessary overlap and have provided a forum for troubleshooting, particularly with regards to interface between different assignments. The meetings are chaired by the company chairman.

1.3 Work procedures

Achieving results that satisfy the end-user/customer, internal customers, as well as company personnel requires a deliberate, carefully planned effort. What's more, people must be given the tools they need to accomplish their objectives.

First, tools are needed for management, meaning planning and achieving the results promised to all partners. C3B uses a simple, computerized management tool that runs on desktop computers and is designed for open-ended adaptation and growth. This tool lets each manager cut through the mass of data available to obtain figures pertinent to successful completion of the work to be done. The tool is not an accounting instrument, but rather a management aid.

Even more Important than the computerized tool itself is the principle of systematic anticipation of action. To ensure optimum results it is indispensable that managers set realistic objectives and prepare deployment of the resources they will need to meet these objectives. In practical terms, this principle calls for a preparatory period lasting about two months before work is launched. During this period, the company's general project supervisor and construction site foreman head a team composed of the different trades and partners who will work on the site. Before construction tasks begin, this team prepares the Work Launch Order and corresponding documentation.

This procedure allows teams to be formed before actual construction begins, and facilitates anticipation and upstream resolution of technical issues, in-depth knowledge of the structure to be built and maximum simplification of certain difficulties that are all too often discovered at the last minute on the site itself.

The procedure also enables the contractors on the construction team to set individual objectives (cost and margins, optimum timescales to improve margins, Quality objectives to respect the terms of the contract and thus satisfy the customer).

2 The quality challenge

Whatever the tools employed by a company, a Quality program must also translate into tangible, measurable results, appraised in terms of Satisfaction:

Customer satisfaction

customer satisfaction covers both the end user, as well as co-contracting partners and the architect (who orchestrates the transition from work schedule to project).

“Internal customer” satisfaction

Internal customers are subcontractors or contractor partners and service providers. These players become internal customers for the company as it interprets the work to be performed.

Satisfaction of company personnel

Satisfaction of company personnel is achieved by establishing a common positive attitude among the different teams, by a shared commitment to meeting objectives and by promoting a healthy working environment within the company.

For all three “segments”, satisfaction is measurable. But the problem is that while the objectives of the Quality Challenge are often very explicit in qualitative terms, they are perceived in a very subjective manner by the different partners, making them variable. Consequently, Quality measurement requires carefully developed scales and tools.

C3B has carried out a number of trials covering measurement scales, encompassing technical performance (assessed after completion of work), adherence to construction rules, standards and codes of practice, and conformity to tender specifications. The results have consistently proven unsatisfactory, however, since the satisfaction of the different players involved depends only to a limited extent on the results of these technical inspections. We are currently experimenting with methods for measuring the cost of non-quality in order to define quantifiable parameters and rank them according to their relative impact.

We have also had considerable success using Quality Observers, who provide much more than basic measurement tools. These highly motivated team members are appointed by management and have no vested economic interest in the site. They are simply assigned to witness the way the company meets its Quality Challenge during work.

3 Seven steps to quality

Meeting the Quality Challenge thus means attaining “triple satisfaction”, which is no easy task. A company must make adroit use of the resources at its disposal. While far from exhaustive, the project management process developed by C3B and described below is indicative of our approach.

To ensure that our Quality process can be applied to each unique project—thus guaranteeing that the product delivered conforms to what the customer wants—C3B has defined seven successive steps, each of which conditions the success of the subsequent step. Following is a brief look at this process, which we call the Seven Steps to Quality.

3.1 Understand the work schedule

The customer and prime contractor express their needs in the work schedule. To satisfy these needs—and thus the customer—the company has to make a commitment to this schedule, and in doing so, to meeting the goals set by the prime contractor.

We therefore carry out a “work schedule review”. This review expresses commitment to the work schedule, while enabling detection of frequent differences between the way the schedule is written and what the customer wants. To determine these differences—the first non-quality element—a “customer survey” is imperative during this step.

3.2 Make sure the project matches the work schedule

Next, the company examines the project prepared by the architect to make sure it conforms precisely to the goals set by the work schedule, i.e., that it contains neither too much nor not enough.

Any differences between the project and the work schedule (surpluses or deficiencies) are detected during the “project review”. These differences correspond to the architect’s work schedule, which is factored into the customer’s work schedule.

The resulting discrepancies, checked during an “architect survey”, constitute the second non-quality element.

3.3 Define the company’s supply

The company now has to decide whether it will submit a tender, and, if so, the contents of the tender.

The fundamental Quality criteria is the degree to which the proposal submitted the company corresponds to the customer’s wishes, the work schedule and the project. If there is too great a discrepancy here, the company can no longer make Quality an integral part of its “supply” and must resort to adjustments in its proposal. Unfortunately, a good many invitations to tender make no provision for the Quality to be supplied, making it necessary to choose between the contradictory parameters in the project and work schedule. The main problem C3B faces today is the fact that the customer’s objectives are rarely totally compatible with the architect’s project.

Exactly what the company proposes to supply for the customer is defined during the “targeting meeting”, an encounter which can turn into a veritable ordeal! Once the company decides to commit itself to the project, it initiates a process aimed at seeking an intelligent balance among the inconsistencies it encounters at different levels. This requires us to establish the relative priorities of various factors and again leads to a delicate situation from a commercial standpoint: we have to keep the confidence of both the customer and the architect, while pointing out certain contradictions in their respective positions.

Lastly, whatever the Quality component in the tender, there will always remain differences between the company’s technical proposal and the work schedule and/or the project. These differences may be deliberate (and thus detailed in the tender) or they may be involuntary (the result of errors or omissions). Whatever the source, these differences constitute the third non-quality element.

3.4 Detailed preparation of work

Even once the contractor, the architect and the customer agree to pursue the project together, work cannot debut immediately. First there must be a preparatory period during which the Work Launch Order documents are prepared. These documents include:

The detailed technical solutions, complete with all plans and descriptions,

Execution procedures, including all management and Quality control methods to be implemented,

The list of estimated costs for construction work and related targets for improving margins.

This set of documents fulfills three purposes:

First, it constitutes the basic tool for execution teams since it contains an exhaustive description of the structure to be built, along with a detailed framework for internal management.

Secondly, it provides the architect's prime contractor with the comprehensive documentation needed to check that work conforms to what the architect has contracted for. In fact, it is preferable that this Work Launch Order supersede the initial invitation to tender.

Third, this documentation serves to eliminate the differences detected during the three first steps to Quality.

This preparatory period requires much more time than is generally accorded between the moment a contract is awarded and the actual beginning of work. However, C3B is successful in "selling" its customers this analysis and preparatory period some 70 percent of the time.

3.5 Total conformity during execution

The challenge facing the execution team is to perform the work detailed in the Work Launch Order—"all the work and nothing but the work". Once on-site there should be nothing left to "discover": the teams simply follow the instructions in the launch documents to the letter.

Only if this condition is satisfied will the spectrum of management and Quality procedures implemented prove effective (self-checks, interface management, work team leadership, do it right the first time, etc.).

What's more, this approach means that site meetings no longer need to deal with organizational matters, but can focus on the job at hand: adjust and correct non-conformity or errors, integrate changes requested by the prime contractor, etc.

3.6 Transparent delivery

Delivery is a fundamental action, particularly once a site has been successfully completed. Problems in the delivery process systematically lead to a negative climate when the user takes possession, and can generate downstream difficulties throughout the guarantee period.

Customer acceptance therefore comprises three phases:

> Pre-acceptance
>
> Acceptance, which thus becomes a simple removal of reserves to authorize transfer of property
>
> The first inventory and inspection visit by the customer, accompanied by company representatives.

3.7 High-performance after-sales service

Optimum management of after-sales service can prove extremely demanding, since Quality service requires customized support for each project delivered during a ten-year period.

This management is designed to ensure tracking of the product to enable effective maintenance actions.

Quality management also generates invaluable technical data on building behavior and thus feedback concerning the efficiency of the techniques employed during execution.

This information is “recycled” within the company as a locomotive for Quality progress.

4. Quality for the future

C3B has pursued its Quality program for ten years now, and this process has led to critical re-evaluation of the very foundations of our management. This brief presentation of our efforts is far from exhaustive, as Quality spans every aspect of our organization. We are also working on Quality partnerships with other project contractors, as well as a quality-driven corporate project.

While a company’s progress can only truly be measured in relation to its own goals, we seem to have an increasingly long road ahead before we can say we systematically satisfy our three key customer segments: end users, project partners and company personnel. Why then don’t we clearly see the “light at the end of the tunnel”?

> First of all, have we underestimated the complexity of the problems to be resolved, and the difficulty of meeting the Quality Challenge?
>
> Secondly, has the market evolved and have customers become more demanding?
>
> And third, is the competitive environment more difficult than when we started?

The answer to all three questions is “yes”. At the same time though, our Quality efforts are far from discouraging. This program spurs greater motivation each and every day, and the ongoing progress process initiated appears truly ineluctable. Given the results achieved so far, we remain firmly convinced that we have embarked on a road that will lead us to Quality heights we cannot even imagine today.

40
Quality in rehabilitation of historical buildings in Portugal

J.A.S.APPLETON

Abstract
This paper gives a general view of the problems related to the quality of rehabilitation of historical buildings.

The different phases of the works are considered, from the promotion until the using of the buildings. The Portuguese situation is generally presented.

1 Introduction

The preservation of historical buildings is nowadays considered a normal problem of culture, because there is a new understanding of history and patrimony; today, old buildings are considered of major importance, even if they can not be assumed as monuments.

So, it is necessary to have a clear understanding how to act when there is a need or a convenience of old building rehabilitation or simply repair of normal or unusual diseases.

Quality in rehabilitation of historical buildings must be considered as a whole, that means, must involve all the participants in building construction (or reconstruction), from the owner to the contractor, including the designers and the producers of building materials.

In this paper historical buildings are defined as those that were built before the advent of Portland Cement; in Portugal this means the period finished at the 30's of 20th century, when buildings were made of masonry structural walls of different kinds and floors, roofs and stairs were mainly timber made.

A short discussion will be presented of the most important items that must be considered during the construcion/rehabilitation period, starting with the programming and designing, and finishing with construction and using, paying attention to the production of building materials and construction components.

First of all, it must be assumed that rehabilitation or restoring historical buildings is necessarily a very specialized job, to be performed by experienced technicians, much more than the construction of new buildings, due to the necessary knowledge of old materials and building technologies. And also because it is fundamental to “understand” the old buildings, that means, to have a clear comprehension of building structural and non-structural conditions, understanding how time and natural and non-natural causes influenced these conditions.

2 Quality in promotion

The owner of an historical building, public or private, must define to the designers the program of the building intervention, paying attention to the specific characteristics of his building. This means that the owner must have a satisfactory knowledge of the building, mainly concerning architectural, historical and technological data, so that he can ask the designers to perform a “reasonable” study of the whole operation.

So, first of all, the owner must organize a “dossier” with all the information available about the building, concerning architectural and constructional data about the original design, and of the recognized alterations of the building, during its all lifetime.

Usually this information is unsufficient, sometimes there is no information available. In such conditions the owner must assure the necessary preliminary works; at least, it is necessary to have up-to-date information about geometrical and technical characteristics of the building. So, the first step is to make the corresponding surveys, and this task can be performed, with some advantage, by the designers, the architect and the structural engineer, in order to have the architectural and constructive plans, views and general sections of the building.

Unhappily, in Portugal, this procedure is not usual, and so the designer begins his job without the proper information;often, the design will be made as if it is for a new building. The patology of the rehabilitation operation thus begins.

It is also of the maximum importance that the owner defines a program to the existing building that is a realistic one. This means that, taking into account “what” is the building, the objectives of the owner must be limited by this knowledge. For example, it must be well understood the possibility of “growing up” the building, horizontally and vertically, taking care of historical and technological conditions. Even if it is assumed that there is always an engineering solution for the more complex problems, the intervention must be limited by historical, architectural and technological “truth” of the building.

Identical reserves must be put on the generalized enlargement of interior spans of building compartments The owner of an historical building must be aware of the importance of this type of intervention; for example, in Portugal, the high seismicity recommends a careful and limited substitution of old structural masonry walls by reinforced concrete or steel beams, even when the resistance to vertical loads—dead and imposed loads—is conveniently assured. The new beams create concentrated forces and stresses in the connections beam/wall, which are weak points of the structure.

The maintenance of interior compartements is then reccomended, as far as possible, and the demolition of structural masonry wall must be carefully studied, paying special attention to the structural analysis concerning horizontal forces.

Finally it is of the utmost importance that the owner assures that he gets the right designers to the job he wants to be performed; as it was said before, rehabilitation of historical buildings is a very hard task, to be made only by specialists, and the cause of problems of non-quality of several cases is just the poor preparation of the design team. The existance of a good design team of specialists, particularly the architect and the structural/construction engineer, and a fair contract between the owner and the designers are the first step to assure a good, well developed study, and also a good quality construction.

3 Quality in the design

The constitution of a convenient design team is so a very important principle to be followed; frequently it is necessary to have the expertised advice of archeology and history specialists, but the fundamental intervention is that of the architect and of the structural or constructional engineer.

In Portugal there is no significant experience of organized design offices specialized in the rehabilitation of historical buildings, so it is quite usual that these studies are performed by non-specialists. The problem is that if an old building is looked out of its own “truth”, the tendency of the design is to be developed as if it is a new building, using the principles, materials and technologies currently used in new buidings design.

A large number of pathology situations in rehabilitation process is then related to the inadequacy of design teams.

Beginning the studies, the designers must assure that the necessary information exists, as it was described in chapter 2. If it is not so, the corresponding works must be assumed by the designers, in order to guarantee that they have a solid, convenient basis for their studies.

It is quite important that the designers understand clearly the meaning of “old” or “historical” building. Concerning the technological point of view, an old building is one that was built before the development of reinforced concrete, and in Portugal this means a long period beginning in the 12th century and finishing in the 3rd decade of the 20th century.

So, these are usually buildings with structural masonry walls and timber slabs and roofs. In Portugal it is not so common the use of iron and steel structures, unless in limited zones of the building. If particular cases are not considered, iron structures are only found significantly in “bow-windows”, in buildins erected by the end of the 19th century.

The knowledge of architectural and structural characteristics of the building is then essencial for the beginning of the design. The information concerning the building shall be transmitted to all the designers, in order that everyone of them can take into account the natural limitations of the design related to the specific characteristics of the building. For instance, considering the period of Lisbon reconstruction after the 1755 earthquake, it is well known the importance of timber structures inside masonry walls; these walls, even when they seem structurally secondary, are always an important part of the whole structural system, concerning the resistance to seismic action. Sometimes, this is not considered, and the design is made in such a way that timber structures are partilly cut or even removed, to enlarge some rooms or to include different types of piping (water, electrical or gaz supply, sewage, etc). The stuctural continuity is then compromised and pathological behaviour is to be expected.

It is also important to refer the possibility of architectural modifications due to inclusion of new bathrooms; in Portugal, the buildings erected before the 20th century often do not have water supply or sewage systems. The rehabilitation of such buildings generally imposes the execution of such systems and these are critical areas of the intervention, because of the possibility of water assessing the building components.

The way such rehabilitations have been currently designed and executed is responsible by a large number of pathologies, mainly in masonry walls and in timber structures; such a situation, related to unexisting or poor design can be observed all over the country.

The knowledge of construction characteristics of an historical building is also of the maximum importance in the choice of building materials and technologies. Of course it is always possible to use new materials and technologies, but it is generally preferable to consider the use of traditional ones, namely when it is not the case of reversible interventions.

In fact, traditional materials and technologies are sufficiently proved by centuries of experience, and so durability can be assured; on the contrary, new solutions sometimes prove to be inadequate only years after application, when it is too late to reconsider.

Unhappily, in Portugal, traditional materials and technologies are almost forgotten in the normal construction practice. Even the schools of engineer and architecture do not teach anymore traditional building technologies and only recently the study of rehabilitation have been introduced in the Portuguese universities.

This lack of preparation of most of the Portuguese designers is then a major problem that must be solved in the next years.

According to the positions assumed all over the world about rehabilitation of historical buildings, perhaps the most important part of human patrimony, the interventions must be, as far as possible, reversible. In spite of this aparent unanimity, this is a very controversial problem, because in the most part of the situations, reversibility is not compatible with the necessary alterations of the building, for instance strenghning of the structures.

When this good, but often theoretical principle is not to be followed, the designers are faced with another fundamental principle of rehabilitation, that of compatibility between the old and the new. This is a very wide problem, because it deals with architectural and esthetical reasons but also with mechanical, physical and chemical behaviour of different materials.

Even when traditional materials are used, the designers must remember that the different ages of old and new parts of the buildings are for themselves generator of different behaviours.

All these considerations point to the fact that it is necessary to organize specific research programs, in order to clarify the characteristics of the existing construction, but also to analyse new and traditional materials to be used in rehabilitation operations; the main effort will be to study the behaviour of different materials, put together by these operations.

Compatibility is a principle of the maximum importance to assure the good performance of the rehabilitated building as a whole, and to guarantee that the intervention will be durable.

Durability must be a main objective of the designers, taking into account that they are acting on the time scale of the historical building, that means, centuries and not decades, in order that the built patrimony can be transmitted to future generations.

In Portugal it is true that talking about rehabilitation and of the use of traditional materials means the needing of improvement of knowledge about them, testing them in laboratory and in situ, elaborating well developed programs of in situ observation of the behaviour of materials and of the building as a whole. It must be considered that the lack of information about those materials and a certain “obcession” with reinforced concrete are obstacles to the necessary quality in rehabilitation.

It is also necessary that the designs are organized clearly and they must be complete, in respect to drawings and technical specifications, concerning both materials and tehnical procedures to adopt.

If it is not so the contractor and the quantity/quality surveyor will be obliged to frequent, inadequate improvisation; this will mean undoubtly poor performance and building pathology

4 Quality of materials and building components

This is a general problem, common to every type of new or old construction, but specially accurate concerning rehabilitation design and construction.

The quality of building materials is, of course an industrial problem, related to the real technical ability of the producers; but the production of building materials and components for construction industry and in particular to be used in building rehabilitation is, first of all, a problem of convenient information of the producers, about the objectives of the production, taking into account, where, how and when will they be placed.

The main characteristics of these products are, as it was said, the compatibility with the old ones and durability. So, the production of building materials and componennts must follow these two basic principles.

In Portugal there is a generalized problem about the quality in this field; there is not a consolidated practice of quality control and assurance. Only a few products are certified. This situation is even more serious concerning historical buildings because dealing with traditional materials the designers frequently do not know even the physical, chemical and mechanical characteristics of the materials to be used. For example, it is almost impossible to find a producer of sand that is able to inform correctly about the chemical composition of the material, or its size curve.

So, first of all it is necessary to consider this a general problem in our country, and the first step to quality will pass by the information of the producers about the importance of quality procedures, after they have assumed that it is fundamental to assure the convenient and complete characterization of their products. We hope that the implementation of EEC Construction Products Directive will help us all.

Quality in the production of building materials determines the necessity of establishing in the factories procedures of quality control; this control is not an objective but it will be a fundamental tool.

Concerning materials for rehabilitation, it is necessary to define short and long time research programs; it is fundamental to understand that the rehabilitation of a building in a certain country or region is always a particular problem, due to the specific characteristics of the original building. So, the results of research programs and commercial and technical information about those materials must be analysed carefully, taking good care of the basis of the studies.

Compatibility tests will be very important ones, carried out in laboratory or on the old buildings, studied then as prototypes. So, it is fundamental to have a sound knowledge about old construction, and then the first tests to be performed will be on the historical building, as a whole (concerning seismic behaviour, for example) and on their parts (walls, floors, roofs, windows, etc).

Durability tests are even more complex, or at least longer, and they can also be performed in laboratory or in situ. A good principle to be followed, even when there is not a convinient plan of testing materials in situ, is to register all the available information about a building in a rehabilitation process (for example, location of the walls, construction characteristics, anomalies observed such as cracking, characteristics of the finishings, etc), to register also all the information about the rehabilitation solutions (for example, in a certain wall, location of new openings, materials and procedures used in parcial or total reconstruction of the structure of the wall, therapies applied to solve anomalies, such as cracking, complete characterization of new finishings, etc). At last it will be fundamental to establish an observation plan so that the behaviour of the building as a whole and of its parts can be followed and technically understood.

If these basic principles were commonly followed, it is evident that lots of problems of building rehabilitation, in Portugal, would not happen. Let us remember, only as a simple example, the poor results of the use of strong mortars on old masonry walls; sometimes, large cracking appears few weeks after the execution of the rendering of the wall. Another typical example is that of the use of impermeable painting, over weak old wall mortars; the formation of water or air bubbles is then almost inevitable.

The use of traditional materials involves some alterations on producers practice. Concerning Portuguese old buildings, it is necessary to improve the production of timber elements for structures, for floor and roof facing, and for other secondary elements; it is also of the maximum importance to “rediscover” the use of lime in mortars, with or even without cement, and in wall painting. Ceramic materials are also very important; developping solid clay bricks for wall reconstruction, making traditional roof tiles and exterior wall tiles are some of tasks to perform.

5 Quality in the execution

In a rehabilitation work, like in any other construction work, the execution phase is the last step before using the building. This means that the contractor has to take care of all the information that comes from the program and from the designs, considering also the limitations of the market about building materials and components, mainly about those specially adequate to be used in rehabilitation of historical buildings.

The builder must understand the importance of his job, so he shall be sure that he gots the convenient workmanship, from the technical director of the works—generally a civil engineer specialized in interventions in old buildings and monuments—until the specialized workers of different formation. As for the designs, the first step shall be the constitution of a good, competent team.

In Portugal, this simple and evident principle is not so simple and it is not at all evident; this means that, unfortunately, it is unusual to have specialized entreprises, with specialized engineers and architects and also specialized workmanship. The same people that are responsible for the construction of new buildings are also involved in rehabilitation of historical buildings.

The absence of a policy of professional formation of workmanship during the last years makes even more necessary the permanent formation in this “school of life” that the works are. The vicious circle exists because this practical formation disappeared simultaneously with the natural disappearance of old experienced carpenters, masons, pavers, etc. It is urgent regaining the knowledge that is missing and the time left is not so much to benefit of the experience still available. The industrial associations and the unions are also responsible for this job.

In a rehabilitation operation the contractor must be aware of the fact that even with good projects the surprises are a constant during the works. It is necessary that the technical director of the job is prepared for a continuous dialogue with the designers, having the ability to distinguish between “small problems”, that he can solves alone and “important problems” that demand the opinion or even the presence of the designers.

The contractor of this type of works must dispose of equipment means adequate to the special kind of intervention he is making; most kinds of works are delicate, because even small operations deals with the equilibrium of the existent building, and so it is not reasonable to use normal equipment, namely in what concerns vibrations induced in the existing building. The work space available is also limited, restricting the conditions on the construction yard and being an obstacle for the movements of large equipment.

The use of adequate materials is also of the maximum importance; the contractor, better than anyone else, will have the right, complete information about the real conditions of the building. It is essencial to be able to register important information, so that it will be possible to transmit it to other people, in the same or in other works. There is a tendency to hide “surprises”, because there is always the risk of delays, in order to make possible the study of these “surprises”, for instance when it is advisable to have a close contact with archeology people.

In Portugal it is worrying that the faults committed during the rehabilitation works are not considered as a lesson for the future; on the contrary it is recognized the constant repetition of errors, in such a way that is possible to say that rehabilitation operations have been frequently the worst disease the building ever suffered, after centuries of time life. It is necessary the public discussion of these mistakes to avoid them in the near future.

6 Quality in use

The historical buildings need particular care; like with old people, old buildings have some natural diseases, due to aging and to misuse.

It is for the user the responsability of a correct utilization of the buildings, assuming a convenient program of maintenance, according to the particular conditions of the building as a whole and of building materials and components.

It is also of the maximum importance that the user assures the utilization of the building in the right conditions, that means in accordance with the specific characteristics of the buildings. Lots of problems in historical buidings are related with misuse, for example, overloading of timber floors, cutting structural elements for compartment enlargement.

Quality in the utilization of old buildings would benefit with the existance of users manuals, including recommendations for simple and frequent maintenance operations. In Portugal, there is no experience of this practice.

7 Conclusions

Along this paper the most important problems involved in rehabilitation process of rehabilitation of historical buildings were pointed out.

It is clearly understood that rehabilitation of old buildings is a task for a specialized team of professionals, working together.

In Portugal the experience in this field presentes important reserves due to poor professional organization of designers, contractors and materials producers.

A better knowledge of the existing buildings, the study of traditional and new materials specially adequate to be used in these kind of operations is also of the maximum importance, just as the formation of specialized workmanship.

Traditional technologies must also be rediscovered; at the same time studies may be carried out to analyse the behaviour of new materials and non-traditional technologies.

Quality of rehabilitation operations implies that all that are involved work together; the owner must be interested and realistic, the designers and the industrials must be professionally competent, the users must be conscious.

8 References

Appleton, João—Tecnologias de intervenção em edificios antigos, Nota Técnica 8/91-NPC, Laboratorio Nacional de Engenharia Civil, Lisboa, Fevereiro de 1991.

Appleton, João—Degradação do parque imobiliário urbano—Situação em Lisboa e enquadramento legal—Uma contribuição do LNEC, Nota Técnica 21/91-NPC, LNEC, Lisboa, Março de 1991.

Henriques, Fernando—A conservação do patrimonio histórico edificado. Relatório 175/90—NCCt. LNEC, Lisboa, 1990

Pennelis, G.—Materials used in the restoration of historical buildings and monuments. Seminário sobre conservação, recuperação e consolidação de monumentos e edificios históricos, LNEC, Lisboa, 1989

Laboratório Nacional de Engenharia Civil (LNEC)—1º Encontro sobre conservação e reabilitação de edificios de habitação. LNEC, Lisboa, 1985

LNEC—1º Encontro Nacional sobre Qualidade na Construção. LNEC, Lisboa, 1986

LNEC—2º Encontro Nacional sobre Qualidade na Construção. LNEC, Lisboa, 1990

LNEC—Manual de apoio a reabilitação de edificios do Bairro Alto em Lisboa. Relatório 81/90—NA, LNEC, Lisboa, 1990

41
Research for an overall approach of quality

Y.AUBERT

1 Preamble

In january 1989, the French Ministry of Equipment granted Qualiform a research subsidy "in order to enable them to pre-operationally drive a regional group of building intervening parties in view of redefining everyone's missions; this is in keeping with a joint reflection and action work about quality and completes the research carried out in the mean time by the Social Science University of Grenoble.

Qualiform will issue a chart summing up the main propositions of the partners which will serve as a reference for their later works".

The chart was therefore to aim at the conclusion of a joint reflection carried out by a group of professionals based on each one's own reflections and experience.

The chart is now completed and signed by all participants firstly in order to finalize it according to the conclusions drawn from experimental operations launched in 1990 applying the chart; then in its final version so that it can be progressively implemented by its present signatories and later by those who will join it.

The present note therefore aims at:

> Relating the progress of research by drawing the characteristics of the professional circles of the Isere department—these characteristics can differ in other departments or regions; also by drawing the conditions under which such a professional mobilization in favor of quality could be reproduced elsewhere. Underlining the essential and original points of the building quality chart in Isere, which make it different from previous published works on the subject.
>
> However it is to be noted that other propositions of the chart (e.g. regarding the preparation of a building site) were already known but they draw a particular force for their future application from their presence in the Isere chart because they were put into shape by the professionals (it is "their" chart) who integrated them into a coherent set which makes them more efficient.
>
> Defining the conditions under which the application of the chart can be developed in Isere firstly through the experimental operations, then permanently, thus making sure that future applications are genuine and particularly that signatories comply with their commitments. This will also enable the joining of professionals who did not take part into its

elaboration but who care to follow the progress proposed by the chart. Finally determining under which conditions such an experience as in Isere could be tried elsewhere, not to adopt its chart but to instigate a thorough inter-professional reflection on a mobilizing step towards quality.

This preamble must also insist on the originalities of the work carried out in Isere:

1.1

It is a joint step aiming at ensuring the quality of a work to be built, not only by everyone's care for the quality of one's own work, but also by everyone's care for making the quality of one's partners' work easier. This target entails the respect of ethical principles on one hand, and on the other hand of common procedures ensuring the reality of this quality aim. More particularly this approach must ensure the personal satisfaction of each partner (including an increase in his margin) and that of each member of the staff (including working safety).

This conception is fundamentally different from some professionals (a few authorities, some leading contractors, sometimes an architecture agency or an engineering agency) who state numerous ill-functionings all along a building operation—then they feel they must dictate the whole building process and namely a number of conditions and procedures which the professionals have to comply with imperatively.

1.2

Even though the Isere contractors' general union backed this work and though a few of its officials actively took part into the debates, the Isere approach is a voluntary step taken by partners wanting to progress whilst disregarding possible concerns of defence of their profession's interests. It does not mean that this work aimed at questioning this or that prerogative, but everyone deliberately considered that priority lay in the joint research of quality and that the bet should be made that this joint research would facilitate the practice of each profession far better than the narrow research by each one of one's sole interest.

1.3

Neither will be found here the results of the reflections of a small group of experts or of "audits" of various specialists. These reflections are issued from a large sample of Isère professionals (about fifty) intending to solve together the problems which they encounter daily.

The research executives—Cristo and Qualiform—initiated it because they felt it met a requirement; then they were its instigators according to their own experiences but the principles settled and the propositions in the chart emanate from professionals.

They decided the works programme during a meeting where forty were invited and fifty participants came, which was very auspicious.

2 The research progress

According to the programme the research consisted in three clearly distinct phases:

A period of interviews between each professional and a member of the executive team.

A two days seminar in three sessions.

Reflections in four working groups leading to a quality achievement in each stage of the building process.

2.1 Interviews

This interviews took place during the summer 1989, which hindered the fixing of appointments—thirty-nine interviews could occur.

The main information to be drawn are the following:

2.1.1 In grenoble there are a number of competent professionals caring to progress in all professions:

Builders authorities who wrote internal documents so that their own missions as builders and managers are accomplished in quality.

Architects who gained a certain competence in feasibility studies of planning and building programmes and/or who set up a self-control procedure in their own operating.

Engineering agencies who proceeded to thorough studies on sequential work and its consequences on work organization and enrichment of tasks.

Contractors who led experiences of training youngsters having the “baccalaureat” school level, and of new working organization, equipment services with an advanced experience of quality management (training policy at the rate of 6 or 9 % of the total wages bill, self-control procedures, etc…)

Also Labour Public Services concerned by concrete preventive experiences and supporting professionals caring to progress in safety (officials from these services permanently took part into the research).

One of the main ideas of these experiences is to “place man at the centre of the approach as the main actor of the change”. And this idea was indeed at the centre of the group reflections.

The existence of those competences and progress will in every profession is undeniably an essential factor of success in the undertaken research. If such an approach is to be made elsewhere, it must firstly be ascertained that these competences and will exist there too.

2.1.2 An almost unanimous feeling comes out of these interviews:

“We cannot go on working so: we must change”. We are stressed , time is wasted, therefore money.

The “system” is anarchic and makes goodwills unefficient. Lack of rigour, of dialogue, of communication, exists at all levels. There are not enough brain-storming and management upward.

The criticism of the “system” is essential in many ways:

> Firstly it is grounded, everyone knows it by experience.
>
> It differs from the positions often taken by professionals: non-quality is not me, it is the other one. Here the “system” as a whole is bad, implying that “the other one” is not perfect but he is like me taken in a system which does not work and which makes side-stepping easy.
>
> Psychologically it is important. A large majority of professionals want to do well and are conscious of acting accordingly. If in order to promote quality, they are firstly told that they must improve their work and self-control it, their immediate reaction is to reject it. On the contrary if the group endeavours to improve the system, then they are necessarily led to question themselves but they do not do it alone, they are equal partners who all question themselves. Then they accept the common step and the consequences it can have on oneself.

Any new similar experience must take these statements into account.

2.1.3 Suggestion for improvement

These interviews allowed to collect quite a number of suggestions to improve the “system” and most of them appear in the chart.

They concern all scopes from the estate and financial planning up to study and work coordination between roads and Sanitation Network and building, via the mobilization of everyone’s competence and know-how, this link between the content of the engineering’s missions and the works devolution method for instance.

This item is longer developed in the chapter relative to the chart content.

2.2 Training sessions

Three identical and successive training sessions took place, as again forty professionals accepted to participate.

Residential sessions in order to immediately favour the creation of a team reflection spirit and to give partners the habit of listening to one another and to help expression.

Each session lasted two days.

The general targets were as follows:

> To approach the key-concepts of modern quality management and to make the participants familiar with it.

To make it easier for them to approach quality in the specific way of the Isere department within a pre-operational research.

The first target was classically reached through alternate discussions and information supplies.

The second target came out as a brain-storming enabling to understand the partners' concerns, why the "system" does not work properly, which suggestions could be made to try and improve it, This foreshadowed the ulterior subgroups' work whose discussions were bound to reach precise outcomes.

During these sessions a number of original concepts of the chart were approached:

The necessity for a common validation of the results obtained at the end of a stage of the building process by the upward and downward actors concerned (programme review between builder and engineering, review of the preliminary scheme between engineering on one hand and the builder, the D.D.E (local equipment direction) and its consultants, the people's representatives on the other hand—; plan review between the engineering and the contractors).

The proposition to consider the project-enterprise gathering the different partners towards common targets and to adopt common procedures (cf. the chapter on the chart).

At the end of this phase the following results seemed to be established:

The quality chart was becoming possible whereas up to then it seemed a far utopia. From that time mobilization started, partners registered in the working groups and started reflection within their own organizations.

Partners of different professions understood one another, cleared corporate rivalry, felt free to speak, to criticize as well as to propose.

Everyone felt that if an attempt is made to cure one after the other different ill-fonctionings stated by common consent, the task is superhuman, generating conflicts, undefinite. Work is to be done otherwise: start all over on other bases, change the states of mind, give up the common practices of searching one's own profit without caring for the others, of continuously lying.

2.3 The working groups

Four working groups were set up to try and work out the chart. They concerned the following themes:

Setting up and programming a building operation.

Conception—Invitation to tender—Preliminary scheme review.

Building site preparation and piloting.

Building site management—Works control.

Several remarks must be made on these subgroups and on the finality of this work of pre-operational research.

> Rather than this sharing out by mission or task groups, a sharing out by more "horizontal" themes could have been chosen (communication, quality training, new working organizations for instance). Since the group was numerous and apparently motivated (which allows to hope a quick broadcasting of the results) but most of its members were new to quality management and what it implies, it seemed preferable to keep to a more classical sharing out within which some of the members had already started reflections or even concrete actions, as the interviews had confirmed. However the team executives were constantly careful that the "horizontal" themes should be thoroughly discussed during the successive sessions.
>
> Apparently this sharing out reproduced—at least—three major interfaces: planning/conception, conception/preparation of the execution, preparation/execution management and control, whilst these interfaces generate ill-functionings against which quality management intends to fight.

To palliate this major difficulty, several arrangements were made:

> Since there is an overlapping area between the four planned themes, each of these major interfaces was discussed twice, once more thoroughly in an upward consideration, and a second time in a downward consideration.
>
> Each subgroup included at least one member of each category of partners (builder, architect, engineering, contractors). In practice it appeared that each professional wished to belong to the upward subgroup compared to his usual mission. In order to better balance the composition of the subgroups, each participant was asked to make two possible choices at least among which the research team decided on one.

Almost twenty volunteers signed for each of the first two groups, about fifteen for the third one, and less than ten for the last one. On one hand contractors tend to consider that a good preparation of the building site is enough to ensure the quality of executions, on the other hand they are not keen on notions of internal control which they do not consider of interest for themselves.

Despite the "prompted volunteering" this group remained fewer and the propositions on this theme as quoted in the chart were partly issued by the team executives with the professionals' courteous but dubious consent.

On the contrary the first three groups after having discussed the ideas mentioned during the training sessions were very lively and fruitful. Almost all the propositions emanate from the professionals, even if some (but not all) of them were already known by the team executives.

The concrete issue of these debates (five sessions of half a day for each group) is the chart—see comments in next chapter.

The professionals are very satisfied with the successful issue of their quality chart and they are all fairly convinced that if it is indeed put into practice, it will completely change both the building atmosphere and the productivity of the building sites. But will it be achieved? A few still doubt and await the experimental operations before they really believe in it. Nevertheless a lot of them significantly declared: “Even if we do not take part into the carrying out of experimental operations we want to follow them up in order to be apple to estimate its real feasibility.

3 Isere building quality chart

3.1

The chart is a voluntary convention between the professionals who worked it out. It can therefore not be compared to a regulation or even to a standard: it only applies to those who sign it. A few consequences follow:

> It does not need to comply with any standard form.
>
> It cannot be copied to be applied elsewhere; its content, worked out by people from Grenoble is valid in Grenoble. A different context can make it inapplicable elsewhere. On the other hand it cannot be criticized because its application is not, by vocation, universal.
>
> On the contrary its main force comes from its voluntary feature in Grenoble. It is not dictated; each one joins it inside a group in front of one’s partners.

3.2

One could think that the listed propositions of procedures could suffice to themselves. The professionals who worked them out believe the contrary. If the implementation of these procedures is not based on the conscious and strict respect of ethical principles which precede them, on the corresponding engagement of the signatory partners, if will quickly become partial, hence of small significance, disappointing and soon given up.

The ideal, the utopia of reciprocal trust is the necessare pledge for success.

3.3

This overlapping between ethical principles and procedures appears very clearly in the project-enterprise concept.

The project-enterprise is the temporary and voluntary grouping of competences which is originated by a building operation. The quality approach proposed by the chart applies to it. It means that at the builders’ initiative, all the actors of the operation are to be led to work in synergy so that at the same time the delivered product, everyone’s profit and own satisfaction and everyone’s working conditions are considerably improved.

As previously said in the preamble this voluntary grouping is fundementally different in its approach from a few actors’ directing habits. But what they try to obtain through their contractual authority can be obtained within a voluntary grouping only if the mutual engagements are carried out. It is hence most important that for each operation which should abide to it, the Isere quality chart should originate an operation chart which is its concrete translation for that operation.

3.4

The overlapping is also visible during the project validation moments. The validation is to state the agreement between the partners concerned when passing from one stage of the building process to the next. This agreement must be formal (procedure) and correspond to a will (principle).

3.5

Finally working safety is considered so important for the following reasons:

> The quality of execution of a piece of work demands safety. It is unthinkable that execution quality management could not impede industrial accidents.
>
> Their is little risk because experience proves that when the quality of execution is specially based on the mobilization of intelligences and competences of all actors including the site staff, then it is almost automatically accompanied by safety.
>
> A very early integration of prevention preoccupations into the building process can only reinforce it and it greatly helps complying with the indispensable steps in the course of the process.

4 —Implementation of the chart

Further to this research phase, achieved in june 1990, the professionals decided to create a Quality Club mentioned in the chart.

Here it is necessary to recall the six concrete targets fixed by the Club.

> To follow up and analyse experimental operations intended for testing the quality chart project.
>
> To subsequently correct the initial project to result in a chart acknowledged by a large number of building public and private professionals and to make it evolve in view of the results of its applications.
>
> To establish the conditions necessary to the strict application of the chart in order to facilitate its learning and to avoid an artificial use which could hinder its development.
>
> To define the contents and organize sessions of training to the overall quality approach for the various professions and qualifications during important building operations and for the new members of the Club.

To allow the exchange of information and experiences with regard to quality management, human resources management, new regulations and quality certification

To ensure or facilitate the information of public and professional organizations on the applications of the chart.

Several development actions are currently in embryo.

42
QA: a step in the right direction?

P.BARRETT

Abstract
This paper briefly describes the meagre take-up of quality assurance (QA) by the construction professions in the UK and puts forward analyses of the appropriateness of QA from a variety of perspectives. Based on this possible ways in which progress in the area can be made are suggested, both in terms of the nature of QA used (much less constrained) and the process by which it is adopted (incremental).
Keywords: Quality Assurance, Professionals, Construction, Contingency Approach.

1 Introduction

Quality Assurance (QA) has become an important issue within the UK over the last two or three years and the construction industry has been no exception to this rapid increase of awareness.

This paper focusses on the position of the construction-related professions, viz: architects, engineers and surveyors, although the arguments probably translate in large part to the contracting side of the industry. The current position is reviewed, problem areas identified and possible ways forward proposed.

2 Current Position

2.1 Forces for Change

There has been quite considerable pressure for professional firms to take up QA, not least from the PSA who have threatened, at some unspecified time in the future, to use only consulting firms that are third-party QA registered (Dalton, 1987). At the same time there have been generous financial inducements from the Government, via the DTI, in the form of grants towards the cost of QA consultancy advice.

On top of these specific factors, the coming of the single european market in 1992 has led to uncertainty amongst professionals and there is a quite widely held view that QA "certification" will be a vital marketing tool in this new context (Beard, 1988; CIRIA, 1988; Anon, 1988).

2.2 QA in the UK

Quality Assurance as represented by BS 5750 (BSI, 1987), or the equivalent document ISO 9000, has been typified as:

> *…first…a formal/orderly approach and, second, it assumes that a defined standard exists and the thrust of the approach is not to fall below that standard. (Barrett, 1989a, p183)*

It has been suggested that this controlled, mechanical, satisficing approach should be termed "Formal Quality Assurance" or FQA (Barrett, 1989b, p355) to distinguish it from other possible intepretations.

In the UK third-party certification is the normal approach to QA. This means firms are endeavouring to surmount a single, relatively large hurdle and then they must make sure they do not fall off their pedestal.

2.3 Take-up of QA

Statistics in this area are difficult to find, but CIRIA (1990a) has indicated that, out of an estimated total of 10,000 professional firms in construction, less than forty have achieved QA registration to date. That is, the take-up has been less than 0.4% despite the inducements and pressure outlined above.

At a qualitative level it would appear that it is the almost exclusively the large professional firms that have been registered (O'Hagan, 1990). The reasons for the dearth of small firms are many and various and are considered in more detail later, however:

> *BSI have said it would certify a two person firm, but certification at this scale could devalue Quality Assurance… (Murta, 1990, p6)*

This reticence is based on the need for a checking function, hence the lower limit of two, presumably qualified, staff.

The question of size of firm may not appear important, but the profile of the construction professions is one of a few very large firms with hundreds of staff and a preponderance of very small firms (RICS, 1974). Based on available statistics (IStructE, 1986; DoEmp., 1989; RICS, 1990) around a quarter of professional firms are sole practitioners and, say, half have five or less staff (qualified and support) and two-thirds ten or less staff.

So, few firms have taken the plunge and a great many of the remainder are rather small and possibly not suited to FQA systems

2.4 Other Reactions

Given that the take-up of QA has been very low, but at the same time certain parties have been very vociferous regarding its efficaciousness, it is not suprising that a certain amount of cognitive dissonance (Festinger, 1957) has occured. In these circumstances various well known reactions are possible.

Certain irrational categories of behaviour (Maier, 1961), such as *regression* ("don't spoil things") and *fixation* (endless repetition of key phrases) together with *aggression* have been clearly evident to this author, but so too have several rational coping responses (Festinger, 1957).

Some involve *extra effort* to make FQA more workable for the construction industry. Interpretative documents (RIBAIR, 1989, Oliver, 1990) come into this category. *Alternative goal setting* is another possible reaction and is evidenced at a superficial level by the use of "new" expressions, such as "Quality Management" (QM) and "Total Quality Management" (TQM). To the extent that these represent real advances beyond the concepts of FQA they would be of interest, however, closer examination reveals that QM is being used synonomously with FQA (CIRIA, 1990b) and TQM (Oakland, 1989) merely means the same concepts, and a ragged collection of "tools", applied throughout an organisation rather than mainly to the "operating core" (Thompson, 1967).

2.5 Summary

There are considerable forces towards the use of QA, which in the UK is interpreted as a formal approach to management, the successful implementation of which is indicated by third-party certification. Take-up has been minimal and mainly by large firms. Reactions indicating cognitive dissonance abound within the construction industry at present and an assessment of the appropriateness of the current approach to QA is required.

In the following section an objective appraisal of QA is attempted. The aim is not to pronounce on FQA as "right" or "wrong", but rather to identify the circumstances in which it appears to be appropriate and those in which it seems inappropriate (Kast and Rosenzweig, 1981; Sidgewick, 1893).

3 Analyses of Appropriateness

A summary analysis of the implications for professional firms is now given, first from the perspective of the motivations of the various key parties, second taking a problem-solving view and, third, in terms of the change process involved.

Throughout, FQA will be considered as a particular management approach and will be tested objectively against the voluminous body of management literature.

3.1 Motivational Factors

These have been analysed in detail elsewhere (Barrett, 1989b) drawing from various sources, and are summarised in Table 1, below.

Table 1: FQA and Motivation

Positive Effects	**Negative Effects**
The Individual	
Formal feedback on performance could increase motivation	Intrinsic motivation probably reduced due to deinviduation
May "help" inexperienced staff	Restrictive for able/ developing staff
The Firm	
Could be helpful if work "programmed" in nature	Dampening effect on flexibility/ innovation
Special case of "first in"	
The Client	
Reliable management of well-defined/sequential projects	Reduced flexibility for parallel working & innovation. Focus on process not product
"Objective" choice criterion	May obscure actual performance as choice criterion

On balance, from the client's, the firm's and the individual professional's perspectives there are many reasons to resist FQA.

3.2 Problem-solving View

This has also been discussed elsewhere (Barrett, 1989a), takes the perspective of the professional firm and is summarised in Fig. 1, below. The factors listed on the left are those which the analysis suggested would be supportive of FQA.

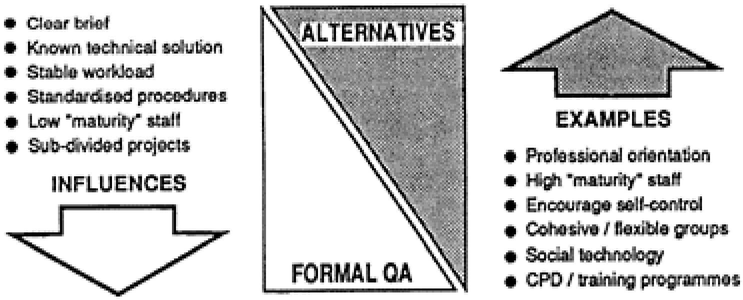


Fig. 1. Factors Supporting FQA/Alternatives

The alternatives shown will be referred to later, but it can be seen that the circumstances in which FQA is likely to be appropriate are not those universally found within construction by any means. Thus, many firms would find it very hard to operate efficiently and effectively using FQA.

3.3 The Implementation Process

Many of the subject firms are small and in general tend to emphasise informal methods of operating (Minzberg, 1979). This has implications for FQA implementation and it is likely that a change of *group attitudes* is required if more formal methods are to be adopted which will greatly increase the energy required to effect the change compared with a stereotypical larger firm which already has a formal approach and only needs to change its *knowledge-base* (Hersey and Blanchard, 1982). This distinction is illustrated in Fig. 2, below.

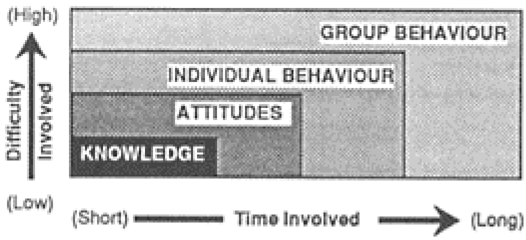


Fig. 2. Changing Knowledge, Attitudes and Behaviour

Johnson (1990) views this type of issue in terms of strategic change and reinforces the above view, saying that: *"change may take place readily within…the recipe"*, that is the prevalent *"cultural web"* of the organisation, but arguing at length that strategic change, even in these circumstances, does not occur as major shifts, but rather incrementally. Johnson's analysis then focuses on the role of symbolic action which he views as critical to the successful achievement of strategic change. It is in this respect that QA may have value—as a symbol. But, he stresses: *"…the importance of communicating meaning and vision in symbolic ways which relate to the 'mundane' reality of those in the organisation."* This argues against the "top down" imposition of procedures which are viewed as irrelevant by those actually doing the work, which is so often the reaction encountered at present.

In reality the vital distinction is perhaps, not between big and small firms, but rather between entrepreneurial and *administrative* focussed. This is a continuum suggested by Stevenson and Gumpert (1985) and loosely mirrors the big/small view but more closely identifies the key factors that influence behaviour. For instance, they suggest that entrepreneurial firms will tend to have "flat" structures with "multiple informal networks". They also think that firms of this sort will try to commit resources in many small steps, thus limiting exposure at each stage. This approach resonant with Johnson's (1990) view, but is greatly hampered by the emphasis on third-party certification in the UK.

3.4 Summary

The circumstances in which FQA is found to be appropriate for motivational or problem-solving purposes are fairly limited and many negative connotations have been identified. Additionally the specific implementation approach stressed in the UK creates its own problems.

4 Possible Solutions

This section will look first at the nature of FQA (what) and then at the implementation process (how).

4.1 What

FQA as it stands is appropriate in some circumstances, but its application would be greatly extended if the systems really were consonant with the characteristics and demands of the construction professions. Work is proceeding to achieve this in various ways. Fletcher (1990) has proposed a “Key Elements” approach in which the needs of the industry come first and the QA systems are designed to fulfil these, rather than *vice versa*. Other moves in this vein include investigations into the possibility of adopting ISO 10000 which has been designed for services (but still not with construction in mind) and the redrafting of ISO 9000.

A whole plethora of issues is raised when the question of performance measurement is considered. The analysis should in the author’s view (Barrett, 1990) be based on a consideration of the client’s expectation/ perception quality gap (Gronroos, 1983), drawing on hard and soft data collected from within and outside of the firm (Silvestro *et al*, 1990), thus, ensuring effective preliminary, concurrent and feedback control (Donnelly *et al*, 1981).

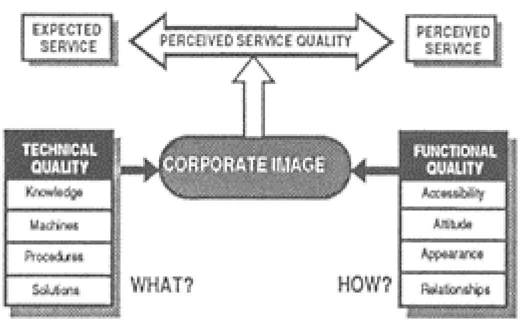


Fig. 3. The Expectation/Perception Gap

Fig. 3 is based on Gronroos’ model and stresses the importance of *how* the service is delivered as well as its technical content. Parallel research in professions outside construction (eg Axline, 1984; Parasuraman et al, 1985) confirm the importance of these “soft” factors.

Silvestro and her colleagues take this a stage further and suggest the range of quality measures shown in Fig. 4, below.

	HARD MEASURES	**SOFT MEASURES**
INTERNAL MEASURES	internal operational data automated systems data management inspection	management inspection and service sampling
EXTERNAL MEASURES	after service telephone call mystery shopper	costumer questionnaire customer survey mystery shopper after service telephone call

Fig. 4. Matrix of Quality Measures

This leads to the consideration of hard/soft *external* measures, which can be elicited through client surveys etc. Implicit in this approach is a concern for what the firm produces? as well as the process leading up to it. Both of these aspects are clearly shown in Donnelly’s control model, given in Fig. 5, below, with the addition of the “preliminary control” of resources, for example the education process through which professionals pass.

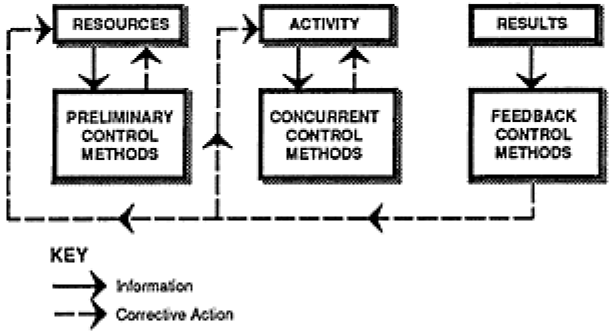


Fig. 5. Control Model

Viewing FQA against the above perspectives it is evident that it tends to concentrate on “concurrent control” to grossly simplified client’s requirements, based on hard data. This raises the danger of “over measurement” (Etzioni, 1964), that is, the distortion of behaviour by giving undue weight to assessment criteria that are easy to measure. In this instance the distortion is likely to be manifested in the form of obsessive and elaborate internal *paper systems*, whether or not they are actually helpful, even relevant, to the achievement of the level of quality desired.

The inclusion of soft data and external aspects would greatly strengthen QA and would possibly provide the opportunity to accommodate the informal approach of the small/entrepreneurial firms.

Referring back to Fig. 1, various alternatives to FQA are suggested on the right-hand side. These stress the inherent *self-control,* the desire to do a good job (Schneider, 1980), to be found in many professionals and developmental aspects (Hackman and Oldham, 1980), both of which can be cultivated to produce high quality work.

4.2 How

The benefit of reduced risk to small/entrepreneurial firms of incremental implementation has already been mentioned. This approach is hampered by an emphasis on third-party certification which has been termed a "revolutionary" approach (Sjoholt, 1990; 1991). In the rest of Europe it would appear that an "evolutionary" approach is more favoured with QA systems growing from within the firm, rather than being imposed (Sjoholt, 1989), and third-party certification considered as very much optional. As a result the changes stand a better chance of being internalised, and so self-maintaining, and the focus remains on what really matters—better, or more consistent, quality work. Additionally, the competitive "first past the post" attitude is less evident and collaborative efforts appear much more common.

This is not to say that the UK approach is wrong, but in this writer's view it is fair to say that the UK approach is not right, or best, or leading the field. Rather FQA will be appropriate in some circumstances and innappropriate in others. It would appear that the latter category may be predominant when professional firms are considered. There are, therefore, lessons to be learnt from QA experience in other countries.

5 Summary and Conclusions

The current situation in the UK has been described. The fairly limited circumstances in which FQA is likely to be appropriate have been identified and possible solutions proposed to make QA more applicable and accessible to the construction professions.

In its present form FQA will either remain a side issue or it will be foisted upon firms resulting in many unintended outcomes. It is suggested that a far more productive way forward is to use FQA when appropriate, but to design different systems to suit other circumstances. This requires a reassessment of FQA in the areas identified in the section above.

A situation where many firms have to contort themselves to suit FQA has not resulted in widespread adoption. In the next few years *Quality Assurance* will have to adapt or die!

Hopefully adaptation will occur and the present situation will be seen in years to come as a first step in the right direction, a phase of development in which QA became an important issue, a symbol of the *desire* to work to consistently high standards. This stage achieved QA must now evolve into a richer, more powerful approach, the tools, techniques and ethos of which are grounded in the reality of the organisations using it.

This is the task facing those concerned with the construction-related professional firm now.

6 References

Anon, 1988, 'QA New Priority in 1992 Countdown' in Architects Journal, 18 May, p9.

Axline, L., 1984, 'Are Your Clients Satisfied?' in Journal of Accountancy, July, pp84–90.

Barrett, P.S., 1989a, 'Quality Assurance in the Professional Firm' in Quality for Building Users Throughout the World, 3 vols, CIB, Paris, I, pp181–190

Barrett, P.S., 1989b, 'Motivating to High Quality Work' in Implementation of Quality in Construction, 2 vols, EOQC, Copenhagen, II, pp355–363 (p355).

Barrett, P.S., 1990, 'Small Professional Firms and the Implementation of Quality Assurance', paper presented at The Economics and Management of Small Firms, BAM seminar at Manchester Businss School, 19 April 1990.

Beard, C., 1988, 'Adapt or Die' in Chartered Quantity Surveyor, May, pp24–26.

CIRIA, 1988, 'A Call for Unity and Understanding', in CIRIA News, No. 2, London.

CIRIA, 1990a, 'CIRIA Launches New Project on Quality Management for Design' in CIRIA Press Release, London, January 1990.

CIRIA, 1990b, 'CIRIA Launches…', answers to questions at launch, 1 February 1990, London.

Dalton, J., 1987, 'Quest for Quality' in Managing Construction Worldwide, 3 vols, Spon, London, I, pp360–366.

Dept. of Employment, 1989, Small Firms in Britain, HMSO, London.

Donnelly J. et al, 1981, Fundementals of Management, Business Publications, Texas.

Etzioni, A., 1964, Modern Organisations, Prentice-Hall.

Festinger, L., 1957, A Theory of Cognitive Dissonance, Stanford University Press.

Fletcher, K., 1990, 'Key Elements for Quality Systems in Building Design and Building Contracting Firms', paper submitted to CIB W-88 Meeting, Oslo, 11 June 1990.

Gronroos, C., 1983, Strategic Management and Marketing in the Service Sector, Chartwell-Bratt, Bromley.

Hackman, J.R., and G.R.Oldham, 1980, Work Redesign, Addison-Wesley, Mass, USA.

Hersey P. and K.Blanchard, 1982, Management of Organisational Behaviour, fourth edition, Prentice-Hall.

IStructE, 1986, 'Development Plan Working Party Report' in The Structural Engineer, vol 64A, No 8, pp216–223.

Johnson, J., 1990, 'Managing Strategic Change: The Role of Symbolic Action', British Journal of Management, Vol. 1, No. 4, pp183–200.

Kast F.E. and J.R.Rosenzweig, 1981, Organisation and Management, third edition, McGraw-Hill.

Maier, N., 1961, Frustration, University of Michegan Press.

Minzberg, H., 1979, The Structuring of Organisations: A Synthesis of Research, Prentice-Hall.

Murta, K., 1990, 'European Attitudes' paper presented to CIB W 88 Meeting, Oslo, 11 June 1990.

O'Hagan, P., 1990, QSs and QA, Final Year Project, University of Salford.

Oakland, J., 1989, Total Quality Management, Heinemann, Oxford.

Oliver, B., 1990, Quality Management in Construction; Interpretations of BS 5750 (1987)—'Quality Systems' for the Construction Industry, CIRIA Special Publication 74, London.

Parasuraman, A. et al, 1985, 'A Conceptual Model of Service Quality and Its Implications for Future Research' in Journal of Marketing, Vol. 49, pp41–50.

RIBAIR, 1989, Quality Assurance: Guidance on Assessment and Notes for Firms, RIBAIR, London.

RICS, 1974, A Study of Quantity Surveying Practices, London.

RICS, 1990, Building Surveying Workload Statistics: 1989, London.

Schneider, B., 1980, 'The Service Organisation: Climate is Crucial' in Organisational Dynamics, pp52–65.

Sidgewick, A., 1893, The Process of Argument: A Contribution to Logic, Adam and Charles Black, London.

Sjoholt, O., 1989, 'The Norwegian Model for Establishing Quality Management in Building Enterprises' in Building Research and Practice, Spon, No 5, Sept/Oct, pp289–293.

Sjoholt, O, 1990, 'Reference Model for Analysing Characteristics of QA/TQM Development in the Building Industry', paper delivered at CIB W-88 Meeting, Oslo, 10 June 1990.

Stevenson H. and D.Gumpert, 1985, 'The Heat of Entrepreneurship' in Harvard Business Review, March/April, pp85–94.

Silvestro R. et al, 1990, 'Quality Measurement in Service Industries' in International Journal of Service Industry Management, MCB University Press, Bradford, Vol 1, No 2, pp54–66.

Thompson, J.D., 1967, Organisations in Action, McGraw-Hill.

43
The quality management system of the professional

E.BEJDER

Abstract
This paper primarily appeals to the professional owner of a building project, i.e. especially to the professional owner's administrator. Besides, the paper also appeals to the other interested parties (coming users, designers, and contractors) of the project in two ways: Firstly the interaction between the quality systems of the different parties is clarified, i.e. the parties achieve transparency concerning their input/output matters related to a project. Secondly the system perceptions and the contents of the subsystems suggested for the professional owner might give inspiration to all the other parties when they are going to develop the quality systems of their companies.

The paper suggests an operative understanding of the quality management system (QM), the quality strategy system (QS), the quality control system (QC), the quality assurance system (QA) and the quality inspection system (QI) of the company. Furthermore the paper describes how the total quality control system of the project is established by the QA systems of the different interested parties.

Keywords: Quality, Owner's administrator, System development, System interaction, Company viewpoint, Project viewpoint, Development task, Operation task, Involvement.

1 Introduction

At Aalborg University we use project orientated education. Each semester (=½ academic year) the students work in groups on a project documented by a report, which is the basis for an evaluation at the end of the semester. From 7th to 10th semester these projects are normally related to problems in professional companies, i.e. a cooperation is established between a group of students and a company. The group works under supervision of one or two counsellors from the academic staff. For further information about principles of education at Aalborg University, Institute of Production see Olsen (1989).

Three students, Lotte Andersen, Henrik Kyhnæb and Orla Jepsen, working, under my supervision, on the 10th and final semester (M.Sc. degree) had established a cooperation with a professional owner/-owner's administrator. The students made a broad and deep analysis of the company and suggested different focal areas. Furthermore they suggested a structure for the development processes of the quality systems. Finally they developed proposals for the content of some of the systems and discussed the consequences (quantitative as well as qualitative) by drawing more attention to the quality viewpoint.

This paper is mainly inspired from this project and from my own experience as an employee in different professional firms. The project reports made by students in cooperation with a company are normally not accessible for anybody but the company, the students and the supervisor as they mainly contain confidential information. This also applies to the project mentioned above. Therefore I cannot refer to this and other projects concerning the specific company information but only present my statements in a general form. I shall also mention that all the companies we (at the university) cooperate with are well managed companies often with many years of operation. Therefore, when we talk about problems and solutions for these companies, it must be perceived as a suggestion/possibility to achieve still better performance.

2 The professional owner/administrator.

Normally you define the owner as the (juridical) person who contributes with money to the project organization and receives the completed building in return. This implies that the owner has the competence to decide with which parties he wants to participate (paid and not paid) and has the competence to say “stop” and “go” at different stages in the project.

This paper primarily concerns the (professional) administration of owner activities which might be done by the owner himself as well as by another company. Different varieties of integration between the role of the owner and the role of the administrator are indicated below:

> Plain administrator.
>
> You are from the beginning of the programming phase hired by the (juridical) owner (or group of owners). Your job might come to an end when the building is finished or maybe after a period of guarantee. Besides you could also be hired to administrate the building during the period of use or during part of this period.
>
> Mixed administrator/owner.
>
> You start as an owner and an administrator. At different stages during the period of realization or in the period of use you might skip the owner role (sell the project) and continue as the owner's administrator, maybe to end of realization maybe to end of use. Ultimately you might be owner and administrator all the way to the end of use.

The primary focus in this paper on the administration aspect does not imply that the owner aspect is unimportant or uninteresting. E.g. the owner aspect includes the right to say "go" and therefore is an instrument to level out your resources. Besides the owner role gives you an extra possibility to win or lose.

3 The quality tasks of the professional owner's administrator.

The pursuit of better quality/efficiency can be perceived from a company viewpoint as well as from a project viewpoint. A model for these viewpoints and the interaction between them are shown on fig. 1 below.

In its pursuit of high external efficiency (company level) the company selects "products" (business fields/areas) which reflect the expectations of the interested parties (well known parties/clients and potential new parties/clients) of the company. This selection of business fields must be done taking into consideration the opportunities and threats in the environment and the strength and faults of the company (the SOFT elements). Furthermore the selection must be done in a way that assures short time as well as long time profit. The portfolio matrix of "The Boston Consulting Group" is one tool you can use in order to increase the external efficiency. I will come back to it later in this paper.

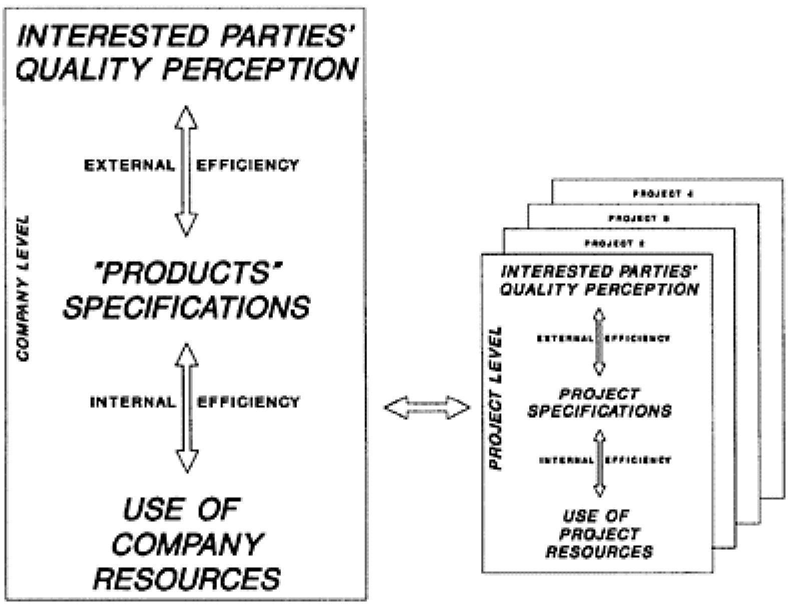


Fig. 1 Efficiency—company level/project level.

Besides, searching for a proper mix of business fields, you must also develop the company organization in a way that leads to a higher internal efficiency, i.e. the company must try to optimise the use of the resources of the company in order to deliver the "products" in the selected business fields in a competitive and a company profitable way.

If the selected "products" include project management/-administration (at the owner level) high internal efficiency at company level implies that you are able to establish high external as well as high internal efficiency in the project according to the right part of figure 1. This part shows that the project specifications (drawings, descriptions and resource disposal/budget) must reflect the needs/expectations of the interested parties of the project in order to create high external project efficiency. Besides, during realization of the project, the use of project resources must be controlled in a way that leads to fulfillment of the project specification (high internal project efficiency). These quality/-efficiency matters on project level are also discussed in my paper Bejder (1989). The perception above leads as a first step to fur (or five) management tasks:

Tasks at company level:

(a) Assurance of external efficiency, i.e. making the right "things" in the company—the development task of the company.
(b) Assurance of internal efficiency, i.e. making "things" the right way in the company—the operation task of the company.

You might also say that the balancing of (a) and (b) is a special task. I would like to emphasize this special task because most companies (my assertion) have their main focus either on (a) or (b), i.e. there are "sales companies" who also do some production (production is a "secondary" problem) and there are "production companies" (very "efficient") who also do some selling (saying: the customers must be idiots if they do not buy the "excellent" products of the company).

Tasks at project level:

(c) Assurance of external efficiency, i.e. making the right things in the project. From an owner administrators point of view this task primarily concerns the programming activities and the suggestion/selection/involvement of proper interested parties (user representatives, designers and contractors).
(d) Assurance of internal efficiency, i.e. making things the right way in the project. This task primarily concerns making agreements (contracts) and follow ups on these agreements between the juridical owner and the interested parties hired by the owner (the designers, contractors and maybe the owner's administrator).

4 The quality systems of the interested parties.

The tasks mentioned above shall be accomplished through the management systems of the owner's administrator in interaction with the quality systems of the other interested parties. Different literature offer various definitions of quality management, quality control, quality assurance etc. In my opinion these definitions seem quite fine at the moment you read them but when it comes to the operational use problems arise. Which parts of "the real life" activities should be put into which system and how do the systems interact with each other. Especially inspired by the group of student (see section 1), I suggest the superior system perception/integrating models shown in fig. 2 and 3 below.

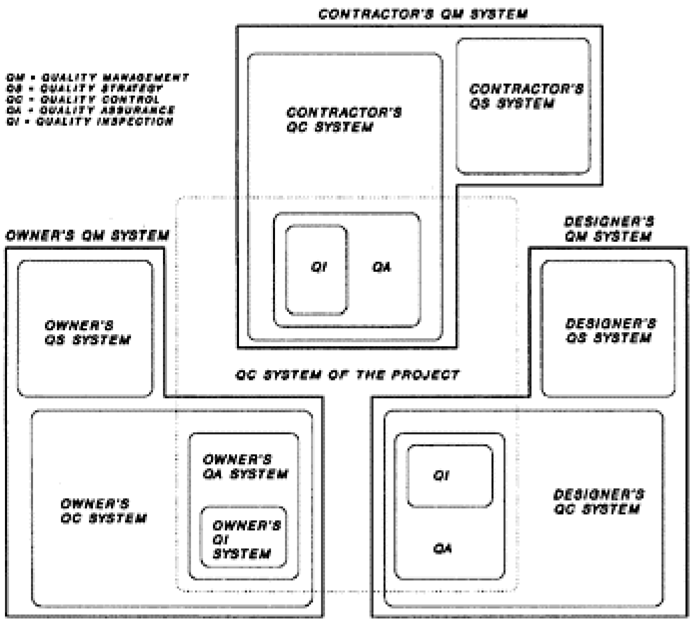


Fig. 2 Quality systems—company level.

Figure 2 illustrates the quality systems of all the three main parties in a building project (provided that the owner represents the future users). Each party has a QM system which is the superior system including all the other systems of the company. The QM system can be "separated" in two systems: a QS system (the strategy system) which uncovers the right "things" for the company to do and a QC system which controls that "things" are made the right way by the company. The QC system includes the QA system which again includes the QI system. The QA system is especially related to the individual (building) projects in which the company is participating, i.e. the QA system assures/documents that the deliveries of your company are in agreement with the contract you have made with your customer (normally the juridical owner). Besides, output from one party's QA system might be an input for another party's QA system. With special emphasis on the owner's administrator, all these systems including the interaction between them will successively be described more detailed later in this paper.

The systems above primarily referred to the individual parties/-companies. If you link the three assurance systems you get the QC system of the project which is illustrated in figure 3.

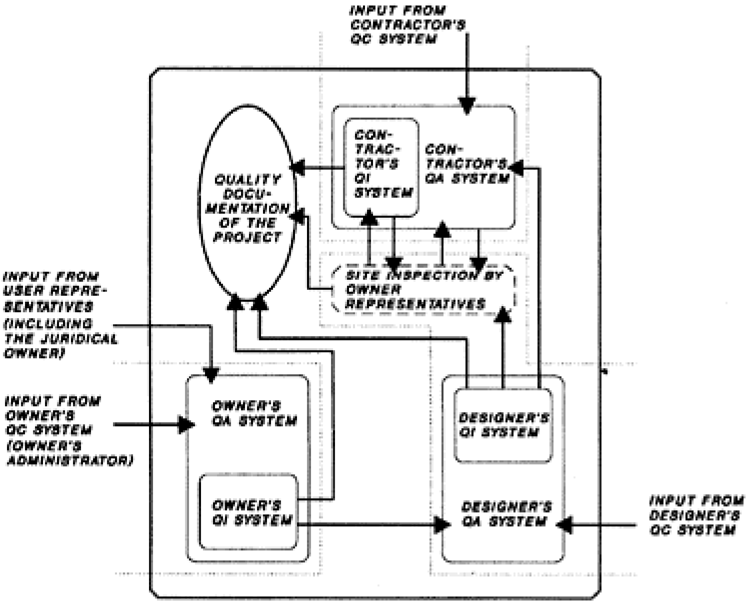


Fig. 3 Quality systems—project level

The owner's QA system primarily reflects the working activities in the programming phase of the project, the selection and organization of the other interested parties and the superior juridical/financial administration of the activities in all the project phases—maybe later also in the phase of use. The designer's QA system (only one designer is shown in the figures for simplification reasons) primarily reflects the work activities in the phase of design and similarly the contractor's QA system takes care of the construction activities.

Compared to fig. 2 you notice an extra system in fig. 3: "site inspection by owner representatives", which is a reminiscence from "older" days. Before the intense interest in the quality viewpoint and the resultant development of quality systems, we (in DK) use to have site inspection roles, normally carried out by the designers, i.e. the architects and the consulting engineers.

One of the main statements of the Danish quality reform work (Byggestyrelsen, 1986/87) is that: "every party is responsible for the quality assurance of his own delivery". Therefore, logically the role of site inspection should pass over to the contractor. Anyway we have not yet taken this step one hundred percent. Maybe because of suspicion, maybe (more positively) because structural changes normally take some time and because the changes might more appropriately be taken in smaller steps ("Rome was not built in a day"). Therefore the role of site inspection by owner representatives still exists in parallel with the QA/QI activities of the contractor. However, the role has changed in accordance with the guidance of the quality reform (I think some consulting companies have not yet noticed that!) from one hundred percent site inspection activities towards advice/inspection concerning the contents of the contractor's QA system and the contractor's use of his QA system (=the contractor's QI system). Thus site inspection in the "field", done by the consultants, should be reduced to very critical aspects of construction and to unforeseen circumstances. These special inspection activities might also be built into the contractor's QA system together with other inputs from the designer's QI system. The contractor's QA system includes specifications with regard to what to inspect, how to inspect, when to inspect, who to inspect, accept criteria etc.. "Who" normally reflects the person in the contractor's organization who should do the inspection but "who" might also in special situations be "external" persons e.g. the designers. In this way you might get a better/more planned integration of the quality assurance activities carried out by the contractor and the owner representatives in the period of construction.

You may also notice that I do not operate with a QM system on project level. This is of course a matter of definition. I connect a strategy system with company considerations concerning selection of appropriate "products" (different business fields). In a project you only select one product—hopefully the "right" one and therefore there is no strategy system in the project. This does not mean that there are no strategic considerations involved in a project but these considerations are made in the other systems of the companies, primarily by the juridical owner and later on documented in the owner administrator's QA system.

The intention of this chapter is to provide an overview of the different quality systems of the companies involved in a building project and of the interaction between these systems in a specific project. In the next chapters I will make more detailed suggestions for the contents of the different quality subsystems in the quality management system of the professional owner (i.e. the professional owner's administrator).

5 The quality systems of the professional owner's administrator.

5.1 The quality strategy system.

This is the system where the company develops/selects strategies for the future. Much literature is available suggesting different procedures. Therefore, I will only make some general advice concerning practical development and use of the strategy systems. All the advice mentioned must be perceived as an inspiration because, I think, basically the "right" way of doing the strategy processes is the way the company chooses—provided that the company does something, does it regularly and does it in a broad consensus/-agreement.

Some companies in the building industry might do the strategy work systematically and regularly (I do not know any of these). Other companies do the strategy work by occasional intuition, maybe initiated by a "sudden" threat or opportunity in the environment. I know a lot of these companies and most of them exhibit good performance concerning the quality of their products. On the other hand, most of them make no, or just a little, profit, i.e they work for fun. Working for fun is basically a good attribute but little profit normally causes problems, e.g. many people use a lot of their time doing "fire fighting".

I think most managers realise that one way to higher profit in the company goes through more planned strategic activities (another way: see Bejder, 1991B, concerning making the “pie” of the project larger). But when these managers realise the volume of work involved in the different strategy processes suggested by theorists or some management consultants (who normally make good profit) they give up. The managers think that before those “idealistic” strategy processes are completed the “world” has changed at least three times. Therefore, I suggest as a beginning a more modest approach towards implementation of strategy processes.

First of all you must realise two possible effects of the process: You might get a strategic plan telling your organization that now we are going this “way”. I think it is a good idea to have a plan all the time. The danger is that, even if you become wiser (e.g. environmental changes) during the time after the planning, you do not change the plan, as you may think that all the efforts made during the process is wasted. I prefer the perception that “we have a plan (well known by our organization) until we make a new one”. The new one might be made next week, next month or in two or three years and the new one might be a minor adjustment of the old one or a radical change in the strategy all depending on the circumstances, external as well as internal.

The other (very important) effect by running through a strategic process is (provided proper participation in the process) the increasing transparency inside and between the SOFT elements (strength, opportunities, faults and threats). If this transparency gets more visible to most of your staff some call it “strategic development” of the company. You can also say that you have established a strategic preparedness of your company. Many “prophets” today emphasise the importance of this aspect and I basically agree but I also see the danger of turning down the planning aspect (i.e. emphasizing the process only). Therefore, my suggestion is: mix some “hot water” with some “cold water” and you get something pleasant, i.e. you improve your capability to make new plans (and implement them) rapidly. Of course the “mix” of the planning aspect and the strategic development aspect must be balanced according to the situation. Roughly a stable situation indicates most planning and a rapidly changing situation indicates most of the development aspect (easy to say—hard to handle).

Besides, the modest approach towards more consciousness concerning development of strategies might take its point of departure in the basic elements in the strategy process. Again, inspired by the group of students I can suggest the basis shown in figure 4 below.

The different processes/systems in figure 4 can be characterized by the task of the process (expected output), the participants in the process, the structure/organization of the process, the technology used in the process and the time schedule of the process (e.g. inspired by H.J.Leavitt, 1978).

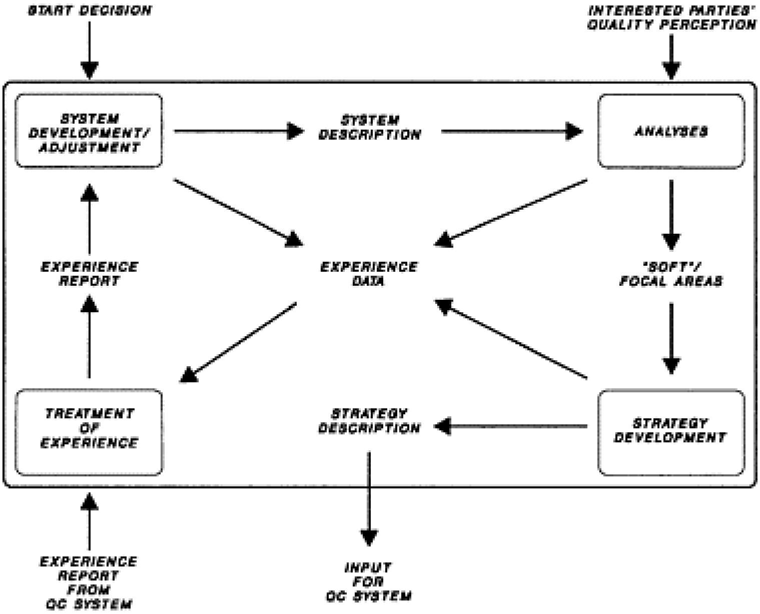


Fig. 4 The basic elements of the strategy system.

5.1.1 The system development.

The task of the first subsystem of the QS system is the development of the system itself (in the first "run"—system adjustment in the following "runs"), i.e. development of the contents of the different subsystems. The result (the system description) should from the beginning be on a superior level (easy to understand) because you can later in the strategy process make it more detailed possibly combined with feed backs. The selection and organization of the participants must be considered from the viewpoint of skills and the viewpoint of motivation. In order to guarantee an ongoing focus on the strategy system a system administrator should be chosen. The "technology" might be literature, courses and may be an external consultant depending on the skills of strategic process organizing inside your company.

5.1.2 The phase of analyses.

The second subsystem concerns the analyses of the strategic behaviour of the company. This phase should, as a beginning, include a superior analysis of performance, i.e. the perception of the internal and external interested parties of the company concerning the expected performance and the accomplished performance of the company. If you have formulated qualitative and quantitative goals/objectives representing the expectations of the interested parties you can compare these objectives with the results of the company activities and in this way uncover possible gaps. Next step might be planning of a more detailed strategic analysis based on these gaps. When agreed on proper topics for further effort you carry out the analyses planned, often suitable for different groups (working parallel), and the results of this work should, for each topic, be documented in a draft for a succeeding coordinated diagnosis. This coordinated diagnosis might later on be an input for companywide hearings resulting in an implementation of the diagnosis. The hearings might also have the effect that some topics must be further analyzed because the analyzing groups have left out some issues.

Earlier I emphasised on the importance of balancing the development task and the operation task of the company. This problem can be handled in the analyzes mentioned above by using the portfolio matrix of "The Boston Consulting Group" (se also for example Foss and Ingerslev, 1980):

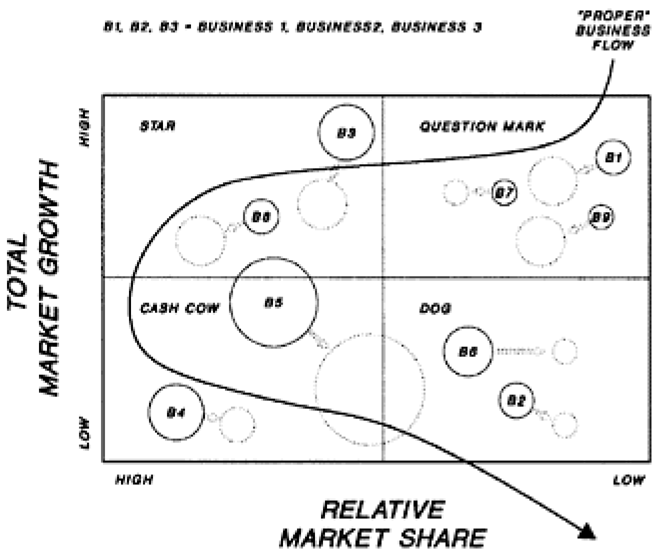


Fig. 5 The "BCG" portfolio matrix.

"Question marks" are business fields with a low market share (compared to the largest competitor) and a high market growth. Cash flow is typically negative because of the needs of investments in marketing, credit for customers, further product development, further automation etc.. When/if you succeed in transforming a question mark to a business field with a high market share you have a "star". Cash flow is now turning positive. Later on, when the market growth and the needs for investments decrease, the star becomes a "cash cow". "Cash cows" generate high positive cash flow (which can be used for other "question marks" and for consolidation of the company's position). Finally, when the life cycle of the business field is running out you have a "dog".

Thus, the idea of the BCG matrix is that a company involves itself in a "question mark" business field and during some time tries to make it a "star". Later on, when the market growth decreases, the business field becomes a "cash cow" and finally when going towards a "dog" you must throw it out of your portfolio mix. In order to assure short time as well as long time profit your company must, at any time, comprise a proper mix of “question marks”, “stars” and “cash cows”.

Therefore, drawing a matrix and putting in your different business fields might give you some warnings. If the main part of the fields are “question marks” you are developing the company to “death”. If the main part are “cash cows” (normally going towards “dogs”) and “dogs” you will have nothing to do in one, two or maybe three years depending of the life cycle of the fields. This might also lead to serious problems in the company.

A special risk for this situation occurs when you separate your company in profit centers (e.g. based on geographical locations) and if you compare the centers looking at “the bottom line” of the balance sheet of each centre. The managers of these centers will naturally make focus on the “cash cow(-s)” and not stimulate “question marks”. Therefore, when using profit centers, you must include accounts of each of the different business fields separately when you evaluate a profit centre. This might lead to the situation that a centre showing “X” on “the bottom line”, for a period, makes a better performance (at total company level) than another centre making two times “X” because it has a different mix of business fields.

When you start drawing the matrix you become aware of the difficulties in placing the different business fields. What is high and low market share/market growth and how do we separate our activities in different fields? I believe this must be cleared up in groups of persons selected from different parts of the company. The members of the groups must learn the underlying basis of the portfolio matrix: “the experience curve”, the correlation between relative market share and profitability, the life cycle conception and the cash flow as a criterion for profitability. Especially in the building industry the life cycle might cause problems because this industry is often highly affected by political decisions.

Concerning the separation of the existing and potential new business fields you (a professional owner/owner’s administrator) might find inspiration in the following topics:

(a) The degree of juridical owner involvement (see section 2).
(b) Your customers, e.g. “business to business” or “end users”.
(c) Public supported or not public supported buildings.
(d) The final product and application, e.g. new houses/renovation of older houses for young people, family houses, houses for older people, public buildings, factory buildings, special factory constructions etc.
(e) The phases you are involved in and the degree of involvement. You might begin the separation into two parts: before the period of use and during the period of use. The period before use might again be separated into programming activities, design activities and construction activities. Normally the professional owner’s administrator will concentrate his activities on the programming level but management at design level and management at construction level (upper level site management) might also be interesting business fields (vertical interaction). Of course, the juridical/financial administration (from the project viewpoint) will in all the phases be a natural element in your working activities.
(f) Geographical locations, e.g. different areas in the country provide different conditions (maybe different stages in the life cycle of the business field). Besides, matters concerning internationalization should be considered, maybe stepwise like: a foreign

customer's building in your country, a customer from your country building in a foreign country, a foreign customer building in a foreign country.

When the analyzing groups have arranged the different business fields of your company in the portfolio matrix (circle area representing the turnover) and the statements have been accepted by the hearings, you have obtained an overview concerning the present portfolio mix. This will give some warnings/advice but you might also add a dynamic dimension by drawing "development" arrows (dotted in fig. 5) from the different fields telling the way they are going at the moment and place the business fields (new size and location) where you expect them to be in one, two or maybe three years from now. Besides, this should be done under different assumptions concerning the environment as well as changing behaviour of your company. Thus you get a more nuanced background for the strategic decisions to follow. The phase of analyses (second system in fig. 4) should also be completed with cause—effect discussions, e.g. based on profit achieved in different projects, analyses of competitors and suggestions for new business fields resulting in an appropriate mix of portfolio in the future. In this way you have developed an overview of the "SOFT" elements, and suggested different focal areas/new possible strategic ventures.

5.1.3 The development of strategy.

The third system in fig. 4 is closely connected with the analysis system mentioned above. The strategy development might be further separated into three phases: evaluation of consequence, priority of focal areas/ventures and elaboration of strategy. Evaluation of consequences includes estimation of the necessary activities and resources needed for the different focal areas/ventures suggested in the analysis, i.e. the evaluation includes a description of activities and their estimated financial effects. Priority of focal areas/ventures includes, based on the consequences above, decisions concerning which of the focal areas/ventures should be started immediately, the succession of the them and disposal of the resources required. Elaboration of strategy includes a description of goals/-objectives and strategies at company level as well as for the different business fields. Besides you describe procedures for the maintenance of the preparedness of the organization. This will result in stimulus (accepted strategy description) sent to the system of operation (the QC system) of the company inquiring for action.

5.1.4 The treatment of experience.

The final subsystem in the strategy system serves the purpose of learning from the processes. As you can se in fig. 4 it is suggested that the system includes experiences from the strategy system as well as from the system of operation (the QC system). The treatment results in a experience report which can be used for adjustments in coming strategic processes.

5.1.5 Consequences of working with the strategy system.

The first time you run the strategic process it will require extra time because of the system development (normally only adjustments the following times) and because of the experience you get by participating the first time. The students mentioned earlier estimated, for the first (full) run, a period of nine months and a use of manpower=£100,000 including people from all levels (approximately one hundred people employed in the company). You can discuss whether the managers time should be taken into account because managers are supposed to do strategic work but it was included in the figure above. Besides, it was suggested that the process should be run through at least each fourth year.

What about the reward? While costs normally can be budgeted with low variance, especially concerning strategic efforts, "income" will be difficult to predict—basically it is a matter of belief. You can as a beginning look at it as a matter of survival. Besides, you can add the fact that your organization works the same "way" (goals/-objectives/strategies are well known and accepted). Further on you can say that the strategic awareness/preparedness of your organization has increased, i.e. you can at an earlier stage observe important changes in the assumptions of your strategic plan and therefore rapidly change your course (less "fire fighting").

The estimations above included a total first run with a broad and deep involvement of the employees. Of course you can reduce the activities as well as the number of participants. On its own the strategic analysis (discussing mix of portfolio) will, compared to doing nothing, be a large improvement. But reducing the participants might lead to less impulses, less motivation and less transparency among the people employed. This will again lead to lack of motivation in the phase of implementation and thereby lack of coordinated creativity in the organization.

5.2 The quality control system.

While the strategy system primarily takes care of the external efficiency of the company (making the right "things") the quality control system secures the internal efficiency (making "things" the right way). If you look at fig. 4 and 6 you notice the interaction both ways between those two systems. In which order should they be developed ("top down" or "bottom up")? You might know whether your weakness is lack of external or lack of internal efficiency. If not you should start looking at your mix of portfolio. A lot of "question marks" and some "stars" indicate the primary need for a (better) control system. A lot of "stars" and/or "dogs" leads to the opposite conclusion. Besides, your customers might presuppose the existence of a quality control or a quality assurance system.

The following model is, in different variants, developed in cooperation with my colleagues and some of my students at the university. The model draws on inspiration from observations of activities in "real life" as well as some logic considerations concerning necessary elements in a control system (se also Olsen, 1989, Jensen, 1989 and Bejder, 1991A).

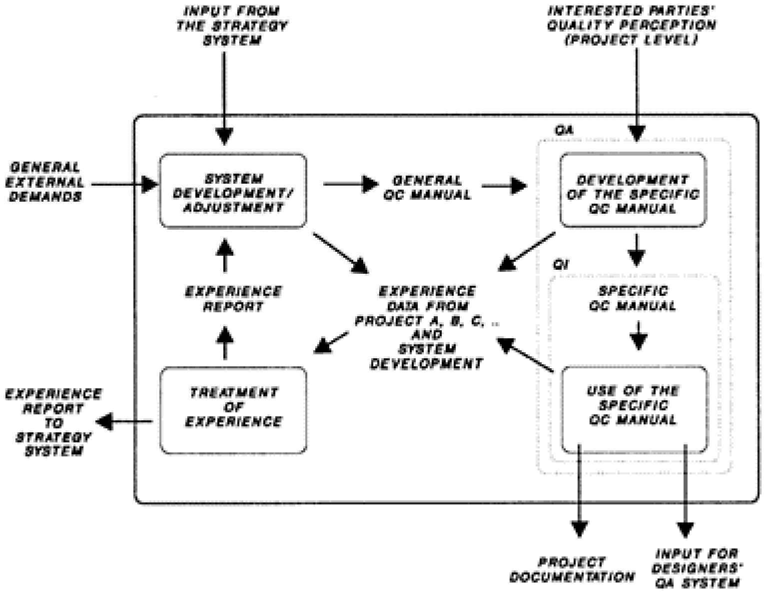


Fig. 6 The basic elements of the QC system.

5.2.1 The system development.

This part of the QC system is, in many ways, analogous to the system development process discussed in section 5.1.1. You should also notice the benefits by linking the QC development process close together with the phase of strategic analyses (chapter 5.1.2). Thus one of the analyzing groups, mentioned there, might handle the focal area: interaction between the QM and the QC system. Besides, some of the people should be involved in the strategic analyzing group as well as in the QC system development group. This interaction will lead to a common perception of the idea of quality.

When you select the QC system administrator it must be clearly stated (my opinion) that he/she is responsible for the system development/adjustment processes, not for the use of the system and, in the end, not for the final quality of the products of the company. This responsibility (use of the system and the final product quality) should be given to/grabbed by “the line”, e.g. the manager of the (building) project and his staff.

The result of the system development process is the general QC manual describing the quality strategy, the quality organization (system organization and principles for operational organization in the projects), system description including the contents of the subsystems of the entire QC system. The description of the subsystems might be structured in the task, the technology, the structure/-organization, the participants and the time schedule.

The general manual might appropriately be separated into a main part (general for the entire company) and some “second level” parts based on the different business fields of your portfolio. A second level part (of the general manual) should, in a more specific way, describe the quality strategy of the business field, general quality activities of the business field, e.g. pre-qualification, collection of experience and internal audit. Related to the different (building) projects you should describe the general quality activities of the different phases (programming, designing, construction and upkeep matters) and the relation between these quality activities, e.g. based on figure 3. Your quality activities concerning the design and construction phases should primarily comprise the audit of the designers' and contractors' QA system and a check on the input output relations between the different QA systems involved in the project.

Again you must remember the double effect by going through a development process: The planing aspect, i.e. in this situation the general manual and later on the specific QC manual telling you what to do/check in the operation part of your company activities concerning this project. Besides, you gain the organizing development aspect, i.e. the transparency (the understanding of the complex relations) and the motivation established among the people of your company involved in the processes.

5.2.2 The development of the (project) specific QC manual.

From the general manual you have the main structure including a check list for the specific manual. Based on the general manual and the input from the juridical owner and the coming users the specific manual is developed by the project manager together with other relevant people from the staff. You might have a procedure telling you that the specific manual should be o.k.' ed by the QC system administrator. But you must not allow the system administrator to create the specific manual—this will not operate properly when it comes to the use of the manual (see also my paper Bejder, 1991A).

5.2.3 The use of the specific QC manual.

This is the operation phase where you carry through the quality assurance activities described in the specific manual. Some of these activities are related to your own performance, e.g. the programming, whereas other activities are related to the coming designers and contractors, e.g. pre-qualification and input/output checks concerning the QA systems of these other parties.

Besides the experience data you notice (fig. 6) two outputs from this subsystem. Firstly the project documentation made in your QA system, i.e. the documentation showing that you have actually done the quality assurance activities you have promised to do in the specific manual. This documentation might, together with the similar QA documentation from the other parties, be given to the project, i.e. in the end to the juridical owner (see fig. 3). The other output is an input for the designers' QA system. This output might be the result of the programming activities (i.e. the building program) and other selected/necessary quality demands for the QA systems of the designers and the contractors.

5.2.4 The treatment of experience.

Analogous to the strategy system I suggest a subsystem for the purpose of learning from the other processes in the QC system. Of course this learning system will, even if it is not formal, exist in the "brains" of the different people employed by your company. But the experience will in this situation be fragmented and you might lose the experience if some of your people go to another company. In my opinion it is quite alright to make mistakes when working with development activities. On the other hand we do not have to make the same mistakes several times by different people. Therefore successful performance as well as mistakes should be treated regularly in a formal subsystem. When I look at QC systems of different companies related to the building industry I see a general remark like: "the system will be adjusted as required". Apparently, those companies have not yet grappled with consequences of such needs—they feel the needs (I believe) but more operational tasks take their time. Therefore, force yourselves to do the treatment of experience by statements in your QC system concerning specifying when to do it. Besides the exchange of experience during the process you also get an experience report which might be used right away for adjustment of the QC system as well as an input for the strategic system.

5.2.5 Consequences by working with the QC system.

Again, a lot of the statements made in the strategy system (5.1.5) may be repeated in this chapter. The basic idea of using a QC system is being ahead of the situation/problems. You do some thinking, planning and checking to avoid "things" going wrong, i.e. more use of preventive cost and less use of cost for "defects". In my article Bejder (1991B) it was estimated that for example the contractors (in DK) might double up the net profit by operating more intensively with their QC systems. Besides, the documentation from your QA/QI system puts your company into a better position if something after all does go wrong.

The students, mentioned earlier, estimated the average annual (preventive) costs to £60,000 for a company with one hundred employees (maybe some of the money is spent already). This figure should be compared to the cost of "defects" made by the company. Normally you do not calculate these defect costs but as a beginning you might extend your accounting system with an account for preventive costs and for defect costs. In this way you get a tool for optimising the mix of costs. Also the audit/pre-qualification of the QA systems of the other parties might indirectly lead to the situation that your activities work out more smoothly (less "fire fighting").

Besides those quantitative reflections you must also notice the qualitative consequences. Your company will be known as a competent and trustworthy partner in the building industry by making the "things" the right way in the first attempt. The quality of your products will become more uniform, i.e. not depending to the same extent as before on individual perceptions among your staff. You can also add that you might be on your way for a certification (e.g. ISO 9000).

6 Final remarks.

In my opinion some confusion exist concerning the contents of the different quality definitions/systems (QM, QC, QA etc.). This paper suggests an operative understanding of the contents inside the different systems and the interactions between the systems.

These interactions (the “main roads”) are shown on company level as well as on project level.

Besides, the paper suggests a modest approach to the system development process, i.e. you start with an overall understanding and develop/adjust the systems in small steps and with the sequence balanced with your needs.

Finally you must realise that the objectives of QM/QC/QA etc. must not be to get things right “on paper” alone. Everyone from the top down must be involved and it must be accepted that implementation will incur a cost, and that the benefits will not appear for two or three years. However, if designed and implemented effectively, firms willing to make the investment should reap the rewards in the longer run.

7 References.

Andersen, Lotte; Kyhnæb, Henrik and Jepsen, Orla; 1990, **Title anon.,** Final project for M. Sc. degree (specialization in management-system design) at Aalborg University, Institute of Production, Denmark.

Bejder, E., 1989, “Development of Quality Specification with Special Emphasis on Reconciliation of Interested Parties’ Expectations”, Conference Proceedings **Implementation of Quality in Construction,** Copenhagen, Denmark.

Bejder, E., 1991A, “Development and Use of Quality Systems in Construction Companies”, Book—Conference, **Practice Management,** Edited by Peter Berrett, University of Salford and Rodrick Males, University of Manchester, published by **E & FN SPON,** London, England.

Bejder, E., 1991B, “From Client’s Brief to End of Use: The Pursuit of Quality”, Book—Conference, **Practice Management,** Edited by Peter Berrett, University of Salford and Rodrick Males, University of Manchester, published by **E & FN SPON,** London, England.

Byggestyrelsen (The Governments Council of Building Administration), 1987, **Vejledning om kvalitetssikring i byggeriet (Guidance for Quality Assurance in Buildings),** Copenhagen, Denmark.

Foss, P., and Ingerslev, E., 1980, **Portefølje—strategier (Portfolio strategies),** AMT’s Bibliotek, Danmarks Tekniske Højskole, Lyngby, Denmark.

Jensen, T.J., 1989, “A Framework for Quality System Design in Construction Companies”, Conference Proceedings **Implementation of Quality in Construction,** Copenhagen, Denmark.

Leavitt, H.J., 1978, “Managerial Psychology”, **Chicago Press 4. ed.,** USA.

Olsen, W., 1989, “A Project Oriented Approach to Quality Management Education in Building Construction and Civil Engineering”, Conference Proceedings **Implementation of Quality in Construction,** Copenhagen, Denmark.

44
Linking building pathology output and quality assurance input

A.van den BEUKEL

Abstract
The development and improvement of practical quality systems should profit from the 'output' of activities in the field of building pathology. Since quality assurance is basically system oriented, that output from building deficiencies should also be analysed on a system level. According to this condition, an analytical tool has been developed, based on the idea that a process is composed of many tasks. And the reliable performance of those tasks depends on the control of 'means', 'knowledge', 'information' and 'ambition/motivation'. These aspects and related sub-aspects are considered as systems. The application of the tool is illustrated by a practical case leading to an improvement of a specification procedure. Finally, it is stated that the presented analytical tool can be a useful tool for getting improved quality procedures. Also, it might well compete with the 'tool' of a quality cost assessment, as far as improvement plans are concerned.

Key words:
Building pathology, Causes of deficiencies, Quality system procedures, System failures, Task performance.

1 Introduction

Building Pathology can be described as: the systematic treatment of building deficiencies, its causes, its consequences and its remedies. The main goal is: the avoidance of building defects. This is well in accordance with one of the aims of Quality Assurance: the avoidance of non-conformity.

It is evident that the cause of a deficiency should be known in order to take the necessary measures. But where does the 'tracing back' from deficiency to cause(s) stop? In general, any event or situation is the consequence of some foregoing event. This leads inevitably to a conclusion about some imperfect human behaviour or knowledge.

Assuming that the analysis of cause(s) is determined by what use is made of the results, three types of cause descriptions are recognized, thus boundering the in-depth search:

* Technique oriented descriptions (what caused the defect?).
* Liability oriented descriptions (who caused the defect?).
* System oriented descriptions (how did the defect originale?).

The first two types of descriptions are more or less self-explanatory. And as a matter of fact, building 'pathologists'—and lawyers—have nearly always been engaged with the questions of 'what' and 'who'.

The notion 'system oriented descriptions' needs more explanation. It is believed that Quality Assurance ('QA') is a tool for managing a process efficiently and effectively. As such, QA is most powerful in preventing deficiencies. But QA is basically system oriented: it deals in a managerial way with matters like organization, resources, communication, information, means, human resources, motivation, systematic feedback. This implies that the output from the building pathology domain—i.e. causes of deficiencies—should be described in terms of system failures in order to be useful as input to the quality assurance domain.

In the author's opinion, this way of looking at causes of defects is hardly practiced by building pathologists. Of course, technical knowledge about causes, mechanisms and measures is important. But thinking in terms of 'system failures' seems to be more important with a view on effectively preventing deficiencies. This was the main idea for developing a 'tool' that might help and feed practical quality systems.

2 Factors of the analytical tool

A building process is composed of several subprocesses. Within any (sub)process, many tasks have to be performed in a reliable way. According to Blaut (ref. [1]) the reliable performance of a task ('T') can be seen as the product of the factors: right means ('m'), right knowledge or know how ('k'), right information/communication ('i') and right ambition/motivation ('a'). Or as a formula:

$$T=m.k^2.i^3.a^x \qquad (1)$$

The powers express an order of importance and the factor a^x expresses that motivation may have either positive or negative influence on the performance of the task.

This might look rather academic or philosophid, but becomes more realistic when dividing these factors into the following sub-factors:

Means:	1)	personnel, 2) tools, machines, 3) goods, products, 4) money.
Knowledge:	1)	skills, 2) education, 3) experience.
Information:	1)	instruction/information concerning 'how',
	2)	,, ,, 'what',

	3)	,, ,,	‘when’,
	4)	,, ,,	‘why’ (=aim),
	5)	communication (=transfer of information).	
Ambition:	1)	satisfaction, 2) management, 3) feedback of results.	

All these sub-factors are important for the performance of a job or task, for instance designing a structure without defects. And one should realize that these sub-factors very much conform with the elements that are explicitly dealt with in modern systems of quality assurance.

3 Relation with process control and ISO 9000

Any business needs the control of certain aspects to control the whole process. Following aspects, based on the Norwegian ‘Model for Quality Management’, are recognized here: General (GEN), Organization (ORG), Communication (COM), Requirements (REQ), Measures (MEA), Purchase (PUR), Time (TIM), Finance (FIN), Realisation (REA) and Experiences (EXP). Other, but more or less simular aspects may be possible.

These managerial aspects are headed in the following matrix, to be explained hereafter.

		GEN	ORG	COM	REQ	MEA	PUR	TIM	FIN	REA	EXP
m.1	personnel/manpower	x	x								
m.2	tools/machines					x	x				
m.3	goods/products					x	x				
m.4	finance								x		
k.1	skills	x	x								
k.2	education	x	x								
k.3	experience	x	x								
i.1	‘how’				x					x	
i.2	‘what’				x					x	
i.3	‘when’				x			x		x	
i.4	‘why’		x							x	
i.5	information transfer			x							
a.1	satisfaction	x								x	
a.2	management	x	x								
a.3	feedback										x

Process control also implicates the control of all activities and tasks. So, the task-performancefactors as mentioned before must have a distinct relation to managerial aspects. The matrix shows in a condensed form, and just as an illustration, where deficiencies of task performances might negatively influence the control of managerial aspects.

Knowing such relations explicitly for a given process and given deficiencies makes it easier the company's management to decide on improvement activities. Since quality system elements, as described by the articles 4.1 through 4.20 of ISO 9001, can be seen as mixtures of task factors and managerial aspects, the matrix may also be helpful in translating ISO 9001-requirements into specific procedures or documents for a specific company.

The indications in the matrix are just illustrations. In reality, poor performance of a task may very well influence more and other managerial aspects. Besides, another choice of aspects could be appropriate. But the essence of the analytical tool, to be explained next, remains intact.

4 Using the tool

The essence of the tool is: recognizing the systems that govern the performance of activities, and relating them to the systems that control the (building) process. It comprises a two-step procedure, applied to a given specific defect or shortcoming:

a) perform an analysis by continuously questioning "which task-factor m.1 through a.3 influenced the given event negatively?" until the basic cause or causes have been found;
b) formulate preventive measures on a system level, taking into account the appropriate managerial aspects.

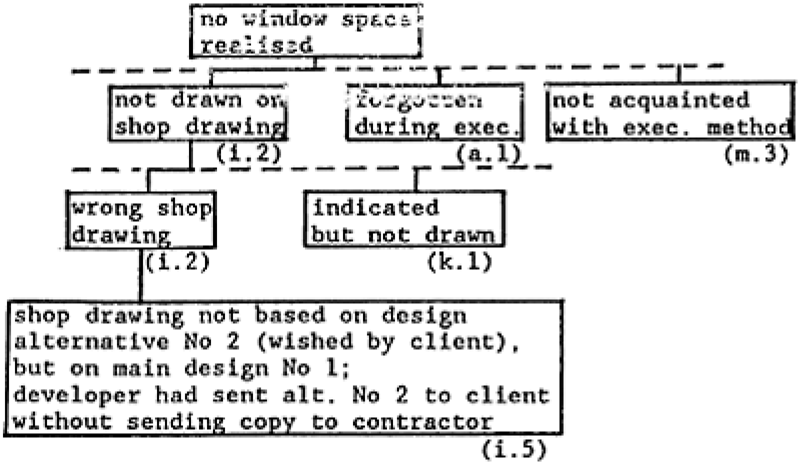
If judged to be worthwhile, those measures can then be introduced in the form of a modified procedure for instance.

Step a) in itself is, or can be, a multi-step approach very much like a fault tree analysis. The given deficiency is considered as a 'top event'. Possible direct causes of that event are collected and considered next. These are in turn considered as undesired events, etc.

The following example, taken from reality, may illustrate this approach. In the Netherlands, very often a 'developer' decides to have dwellings built and sells them 'on paper' to future owners/users before starting the actual process of works execution. The owner/user makes his decision on global design plans with alternatives for some details (choice of floor tiles, minor architectural changes, etc.).

In a certain case, after concreting an outer wall of a two-dwelling building (out of a series of uniform buildings), the future user noticed that no window space had been realised. This was not in accordance with the plan was given.

The analysis (first step) might resemble the following 'tree':



The consequences of the defective transfer of information were considered unacceptable. It was concluded that a modified procedure was needed. That procedure (step 2 of the analysis) should control the flow of information by demanding that specific data sent from the developer to the future user must be copied and sent to the contractor, with an additional note in case of information deviating from 'normal' information.

5 Final remarks

It is believed, and already confirmed on a very restricted scale, that the application of the explained 'tool' may contribute to the development and implementation of practical quality systems and its procedures. In this sense the approach can be compared with a quality costs assessment, which is a powerful means for effectively controlling an industrial process. Quality cost assessments are very effective in non-building industries. But the application of such an assessment to the building process turned out—in our experience—to be less effective than originally believed. For that reason, the tool of analysing deficiencies on the system level of task performances might compete with, or might substitute a quality cost assessment.

Experiences so far have only been gained for modest contractor processes. The described tool is also thought to be useful for getting improvements in the quality system of the total building process. But concerning this aspect, experiences and adequate information are still lacking.

[1] Blaut, H., Gedanken zum Sicherheitskonzept im Bauwesen, Beton—und Stahlbetonbau, 9/1982.

45

Quality assurance and management in building construction research and practical contributions

A.A.BEZELGA and E.T.de SOUSA

Abstract

This paper presents the principal topics of research and practical work developed at the Instituto Superior Técnico—Technical University of Lisbon, in the field of Building Quality. The work is referred to under three main headings:

Project Quality Evaluation.

Quality Assurance and Management of Building Projects.

Building Components Quality Assurance.

Keywords—Quality Evaluation, Quality Assurance, Quality Management, Proj ects, Components.

1 Introduction

This paper presents some studies and applications on the subject of quality in construction of buildings which have been completed over the last few years at the Technical University of Lisbon (Instituto Superior Técnico—Civil Engineering Department—Management, Quality and Economics Group).

The work carried out is basically centred on the three following areas:

Project Quality Evaluation.

Quality Assurance and Management of Building Projects and Firms.

Building Components Quality Assurance.

There follows a brief summary of the research and applications which have been carried out.

2 Project quality evaluation

In the area of "Project Quality Evaluation", three pieces of work were carried out which are worthy of note:

The elaboration of a multicriterial evaluation method to analyse various solutions or projects together.

The preliminary conception of a method to evaluate the quality of buildings for housing in Portugal.

The definition of criteria for assessment of a conception-construction tender for social housing projects.

2.1 Multicriterial analysis method

A system was developed in the Instituto Superior Técnico which enables evaluation and classification of projects or building element solutions to be carried out, based on the ELECTRE method of multicriterial analysis[3].

The system contains essentially two programme blocks—the file management block and the block for ELECTRE method algorithm processing.

The system as developed permits a large number of applications, and it is especially meant to be an aid in evaluating and classifying projects in terms of quality and economy, in appreciating proposals in tenders and in analysing solutions during the design phase.

2.2 Method to evaluate the quality of buildings for housing

A study was carried out about three years ago to analyse the viability of developing a method to evaluate the quality of buildings for housing to be applied in Portugal.

This study was carried out by the Technical University of Lisbon (IST), the University of Oporto (FEUP) and the Associação dos Industrials de Construção Civil e Obras Publicas do Norte (AICCOPN).

Its aim was to create a new method taking in account the following objectives:

To provide information to housing users and building firms.

To establish a quality profile—in overall terms—easily understood by users.

To give results not affected by the people carrying out the evaluation.

To be consistent and give reliable results.

To conform to Portuguese regulations and standards.

To have the possibility of evolution.

This study led to the establishing of a proposal of grids for quality evaluation, whose summary frameworks are presented in Figures 1 and 2. A more detailed analysis of the study is presented in Bezelga, Abrantes and Macedo (1987).

FIGURE 1—METHOD BEING DEVELOPED PROVISIONAL GRID OF EVALUATION

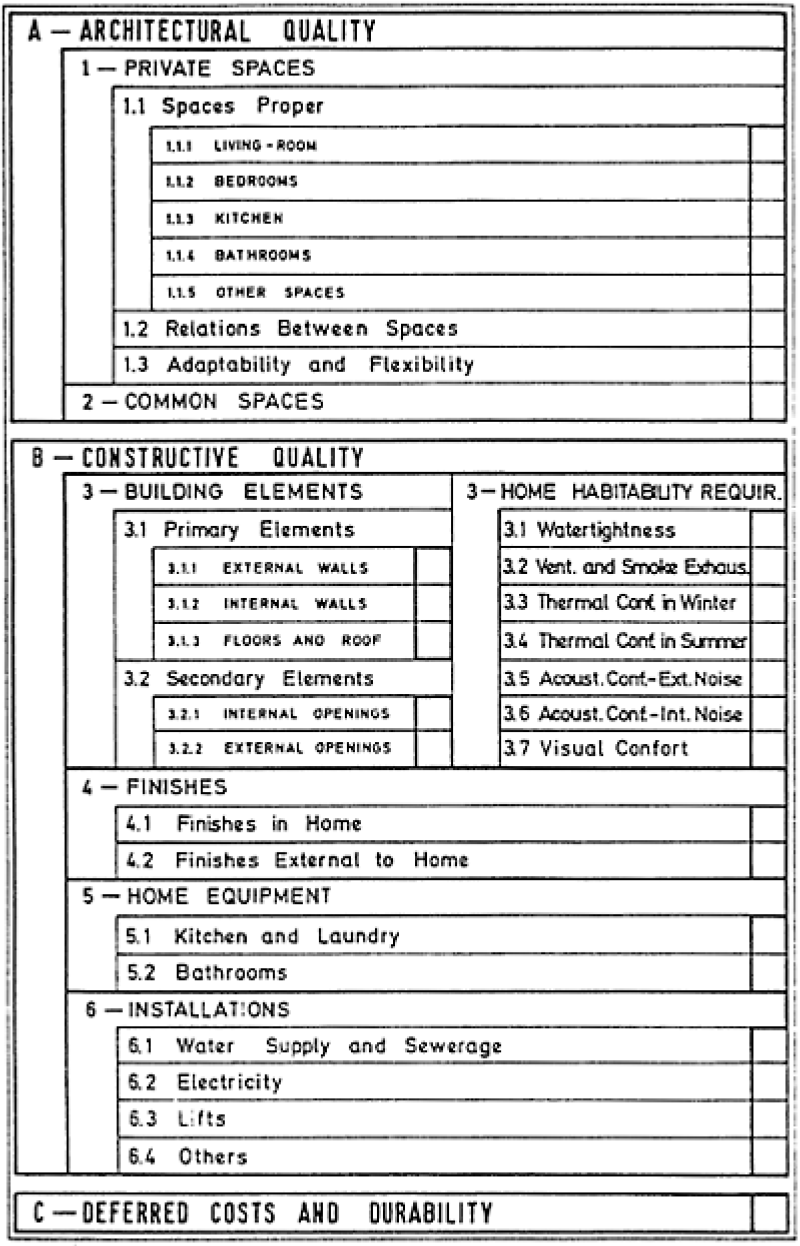
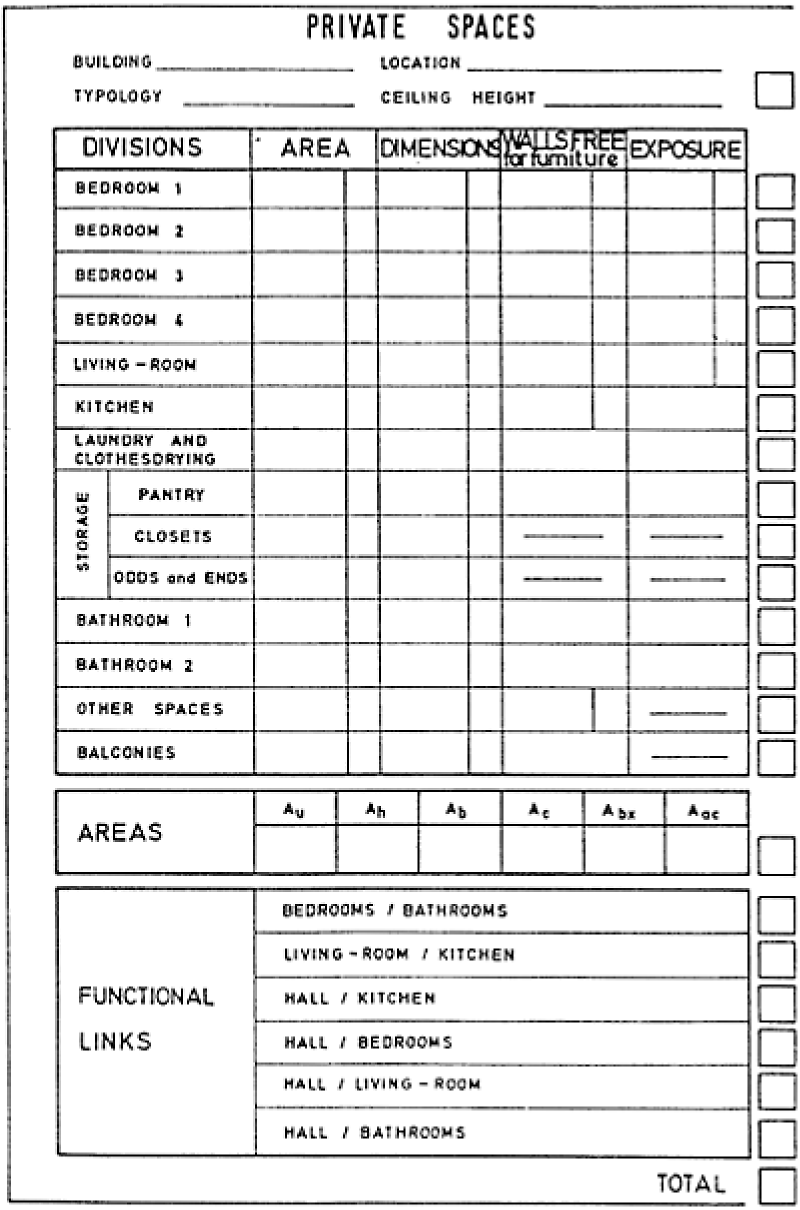


FIGURE 2—PRIVATE SPACES—SYNOPTIC CHART



PRIVATE SPACES

BUILDING ______ LOCATION ______

TYPOLOGY ______ CEILING HEIGHT ______

DIVISIONS		AREA	DIMENSIONS	WALLS FREE for furniture	EXPOSURE
BEDROOM 1					
BEDROOM 2					
BEDROOM 3					
BEDROOM 4					
LIVING-ROOM					
KITCHEN					
LAUNDRY AND CLOTHESDRYING					
STORAGE	PANTRY				
	CLOSETS			—	—
	ODDS and ENDS			—	—
BATHROOM 1					
BATHROOM 2					
OTHER SPACES					—
BALCONIES					—

AREAS	A_u	A_h	A_b	A_c	A_{bx}	A_{oc}

FUNCTIONAL LINKS	
	BEDROOMS / BATHROOMS
	LIVING-ROOM / KITCHEN
	HALL / KITCHEN
	HALL / BEDROOMS
	HALL / LIVING-ROOM
	HALL / BATHROOMS

TOTAL

The final evaluation grid was reached based on the following considerations:

Analysis of existing methods of evaluation.

Analysis of life cycle cost, cost/efficiency, cost/ benefit, multicriteria and value analysis.

Analysis of specific evaluation methods us for buildings for housing—SEL, Office Federal du Logement (1978),

QUALITEL, Association Qualitel, last edition, and others;

Portuguese regulations, standards and studies.

2.3 Quality promotion in conception-construction tender for social housing—criteria for assessment of tenders

Detailed criteria for assessment of tenders were prepared with special reference to the preparation of a conception-construction tender for about 2000 housing spaces. Both the cost of construction and the overall quality of the projects were considered in assessing the entries. The main points that were considered in the definition of the construction value were the best use of space from the users' point of view, the keeping of conservation expenses to a minimum, the possibilities for room division and the choice of suitable building enclosures [4].

3 Quality assurance and management of building projects

In the field of quality assurance and management of building projects two types of work were carried out:

A methodological study concerning the adaptation of European standards EN 29000 to building projects in Portugal, given the characteristics of the Portuguese construction industry.

Applications of the methodological study on building projects.

3.1 Methodological study

As the EN 29000 standards are especially suitable for manufacturing industries, it was necessary to adapt their recommendations to the building projects that were being analysed.

Given that the building firms involved did not have their own quality manuals, the quality assurance programmes proposed consisted, basically, of the following:

The conception and development of a project quality system:

Creation of a project Quality Manual.

Creation of project Quality Assurance Procedures. Creation of an Inspection and Testing Plan for the project.

The implementation of quality project management:

Management of the quality system created.

Management and control of the Inspection and Testing Plan.

Carrying out of audits on the operation of the system, at various levels.

3.2 Application to building projects

The applications which were carried out basically followed the two points referred to in 3.1: i) definition of project quality system; ii) implementation of quality project management.

The definition of project quality system was founded on the elaboration of three base documents, which are referred to in more detail in 3.2.1. The implementation of project quality management results in the execution throughout the project of quality documentation briefly referred to in 3.2.2.

3.2.1 —Project quality system definition

The documents elaborated on are described in the following as Doc.1, Doc.2 and Doc.3.

Doc. 1. Organization of quality system

The clear definition of:
The quality policy for the project.
The project management organogram.
An organogram for the "quality" function.

Doc. 2. Procedures for the implementation and assurance of quality

For each production sub-group (excavation, foundations, structures, brickwork, floor and wall finishings, etc.) or for the project as a whole, according to each case, the procedure for the required quality assurance was defined, for the various quality functions.

In the cases of the projects analysed the quality functions were the following:

Quality in the project.
Quality in supply.
Quality in production.
Control during production and inspection of products and services.
Inspection of measuring and testing equipment.
Non-conformity and corrective actions.
Staff and workforce training.

Doc. 3. Inspection and Testing Plan

For each of the production sub-groups (excavation, foundations, structures, brickwork, etc.) an Inspection and Testing Plan was drawn up which included:

A flow chart of the production cycle. (see e.g. Fig. 3)
Identification of the inspection and testing points in the production flow chart, (see e.g. Table 1)
Definition of the logical circuit of decisions to be taken.
Definition of procedural systems for inspection and testing described in the grids.

3.2.2 Project quality management during project execution

In the project quality assurance programmes developed there were also specified:

> The quality documentation required during quality management of the work (reports on inspections, tests, qualifications, validity, auditing, calibre, etc.).

The type and intervals of the audits to take place.

4 Building components quality assurance

A model was drawn up for an Inspection and Testing Plan for the manufacture and placement of precast concrete panels, for the future certification of quality of these building components [5].

During this symposium a paper will be presented which covers this topic, but only concerning the sub-section of the placement of the panels in the building.

5 Conclusions

The application in Portugal of the methodologies for evaluation of project quality, assurance systems and project quality management has developed very slowly over the last five years.

However, there can today be noted a tendency towards a marked change, with a rapid development, to which a number of factors have contributed and continue to contribute:

> Membership of the Single European Market.
> The EEC Directive concerning Building Products.
> The introduction by the Portuguese Institute of
> Quality of a National System of Quality Management in its various components—standardization, qualification and metrology.
> The increasing demands of the market (cost, quality and deadlines) and greater competition between firms.

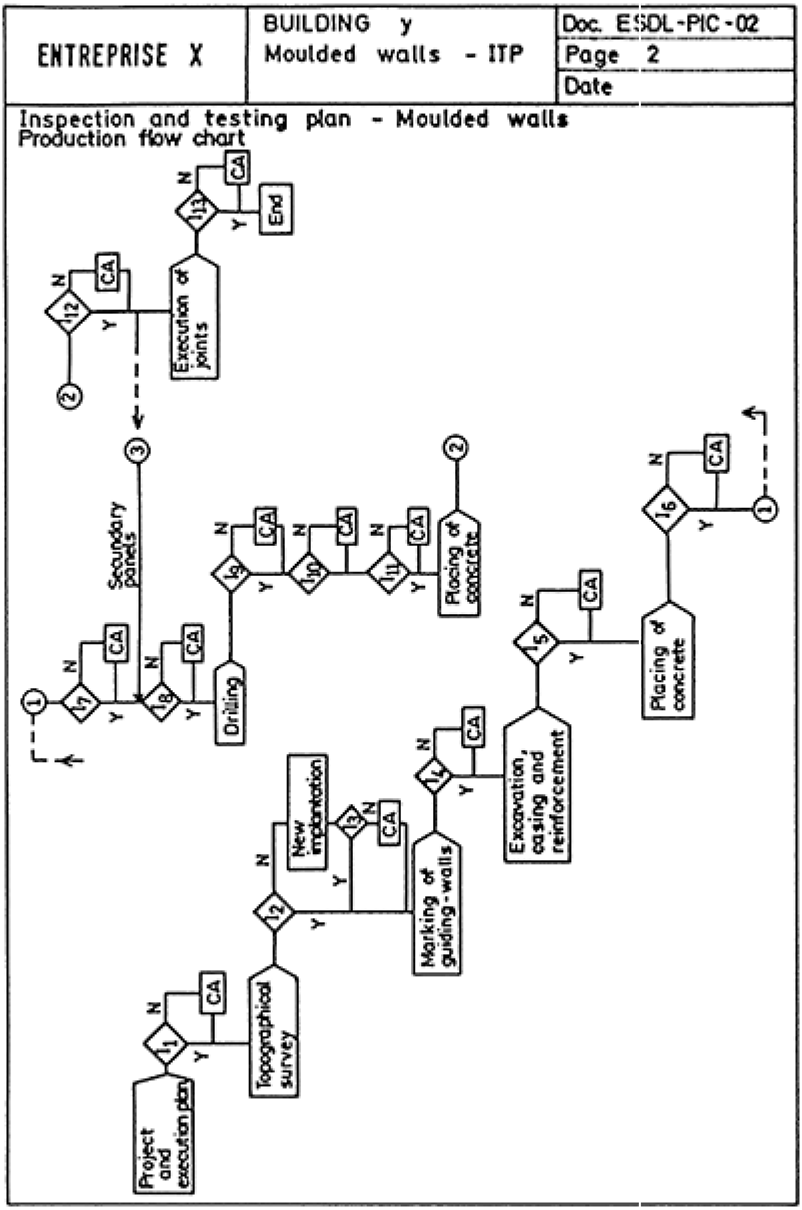

ENTREPRISE X
BUILDING y
Moulded walls - ITP
Doc. ESDL-PIC-02
Page 2
Date
Inspection and testing plan - Moulded walls
Production flow chart
Project and execution plan
Topographical survey
Marking of guiding-walls
New implantation
Excavation, casing and reinforcement
Placing of concrete
Drilling
Secundary panels
Placing of concrete
Execution of joints
End
CA
Y
N

Fig. 3

Table 1

ENTREPRISE X		BUILDING y INSPECTION AND TESTING	Doc. ESDL-PIQ-02 Page Date		
Inspection and Testing of Casing and Metallic Reinforcement of Guiding Wall 15					
1	ACTIVITY	ACCEPTANCE	SUPPORTING	VERIFICATION	
				YES	NO
1	Implantation of casing in accordance with that forecast				
2	Rigidity and support of casing		Doc. ESDL-PROC-02 Plan of surrounding supporting walls		
3	Transversal mettallic reinforcement in accordance with type detail	See to the detail—2 cm apart	Plan of implantation of guiding walls		
4	Longitudinal mettalic reinforcement in accordance with type detail	See to the detail			
5	Thickness of wall	Less size in minimum equal to that demanded in detail			
6	Distance between casing faces accord ing to detail	Differences of less than 1cm			
7	Depth of excavation according to that forecast	Differences of less than 5cm			
Sign	The Director of the work		Date		

Teaching and research in the universities, particularly through higher degree courses.

Activities of Associations and Institutes connected to building construction and to quality.

The carrying out of Symposia, Meetings and other scientific and technical activities.

As a result of these factors some considerable initiative is beginning to be shown, particularly in the following areas:

Certification of construction products. Introduction of project assurance and quality management systems.

Certification of companies—producing materials and consultancy firms—and of construction projects.

References

1—BEZELGA, A.A., ABRANTES, V. and MACEDO, J.P. (1987) Establishing a Method of Quality Evaluation of Housing Building Projects—an Experiment in Progress, in **Quality: A Shared Commitment** (ed. Richard Grover), Institute of Quality Assurance, London, pp. 363–378.

2—BEZELGA, A. and OLIVEIRA BRAZ, A. (1990). Quality Assurance in Building Projects—Need for Innovation in Project Management, in **2º Encontro Nacional sobre Qualidade na Construção,** LNEC, Lisbon, pp. B1–B14.

3—BEZELGA, A., TELLES DE MENEZES, E. and MACEDO, J.P. (1987). Evaluation and Automatic Classification of the Performance/Cost Relation of Building Projects Based on Multicriteria Analysis, in **Proceedings of the 4th International Symposium on Building Economics,** SBI, Copenhagen, pp. 136/142.

4—NETO, F., BEZELGA, A., FERREIRA, R., CARDOSO, A.L. et al. (1986). Quality Promotion in Conception Construction Building for Social Housing—Criteria for the Assessment of Tenders, in **1º Encontro Nacional sobre Qualidade na Construção,** LNEC, Lisbon, pp. 2/1.35–2/1.79.

5—TEIXEIRA DE SOUSA, E. (1990) **Garantia de Qualidade na Prefabricação e Montagem de Paineis Prefabricados de Betão, Contribuição para a Elaboração de um Piano de Inspecção e Ensaio.** Instituto Superior Técnico, Lisbon.

46
A new approach of quality in the building industry in France: the strategic space of the major actors[1]

J.BOBROFF

Abstract
Changes in economic rationality conduct the French firms, especially the largest to a new approach of quality where the major actors organise their "strategic spaces". The particularity of the product (housing) and the specificities of the work process in building industry, lead to a new approach in terms of global performance. They develop strategies of adaptation facing the incertainty of a changing world. New forms of cooperation appear involving the different partners in other relationship.

The French building industry and the actors involved, try to develop quality around two different areas:

Therefore, to approach the question of quality, we have to tackle it by the standards, the norms of the product (durability, maintenance for a given cost), and by the performance of the process (delay, benefit, productivity).

The major actors involved, in France are: the client investor, the architect and the construction firm. They try to develop different policies more or less forceful, but all of them are concerned with the control of conception, design and the management of interfaces of the different phases.

We will try to develop a typology of their interventions.

<u>KeyWords:</u> Quality, New rationality, "Filière", Actors, Strategic space, Cooperation.

* quality in the product (architects, client-investors and consumers)
* quality of the process, of the organisation, of the work process, but also of the relationship in the sector (firms, engineers, surveys…).

1 These results come from a research financed by the French Ministère du Logement, de l'Equipement, des Transports et de la Mer (Plan Construction-EVMB).
We have communicated on this subject in International Symposium: Stockholm, Suède (1/6/90); Moscou, URSS (4/9/90).

1. Introduction

The French building industry has been highly concerned with the crisis and confronted during the eighties with important economic and social change.

I just would like to recall some major ruptures:

* heavy losses after a long period of expansion,
* bi-polarisation of the sector into a few large firms developing offensive strategies and a multitude of small companies.
* redefinition of the largest companies methods, with a special accent on real estate, design, coordination and control, on the one hand, but on the other hand, using all subcontracting forms to disinvolve themselves from direct production.

Such changes question the preceeding attempts of rationalisation and lead the companies to review their position in the production process and in the work organisation (1). They lead to a particular organisational model, founding a new type of rationality. Quality takes up importance in the redefinition of this model.

2. Main changes founding a new rationality

2.1 A global approach in the bidding industry

We face an evolution from a fragmented rationality to a more integrated system (2). Building companies try to control and organise, as far they can, the total coherence of the activity. The accent is put on managing the interfaces of the production process, with an approach in terms of global perform: less attention to the direct efficiency of the work for the benefit of other functions (design, piloting, coordination, and control). We can observe a new functioning oriented to an “assembly role” (“ensemblier”) (3).

Therefore, productivity and quality have to be understood in a more global approach, in the context of a global efficiency.

2.2 A new place conceded to the incertainty

This outline conducts the actors of the process to develop stategies of adaptation to a changing world.

It endeavours to expand steady networks, which they can trust. In these networks, the control of conception looks very important to the different actors and the condition to get under control the product.

The largest firms are more in advance to develop the strategies that we call “ensemblière”.

1 Campagnac, E.
2 Veltz, P.
3 Bobroff, J., Campagnac, E. et Caro, C.

Actually, the whole building activity of the sector (“filière”) is characterised by power-relationship. However, cooperation appears as a necessity to manage the incertainty in a branch involving so many and so different trades, status and interests.

2.3 The data flow

These new ways of relationship require to break the dividing up between the functions (1). A larger place is devoted to the constitution of data networks, particularly to increase productivity and quality. As the production managemement model, tries to optimize the production in line flow productive system (KAN-BAN, Just In Time, 0 stock), we observe same attempts to organise data flow.

Computerisation is the key of this system (2).

2.4 Evolutions in quality policies

Without detailing the history of the quality concept in industry, we wish to recall some major evolutions in methods (3).

After a first phase, devoted to survey, with conformity controls, in an “a posteriori approach”, the quality management put forward the process control to avoid rejects.

Then, an important rupture comes with the introduction of an “a priori approach” and the necessity to set up reliability on the whole production chain (quality insurance, certification, value analysis).

Actually, we are in a new phase: the “total quality”, including an organisational approach of the whole company and a managerial policy oriented to relationship of human resources and cooperation in and out the firm.

The economic approach of building industry leads to avoid costly repairs and to favour “a priori” controls. The sector, by the configuration of its process, is now particularly concerned by these last evolutions, which put a special accent on the organisational rationalization.

3. The building industry shows particularities

Facing the other industries, we can point some specific elements:

1 Campagnac, E., Picon, A., et Veltz, P.
2 Veltz, P., Sociologie du travail
3 Collective Report

* a multiplicity of people have to collaborate in the production of the same product. They represent different status and trades and develop specific and sometimes contradictory stakes. Cooperation appears however as a necessity.

* the work process is modelised by the constraints of the site; it is characterised by a “double variability” developed by Myriam CAMPINGS (1): an external variability founded on the product and the market heterogeneity, and an internal variability founded on a specific and changing work process, located on the site.

The specificity of the work process leads to some difficulties, particularly to separate control and regulation tasks from direct production tasks and to manage the risks (2). Autonomy appears as a necessity on the site. Therefore firms are looking for flexibility of the productive structure and tackle the question of quality by reliability of relationship.

4. A specific approach of quality in building industry

4.1 Housing is a social goods

Even if housing is intended to the market, it is a specific product, different from an industrial goods: it is a social goods, (connection with land, space organisation, collective policy), requiring a social arbitration. In France, nothing can be built without a building licence, which tries to guaranty collective interests.

To integrate quality, the building industry is obliged more than the industrial sectors, to develop, beyond strictly commercial trade, other forms of exchange and cooperation.

4.2 A specific configuration of the relations between design and execution

Controling the design, appears actually to all the actors, the major interface of the chain. Particularly we notice an increasing need for contractors to pay more attention to design.

We observe many attempts to question the relation between the building design and the preparation of its achievement and to redefine the functions.

4.3 Building industry: quality of the product, or quality of the process?

Of course, a narrow link exists between the two approaches and we can’t imagine to get quality of the product without taking care of the process course. But we can say that the actors involved in the production of the buildings, tackle the subject through different ways. Some are more oriented on product quality (architect, client, investor, user). Others, like the firms, are more involved in the building production, and led to focus on the quality of the process, on its organisation, its efficency, its productivity.

1 Campinos-Dubernet, M.
2 Dutertre, C.

Hence, we are confronted with different status for quality: quality of the products, or quality of the process, of the organisation. The consequences are important on the methodological level, the various approaches and methods refering to economy, management, or sociology.

All the difficulty for the firms, consists in this ambiguity of the quality approach, which tries to improve the execution process (by methods); but too, the relationship in and out of the firm.

4.4 Quality, a notion to be reexamined

An approach of “quality” in building industry, and an attempt to give its definition, lead to question the measures and the criterions. Do we have to tackle it by the requirements of the user or by the standards, (the norms of the product, in terms of durability, maintenance for a given cost); or rather by the performance of the process (in terms of delay, productivity, benefit)?

Quality was a traditional key-word in building industry, based on the craftsmen culture. But the production context is now different. The worker does not produce anymore a complete work from the begining to the end and therefore can’t master and control his labour.

The question is: how to restore the product unicity in its production process?

5. A French key-concept to approach quality: “la filière”

The “filière” is a French definition, hard to translate: “an organised system of commercial and non commercial relationship, including a specific organisational frame and constituting a strategic space”(1). This definition which insists on the organisational approach, shows the conflictual aspect of the action field of the different actors.

Confronted with the constraints, they try to extend their intervention area, but can’t avoid to set up cooperation modes, beyond strict economic relations.

This relationship present a particularity: according to the deals and the opportunities, some actors are involved in the network, as client or as contractor, expressing at one time the needs of the final user or, at another time requests of the intermediary partner.

Therefore, in the actual context, where non commercial relationship appears as important, we can observe an extension of the intervention in organisational and relational areas.

1 De Bandt, J

6. The strategic space of some French actors

In our research, we try to analyse evolutions of rationality forms from the point of view of the major actors involved in the "filière". We will give some examples, to show how they try to model their strategic space in accordance with their stakes, and how consequently, they take position in the quality field.

Some look more offensive than others, but they all admit that execution reliability and profitability have to pass through the control of design and the management of interfaces. So, they take particular care to be largely involved upstream on the chain.

6.1 The client—investor

He tries to reinforce his position, facing the general contractor who develops a strategy that we call "ensemblière". To protect the quality of the product, avoid the impoverishment of the specifications, he is obliged to keep the control of the order, of its content and its cost. Some of them, to identify the nature of the risks and guaranty the technical reliability of the operation, choose to lean on technical assistance, external or internal ingeniery. They take action at the beginning of the design, to control the way of the process. They select the products and prescribe special agreements.

Others manage quality of the product, taking care of the norms, using check-lists, analysing the mistakes to find the critical points; or recommend special products or industrial components coming with organisational methods (sequencial organisation of the tasks for example)

The French law suggests to include a "S.D.Q" (quality scheme guide) for the public sector. It is a quality-plan imposed to all the contractors and subcontractors, involved in the operation.

Some others, try to develop a more participative action among the sub-contractors they coordinate. They organise the spreading of the quality plan, and training among the small firms and their workers. The French National Marine try to broadcast such a Total Quality Plan, for all the constructions they order and they have in charge. They train their agents as "quality—instructors" and organise training for the small firms of the town where they build.

6.2 From the architect—designer to a "constructive ingeniery":

The architect's role is very important to defend the use of the building, the program quality and the product in its relation to the space and the environment.

Facing the new constraints, the architects would have to redefine their practises.

But in France, they are not always prepared by their culture and their training to be involved in the technical and organisational changes, of the building industry. Therefore they are often assisted by engineering consultants to develop a necessary synergy between their design and the production process.

Some large building companies, to favour a better integration between the program and their production methods, grant a major role to conception and develop integrated architectural departments.

Moreover, clients use to impose a collaboration between the architect, limited to his designing role, and survey departments entrusted with piloting, prescription and coordination.

Some engineering companies are developing the same strategies “ensemblières” as the major building companies, taking in charge all the activities, and elaborating for their clients, in a “constructive engineery”, a complete “key-ready” construction. They try in that way, to solve the difficulties linked to the management of the interfaces between the needs of the client and the other interventions.

6.3 The big corporation: different ways to approach quality

By the specific work-process developed on the site, the large firms are the most concerned, among the actors, by the requirement of flexibility. For a better control of the interfaces, and to take care of productivity and quality, they are obliged to widen their field of action.

We can observe a wide variety of steps, among which we distinguish two principal ways to set up quality:

* a technical approach, more specifically implemented on the sites and oriented on management methods and control proceedings.
* an organisational way, trying to transform the whole structure of the firm: (total quality policy). It consists in a complete project for the firm.

These choices often coexist in the same firms; they generally correspond to different stakes and corporate culture.

However, the observation of these policies in the companies, allows to propose some typological elements for helping to classify the different proceedings employed by the firms.

7. Four types of proceedings implemented in the quality policies of the companies

7.1 A marketing and commercial approach

Facing a tougher competition, the companies to sell the quality of the product, try to put forward this approach, selling at the same time the quality image of the firm.

Proposing a complete service to assist the client, they estimate the demand, elaborate the project with the client, arrange the finance, identify and secure the site, manage design and construction, and take care of maintenance. They can manage the entire building: an offer strategy.

It is one favorite way for the general contractors to justify their activity; even if this strategy, that we call “ensembliere”, is often accompanied by subcontracting of numerous production tasks.

For example, one of the largest european firm proposes to the town councils, a patrimonial diagnosis and a plan taking in charge the whole intervention. More than a product, a project, the firm tries to sell a service.

A methodological question has to be asked: Is it the same way for a firm, to manage the quality of a product or to manage the quality of a service?

7.2 An approach aimed at the rationalization of the organisation

Quality plan consists in attempts to formalize organisational requests and initiate a better transparency in the system, particularly on the site, yet considered as a “black box”.

A special attention has to be given to the circulation of data and to the harmonization of the methods (punctual interventions or total quality with long term plan).

It will be the oportunity to tackle the general organisation of the firm. This approach can’t avoid implication and requires a special effort of the management board.

7.3 Development of the human resources

We can’t consider this approach as a step in itself. Many proceedings used in quality policies try to increase the men. But this approach implements some particular proceedings around the “participative management”.

Two type of policies are put forward by the companies which place the accent on the human resources:

* Motivation policies, particularly oriented to the staff. They often come with a managerial philosophy around a participative harmonization of the actions and social innovations (firm’s charter of beliefs, communication). This policy appears to the company like a special ethic intended to initiate commun values and unite the men around a corporate culture.
* Labour skills upgrading on the site.

    As we told earlier, regulation and control tasks can’t be totally cut from production tasks and post-controls appear too costly. The building firms are obliged to take great care with the manpower qualification and to help the workers to develop autonomy and self-control of their own work. The respect of quality on the site is highly dependant upon works and life conditions on the site and upon safety.

The firms can choose or combine two types of methods to get quality on the site.

* “a priori methods”: trying to give the proper work conditions and the proper qualification level.
* or “a posteriori methods”: to control the results with more or less sophisticated tools and procedures. But these types of controls to be efficient have to be prescribed by special training.

7.4 Partnership appoach and cooperation with the small firms

Facing the incertainty of the economic sytem, attempts to set up a "strategic space" based on cooperation modes (1), appear as very important. Either to transfer conformity norms, or to institute steady relationship, the big corporation has to organise partnership systems. It is useless to manage quality on a limited part of the work, if some of the contributors in the project are beyond control.

Management of quality is an opportunity to create evolution in subcontracting relationship and helps transformations in the small firms involved in a Quality Plan.

Quality beeing a traditional value among the craftmen, the quality management has to be founded on delegation, confidence and self-control of the production.

Quality policies can be a way to develop non commercial relationship, built on knowledge transfers. It surpasses the usual frame of the conformity norms, and allows other types of agreements. From their part, small firms and craftsmen take the initiative to group together and develop specific approaches from their own culture.

Today quality in France presents a content more and more complex, giving birth to a great number of integration strategies.

But we are not facing an univocal answer: these numerous proceedings, methods and knowledge transfers can be a way to initiate others partnership relations. They can also be a way to increase the gap between the firms and extend the subordinated relationship in a larger competition.

1 Bobroff, J., Caro, C.

REFERENCES

de BANDT, J. (1988), La filière meso système, in Traité d'économie industrielle sous la direction de ARENA, R. BENZONI, L. de BANDT, J. ROMANI, P., Economica

BOBROFF, J. CAMPAGNAC, E. CARO, C. (1988), De l'entreprise générale a l'entreprise ensemblière: changements organisationnels et nouvelles approches de la productivité dans les grandes entreprises de construction in Cahier d'EVMB n°32, Paris

BOBROFF, J. CARO, C. (1987), Démarches ensemblières: Quels modes de cooperation d'ensemble avec les PME. CERTES-DAEI

CAMPAGNAC, C. BOBROFF, J. CARO, C. (1991) Approches de la productivité et methodes d'organisation dans les grandes entreprises de la construction EVMB—Plan Construction Col. Recherches Paris

CAMPAGNAC, E. (1987), Les evolutions de la gestion de projet et leur impact sur les conditions de travail. Fondation Européenne pour l'amélioration des conditions de vie et de travail.—Bruxelles

CAMPAGNAC, E. PICON, A. VELTZ, P. (1987), Informatique, conception et realisation dans le bâtiment, CERTES—Plan Construction

CAMPINOS-DUBERNET, M. (1984), La rationalisation du travail dans le BTP. Des avatars du Taylorisme orthodoxe au neo taylorisme in Le Taylorisme sous la direction de MONTMOLIN, M. et PASTRE, O. Ed. La Découverte Paris

DUTERTRE, C. (1988), Flexibilité organisationnelle et productivité dans le batiment EVMB—Plan Construction Col. Recherches Paris

VELTZ, P. (1987), Réseaux dans l'industrie, Industrie en réseaux. CERTES Paris

VELTZ, P. (1986), Informatisation des industries manufacturières et intellectualisation de la production, in Sociologie du Travail 1–86 Paris

RAPPORT COLLECTIF, (1991), La qualité en chantier: gestion de la qualité et qualité de l'habitat EVMB Paris

47
Identification of research needs and implementation of research results in building science

J.FERRY BORGES

ABSTRACT
Two important steps in research management are: identifica tion of research needs, and implementation of research results. These problems are first presented in general terms and then detailed in relation to building science and, particularly, to management, quality and economics in housing construction.

Keywords: Building science, Research Programming, Guidance Documents, Standards, Housing, Construction.

1 Introduction

According to an ideal scheme, identification of research needs should be related to societal development objectives. The arrangement of national needs in accordance with national and regional plans and gathering them together in World plans would help to orientate national and regional research activities. The implementation of this policy has been recommended by the United Nations in very broad terms.

A Method for Priority Determination in Science and Technology has been suggested by UNESCO, (Method for Priority Determination in Science and Technology Science Policy Studies and Documents, no 40, UNESCO, Paris, 1978). The main feature of the method consists in identifying development objectives, revealing relationships between objectives and scientific and technical activities and in establishing priority charts for the different activities. The implementation of this method is based on the formation of panels and the nomination of moderators. The setting of priorities is meant to be used in the planning and budget processes.

An example of identification of research needs in Building and Civil Engineering is given by the U.K. National Economic Development Office (NEDO) by preparing on behalf of the Building and Civil Engineering Economic Development Committee the report Strategy for Construe-tion R & D, London 1985. Along these lines the Institution of Civil Engineers published a report on “Construction Research and Development”, Volume 1, Organisation and Funding, and Volume 2, Market Sector Priorities, London, 1986.

International associations, such as the CIB—International Council for Building, Research, Studies and Documentation, RILEM—International Union of Testing and Research Laboratories for Materials and Structures and IABSE—International Association for Bridge and Structural Engineering, have prepared long term research plans covering their activity fields. However these plans express general aims of these associations and do not cover research priorities.

In the European Communities the Single European Act includes in Subsection V—Research and technological development—general rules to formalize the preparation of pluriannual framework research programs. It is indicated that framework programmes shall establish the scientific and technical objectives, define respective priorities, indicating the general lines of action and establishing the financial amount necessary.

According to these rules framework programs have been published by the EC covering the periods 1984–1987, 1987–1991 and 1990–1994.

In 1987 the Commission of the European Communities asked the European Communities Chemistry Committee to report on the identification of research needs. Studies of this type are useful to guide research management in specific fields.

2 Research needs in building science

The main aim of building science should be to support the decision process of all participants in construction activities. This involves identification and formulation of problems, definition of aims, modelling of behaviour, accumulating technical knowledge, preparing guidance documents on the design and execution of works, judging the results obtained and planning of future activities.

This knowledge concerns not only architecture and engineering but also many other scientific domains, such as: economy, sociology, psychology, medical and juridic sciences. In general, building problems are multi-disciplinary and have to be dealt with as such. Consequently, research institutes in building should be organized in order to involve in these studies adequately specialized teams.

The CIB has paid much attention to the identification of research needs in building. The main theme of the 5th Congress, Versailles, 1971, was “Research into practice the challenge of application”. In the proceedings of this congress many references to research needs are included and the same occurs in the subsequent congresses. However these meetings have not been organized in order to reach an international consensus on the identification of research needs. In the same way the 17th Congress, to take place in Montreal, in 1992, includes research as a general viewpoint to create practical solutions, but no discussion of the methodologies of building research planning.

In the following some promising research themes on building science are identified.

To improve construction management, quality assurance and economy in housing, most needed research activities concern information technology. The basic concepts and the tools which are necessary to go large steps ahead, as compared to present practice, already exist. The implementation of present possibilities is pending on studies how best to organize the information and on the carrying out of the enormous volume of work to create and permanently to update the required data banks.

International standards on quality systems to be used for internal quality management and for external quality assurance purposes are well established (ISO Serie 9000, 1987). These standards are of a very broad scope. Research is needed on the social and physhologic aspects, of the professional behaviour of the participants in the building process. These studies would allow to differentiate quality management procedures on observed data, allowing to minimize non-quality costs.

Comparative studies on the liability and technical insurance procedures adopted in different countries have been carried out recently. Proposals to implement a unified legal system in EC member states should be based on further socio-economic studies in these fields to which juridic sciences should play an important rôle.

Disaster prevention and mitigation is taking increased importance in modern societies, both concerning natural and man made hazards. However technical and economic studies disregard the phychological aspects. Studies on social psychology emphasize the need to distinguish between objective and subjective risks, the second formulation being particularly important to understand human behaviour in risky situations. The perception of risk activates cognitive and perception mechanims which tend to minimize the perceived risk leading to a reduction of preventive measures. An important research theme consists in investigating how to modify this situation.

Most of the research themes mentioned would lead to the improvement of standards, thus being considered as pre-normative research. Attention is called to the importance of post-normative research which would be mainly concerned with the way standards are effectively implemented. To improve quality it is particularly important to benefit from lessons of practice covered by adequate pathology studies.

Past experience shows that the progress in building techniques has derived mainly from the use of new or improved materials. Thus the value of research in materials science should be recognized.

The examples of research needs presented did not empahzise the interest of socio-economic studies, particularly on housing. This is a very important research domain with direct influence on housing quality and availability.

3 Implementation of research results

The implementation of research results leading to the creation or improvement of industrial products is carried out by development and demonstration activities. In engineering the information of designers, builders and producers of materials and components is mainly carried out by guidance documents. Thus the usual cycle:

> Identification of research needs → Research programming → Research activity → Evaluation of research results → Developing and demonstration → Production → Use → Colection of lessons from experience

is substituted by the following one:

> Identification of research needs—Research programming → Research activity → Evaluation of research results → Synthesis and harmonization of research results → Preparation of prestandardization guidance documents → Standardization → Design → Use → Lessons from experience.

The second cycle only differs from the first one by substituting development and demonstration by synthesis, harmonization, prestandardization and standardization.

The preparation of standards constitues an efficient way of putting into practice research results. Organizations in charge of this task at international level are the International Standards Organization, ISO, and the European Committee for Standardization, CEN/CENLEC.

Scientific and technical associations have been producing states-of-the-art reports, codes of practice, international recommendations, model codes and analogous documents, which may be considered as prestandardization documents.

The preparation of Eurocodes by the iniciative of the European Communities is a good example of large scale standardization. This standardization activity, which involves the synthesis and harmonization of research results interpreted under a common methodology, not only fulfils the task of demolishing barriers to free trade but also introduces into practice valuable research results.

4 Conclusions

Studies on the identification of research needs are usefull to guide on the planning and evaluation of investigations mainly in fields which up to the present have not been covered by running programmes.

Building science, particularly concerning management, quality and economics in housing construction, presents a multi-disciplinary character so wide spread that further justifies the special interest of this identification.

Research in the domains of information technology, sociology and psychology of professional behaviour, legal liability, technical insurance, social psychology concerning disaster prevention and mitigation and, in general, pre and post-normative research, is recommended.

On the other hand, it is considered that the preparation of guidance documents at the European level, by direct collaboration between international associations, research institutes and standardization organizations, would much contribute to implement research results

5 References

CIB, W87, Post-Construction Liability and Insurance—Monograph in preparation, to be published in 1991.

Disaster Prevention and Mitigation—Vol 7—Economic Aspects, Office of the United Nations Disaster Relief Coordinator. United Nations, N.Y. 1987.

Mathurin, C., (1990) Study of Responsabilities, Guarantees and Insurance in the Construction industry with a view to harmonization at comunity level, Final Report III/8326/89-EN, Commission of the European Communities, February 1990.

48
The graphology of inspection and planning

C.W.J.BOS

Abstract
Condition models, in conjuction with minimum guality standards, makes it posible to trace the degredation process over a period of years. For the paint system on wood frames and exterior wall cladding are the defects and criteria characteristic of this process identified and classified in a condition reference spectrum enclosed in a manual.

By means of text and photographics the manual describes the characteristic defects in the successive stages of the degradation process and establishs a relation ship towards the maintenance planning. At this time the inspection system is tested by practical experience, after which a expert system will be developped.

Keywords: inspection methods, painting, wooden frames

1.0 Introduction

An interesting theme in the field of the management and maintenance of property is the way in which the state of repair of building elements is determined. Property managers need to be aware of the condition of the buildings in their care at all times and, since neither buildings nor maintenance budgets last forever, managers and owners must establish priorities for maintenance work. Maintenance inspections are intended to enable them to do this.

It is essential for maintenance inspectors to have a thorough knowledge of both the process of degradation and the maintenance measures available to combat this process. Yet, in spite of this often shared knowledge, in practice the opinions of inspectors concerning the actual state of repair of a particular building can vary widely.

This is illustrated by the frequently cited example of the five inspectors who all give an individual assessment of the condition of a certain set of steel facade frames. Instead of the unanimous report that the client, in his innocence, expects to receive, the inspectors give conflicting advice on the best action to be taken—each for apparently plausible reasons. The recommendations vary from touching up the paintwork here and there to suggesting that the facade be completely replaced.

Although, at first glance, this example may appear to be rather far-fetched, those familiar with the situation know that reality very often surpasses the imagination. As with any other rapidly developing field, the time has come when standard methods of measurement and objective assessment criteria need to be created to ensure the uniformity of maintenance recommendations.

2.0 Policy on quality

More and more property managers and maintenance consultants are gradually coming to recognise the need for instruments to guarantee the objectivity of inspections. They realise that, without such instruments, their own policies on quality can have little substance. In spite of this growing awareness, however, attempts to meet this need have so far been made in a wide variety of different ways.

Maintenance consultants, for example, organise regular internal sessions at which inspectors discuss their experiences, with the aim of devising their own “standard practice” with which to approach their clients. This is, however, not always set down on paper, with the result that it remains a closed book to outsiders.

In principle, since it is the client who is paying for the service, he should also be responsible for formulating the policy on quality to be implemented. In practice, however, little more than lip service is paid to this principle in discussions between the client and the consultant. The client cannot be considered to be making his mark on quality policy simply by showing the inspector a few examples of faults.

3.0 Basic guidelines

Recently, there has been an observable tendency in larger inspection assignments for the consultant and the client to draw up quality policy on the basis of joint consideration of a pilot project. As a result of this, guidelines are formulated for the benefit of the subsequent project. These guidelines can range from a few sheets of A4 paper to a complete handbook.

A comprehensive handbook contains not only general information on the properties of materials and faults and how to recognise them, but also the procedures relating to inspection and registration methods. It also describes which maintenance measures are suitable for which kinds of faults. This provides the basis for a complete system of quality assessment, centred around clear methods of measurement and objective inspection standards.

At present, however, most property managers still appear to rely completely on the skill of the inspectors in drawing up a quality policy on the basis of the state of repair of the building as they find it.

4.0 Condition reference chart

In recent years, the Ministry of Education and Science has been involved in the development of quality assessment systems. As part of this project, the Centrum voor Onderzoek en Technisch Advies (Research and Technical Advice Centre) was assigned to conduct research into methods of inspection and maintenance planning for facade paintwork. A method was devised which outlined procedures to be followed from the inspection of the paintwork to the drawing up of a maintenance plan. The central feature of this method was the condition reference chart.

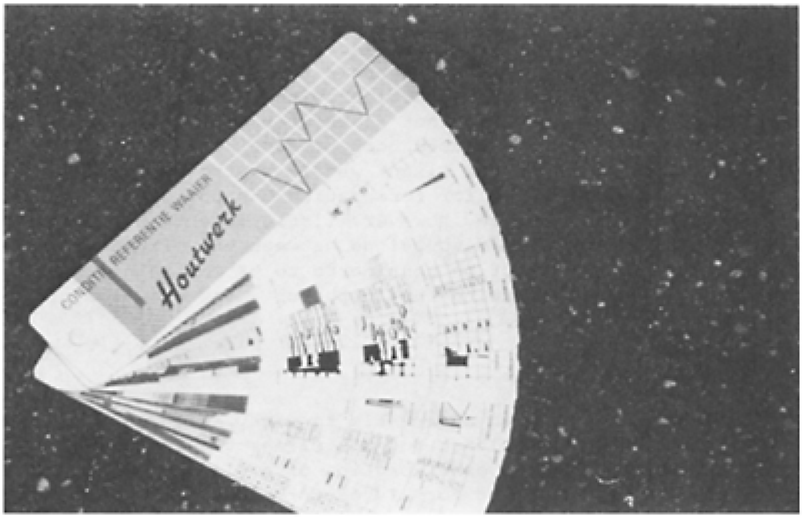


Figure 1: Condition Reference Chart

The first stage of the research examined the degradation process in paintwork on wooden facade materials, with the intention of determining at what point action should be taken to combat the degradation. This point is called the minimum technical quality level. If the quality level falls below this, the costs of maintenance will be less than the ultimate costs of restoring the technical quality. In addition to the technical minimum, a minimum aesthetic quality level is also employed, (figure 2)

The research concluded that wooden facades should be considered to have reached the minimum technical quality level if the moisture content in the wood exceeds 21% over an extended period, which would create an increased risk of rot. The period required for rot to develop depends on the temperature and the extent to which the wood has been preserved, by natural or artificial means.

Excessive moisture can be absorbed by the wood if multiple faults appear in the paintwork, the wooden base or around window seals. The minimum technical quality level can therefore be ascertained on the basis of these faults.

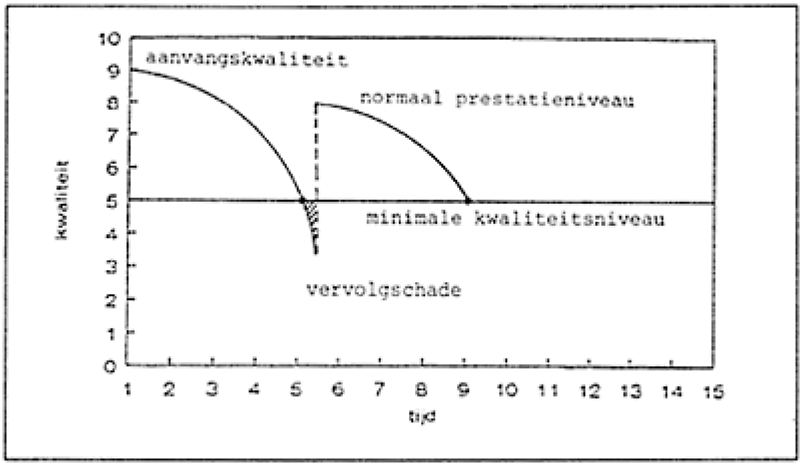


Figure 2: The degradation process

If the aesthetic quality level is also taken into account, there are in total about fifteen different faults that can be ascertained in the paintwork, the base or around the window seals. These include faded, powdering or cracking paintwork, loose seals and open joints. These faults will all have widely varying effects on the technical degradation of the facade. Faded or dull paintwork, for example, will have no adverse effects, while loose window seals, splits or open joints will create a considerable risk of rot developing.

The rate of degradation, i.e. the speed with which the faults manifest themselves, depends not only on the intrinsic properties of the facade—such as the base and the finish—but also on the extent to which it is exposed to the elements, in particular, to moisture, temperature and ultraviolet rays. This is why the rate of degradation may be different on horizontal and vertical members, or may vary according to the direction in which the facade faces.

Degradation reference charts are used to enable the connection to be made between the extent of the faults and the period of exposure of the paintwork.

The condition reference chart consists of a set of photographs projecting faults in various stages of degradation, together with a description of the method of measurement and the standard classification. The intensity, the extent and the frequency of the fault are measured, the latter establishing whether the fault only occurs in the facade on a small scale or frequently enough to constitute a structural problem. The intensity is determined using a transparent grid which is divided into sections and based on the standard width of a wooden frame.

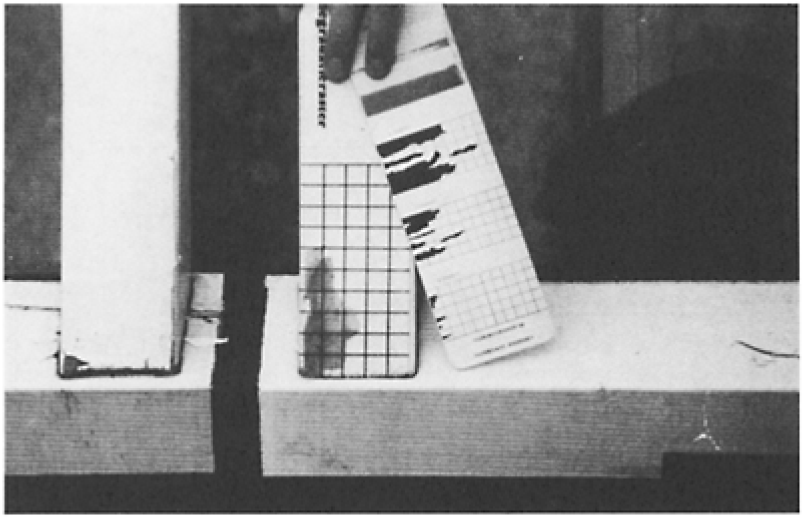


figure 3: Measurement of the intensity of flaking

5.0 Universal characteristics

Quality assessment systems are generally speaking deeply rooted in the conceptual frameworks of particular disciplines. Yet most systems designed to measure the condition of building elements prove to have universal characteristics. This universal character is particularly apparent in the procedure employed to draw up a complex picture of the damage on the basis of the underlying faults.

In order to describe these faults, quality assessment systems use the following variables:

– type
– intensity (seriousness)
– extent (frequency).

Observation generally starts with identification (recognition) of the types of underlying faults, to enable an overall picture of the damage to be established. The combination of the faults then determines the nature of the action to be taken (table 1).

Table 1. The effects of various faults on the technical degradation of a wooden frame (pine).

Fault	Effect on technical degradation
Faults in paintwork	
Accumulated dirt	–

Graffiti, etc.	–
Dull paintwork	–
Faded paintwork	–
Powdering	–
Cracking	++
Blistering	+
Flaking	++
Poor adhesion	+
Faults in window seals	
Loose seals	+++
Cracking	+++
Faults in base	
Cracking (plywood)	+++
Delamination (plywood)	++++
Insufficient play around rotating components	+
Open joints	+++
Splitting	+++
High moisture level	++++

– =No effect

+ =Slight effect

++ =Moderate effect

+++ =Great effect

++++ =Very great effect.

After the faults have been identified, they are classified on a numerical scale. This is generally based on the two variables, intensity and extent, each of which has its own particular field of application. In the ISO 4628, for example, evenly spread degradation—such as dull or powdering paintwork—is measured in terms of intensity. For faults which, on the other hand, are distributed irregularly across the surface of the paintwork, it is not the intensity but the extent which is indicative. Examples of this would be flaking paintwork or blisters in bitumen roof coverings. These can be expressed in terms of the percentage of the total surface inspected.

6.0 Combination of intensity and extent

The determination of these variables appears to have eased the way to a problem-free application of quality assessment systems. It should however not be forgotten that the variables are intended to be used in laboratories on small samples of between one and two square decimeters. On such limited surfaces, intensity and extent can be measured independently of each other without this resulting in any misunderstandings.

In practice, however, inspectors are not concerned with small samples, but with acquiring an overall picture of the faults found in a building element or section as a whole. This picture cannot be drawn up on the basis of a one to one comparison with the standard faults. Intensity and extent can no longer be considered independent variables, but related phenomena which can only provide a true picture of the condition of the element when taken together. (figure 4)

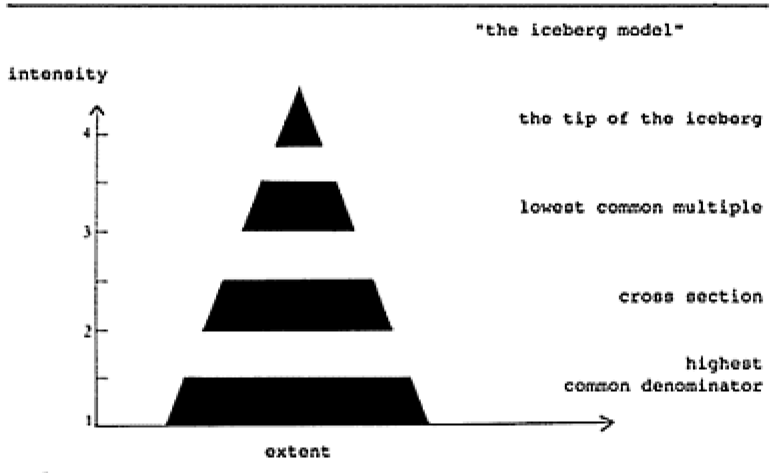


figure 4: In the absence of clear guidelines, inspectors are free to use their own intuition to estimate intensity and the extent.

An inspector who is confronted with a particular pattern of damage has the problem of deciding what combination of intensity and extent gives the most reliable picture of the real situation. Should he, in terms of the “iceberg model”, only consider the “tip”, i.e. take account only of the faults which are most in evidence? Or should he also include the bulk of the iceberg underwater and indicate the extent of faults that are as yet barely visible, if at all? It is also possible that he may make a choice that lies somewhere between these two extremes.

For a detailed picture, at least three different combinations of intensity and extent would have to be measured and classified accordingly. This, however, makes the procedure very time-consuming.

In the event of a limited inspection, it would be sufficient to measure only a combination of intensity and extent considered to be indicative. It will be necessary to develop an evaluation scale for this purpose.

In the case of a very general inspection, extent and intensity can be combined and expressed in terms of a single assessment figure.

In the condition reference chart, a single combination of intensity and extent is used to establish what maintenance measures are required. The picture is compiled by taking the tip of the iceberg in terms of intensity (i.e. where the fault is at its worst), whereas for the extent, the whole surface is measured, irrespective of the intensity, even where the fault is only slightly in evidence.

This procedure is directly connected to the decision as to what maintenance measures are considered necessary. The nature of the fault determines the action to be taken. The intensity determines the time at which it is to be carried out and is therefore linked to planning. The extent indicates the costs involved, but can also tip the balance in favour of alternative action.

7.0 Objective or intuitive inspection

The Tao diagram allows apparently conflicting variables to be shown in such a way that the underlying harmony of their relationship is revealed. The diagram in figure 5 illustrates the apparent contradiction between objective and intuitive inspection methods in this manner. This can be described as follows.

With objective inspection, if a large number of faults must be classified, the diagnosis will soon become very complex. A lack of sufficient coordination in recording the faults results in a fragmentary picture of the real situation and produces a form of illusory certainty. Individual faults can be generalised to a greater degree by the identification of fixed patterns. This is illustrated in the diagram by moving in the direction of intuitive inspection.

In the case of intuitive inspection, the inspector has a greater freedom of movement which will result in a more personal diagnosis. The absence of uniform criteria results in a broad assessment, too general to allow sufficient verification and therefore increasing the risk that a policy might appear to exist when this is not the case. If the inspection guidelines are applied more rigorously, for example by examining the individual faults that constitute the general pattern, we then move through the diagram in the direction of objective inspection.

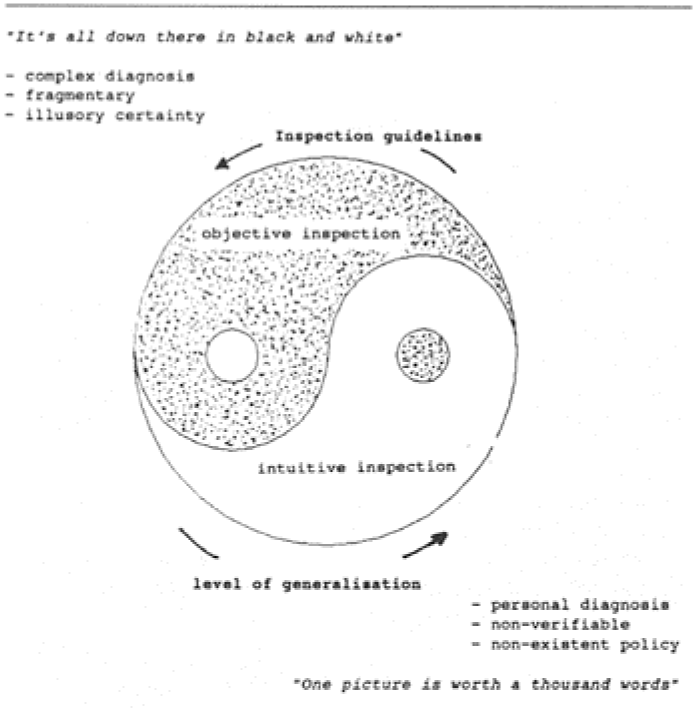


Figure 1: Maintenance policy should provide guidelines for the inspection method, while the results of the inspection should determine the maintenance policy.

This explains why a visual catalogue of damage, containing photographs of observed faults, is of real significance for the practical application of a quality assessment system. Although by nature subjective, a photograph can be worth more than a thousand words. Yet, at the same time, measurable variables should be included in the accompanying text to ensure that objectivity still has the last word. The use of text and photographs in conjunction therefore provides a perfect combination for a quality assessment system.

8.0 Conclusion

Quality has always called for considerable commitment from those involved at the actual construction phase. Even now, the greatest attention is given to guaranteeing that new buildings meet the specified quality requirements on completion. Clients can call upon a comprehensive range of standards, certificates, quality declarations and methods of measurement to back this up, while manufacturers, suppliers and governmental authorities all encourage the development of such quality instruments.

The construction phase is, however, only a short period in the total life of a building. The quality of the construction on completion is therefore nothing more or less than the condition of the building at one particular moment in this lifetime. In contrast to the construction phase, which is brief, there are practically no instruments at all to support managers in making objective assessments of a building's condition during the subsequent, far longer period of actual use. This has meant that, until now, maintenance inspectors have enjoyed a large degree of freedom in assessing the condition of building elements on the basis of their own knowledge and experience.

As a manager of educational buildings on a large-scale, the Ministry of Education and Science recognised the need for quality asses sment systems a number of years ago. The first phase in the scientific development of these instruments was specialist research into the process of degradation of bitumen roofing and facade paintwork. As regards the paintwork, this research resulted in the development of a quality assessment system in the form of the condition reference chart, allowing the condition of the facades to be established on the basis of clear methods of measurement and objective inspection standards.

The central feature of this system is the visual damage catalogue, which makes it possible for faults to be both recognised visually and measured objectively. The accompanying fault classification makes it possible to establish priorities in greater detail and to plan maintenance measures. To this end, the quality assessment is linked to a system comprising specifications, calculation and planning.

At present, an evaluation of the condition reference chart is being carried out, comparing it with various other assessment methods in use elsewhere. This involves assessing the condition of the paintwork of three different buildings, employing the various systems, and evaluating the results obtained.

Considering the wider relevance of the evaluation, the Ministry has decided to work together with the Stichting Bouw Research (Building Research Council) to distribute booklets of the assessment system to a wider public. In the same way, it is also the intention to develop a less sophisticated automated version of the system, so that the inspection and planning methods can be made available for general use in computerised as well as in manual form.

Finally, research has shown that the greatest challenge in the development of quality assessment systems is to strike the best balance between their scientific validity and their practical applicability.

Literature:

1. Handleiding inspectie en onderhoudsplanning voor baanvormige bitumineuze bedekkingen (Inspection and Maintenance Planning Guide for Bitumen-type Roof Coverings), March 1989, Bureau Dakadvies (Roofing Consultants), Gorinchem.
2. Onderzoek grondslagen voor inspectie en planning van buitenschilderwerk op hout (Research into the basic principles of inspection and planning for external paintwork on wood), June 1990, Centrum voor Onderzoek en Technisch Advies, Haarlem.

3. Bos C.W.J. Vastgoedbeheerder gebaat bij system voor kwaliteitsme ting (Immovable property managers benefit from system of quality assessment), Renovatie en Onderhoud (Renovation and Maintenance), no.5, May 1990.
4. ISO standard 4628, Paints and varnishes; Evaluation of degradation of paint coatings; Designation of intensity, quantity and size of common types of defect

49

The use of aluminium systems in buildings. A model for quality assurance on installation

A.J.OLIVEIRA BRAZ

Abstract
The selection of an aluminium system of recognized quality as regards components and accessories, although necessary, is not, in itself, sufficient to assure the finished quality demanded by aluminium glazing frames. In effect, the non-quality normally observed in aluminium glazing frames is the result of the significant complexity of its process of installation, not only as regards the technology, which is increasingly more advanced, but also as regards its harmonic integration in the management of the undertaking.

From the above, there can be inferred the necessity for companies producing aluminium glazing frames not to limit themselves to the mere selling of materials but rather to complement the sales with a “package of services” which will enable them to assure, during installation, not only the correct erection procedures but also the compatibility of the activities and interests of the various parties intervening in the process: developer, architect, building-contractor, installer, etc.

In this paper, after a brief analysis of the present situation in Portugal, a proposal is made for a model of quality assurance for the installation of aluminium glazing frames, it being understood that the installation process covers the set of activities regarding the design and execution of the job which transforms the aluminium system into frames and the application of these to the buildings. From our point of view, such a model should consist of the set of services set forth in the text.

Keywords: Aluminium systems, Buildings, Glazing frames, Installation, Quality assurance, Quality management.

1 Aluminium systems for buildings

The aluminium glazing frames are conceived and constructed from a base consisting of a series of aluminium profiles, completed by various accessories and gaskets; this set of materials, known as the aluminium series, must subsequently be transformed so as to obtain the finished product, the frame, which is the structural support of the glazing.

In Portugal, the producers of the systems only design and manufacture the aluminium series and, for this reason, are only able to control directly the quality of the components and accessories supplied by them.

In this way, and until the finished product is obtained, various stages of the product cycle escape their direct control since these stages are foreign to them, namely:

a) The prescribing of the system, that is, its adaptation to the building's architectural solutions, which activity is the responsibility of the architects;
b) The production of the frames and their installation on site, which is the responsibility of installers experienced in the system;
c) The harmonization of the logistic planning of the necessary materials with the planning of the construction, which is the responsibility of the undertaking coordinator: developer, contractor or other designated third party;
d) The inspection and testing of the frames, the responsibility for which lies with the site quality control manager.

Considering that the manufacture of an aluminium system is an industrial production line process, where systematic statistical quality control of production can be carried out, it is easy to see that it is possible to obtain an aluminium glazing frame, the final quality of which is not up to expectations, even though its components and accessories are of high quality.

In reality, the quality of the aluminium glazing frames is not the exclusive responsibility of the system manufacturer; on the contrary, there is a responsibility shared with the various parties intervening in the process of transforming the aluminium series into a finished product. Moreover, even the developer of the undertaking, with his strategic management decisions, may exert a strong influence, as will be seen below.

Therefore, the production cycle of “aluminium glazing frames in buildings” covers two distinct principal areas: the design and line production of the aluminium system available on the market and the INSTALLATION of the aluminium glazing frames; in this latter area, object of the analysis which we propose to undertake, all the phases which are normally considered to escape the direct control of the manufacturer of the system are included.

2 The non-quality of aluminium glazing frames in Portugal

It could never be said that the non-quality of aluminium glazing frames in Portugal is the exclusive result of the process of installation; in effect, there exist in the Portuguese market low quality aluminium systems which were designed and manufactured solely with a view to achieving the lowest possible initial cost.

It is obvious that the construction of aluminium glazing frames based on these aluminium series does not offer any assurance as to acceptable levels of performance, neither from the point of view of comfort nor as regards durability, nor yet, on occasion, as regards safety. This non-quality is self-justifying and it is considered unnecessary to go into details; we will therefore focus our attention on the non-quality which is a result of what we shall denominate the process of installing aluminium glazing frames in buildings.

From our point of view, in the installation of aluminium glazing frames there are various causes of non-quality; an analysis is made of those that have the greatest impact.

2.1 The use of incoherent quality policies by developers

It is possible to find partial and incoherent quality policies amongst the developers of buildings.

In fact, and although at the outset a decision may have been taken to promote the construction of a building of acceptable quality levels and, sometimes, even of high quality levels, at a later stage the developers condition the final quality of the undertaking and consequently that of its aluminium glazing frames, by deciding:

a) Not to invest in a sufficiently detailed design which would eliminate undefined situations and ambiguities;
b) Not to invest in design review, to be undertaken by a competent authority;
c) Not to invest in an Inspection and Testing Plan—ITP—for the job, which would permit the implementation of quality control throughout all the phases of construction and, obviously, of the installation of the aluminium glazing frames;
d) To exert pressure on the installer to submit prices of doubtful economic viability, which are certain to affect the final quality of the installation.

2.2 Insufficient knowledge on the part of the aluminium system specifiers

No-one knows the capacities of his system to satisfy the architectural needs of the undertaking better than the aluminium system manufacturer.

Nevertheless, the specifiers do not always consult the manufacturer’s technical department with the result that it is possible to find the following causes of the non-quality in the installation:

a) Imprecise design and technical job specifications give rise to the taking of incorrect decisions during the actual work of installation, due to schedule pressure;
b) Design and job specifications which are omissive as regards aluminium frames, leaving the work entirely in the hands of the installer who may not have the required technical competence;
c) Undue simplification in the use of the profiles of the series, with a view to cost reduction;
d) Incompatibility of the architectural solution and the characteristics of the system, usually in connection with the interface between the fixed frame and the opening; due

to this incompatibility, unnatural adaptations are made to the system, reducing its performance.

2.3 Deficient transformation of the aluminium system by the installer

No-one better than the system manufacturer knows the correct erection procedures for the aluminium profiles, the accessories and the gaskets.

Nevertheless, the installers do not always request the necessary technical back-up, frequently acquiring and transforming the aluminium system based simply on commercial literature. In this way, it is possible to find non-quality due, essentially, to the following reasons:

a) Deficient technical specialization concerning the series on the part of the installer, sometimes resulting from the attitude of "I know everything there is to know about my job";
b) The making of undue alterations to the system due to lack of knowledge either of the correct procedures or of the adequate components and accessories;
c) Deliberately lowering the quality level of the finished product, as a means of defence against the pressures of the developers to practice economically unviable prices; this attitude is serious since it is premeditated and is done without the knowledge of the aluminium system manufacturer;
d) In lowering the quality level of the finished product it is customary to omit components or accessories or to adapt to the series, components and accessories of lower quality, acquired from the competition;
e) The insufficient training of the installers work force, specially the more recent workers, due to the absence of continuous job training;
f) The incapacity of the installers to evaluate, from the design and job specifications, their technical competence to undertake the more evolved aluminium glazing frames: sometimes they only realize its complexity during the course of the job.

2.4 Deficient coordination of the installation

As is generally known, not meeting delivery dates may seriously affect the quality of the work, especially in complex procedures which have intimately connected interdependence.

Since the installation of aluminium glazing frames is of some complexity and has inter-connected activities which are not always coordinated, it is possible to find non-quality resulting from the lack of harmonization of the construction planning with:

a) The logistic planning by the supplier of the aluminium system;
b) The ITP activities concerning the installation of the aluminium glazing frames in the building;
c) The specific training and qualification activities of the installer's staff;
d) The installer's production planning.

2.5 The restraints of the aluminium system manufacturer

As any other company in an open, freely competitive market, the aluminium system manufacturers exist in order to sell products which are able to meet the demands of the consumers. However, their direct customers are not the end-users of the product but those intervening in the installation of the aluminium glazing frames.

A technical-commercial ambiguity is thus generated in the market, since the aluminium system manufacturer's customers are simultaneously co-producers of the aluminium glazing frames and, as such, are also responsible for their quality; there results from this ambiguity, as is obvious, a strong external restraint on the manufacturer of aluminium systems regarding his quality policy. In fact:

a) Their survival as a company depends on turn-over and, therefore, they cannot indiscriminately limit their customers;
b) For their part, the customers naturally manage their companies according to their own quality policies, which are not always in synchronism with those of the aluminium system manufacturer;
c) As a result of this independence of quality policies, the aluminium systems manufacturer is normally only asked to intervene in situations of non-quality in the latter stages of the installation and to undertake the repair of mistakes ascribable to third parties.

In conclusion, the manufacturer of the aluminium systems normally finds his quality policy heavily constrained by technical-commercial factors which are largely beyond his control. On the other hand, it is an irrefutable fact that, in cases of non-quality of aluminium glazing frames, it is the manufacturer's reputation which suffers: it is easy to trace the responsibility to his name usually stamped on the accessories; as far as the responsibility of third parties is concerned, the end-user has neither the information not the technical capacity to evaluate it.

3 A model for quality assurance on installation

In view of the above, there only remains to the manufacturer of the aluminium systems the possibility of endeavouring to involve in his quality policy all the customers who participate in the co-product ion of the aluminium glazing frames in buildings.

To this end, in our opinion, a quality system should be devised and implemented, in accordance with the Model of Quality Assurance on Installation (shown in fig. 1) which includes the under-mentioned functions.

3.1 Design support

Support to design is intended to assure the specifiers, that is the architects' studios, that the adaptation of the aluminium system to the architectural characteristics of the building is carried out correctly.

This technical-commercial service, besides divulging the principal characteristics of the product, should also be of assistance in the following:

a) Identification of the applicable regulations;
b) Identification of the technical requirements, specially crucial as regards safety, comfort and durability;
c) Identification of the documentation defining the standards of the technical requirements;
d) Resolution of conflicting technical requirements;
e) Research of efficient technical solutions, specifically in special cases of architecture;
f) The graphic visualization of the details of the technical solutions (CAD);

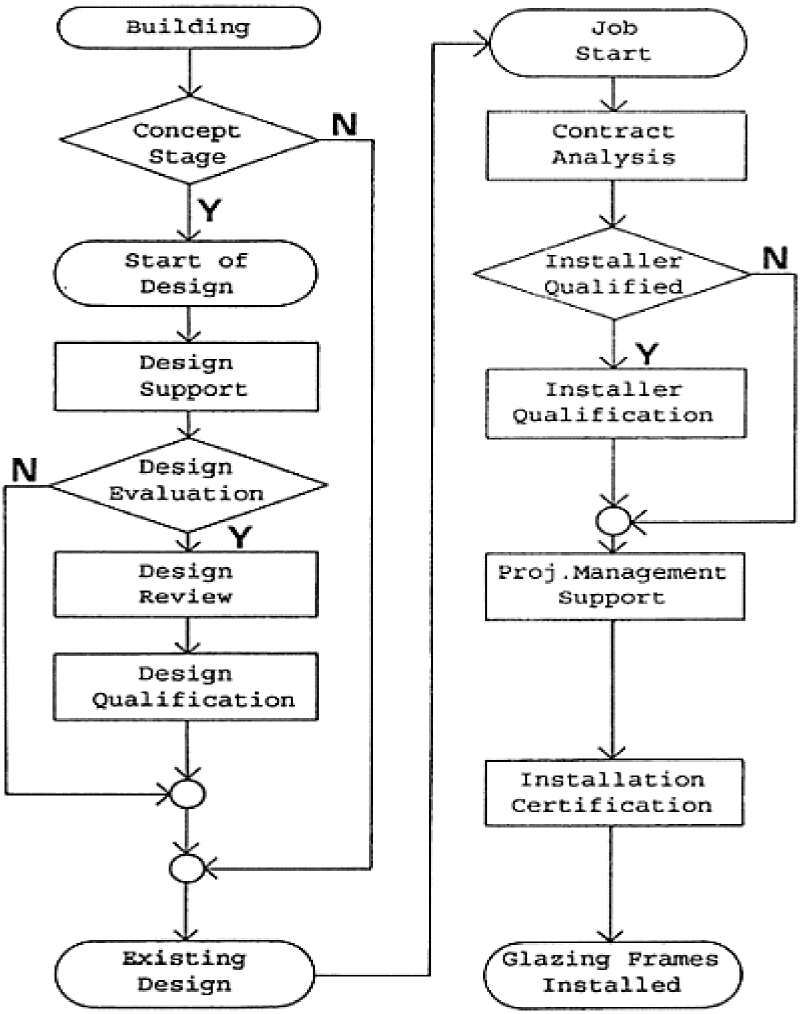


Fig.1-Quality Assurance on Installation of Aluminium Glazing

Frames in Buildings: Flow Chart of the Model.

g) The economical analysis of the solutions, by means of optimized estimates of the materials involved.

3.2 Design review

Although the design review is an activity that could be included in the design support, it was considered preferable to analyze it independently, given its importance.

In effect, design review is a service which is fundamental to the mitigation of non-quality of the aluminium glazing frames in buildings, since it permits a preventive action in an early stage of design.

This service, which is considered to be crucial to the quality assurance on the installation of aluminium systems, should be based on the following possible actions:

a) Verification that applicable regulations are complied with;
b) Verification of the correct specification for the technical requirements;
c) Analysis of the documentary standards which back up the specifications of the technical requirements;
d) Search for conflict between the technical specifications;
e) Evaluation of the solutions proposed for the project as regards its functional performance, based on comparisons with practical cases already carried out;
f) Making alternative calculations in order to confirm the designed calculations.

3.3 Design qualification

Whenever necessary, the design review should always be supplemented by the experimental qualification of the solutions that have been adopted, especially those in which the actual performance is not known.

On the other hand, the design qualification also permits the undertaking of experiments devised to improve the performance of solutions which were only developed theoretically.

Thus, the activities concerning the design qualification include the following phases:

a) The making of a prototype based on the solution to be qualified;
b) in making the prototype, to analyze the suitability of the procedures and specifications of the design as regards the manufacturing aspect of the solution;
c) The carrying out of tests to evaluate, in practice, the performance of the prototype as regards the fulfillment of the design requirements;
d) Whenever necessary, the introduction of alterations to the prototype and the repetition of the tests;
e) Possible alterations to the design, so as to take into consideration the improvements determined by the experimental analysis of the prototypes.

3.4 Contract analysis

Contract analysis is a service intended to assist the installers in the analysis of their capacity to comply with the technical job specifications.

At the same time, it allows the aluminium system manufacturer to evaluate the capacity of his series of profiles to fulfil the technical requirements as specified in the job specification in those cases where design support was not posssible.

Thus, this service consists of the following aspects:

a) The analysis of the correct definition and documentation of the specified technical requirements;
b) The analysis of the technical capacity of the product to fulfil the specified technical requirements;
c) The evaluation of the technical capacity of the installers as regards the fulfillment of the technical job specifications;
d) Support in the preparation of estimates with the optimization of the necessary materials.

3.5 Installer qualification

The intention of installer qualification is to assure that his staff are able to carry out the project in a professional manner.

To this end, the service should cover the following activities:

a) Analysis of the need of the staff to undergo job training in order to carry out the project;
b) Possible general training of the staff in the procedures used in the transformation of the aluminium system;
c) Specific training of the staff as regards the special processes involved in the design;
d) Training the staff by making prototypes;
e) Possible experimental qualification of the prototypes.

3.6 Project management support

As is known, quality also implies the adherence to the construction planning schedule.

Regarding the installation of aluminium glazing frames in buildings, the maintenance of the general construction schedule depends on the coordination of the various parties involved: the logistics of the aluminium system manufacturer the contractor, the aluminium glazing frame installer and the site quality control.

The aluminium system manufacturer has every interest in involving these co-producers in his quality policy and, therefore, has every reason to assist the site management as regards the specific job of installing the aluminium glazing frames.

It is therefore recommended that a service be set up to give support to the site management, which should cover the following headings:

a) Detail of the planning of the installation of the aluminium glazing frames, from the ordering of the materials up to the delivery of the finished product, including the installer qualification, should this be pertinent;

b) Harmonization the planning of the installation of the aluminium glazing frames with the general construction programme;
c) Coordination of the activities stipulated in the plan of the aluminium glazing frame installation.

3.7 Installation certification

The implementation of ITP is the responsibility of the construction quality control organization; however, this entity does not always give the same attention to the installation of aluminium glazing frames as that with which it controls other phases of construction, traditionally considered to be greater responsibility: for example, the foundations, the structure, the roof, etc.

In other times, when the frames were limited to doors and windows of reduced dimensions as compared to the facade of the building, and although such a practice should not have been accepted, one could nevertheless endeavour to understand such attitudes; however, with the adoption of large areas of aluminium frame glazing, which, these days, can cover the entire facade of the building (curtain walls) and even the roof itself (verandahs), such attitudes are, at the very least, unadvisable, from an economic point of view.

Moreover, with the recent introduction of legislation concerning the rights of consumers as regards damage due to defective products [1], all parties concerned with the installation of aluminium glazing frames (from the developer to the installer) are responsible for the quality of the finished product [1 & 2] and not just the aluminium system manufacturer and the installer, as used to be the case.

The advantages that result from the certification of the installation of aluminium glazing frames to the benefit of all concerned in the process can thus be clearly seen; as far as the aluminium system manufacturer is concerned, he will have the additional advantage of improved reputation as regards quality, with the resultant credibility of his product on the market.

Since the aluminium system manufacturer is the entity which has the greatest knowledge of the technology employed in this very specific branch of the construction industry, he is in a very good position to be able to help his customers with the installation certification process for the aluminium glazing frames; he should therefore collaborate in the following activities:

a) Detail of the Installation Inspection and Testing Plan—IITP;
b) Harmonization of the building’s ITP with the IITP;
c) Coordination of the activities stipulated in the IITP;
d) Support to the inspection and testing of the frames on delivery to the site;
e) Support to the inspection on completion of the installation of the frames in the building.

in cases where there is a closer commercial tie, the aluminium system manufacturer may even certify the installer’s production system; in such cases, the assistance which the latter should receive would be concerned with the following headings:

f) Design and implementation of a production quality control system;

g) Carrying out an external quality audit in order to certify the system;
h) Carrying out periodic external quality audits to verify that the quality system is being maintained.

4. Conclusions

As can be inferred from the foregoing remarks, the production cycle of "aluminium glazing frames in buildings" covers two large and distinct areas:

a) The design and industrial production of the components and accessories of the aluminium system;
b) The installation of the aluminium glazing frames in the buildings.

In our opinion, both these areas should have their own quality systems which should assure the desired and expected quality of the products.

4.1 Quality assurance of the aluminium systems

In order to assure the quality of the aluminium systems, the manufacturer should design and implement a quality sys tem that will allow him to control his production lines; the quality assurance model implemented must give material proof that such a system works continuously and efficiently.

If this procedure in the market is, at present, voluntary in Portugal, it will shortly become obligatory, not only in our country but also throughout the European Commu nity. In fact, the EEC directive on building materials [3] will oblige manufacturers to prove that their products conform to the essential requirements of the buildings, basing themselves on quality systems whose models of quality assurance are specified in the series of European Standards EN 29000.

Within the scope of its quality policy, Technal Portugal will shortly promote the certification of its Quality System by the IPQ—Instituto Português da Qualidade (Portuguese Quality Institute).

4.2 Total quality assurance of aluminium glazing frames in buildings

The Total Quality of the aluminium glazing frames in buildings is only possible if its installation is also controlled by a quality system which complements that of the manufacturer of the aluminium series.

This paper is intended to contribute to the creation of a model of quality assurance for the installation of aluminium glazing frames in buildings, by divulging the experience that Technal has acquired in the field of customer technical service assistance.

Finally, let it be said that the correctness of Technal's quality policy was recently recognized by Portuguese legislation [4] when it created the LNEC Quality Mark for Construction Undertakings; in effect, the quality certification mechanisms that were recently made law, incorporate in its entirety the "technical service package" which Technal has for many years placed at the service of its customers.

However, in order that these may also benefit, in future, from the advantages offered by this national quality mark, Technal Portugal is to request LNEC—Laboratório Nacional de Engenharia Civil (Portuguese National Civil Engineering Laboratory), as soon as possible, that its Quality Department be granted the status of "Technical Control Entity of Specific Scope".

5 References

1—Decree-Law nr. 383/89 dated the 6th. November. Diário da República, 1st Series, nr. 255. Imprensa Nacional Casa da Moeda, Lisbon, 1989.

2—Caria, Maria Carminda—**Objective Liability of Producers of Defective Products**. Laboratório Nacional de Engenharia Civil, Lisbon, June 1990. Proceedings of the 2nd. National Encounter On Quality in Construction, Theme D, pp. D.41–D.48.

3—EEC directive 106/89 concerning Building Materials. Official Journal of the European Communities, Series L, Nr. 40, 11th. February, 1989.

4—Decree-Law nr. 310/90 dated the 1st. October. Diário da República, 1st. Series, nr. 227. Imprensa Nacional Casa da Moeda, Lisbon, 1990.

50
Human and psychological aspects of the implementation of quality control in construction

J.CALAVERA

1 Introduction

Over the years many people have worked on strictly technical subjects related to Quality Control and Quality Assurance and its implementation in construction. Over this time we have all frequently reflected on the human aspects entailed in said activity, but we have possibly been more active in writing and publishing on the technical aspects rather than those of a human nature.

The work which follows attempts to compensate this imbalance.

2. The word "Control"

The word "Control" is possibly not the most adequate, this depending largely on the language employed and which in some cases may have a rather negative nuance. The expression "Quality Assurance" does not only correspond to an ever increasing concept of control activity, but may be considered to be a more attractive term. Certainly in some languages the translation may appear to be over attractive. With the passing of time both terms have suffered a loss in meaning as a result of their application in advertising to a greater or lesser extent.

This phenomenon has occurred with many technical concepts and Quality Control is no exception. Some technical terms such as "Quality of Life" have practically had to be abandoned in technical circles due to their distortion by publicity agencies. Something similar is happening with the term "Intelligent Building" which is fast being substituted by the more exact expression, "Centrally Controlled Building", which though being longer is technically more correct and fortunately less tempting for advertising jargon.

3. Types of Control

Many types of control exist according to the light under which they are considered and we will speak of some of these later on. However, a basic distinction to be made is that between "Production Control and Acceptance Control". There is frequent confusion in the presentation and analysis of these two concepts.

Some people try to present both concepts as being synonymous. This is not true; and a simple example will serve as an illustration. When making concrete, the object of Production Control is to assure that the quality agreed is reached at minimum cost. The function of Acceptance Control is simply to verify that the quality agreed is reached, and the cost of the same is not an element of appreciable importance.

While both types of control are not synonymous, they both seek quality while representing clearly different interests. Yet the tendency to consider both types of control as antagonistic is equally erroneous. According to the degree in which both controls coexist, the easier it is to obtain a better quality of work. Work carried out according to the dictates of Production Control alone will be subject to a strong tendency to reduce costs. Work carried out according to the dictates of Reception Control alone will, in turn, rapidly reach a situation where construction has to be interrupted due to the failure to reach the required quality.

The above may be summarized by stating that both controls are neither synonymous nor antagonistic, but are complementary and together make up the basic foundation for good quality.

When further considered, control may be subdivided into that referent to Design, Materials and Construction. These concepts are analyzed in the following section.

4. Control of Design

All the statistical information available indicates that the distribution of causes of damage in buildings is very similar in different countries. The tables in figures 1, 2 and 3 contain summaries of the Doctoral Thesis of J.A.Vieitez (1), see also CALAVERA, J. (2) and (3). As may be seen, the results coincide extraordinarily between one country and another. By way of an example, figure 4 represents the average distribution of the causes of failures in all of the European countries analyzed in the previous tables.

The above shows the Design stage recurring as the cause of damage and clearly reveals the fact, well known by Insurance Companies, that the Design Stage is the main introductory of risk in construction, followed closely by the Execution Stage.

This has led to the ever increasing need for Quality control to begin with the Design Stage itself. Howeveer, the implementation of this type of control, apart from the technical considerations which are certainly very special, presents difficulties of a human and psychological nature which are of importance but greatly differ from the other facets of Quality Control, such as that of Materials and Execution.

There are occasions where some Designers show either expressed or tacit resistance to seeing their project subject to control. It is evident that complex psychological determinations exist in such resistance, which may include, on the one hand, the desire not to see the quality of the design itself evaluated in such a clear way, and on the other, the presence of an evidently important sense of vanity with regards to the subject. On many occasions some designers attempt to present Design Control as a personal affront.

This situation, of course, only arises in the Construction world. We may frequently pause to consider the fact that it is practically only in Construction in general and particularly in that of Buildings where the figures of Designer and Constructor are separated. This does not occur in the mechanical, aeronautical or naval industries where all the figures are integrated within the same organization. And naturally the idea that the design carried out by a person or team has to be controlled by another is of common practice.

Clearly no Naval Engineer would consider the control of his project to be an offence, (The Control Organizations control Design and not the Designers) and this occurs similarly in many other industries. Even and this occurs similarly in many other industries. Even in the Construction Industry itself, it is common for many Administrations in different countries and in particular the Ministries related to Construction, to have Offices dedicated to Supervision whose duty is precisely to control the design carried out by other officials within the same Ministries. Such activity has never been considered as an affront to those people whose projects have to be controlled.

Practical experience shows that the better Design Organizations fully accept the idea of Design Control. This is probably due to the knowledge that this test will reflect favourably on themselves and will oblige some of their competitors who work on a lower threshold of quality, to improve their organizations, and thereby raise their fees to a reasonable level. With the exception of the previously mentioned case of personal pride, the main difficulties frequently arise in those Organizations with unsatisfactory Design Quality.

Of all the Control activities, Design Control is perhaps the one which presents conditions of personal relations with more psychological and human nuances. It is particularly important to underline that Control Organizations control Design and not Designers, that is to say documents and not people. On the other hand, the Technicians belonging to Organizations of Design Control do not know how to design any better than the Designers themselves. It is simply that they know how to control them better.

All above may be self evident for many, but in practice, there continues to be an elevated number of cases of Designs which are not submitted to an independent and reasonable control within the Construction industry. As a result the application of Control Techniques at other stages while giving satisfactory partial results is not enough to avoid poor quality.

5. Control of Materials

The field of Material Control is rapidly evolving area. This is probably due to the heavy industrialization now involved in the production of construction materials, an aspect which has meant the intense application of Quality Control to this stage.

a) Tests and Control

The first important aspect to point out is the frequent error made by those whose confuse Material Testing with Quality Control or, if preferred, the Laboratory with the Organization of Quality Control. In short they are people who make the naive mistake of thinking that satisfactory test are a guarantee of good quality. The Test Laboratory is clearly an indispensable tool for the carrying out of Quality Control, but it is no more than a tool which is of little use unless it is integrated within the complete Quality Control activity.

b) Mediocre, Correct and “Perfect” Laboratories

Laboratories are frequently classified from various different points of view: official and private, dependent or independent, etc… Nowadays, however, the most important characteristic is whether they are efficient or inefficient.

As such it is important that a Book or Register of Records of Correction exists within the laboratories, in which the human and instrumental errors, which inevitably occur throughout the life of the laboratory, should be recorded. There should also be a record of how the matter was communicated to the persons involved. Of course, a laboratory which committed frequent errors would be unacceptable, but in our opinion a laboratory that “never” reveals errors is equally unacceptable.

c) Quality begins at home

The laboratory is one of the Organizations which should have the most explicit plans of Internal Quality Assurance, Systems of Inspection and Calibration to instruments, etc…

d) Certification: charade or a real guarantee?

Nowadays we may speak of the charade which sometimes surrounds Certification Schemes. The idea of Certification is certainly excellent for all materials and, in fact, represents the most efficient way of avoiding the carrying out of an excessive number of tests for each work. In this respect a good Certification Plan allows a high level of guarantee with reduced control costs, and does not only simplify the work of Quality Control Organizations, but also makes them faster and establishes guarantees in a more transparent way for all those involved in the construction process.

However, the pressure on this sector has been quite overwhelming for some time now. The number of organizations wishing to guarantee the others is growing and at times confusing. In practice Organizations of perfectly logical and disinterested institution coexist with Organizations with chaotic levels of confusion who look upon Certification simply as a direct method of financing by which to cover patches in their budget.

The attempt to extend the process of certification to other activities apart from that of materials has been evident for some time now. Among these it is worth pointing out the certification schemes for Laboratories. Personally, I do not have anything against certification for laboratories and feel that if such certification is correctly conceded and efficiently supervised they are a way of revealing the real quality of the laboratories.

However, the proliferation of Certifying, Accrediting and Homologizing Bodies, etc.. implies that the Manufacturers of Materials and Equipment and Laboratories have to dedicate an important amount of time demonstrating that they are carrying their work out satisfactorily rather than actually doing their work well.

Recently a case occurred in Europe where a manufacturer of materials received five different authorizing bodies over the space of the same working week, and of course, their criteria did not exactly coincide.

There is a clear need to put order and rationality into the process, and to interconnect the Accrediting Plans internationally in order to avoid duplicity. It is also worth remembering the need for the Accrediting Bodies to have sufficiently expert personnel for their tasks of authorization and that within the organization itself there exist an internal Quality Assurance system which is no less rigid than that required everybody else.

Accepting the above, the ever increasing interest in accrediting laboratory activity with regards to both instrumental and human aspects is surprising. In this respect it may asked why this is considered to be so necessary when on the other hand it is not considered necessary to accredit the activities of the Design Offices in as much as their instrumental (computers, etc…) and human aspects (See again Fig. 1 to 4).

e) Research Testing and Commercial Testings

A subject which has aroused controversy over the years (and in particular in the United States where the controversy was extremely heated), is that of the competence of Private Laboratories and University Laboratories or those of Research Institutes financed by public funds. It is difficult to give a categorical opinion on this subject, but it is clear that the University laboratories and in general the Research Institute laboratories have a function which is not that of carrying out tests of a commercial nature for the normal activities involved in Construction. Their presence in this field may certainly appear logical, but only in cases in which they take the role of a substitute due to the lack of laboratories in a particular area or when dealing with very specialized subjects which are not covered by Private Laboratories. But from this point on the activity should be carried out with care, otherwise they may enter into an area of unfair competition, working at a theoretical cost lower than the real cost by way of using goods, personnel and equipment for commercial tests when the same have been paid for with other intentions in mind. We should recall from arguments over the same subject in various parts of the United States, that the question arose on whether University Laboratories and Research Institutes which carry out commercial testing should abandon the simultaneous financing from public funds.

The above may vary not only in that regarding Laboratory tests, but also in the carrying out of Design and Reports in competition with working professionals.

It is difficult to establish the limits, but it is clear that these limits should exist.

f) “Microcertification”

Within the process of certification, in which we have noted the sometimes considerable excesses now produced, a particularly worrying aspect may be called "microcertification". That is to say that instead of working along simple, common and general lines, it is now being noted on occasions that Bodies of ever reducing circles are trying to create their own Certification Schemes, which leads to a great amount of confusion in the setting out and operation of all the certification systems and to an atomization of the process.

6. Control of Execution

Site Inspection poses many problems, which are largely of a human nature. There follows an outline of the most important:

a) The "Crisis of Knowledge"

The first may be called the "Crisis of Knowledge". The Construction world is evolving at an incredible rate. The number of materials and techniques continually increases. The information acquired with practice is of increasingly relative value when the known product is no longer used in the market and is replaced by another. All this leads to the value of experience being more and more relative and that of new knowledge more and more important. This means that those people who do not keep up to date in their profession will have difficulties with regards to the relationship Building Technician versus Controlling Technician.

b) The figure of the Inspector

One of the essential points in the implementation of control is to find adequate personnel to carry it out. And in particular in that referent to Site Inspection, the make up of a good Quality Control Inspector implies a long and complex process. This person certainly requires an even balance of theoretical knowledge and practical experience, as this is the only way in which he or she can gain the respect of those Technicians whose work have to be controlled. In addition to the above the inspector must be both firm and tactful, though this is frequently associated in some way with being likeable, it is very often not the case. Perhaps it is more related to correct behaviour with a certain impersonal accent. Experience shows that the "good fellow" is not normally a good inspector.

The Inspector's willingness to collaborate with those people intervening in the control process is of upmost importance. Those persons who do not have this quality should not be Inspectors. And particularly those persons who obtain some satisfaction on detecting any type of defect should immediately abandon their work in Quality Control.

c) More atributes than variables

One particular pychological aspect of Site Inspection is that the other aspects, such as those managed in Design Control and in Material Control are easily expressed as variables and as a result are susceptible to numerical control. In Site Inspection we are frequently obliged to control attributes and this accentuates the rather subjective character of the activity, which requires specific precautions. The attempt to sometimes "dress up" a control of attributes by way of numerical scales in order to present it, falsely, as a control of variables, is in our opinion the wrong way to go about it and a little dishonest.

d) Reports and records

The writing up of reports is a subject of special importance. Those persons undertaking such work require specific characteristics, in particular that of being able to write concisely, with perfect clarity and independence, without losing at the same time a strictly correct tone and on no occasion whatsoever cause the slightest offence. All the above has been crystalized over the years into the custom of writing reports which do not seek to reject parts of the work but to establish what is commonly known as “Technical Reserves” which show that the Independent Control Organization, at that particular time, does not agree to accept the said part of the work. Said “Technical Reserves” are cancelled the moment the Constructor shows evidence that the defect has been corrected.

7. Two general questions

We should underline two points which are not considered sufficiently:

a) The complexity and elevated number of techniques presently involved in building

A building today is an extremely technically complex object, in which a large and ever growing number of techniques are involved. In order to embrace the whole building in its entirety, the Control Organizations need to have the availability of technical personnel of very different classes: Architects, Civil Engineers, Mechanical Engineers, Chemists, Physicists and Geologists, etc… A Control Organization which is low on personnel can only offer a poor and incomplete service.

b) The “divergence” of interests

Withtin the activities of Quality Control related to both Materials and Construction, we are finding what may be called a “divergence of interests”. This being situations where the Design Office, Manufacturer of Materials or Constructing Company, are really interested in passing the Quality Control satisfactorily, as they consider the Quality of the Company to be a good one and that the control will demonstrate their good quality. They also feel this an advantage over unfair competition who work in the same field but with unacceptable standards of quality, and who would be exposed if the Control were extended to themselves. However, these situations sometimes give rise to the strong opposition of representatives of these firms to the introduction of Acceptance Control. These are cases where the opposition arises from a question of personal pride of the employee who has, at that moment in time, different interests from those of the firm to which he or she belongs. Those who have practical experience in Quality control will know that this situation is common.

8. Conclusions

In the above we have tried to show that while Quality Control is a highly technical activity, by way of the use made of it in laboratory tests, comparisons of codes and standards, etc…, its components, however, are not only of technical nature. In fact a very important aspect in the majority of the activities is precisely that of the human relations between the parties involved and in particular the pychological aspects involved in the planning and carrying out of control. In all the above we have not tried to do any more than leave the subject open to debate for the future. In the different sections above we have raised those aspects that are more frequently the cause of conflict.

LOCATION	PERIOD	NR. OF CASES	OBJECT OF DAMAGES						KIND OF WORK		
			(D)%	(E)%	(M)%	(U)%	(V)%	Σ%	ENS.Y VIV.	IND.	COMER.
BELGIUM II.	1976 TO 1978	1800	46.0	22.0	15.0	8.00	9.0	100	–	–	–
DENMARK	1972 TO 1977	601	36.6	22.2	25.0	8.7	7.5	100	–	–	–
ROMANIA	1971 TO 1978	832	37.8	20.4	23.1	10.6	8.1	100	–	–	–
YUGOSLAVIA	1976 TO 1978	117	34.0	24.2	21.6	12.2	8.0	100	–	–	–
FRANCE	1968 TO 1978	10.000	37.0	51.0	4.50	7.5	–	100	68	14	18
HAMBURG	TILL 1978	95	40.3	29.0	14.8	9.2	6.7	100	–	–	–

D-DESIGN; E-EXECUTION; M-MATERIALS; U-USE; V-VARIOUS;

LOCATION	PERIOD	NR. OF CASES	OBJECT OF DAMAGES						KIND OF WORK		
			(D)%	(E)%	(M)%	(U)%	(V)%	Σ%	ENS.Y VIV.	IND.	COMER.
UNIT.KINGDOM I.	TILL 1974	510	58.0	35.0	12.0	11.0	2.0	118	–	–	–
UNIT.KINGDOM REDUCED	TILL 1974	510	49.1	29.6	10.1	9.3	1.7	100	–	–	–
UNIT.KINGDOM II.	1970 TO 1974	–	49.0	29.0	11.0	10.0	1.0	100	–	–	–
FED. REPUBLIC OF GER	1970 TO 1980	1.576	40.1	29.3	15.4	9.9	7.1	100	–	–	–

MANY											
NORTH RHINE LAND	TILL 1978	481	40.5	28.8	15.0	9.6	6.1	100	–	–	–
BELG IUM I	1974 TO 1976	1.200	49.0	22.0	15.0	9.0	5.0	100	–	–	–
	D-DESIGN; E-EXECUTION; M-MATERIALS; U-USE; V-VARIOUS;										

LOCA TION	PERIOD	NR. OF CASES	OBJECT OF DAMAGES						KIND OF WORK		
			(D)%	(E)%	(M)%	(U)%	(V)%	Σ%	ENS. Y VIV.	IND.	COMER.
BELG IUM III (SECO)	SINCE 1958	1350	54.0	29.0	5.0	11.7	11.7	100	–	–	–
SPAIN	1969 TO 1983	586	51.5	38.5	16.2	13.5	4.1	123.7	57.3	11.7	19.5
SPAIN REDU CED	1969 TO 1983	586	41.2	31.1	13.0	10.9	3.2	100	–	–	–
MEAN VALUES	–	–	42.0	28.5	14.6	9.6	5.7	–	–	–	–
	D-DESIGN; E-EXECUTION; M-MATERIALS; U-USE V-VARIOUS										

BIBLIOGRAPHY

(1) VIEITEZ, J.A, "Patologia Estructural. Aspectos Quimicos, Normativa y Estadistica". Tesis Doctoral. Universidad del Pais Vasco. Escuela Superior de Ingenieros Industriales de Bilbao. Marzo 1984.

(2) CALAVERA, J, "O Controle do Proyecto" I Symposio Nacional sobre Garantía da Qualidades das Estructuras de Concrete". São Paulo. 1990.

(3) CALAVERA, J, "Patologia de Estructuras de Hormigon Armado", "I Congreso Latinoamericano de Patología de la Construcción y III de Control de Calidad" a celebrar en Córdoba (Argentina) del 17 al 20 de Abril 1991.

51
QMS and the management style of a house builder

I.E.CHANDLER

Abstract
Quality management systems are being used mainly by contractors, with only a few house builders adopting formal processes. Following on form previous research relating to implementation in a wide variety of organisations a private house builder/developer has been investigated with regard to management style and comparison with contractors. Significant differences have been found.

Keywords: Quality, Management, Style, Housebuilder, Implementation.

1 Introduction

The basis for this paper arises from work carried out in the production of training/learning materials for the implementation of quality management systems [QMS] for organisations in the construction industry. In order to give authenticity and reflect practice in QMS a number of companies were surveyed with a questionnaire and half of them were visited for a follow up structured interview. This work is described more fully by Chandler [1990]. Whilst the survey concentrated on issues relating to implementation the management aspects were also considered. It is the management structure, strategy and style which sets the scene for QMS. The essence of this paper is the implementation of a QMS and its relationship to management into a house building company producing houses for sale to individuals. The majority of quality assured firms in the process of construction are contractors. They gain work by tender or negotiation and have the client/customer [usually through fee based professionals] producing the specification and drawings for the building. House builders in the U.K. carry out design/specification functions within the direct control of the organisation. They determine shape, size, materials, level of quality in specification of the house in response to market conditions. They work from a limited number of house designs which they seek through planning permission to place them on sites forming

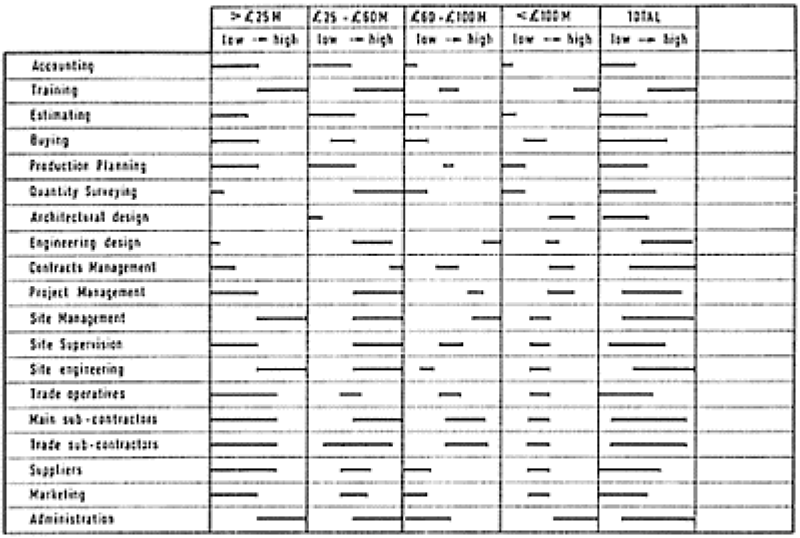


Figure 1.

Figure 2.

	Rating	Comment
Accounting	1	same as similar companies
Training	–	very poor training record
Estimating	3	some change required
Buying	3	change in procedures
Production Planning	3	site design procedures changed
Quantity Surveying	1	most companies had high change
Architectural design	1	using existing procedures
Engineering design	1	using existing procedures
Contracts Management	n/a	applicable only to contracting
Project Management	n/a	applicable only to contracting
Site Management	3	significant levels of change for all
Site Supervision	3	changes for medium to large companies
Site Engineering	4	most degree of change for all
Trade operatives	n/a	house builders use specialists as
Main sub-contractors	n/a	labour only and suppliers
Trade sub-contractors	2	have integral high levels of

Suppliers	2	meeting specified requirements
Marketing	n/a	surprising—as selling a product!
Administration	4	much change in general procedures

Levels of change
Rating 1—low to 5—high

estates. These can vary in size from 3–4 to 300 units. It is possible to obtain type approvals nationally, with external appearance modifications to meet local architectural nuances. Each plot on the estate will have a house type allocated. The purchaser buys plot and type as one package with minimal choice of specification. Some builders will offer a range of kitchen and bathroom fittings which can be selected if the house is 'bought' before construction commences. Variations are kept to a minimum by the builders as they wish to maximise standard fittings and gain economics of scale. Customer choice means more administrative work in providing the options and instructing the suppliers and installers.

House design style and standard is said to be determined by the market i.e. house buyers. The houses are sold virtually as a take it or leave it product based on what has sold in the past and the locality.

The management system for a house builder is based on the premis that a product is to be sold from a range to individual customers who can buy elsewhere from a choice of other sites/types giving the same basic accommodation.

In seeking the relationship between management structure, strategy, style and a quality management system in house building two criteria will be analysed. Firstly the management functions will be compared to those of other builders in contracting. Secondly, with respect to achieving 150 9000/BS5750 Quality Systems typical quality manual clauses will be compared between contractors and house builders. These will be drawn together and conclusions drawn.

2 Survey of Management Functions

A questionnaire was sent to twenty companies in the construction process which asked for the level of change in the listed management functions. A scale of 1 to 5 [1 is low, 5 is high] was used. The overall results are shown as Fig. 1. The actual results from a house building company are shown on Fig. 2 with comment on their relationship to the overall results. The house builders were a regionally based subsidiary of a national company, turnovers respectively £27M and £100M.

The house builder [typical] does not employ any site operatives other than a manager. All trades are independent sub-contractors. The management structure moves up from the site to Production Manager and/or specialist managers such as Technical Services, Design, Quantity Surveying, Land Buying, Materials Buyer. Each may have subordinates. Site Engineers are usually main office based visiting sites as and when required. A large estate could have a resident engineer and quantity surveyor.

In looking at the comparison between the Figs 1 and 2 attention is drawn to some significant factors. The company analysed carried out no training but all others found that significant changes were required in the training function. One wonders how the QMS was implemented without any training! Higher levels of change in estimating were experienced, perhaps because they had to be integrated more fully into the initial development appraisal processes. Again buying and production planning had to cope with a change above normal. It was to be expected that design should require the least change as this was a fundamental element of selling the product. Tight procedures ensured the designers had a system which tuned into market demands and site construction problems. Feedback processes already existed.

Site management functions realised a change with engineering experiencing the greatest shift. It might be expected that as accuracy and procedure is a norm of their job then minimal change would be necessary. The reason is that under a QMS more testing and record keeping is required and that the engineers do this, not the site manager. The engineers are responsible for foundations, under ground services, roads/pavements and materials. All these can be tested and verified and need to be recorded as essential to the 'traceability' clause in ISO 9000. This job function changed the most for all companies.

Traditionally house builders have always produced clear specifications, drawings and quality standards for their suppliers and installers. They are used to meeting the required specification and need only to improve their paperwork processes. Generally the other companies saw change in sub-contractors processes.

It is not known why marketing was not seen to be applicable, perhaps as this was carried out by an independent estate agent selling the properties. These agents would advertise, deal initially with customers and handle the contractual paper work.

As with all companies the house builder saw a high change in administration. As a QMS manifests itself in documentation this is not surprising.

In summary the house builder reflects the overall picture of change with the exception of engineering design. This was contrary to the trend in that least change was experienced. Also as no training was carried out it follows that a change of practice and attitude could not be registered! This negative attitude to training is common in U.K. construction companies. In this case it begs the question as to how a QMS can be implemented without training and how it can be maintained, and meet Clause 4.17 stating that "the supplier shall establish and maintain procedures for identifying the training needs and provide for the training of all personnel activities affecting quality during production

Figure 3.

Contest list of quality Manuals.

House Builder		Contractor	
A	Company Organization	1.0	Index
	and Personnel	2.0	Introduction
		2.1	General
B	Land	2.2	Management of construction
	Land Acquisition	2.3	Q M S Implementation
		3.0	Responsibilities

C	Development	3.1	General
	Site design and layout approval	3.2	duality Group
	Pre- build planning	4.0	Operations procedures
		4.1	Acquisition
		4.2	Pre-construction
D	Costing	4.3	Construction
	Supplier and contractor	4.4	Post construction
	quality assurance	5.0	Audits
	Supplier and contractor	5.1	Audit records
	ordering process	5.2	Audit personnel
E	Construction	5.3	Auditor training
	Construction management	6.0	Training
	Goods receiving and stores	7.0	Commercial & Engineering Services
	operations	7.1	General
	Customer complaints and	7.2	Value engineering studies
	feedback	7.3	Additional Quality Advice AQUA reports
F	Sales	7.4	Technical cross flow
	Sales enquiries	7.5	Quality plan input
	Sales order processing	7.6	Problem solving
		7.7	Procurement
G	Product Range	7.8	Cost planning
	Introducing new house types	8.0	Distribution list
	Modifying existing house types	9.0	Amendment record

and installation". Training is seen as essential by some construction companies, Hobbs [1990].

In the follow up interviews with quality managers in the organisations it was clear that the essence of a QMS was in the capture of the hearts and minds of the personnel. A clear documented rational and well founded procedural system can be established in paper early in the implementation process. The management task is to ensure that people fully understand it and take it as a natural element of every day work activity. This is the concept of doing it right first time. A QMS is not a 'add on' to practice—it is practice. A telling device to make this point is to present a card which says 'if you want to know who is responsible for quality, turn this card over'. On the other side is a mirror. Until that realisation is within all personnel an effective QMS will not be operative.

Whether the organisation carries out contract work or builds private houses the attitude towards achieving specified requirements is the same. It will differ in approach, function and responsibility and this will be explored next by comparing typical quality manuals from a contractor and house builder.

3 Analysis of Quality Manuals

The basic section heads of two quality manuals are listed on Fig. 3. Before entering into this analysis one or two precautionary statements. A paper based analysis can only be superficial and point up issues for further exploration. Even though interviews were undertaken to probe behind the printed word only limited insight was gained. The practice of interpretation of the quality manual procedures is constantly changing within organisations as more is learnt and improvements made. An example is that in a roofing company one procedure was on the 17th amendment. Indeed it is to be seen as a benefit of implementation that an amendment means that the procedure has been improved which will result in better practice. It gives discipline to encouraging and implementing management improvements.

The house builders manual provides more details of procedures, whereas the contractors gives guidelines and overall responsibilities. Detailed procedures on particular activities are documented separately. In a numeric word for word comparison the contractors documents are over double the size.

Initially considering the general areas both commence with a general introduction setting aims, objectives, policies and purpose. After this the approach to describing the QMS is quite different. The house builder sections follow the functional management groupings in the organisation, which is also in a general process direction, from land acquisition, development issues, financial consideration, construction and sale. The contractor's manual is centred on QMS terminology and process. For example, the headings of QMS implementation, Quality Group, Audits, Training, Quality plan input are all concerned with the internal management process centred on the concept of a QMS.

Both the companies rely totally on sub-contractors to carry out the site work. The directly employed management responsibility reaches the site with site managers and assistants, who may have specific specialist functions, such as cost control or site engineering. Therefore the approach by both companies is similar in that the actual responsibility for 'as built' quality is not in their direct control. It is covered by contract. On this basis it might be thought that similar attitudes to management function and responsibility might prevail. As will how be seen it does in some particular instances but not generally.

Both manuals describe procedures for obtaining work, although with house builders this is the purchase of land upon which to build [B, C] and for contractors [4.1, 2] to get onto tender and/or negotiation lists in order to get contracts. The house builder immediately gets ownership of an asset, land, which is then within its direct control as to what then happens. In the acquisition process, tendering and pre-construction, the contract inherits a preconceived set of specifications, designs, professionals, known client and so on. The job is then to organise these into an economic construction process. Management is both internal and external with the contractor. External management activity within limits such as discussion with selling agents and planners does not come into the process until the construction phase, such as the inspections by the organisation providing a ten year warranty and the house buyer. Design, cost and construction planning are all within the direct control of the house builder. The emphasis of the QM system is on internal customer relations. But the ultimate customer is the house buyer who may not be identified in person until the house is built. Therefore as with most consumer products the manufacturer does not know who the customer is—they are selling to perceived customer wants, desires and perceptions. The contractor will be in communication with the client [or clients representative] from day one of the process.

Although marketing was not noted as requiring any change in the Fig. 2 analysis it is obviously important when appraising the development potential of house building land. What types of house will sell? Detached or attached? High specification or low? Density per hectare? As this activity has always been carried out by house builders it should not require much modification. Much marketing is based on local factors, such as schools, shops, transport and so on. Some companies carry out market research by sample questionnaires on a population, but these are very rare. It might be that prospective buyers walking into show homes are asked to give information on what attracted them to the particular estate, what accommodation they are seeking, any particular layout, types of kitchens and bathrooms. There is little evidence of house builders undertaking comprehensive market research surveys. One builder says that their research consists of seeing what else is being built in the area and either providing a different layout and specification to a similar house type or providing a ‘niche’ type of house.

The management function in acquisition differs between the companies—the house builder relates to an unknown customer whereas the contractor is immediately working within prescribed specifications and has a definite client.

The house builder makes very strong reference to the financial aspects of the business by devoting a section to it. No specific reference is made to costs by the contractor. The house builder’s manual refers to the identification of financial risk factors in overall cost terms and in the selection of the sub-contractors and suppliers. There are procedures for checking the integrity of the sub-contractors via references; interviews; examples of previous workmanship and so on. A strict control is placed on the financial running of the estates. This is so because the builder will not receive any money, in most circumstances until completion of the house. If the house is sold at empty plot stage it is possible to obtain stage payments after completion of foundations and then at roof completion. But much money would have been expended on estate works such as roads and sewers. Each house will bear a proportion of these costs only retrievable when the sale is complete. Therefore the house builder will generally have to commit more money in the early stages of a project than a contractor. A contractor, after 1 month will have a process of interim payments based on work done. Cash flow is more dependable. In a slow house market cash may only be generated when the house is complete. In order to obtain a production flow through an estate houses will be built even though no buyer has materialised.

Whilst the contractors management is concerned about cash flow and profitability this factor is a major concern of the house builder. The management must be extremely sensitive to cost factors. As the manual states ‘The development department is responsible for production’. All decisions relating to costs are taken at head office level by senior managers based on the use of standard house types using pre specified materials and components. This factor now leads to a comparison of site manager roles and responsibilities.

Section E of the house builders manual gives as one objective:

'We produce houses that comply strictly with the design/specification requirements of both [company] and all statutory and regulatory bodies [i.e. National House Builders Council, local authority building control etc.]'.

The site managers role is to build to the specification and programme produced by the senior namangers. Little or no control is exercised by the site manager on varying labour rates or obtaining different materials. The site does have responsibility for:-

'any defects are identified, reported and rectified at the earliest opportunity'.

The emphasis is on the site producing the right quality within the constraints set by the development department.

Again in the procedures describing the pre production and pre build meetings a clause states:

'All works shall be carried out in accordance with the drawings and specification provided…carried out strictly in compliance with the requirements of the Health and Safety at Work Act'.

There is no external specification with a formal set of preambles providing a clear indication that certain obligations have to be met. This is given in the manual. There are no client sponsored prompts to keep the management aware of the wider issues. It requires a well structured, constantly repeated note within all procedures to meet these obligations. In the everyday harried activity of managers these can be pushed to one side, especially when all control is internal. There is no client to knowledgeably oversee the site activities.

The site managers role can be said to be unhampered by the burden of financial responsibility and can therefore concentrate on quality matters. This is clearly enunciated in the manual:

'…each contractor is made aware that he is responsible for the quality of his own work and that inferior work will be rectified at his own cost'

The site manager carries out inspections as regards 'quality and completeness'. In practice this means that the sub-contractor is not paid until the site manager verifies that the work meets the required standards. After this the cost controller can process the payment.

The contractors identify a procedure to deal with non-compliance. The contractor raises a Corrective Action Request. This is similar to other contractors procedures. The house builder does not hold back any retention monies from its trade contractors, nor does it require a 'Certificate of Compliance'. The site managers signature is proof of compliance. The house builder is concerned about getting it right and two procedures are used.

Where a defect has been found, for example a poor performing component or unsatisfactory material a 'Defect Action Note' is prepared. The root cause is identified and rectified in order to prevent a recurrence of the defect. This is fed back into the design/development process. Since the introduction of the QMS a 'design panel' has been constituted comprising all the senior managers. It is here that the 'Defect Action Note' is discussed as a quality issue.

The second procedure undertaken by management is centred on the customer. There is a Customer Services Manager who liaises with all customers and other managers. If the customer has bought prior to completion they are informed of the handover procedures. There is a ‘Preoccupation Assistance Sheet’; Customer Final Inspection Sheet [the customer, services manager and site manager jointly inspect the house immediately prior to handover]; ‘Maintenance Check Form (Customer Service Order) and other basic literature. The customer is part of the quality system, albeit at the end stage with respect to the product. As the manual says ‘… actively encourage feed back on our standard of design, production and services. Remember unless we have comprehensive feedback we will never learn and improve’.

The contractor has a feedback and review procedure based on the documents showing what was built. This is undertaken with the client. There is no department to deal with this, it is project managements responsibility. Also there is a feedback mechanism to reinforce current awareness of the latest construction techniques which integrates with a Technical Experience Retrieval Module and Value Engineering studies carried out during or after design stage. To be effective VE should be carried out early in the design process. The contractor runs seminars which allow suppliers etc. to update the management on latest techniques and products. This is under 7.1 to 6 in the manual.

The house builder has a section on its product improvement. Procedures are provided for introducing new house types and modifying existing types. It has been mentioned that a Design Panel now undertakes this task. It used to be done by one or two managers. This did not meet requirements in that they could not hope to be cognisant of the latest techniques, products, customer demand and complaints. Now a wider range of expertise is involved which will benefit the company. All factors can be considered in creating their product to meet market demands and cost constraints.

4 Conclusions

Prior to bringing together this discussion focussing on management functions and quality management procedures reference is made to other studies and practice. Glover and Glover [1989] considered whether the benefits of a QMS can be seen in housebuilding companies by comparing a range of financial ratios, twenty in all. Companies adopting QMS were characterised by lower returns on net assets, lower profit margins and a lower net asset turnover ratio. In other words they performed worse than companies not adopting a QMS. But these companies were thought to have turned to a QMS to improve their profitability. Or it may be that the implementation of a QMS has caused a management upheaval and added to costs. These companies also have low trade creditor turnover ratio, low labour costs relative to operating expenses and high turnover per employee than non-QMS companies. It has been stated that the house builder analysed here relies on sub-contract services and that the ultimate responsibility for product quality is with them. This would indicate, say the Grovers, that it is easier to introduce quality management in which the management adjustment is borne by outside suppliers or that the company making greater use of external services find a need to exercise greater control of the supplied quality. On balance the house builder referred to in this paper had more internal changes than was experienced by its external suppliers. This infers an appreciable change in management practice. This is hidden, but very important agenda behind the implementation of a QMS; that it is about attitudes and not paper systems. Ridout [1987] describes a house building companies move to quality management. The company admitted to losing in poor workmanship, duplication of effort and general tardiness £10M in lost sales revenue in a year. Their approach was to introduce a five year campaign that was not directed towards achieving third party accreditation. The emphasis would be on people “Quality management is about people, not systems. Everyone should be a quality manager”. A series of training courses are provided which concentrate on personal performance, not paper systems. D’Arcy [1988] on this same company quotes the managing director “Believing in oneself is what it is all about. There are real changes to the individual. You become more positive and analytical. It makes people think. And some of the thinking that comes out of it is quite radical”.

Seymour and Low [1990] have identified two tendencies (T1) (T2) which are based on the perspective taken on a number of key themes. (T1) stresses the need for precise criteria, measurable factors and economic value. (T2) rejects attempts to exclusively define the issues in technical/scientific terms by saying that there are limits to quantification and measurement. It means that there will always be irreducible elements with the means preserved or developed for handling them. The house builders QMS veers towards this tendency (T2) whilst the contractors leans towards (T1). Both, though are nearer to (T1) than (T2). The house builders reliance on sub-contractors means that as Ball [1988] states “Adaptive and instantaneous site management strategies have to be replaced by more careful pre-site planning of work flows”. This means more control by senior management, who then see the implementation of a QMS as bringing further order in the planning process.

There is a significant change in the management style of the house builder which is not wholly brought about by the adoption of a QMS. Some changes have occurred in the past decade due to a change in the social/economic structure of the construction industry, Ball. Those changes directly related to a QMS are in administrative and site engineering functions followed by the pre-production functions and site management. It is mainly in paper process procedures. It remains to be seen if any fundamental shifts occur away from ‘technical’ solution to quality issues to one that as Ferry [1984] says quality becomes simply the end product of properly qualified people taking care.

6 References

Ball, M. (1988) **Rebuilding Construction. Economic Change in the British Construction Industry**. Routledge.

Chandler, I.E. (1990) **The Implementation of Quality Management Systems into Construction Companies**. New Zealand Institute of Building Biennial Conference 25–27 October.

D’Arcy, J. (1988) **Building Success on Foundations of Quality**. Contract Journal 5 May.

Ferry, D.J.O. (1984) **The Role of the Building Professions in the Achievement of Quality** in Quality and Profit in Building Design. Eds Brandon and Powell. E. & F.N.Spon.

Grover, R.J. and Grover C.S. (1989) **Quality Management and the Efficiency of Construction Firms**. Quality Assurance Vol. 15 No. 4. December.

Hobbs, T. (1990) **Total Quality Management**. Chartered Builder. May/June.

Ridout, G. (1987) **McCarthy’s Mission**. Building. 3 May.

Seymour, D. and Low S.P. (1990) **The Quality Debate. Construction Management and Economics.** Vol. 8 No. 1. Spring. E. & F.N.Spon Ltd.

52
Lack of quality in construction—economic losses

M.CNUDDE

1. Generalities

My lecture will especially concentrate on describing the situation on the Belgian market and is based, on the one hand, on the studies carried out within the Belgian construction section of EOQ (European Organization for Quality), whose secretariat is in charge of ir. J.Heirman from AIB/VINCOTTE and arch. M.Cnudde of the CSTC, and, on the other hand, on the experience I have acquired at the Centre Scientifique et Technique de la Construction (Belgian Building Research Institute).

In September 1985 the 4th European Congress on Construction Quality Management was held in Brussels. After that Congress, the Belgian construction section of EOQ was founded, chaired by R.De Paepe, secretary-general of the Ministry of Civil Engineering.

The three following working parties were immediately set up:

The first group, called “The client and quality” and chaired by Prof. G.Ost, is intended to study the client’s needs; the first results of its work were published in “The Guideline for the Client by the RPS-method”. It consists in a guide that helps the client to define his requirement programme properly.

The second working party, chaired by ir. Franssens, chief engineer and director at the Ministry of Civil Engineering, is very active in the field of the certification of construction products within the European Community.

The third working party is chaired by R.Declerck, a contractor and vice-president of the CSTC. It is responsible for the publication of:

a checklist for the preparation of the building site;

the Guideline for the Drawing up of a Quality Manual, which ir Ph. Gosselin will deal with in more detail.

2. Introduction

As far as construction quality is concerned, I would like first to go back to the post-war years, characterized by a strong housing demand. Given the economic growth and the favourable situation on the market, the sector tried to increase the productivity per unit of hourly wages.

This trend translated into a process of industrialization and prefabrication, that should have given cheaper standard housings to a larger public.

Those prefabricated houses, whose various components could be manufactured under nearly ideal conditions, should have turned into long-lasting and high technical quality products fully satisfying the user thanks to their high level of perfection and adaptability. If the elements themselves have reached a high degree of technicity, the construction industry could not get the seal of “industrial quality”.

Meanwhile, the economic situation has deeply changed. The purchasing power has crumbled and a new state of mind is borne, which conditions the requirements of the future client.

Notions like urban renovation, rehabilitation, environment, joy in life, etc., have entered the common use. The client has adopted such a purchasing behaviour that he can get his money’s worth, always in search of quality.

Moreover, we are faced with the fateful date of 1st January 1993, when the single European market accounting for 320 million consumers is created. We have inescapably to get used to that new situation, that will not only generate new standards and guidelines but also and above all a new mentality.

Consequently, the building sector has to adapt taking into account the recommendations of the European guidelines and especially standards 9000 to 9004. To be competitive, it is necessary among others to introduce “total quality” both in our research units and in our businesses, in order to supply a high-quality product at the end of the production line and even beyond; this could be called the “after-acceptance service”.

3. How to define quality?

Quality is a notion that has been known from time immemorial but that, until these last few years, had a rather subjective connotation. Nowadays, the client asks more and more for the proof and the assurance of the quality.

The French recommendations EOQ84-AFCIQ are rich in expressions like quality product, quality service, quality of the environment, quality of life, etc.

The ISO standard 8402 defines quality as follows: “the totality of characteristics” of a construction work “that bear on its ability to satisfy stated or implied needs”. Personally, I prefer the definition given by the American prof. Dr. Juran.

Quality=Fitness for Use

Nevertheless, the construction sector differs from the other industries by:

The uniqueness or the low repetitivity of the work
The number of activities involved in a construction
The multiplicity of parties.

4. Does lack of quality exist in the construction industry?

Following an analysis and a synthetic study, the Direction des Avis Techniques (Direction for Technical Advice) of the Belgian Building Research Institute has reached the results shown in fig. 1.

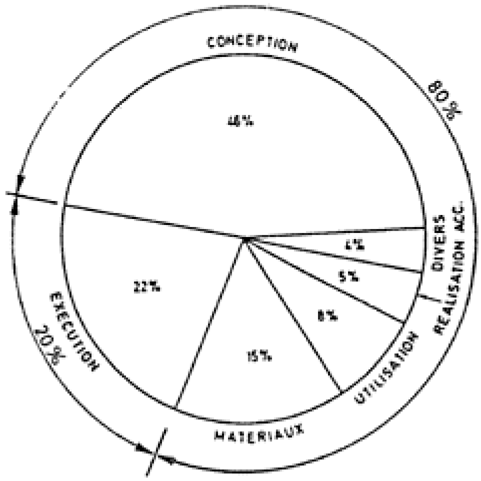


Fig. 1

As can be seen, the well-known 80/20 ratio, established for the industry by the American prof. Deming, can also apply to the building sector. In other words, 80% of the causes of lack of quality can be attributed to the management, responsible for the careless implementation of a study, for the bad preparation of the activities, for an improper use of materials. A deeper analysis reveals the pathological aspect of damage.

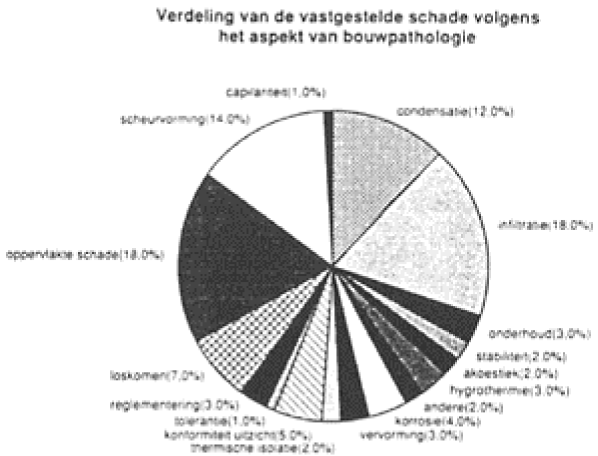


fig. 2

In view of those observations, the lack of quality in construction activities can be attributed to the unsuitability of training for the level of quality required and, consequently, to the imperfection of the study, design and specifications.

5. Comparison with other European countries

It is always useful and instructive to compare the situation at home to the one in other countries, as far as data are available.

The table below compares the distribution of the causes of damage in a few countries.

Cause of damage	Belgium %	Great-Britain %	West-Germany %	Denmark %	Rumania %
Project	46	49	37	36	37
Materials	15	11	14	25	22
Misuse	8	10	11	9	11
Miscellaneous	9	1	8	8	11
Execution	22	29	30	22	19

A striking similarity between the various percents can be noticed, even though the data available are incomplete and the enquiries have been carried out differently according to the country.

One can also wonder if the construction industry is not less impregnated with the notion of quality than other sectors. I immediately reply in the negative and will put forward as simple proof the scheme published by the Dutch insurance companies, that show the distribution of the causes of damage in the sector of metallic constructions.

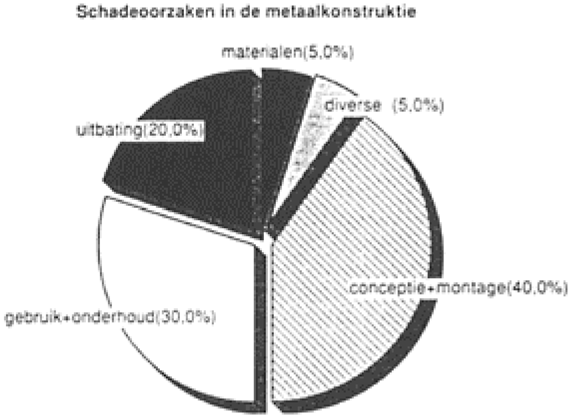


fig. 3

6. The client and quality

At the origin of the construction act, there is an intention that develops from idea to desire, then to demand. It is important to define that intention properly, on which the quality of the building work, both as a living place for the users and as a functional system to manage in space and time, will depend.

Because of the initial choices he makes, the client holds a considerable power and responsibility in the field of the quality and economy of the construction that will be built and afterwards managed.

The client is therefore a real keystone in that process.

He can make it coherent and homogeneous if

1) he clearly defines the destination of the building work
2) he selects his future partners properly
3) he determines the most appropriate organizational system
4) he is sure of the competence and the quality of the performances of all partners.

In short, we can conclude that three factors of quality play an important part in the construction:

1 the requirements as to the technical quality specific to the occupation or the exploitation of the building (requirement programme)
2 the requirements as to the quality of the construction from the technical and physical points of view (graphical expression and technical specifications)
3 the quality requirements as to the environment (town planning requirements).

7. The contractor and quality

The diagramme in fig. 1 reveals that 22% of the cases of lack of quality can be attributed to the execution, that comes second on the list of the causes of damage. That percent equals to the cost paid by the contractor to repair the damage due to a poor execution. Moreover, it is worth noticing that the notion of “total quality management” does not belong to the common practice yet in the building sector, despite the considerable evolution observed these last few years. My colleague, Ph. Gosselin, will deal with this subject more in detail and will display the results of the enquiry carried out in Belgium on this matter.

Nevertheless, we always tend to wait that a customer complains about the damage undergone, which afterwards have to be repaired in accordance with the guarantee period agreed upon, at the end of a legal action.

To improve that situation, a change in mentality is necessary.

The key person in that field is the man himself.

So it would be necessary to develop a certain degree of selfcontrol at all levels, not to conceal defects but to mention them to the person in charge of the building site and to repair them.

Most of the time, total quality management in construction should consist in reorganisation.

In that field, knowing the cost of “lack of quality” plays an important part. To know that price exactly, all relevant data have to be picked out and analysed and then, conclusions have to be drawn.

Knowing that factor cost is the best way to stimulate the employees of a company, from top to bottom, to accept improving actions and to introduce total quality management.

8. Cost estimate of lack of quality

We do not have exact figures but estimations of the cost of lack of quality. At the 4th European Congress on Quality Management in Construction (September 1985), the percent of 10 to 15% of the turnover was put forward.

The CIB Congress in Paris in 1989, as well as the EOQ Congress in London in October 1987, in Copenhagen in September 1989 and in Dublin in 1990, not only confirmed that figure but even increased it to 15 to 20%.

The Agence pour la Prevention des Désordres et l’Amélioration de la Qualité de la Construction in Paris cautiously mentions 12%.

To give a picture as faithful as possible to the situation in Belgium, we have followed three buildings from the adjudication stage till the acceptance of the main structure, which enabled us to put forward the figure of 20%. The theoretical enquiry followed by Ph. Gosselin reaches 15%.

In conclusion, 17% looks very realistic. For Belgium in 1989 this means a cost of:

Investments 1989 in BF thousand million		Cost of lack of quality—17%
Private	175	29,75
Non-residencial builsing	230	39,10
Civil engineering	73	12,41
Miscellaneous	9	1,53
Total	487	82,79

i.e. the amount of the VAT in construction or more or less ECU 2 thousand million.

9. The Japanese model

Until recently the Japanese competition was not taken seriously. Japanese products were cheap but badly considered as to quality.

The asset of Belgium, as well as of the United States, consisted in its capacity of innovation and technological research, moreover based on an image of quality and reliability.

Nowadays, the situation has changed a lot: Japanese products are still famous for their low prices but now also for their quality.

We did not understand in the 60s-70s how well Japanese high leaders had realized that in order to take up the economic challenge on the American and European markets, they had at first to develop a policy of quality and that price only could not ensure them a place on the world market.

To reach that objective, they namely resorted to Juran and Deming, famous American specialists.

In the field of housing too, even though the results are less spectacular there, economically less tangible and not yet known in our construction sector, the Japanese endeavour to produce a housing stock in accordance with the ISO and ASTM standards. The Japanese effort to control quality is not only directed to the huge interior market but also to export. The “Pilot House Projet” and “Housing 55” operations launched in 1976 prove that trend.

After a mission to Japan, the chairman of the CNC, R.Maes, summarized his impression as follows:

“The Japanese have three main goals:

a) to get closer to the European culture and refinment
b) the German qualitative “Gründlichkeit”
c) the American industrial efficiency.”

The Japanese have quickly realized that applying the strict and efficient principle of “Quality=Fitness for Use”, they would succeed not only in conquering the market coveted but also in increasing their productivity and benefits.

Nowadays, all Japanese are aware of the fact that everyone has to contribute to manufacturing a high-quality product by a conscientious work and that everyone at his level has to try systematically to find ways of improving the quality of his work. That is what the Japanese call “company-wide quality control”.

10. Future prospects

Regarding all the facts above-mentioned, there is no doubt that the concern for the improvement of quality has to become a must.

For construction companies, that is also a mean to increase their productivity and benefits and to improve their image.

An effective quality control is only possible with a change in mentality. The latter implies a collective engagement that comes within the framework of a new type of management able to improve quality.

To reach an optimal result, the effort must not be limited to the company but has to extend to all partners in the construction act, i.e.

– he client
– the architect and the research unit
– the contractor.

Moreover, the responsibility for quality must be accepted and taken on effectively by all partners. Nevertheless, most quality problems can be solved by good sense and a realistic approach.

Answering the following questions makes it possible to manage total quality effectively:

– at which stage has the lack of quality been noticed?
– at which stage could it already have been noticed?
– what can be done to avoid a recurrence of that lack of quality?
– who and at which level should be motivated?

That creative way of thinking deals with total quality management from different points of view, each one being adapted to one of the construction phases; then, it is really beneficial to everybody.

Within the traditional trilogy (client, architect, contractor), everybody according to his responsibilities has to try to carry his task through to a successful conclusion, to get involved in and accept a dialogue that makes it possible to define together the various aspects of the project from the point of view of quality.

The workers on the building site must have the possibility of blooming and feeling intimately linked to their work, which reinforces the sense of quality once more.

11. Quality-price ratio

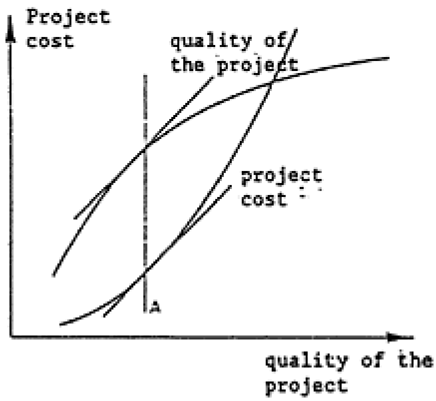
Damage distribution schemes show that the lack of quality of the project is responsible for almost half the damage cases appearing later on.

Exceeding the price initially agreed upon is a very important factor. Consequently, it is absolutely necessary that price and quality requirements are considered as soon as the project starts.

We should not forget that the excess of quality can prejudice good working as well as insufficient requirements.

So, those factors have to be deeply considered by the project designer. Because of his function in the construction process, he influences the price of the building. The client is the person who wishes to obtain a construction work characterized by a certain level of quality and perfection.

Professor Juran represents the project-quality- price ratio in the scheme below.



It reveals that a certain level of perfection should not be exceeded if one wishes to design a project at a sensible price.

It is true that the A threshold of quality varies from one project to another. For example, the nuclear industry and military clients impose higher levels of quality than those usually required in the building industry.

The surest way to fix a limit of quality consists in finding a compromise between the degree of perfection desired and the price one is ready to pay to get it.

Clarity is another aspect of quality. Plans, dimensions, technical specifications, reference standards, etc., must be complementary and not contradictory, as it is too often the case.

The PC's introduced in the offices of project designers and in research units can change that situation, which is also aimed at by the different computer studies of the BBRI for the building sector.

12. The user and quality

Quality management must be carried on after acceptance of the building and taken upon by the user. The “Carnet d’entretien des bâtiments” (Building Maintenance Book) published by the BBRI tells that 30% of the damage to buildings could be avoided if normal maintenance was carried out.

Following a certain number of analyses of artificial ageing of buildings, the Direction for Technical Advice of BBRI has observed that such a phenomenon is mostly due to a lack of elementary maintenance and that the user does not understand properly all what the notion of “construction” implies.

Many users think that a building and its various parts keep their original proprieties, functions and aspects without any maintenance for 10 years or even more; thus they do not manage their good “as a good father should”, i.e. they do not take care of its quality nor ensure its regular maintenance.

To close this chapter on quality management, I would say that the client must not only be sensitive to the notion of quality but also convinced of the role he has to play to ensure the maintenance of the quality.

13. Conclusion

Most problems linked to quality can be solved by a minimum of good sense and realism, by a return to the basis or by transfer of knowledge.

It is a mental or intellectual process by which the thought classifies, recasts or transforms the experience and knowledge previouly acquired to make new ideas and concepts appear.

That creation power makes it possible to enlarge the definition and the framework of the problem of quality, examined from different points of view. It multiplies the number of possible solutions.

The transfer of knowledge and an open dialogue play an important part. Mutual confidence between all construction partners, including workers, is the absolute condition for an efficient transfer of knowledge. It is necessary to carry out a real participation strategy and to realize that quality management will become unavoidable because of the appearance of a new generation of users from the single European market accounting for 320 million consumers, who will show more and more demanding as to quality.

To manage quality consists in designing and implementing in such a way that the usability and maintenability become normal features inherent to the construction product.

Looking for and managing quality is profitable to everybody.

53

Construction quality and management—its delivery and discipline in housing and other building sectors

T.CORNICK

Abstract
Improving quality is of concern to all areas of industry in both the developed and developing parts of the world. This concern has been met in the construction industry through attempting to adopt the principles of quality management and assurance used in other industries to its own processes. The adoption of these principles is meeting with various degrees of success depending on the approach taken and will impact on forms of procurement and professional and commercial responsibilities. This paper describes how the principles of quality management are best adopted by the construction industry at large, the implications of different methods of project procurement on the successful application of those principles and how professional and commercial should be changed to cope. It goes on to propose that Housing—out of all the building sectors—has specific needs to be satisfied by the application of quality management principles and that, due to the usual method of procurement used, should be the most adept at successfully adopting those principles in full.

Keywords: Construction Management, Quality Management, Procurement Methods, Housing.

1 Quality in Construction

Quality has been defined as "meeting agreed requirements" (1) and throughout a building project a "chain of conformance to requirements" can only be realised by controlling the inputs to every task in every phase of the project process (2). The concepts, principles and mechanisms for managing quality in any product or process have come from the manufacturing industries where there is usually a single and continuous responsibilty for both the design and production of an artifact by a single party. This fact is reflected in the

International Standard for quality (3) and has caused some confusion when the construction industry attempts to adopt the Standard to its own work.

The independent professional designers—i.e. the architects and engineers—have a product of "design" whilst the commercial contractors have a product of "construction" through contractually separated agreements and contracts to the client (4)(5). However, the quality of each of their "products" affect the quality of the other's "product" and together affect the quality of the client's "product" i.e. the building or civil engineering construction. So far the UK construction industry sectors have each made their own interpretation of the Standard to their own field (1)(6) with little attempt at a collective and integrated interpretation. However, if quality is to be realised in the final end-product of the design and construction process, the application of a quality management system must be made to the project as a whole through the mechanism of a "quality plan". This "plan" must not only be the expression of how each participating designers' and contractors' own quality management system impacts on their particular contribution to the project, but also how the project as a total and continuous process is to be controlled. Such a project (quality) control plan must be both dynamic to cope with the evolution of the project from briefing through to construction—and even on to maintainance from the client's point of view—and integrating to cope with the interdependence of the various activities of one participant upon another—e.g. the design consultant's design output as an input to the specialist contractor's detail design for a particular element of construction (7).

Therefore, in the author's opinion, for a quality management system to be effective on a construction project and quality to be realised in its final outcome—i.e. the building or civil engineering works—the form of procurement used must be supportive of a single and continuous process that can integrate the design and production functions. A model for ensuring that a "chain of conformance to requirements" is achieved through such a single and continuous process for a building project—and which equally applies to a civil engineering project—has been theoretically proposed and forms a fundamental basis for applying quality management systems in practice—see Appendix 1.(8).

2 Management of Construction

The management of construction has been carried out in practice both in the UK and other countries through using a variety of "procurement" methods with their attendent supporting contracts each of which responds to different traditions and individual project prodedural and technological requirements (9). Essential to all these methods is a clear relationship between all the participants in terms of contractual links and managereial authority and responsibility. It is also recognised that the key to success in the management of construction projects is in leadership and team-building of a variety of diverse disciplines in acheiving a common goal. Essential as design and technological skills and knowledge are in construction, their effective application can only be realised by managing the various individuals and organisations—who may never have worked together before—in a harmonious and productive manner. Managing projects has therefore some distinctive features that do not necessarily apply to the management of companies, although many of the human behavioural, communication and leadership issues are common to both. Managing construction projects also has distinctive features not found in other projects that way be undertaken in the manufacturing industries and other areas of commercial activity. This distinctiveness between construction and the other industries been cited as one of the reasons why percieved "quality faults" might appear to be more prevalent in the construction process than in the manufacturing processes. The significant differences between both processes and which therefore gives the management of construction projects its distinct charactaristics, have been listed (10) as follows:-

1) Almost all construction projects are unique, single order, single production runs,
2) Unlike manufacturing industries, which have a fixed factory site, construction sites are unique in terms of environment and condition,
3) The life-cycle of construction projects are longer than those of most manufactured products; and buildings (civil engineering works) continue to evolve throughout their long life-cycle according to time and circumstance. This includes changes in use and modifications to the building (civil engineering works),
4) There are yet no precise standards for the evaluation of overall construction quality, as there are for manufactured products,
5) The participants in both the design and construction stages are likely to change from project to project,
6) Feedback can be remote in time from the design and construction activities, and is difficult to process in a way that enables it to be returned to the original design office to form a database for future designs,
7) There are conflicting cost criteria between capital and maintenance expenditure. Very often there is no related design control on value for money based on the concepts of quality, durability and reliability,
8) The user of the building is seldom the purchaser, therefore immediate consumer response to the quality of the building is lacking.

The above list shows that unless the method for procuring construction projects can become more like that for the manufacturing industries, many problems will remain for the management of construction projects to achieve quality. For example, taking point (4) from the above list, precise standards need to be described if design and construction criteria objectives are to be sensibly defined for management. Taking point (7) from the above list, balancing capital and maintenance criteria can only sensibly be done by a fully informed client being involved in the design process.

Therefore, in the author's opinion, the approach to management of construction projects that will ensure that quality as percieved by the client/end-user will be achieved must be one that more closely relates to the manufacturing industries than that of the traditional way of procuring construction projects. This is because the traditonal way of procuring construction creates a **dis**-integrated and **dis**-continuous process for "design" and "production" whereas, by definition, the manufacturing industries have an **integrated** and **continuous** approach for "design" and "production". Although the "uniqueness" aspects of a construction project cannot, by definition, be changed, an approach to procurement, that provides both integration and continuity of process and purpose can start to change the characteristics of a construction project to allow management for quality. This is because, an approach to the procurement of, and therefore by implication the management of, a construction project that continually involves the client/end-user in decision-making and develops the design to meet specific production and performance criteria will reduce the essential significant differences (3) to (8) cited on the above list.

Research in the UK (11) has shown that in fact the "uniqueness" of construction projects—differences (1) and (2) above—is not the underlying cause of "quality related events" but rather the inability of the people involved to resource plan for and communicate between the traditionally separately controlled design and construction processes.

3 Methods of Project Procurement

A government sponsored study (12) in the UK in the early 1980s suggested that clients had essentially four alternative paths they could follow in procuring their construction projects. These were as follows:

1 Traditional—	consultant designs for a fee and contractor constructs for a price.
2 Design and Build—	single contractor designs and constructs for a price.
3 Design and Manage—	single contractor or consultant design and manage for a fee and specialist contractors construct for a price.
4 Management—	consultant designs for a fee and separate contractor or consultant manages for a fee and specialist contractors construct for a price.

In each method the key participants, defined by their function, of Designer (the "architects/engineers"), Construction Manager* (the "construction contractors"), Specialist Contractor (the "construction sub-contractors") and Client (the "owners") are contractually arranged in slightly different ways. (The term Construction Manager* is used as this is a more precise definiton of this participants function as all the actual physical construction is carried out by the sub-contractors—many of whom now even complete the detail design of the construction element for which they are responsible.) The clearest method in terms of the risk, responsibility and relationship of the above paths are the Traditional and Design and Build methods. In the former method, the architect/engineer contracts with the client to produce the design for which the contractor tenders and when the contract to construct is made the architect/engineer monitors the construction contract on behalf of the client. In the latter method, a single firm (13) or a joint venture (14) contracts with the client for the design and construction based on either a brief or a concept design. Variations in both methods can allow for either a "lump sum" or "negotiated" approach for agreeing a price for both the design service and the actual construction.

In the Traditional method, the design has to be completed in some detail to allow the contractor to realistically price for his contract. Not only does this, by definition, mean a sequential approach to design and production for construction but also that the design itself actually becomes the "contract" that the participant responsible for construction has to fufil. This situation is probably the root cause of the "adversarial" nature of the Traditional form of contracting—i.e the participant responsible for "production" has had no direct involvement in developing the design in detail for “production” that he has now contracted to produce—and why the other methods that change this situation are now being seriously considered (14)(15).

The other three methods all allow a degree of integration between the design and construction processes—and consequentially a simultaneous approach to design and production for construction -but with slight variations on how the responsibilities and risks are carried by each participant. In Design and Build the total responsibility and risk for both design and construction is carried by the Construction Manager* as a contractor to the Client—the Specialist Contractors all being his sub-contractors. In the Management method, it has been confirmed by a recent study (15) that the Construction Manager* carries a separate management responsibility and risk for realising the construction equal to that of the Designer achieving the design for the Client who himself must take the overall risk and responsibility for the project through his continous involvement in the process. Design and Manage appears to combine some of the features of the other two methods but it is only the Management method that allows the Specialist Contractor a direct involvement—especially in the detail design phase—through a direct contract with the client.

Therefore, in the author’s opinion, the methods of procurement for construction projects that support the **integrated** and **continuous** approach to design and construction responsibilities are the ones that provide the best chance of realising quality as percieved by the client. This leaves only the Design and Build and Management methods from the above list as both being clear in terms of their contractual systems and allowing detail design to be developed in conjunction with the participant responsible for the construction of the project. The advantages and disadvantages of each of those methods can be cited as follows. In the Design and Build method, the Client has the assurance of a single contractual responsibility from the Construction Manager* for the totality of his project—both in terms of cost, programme, and design performance for the whole construction and production standard of the Specialist Contractors. He does not, however, have a direct relationship with the Specialist Contractor and may not be fully appraised of the various “design and production options” in terms of value for money that could be realised as the total project process is, by and large, outside of his control. In the Management method, the Client has the assurance that he is controlling his project as the design and construction processes evolve over time—and consequently is fully and continually appraised of the various “design and production options” in terms of value for money—and can directly deal with Specialist Contractors with the professional advice of his Designer and Construction Manager. He does not, however, have a single contactual responsibility for the total construction project as contractual reponsibility is divided between the Designer, Construction Manager and each Specialist Contractor. Both methods support integration and simultaneous design and production process control with the Management method allowing the Client a greater involvement in the decision-making process in considering “design and production options” in terms of value for money for his total project.

4 Professional and Commercial Responsibility

Regardless of method of procurement, the construction industry, both in the UK and abroad, comprises designers—who carry with their professions of architecture and engineering a "duty of care" and all that it implies—and general or specialist contractors who provide a "product" against a specification and all that it in turn implies. Although the complete and detailed legal implications will not be discussed in this paper, it is suffice to say that overall responsibility and risk for the total construction project can be somewhat complicated. On the one hand, each participant has a responsibility to themselves to protect their own "professional" or "commercial" interests depending on how they are contractually involved in the project. On the other hand the client should be able to expect it to be clear how responsibility—and consequential risk—is being carried by both himself and the other participants in his project. The mixed responsibility situation in construction projects probably causes confusion all round and, with the client wishing to protect himself in the long-term through such devises as "collateral warantees" (16) and "project insurance" (17) are currently being considered in the UK. On the one hand the client is seeking more and more risk protection and on the other hand the "professional" architects (and to lesser extent, engineers) find themselves facing more and more onerous risk liability.

As yet, the application of formal Quality Assurance to projects is not seen as the total answer to these responsibility/risk problems, because no real track record of its effectiveness yet exists in practice. Even in the Design and Build method, the "professional" architect's and engineer's "duty of care" has now in effect shifted from the Client to the Construction Manager* if the method is done by means of a joint venture rather than a single firm. However, from the client's point of view, in a Design and Build method this "professional" liability from an independent architect or engineer is no longer an issue as he has accepted the "commercial" liability—and whatever guaratees may go with it—provided by the single firm or joint venture legal entity.

Therefore, in the author's opinion, the contractual arrangement that simplifies the responsibility into just one type—i.e. either a "commercial" or "professional" liability—for the total construction project should clarify "risk" and—what is more important—how that "risk" can be protected and seen to be protected. With regard to this objective, the Design and Build method comes to the client with a "commercial liability" whereas the Management method comes with a "professional liability" for the total construction project. However, in the Management method the Client does also obtain a "commercial liability" from the Specialist Contractor.

5 The Needs of the Housing Sector

So far, in this paper, the situation has been considered where a client requires a "bespoke" construction project from the construction industry at large in all the **non**-housing sector areas of the construction market. Although this same situation can still apply in a number of areas in the housing sector—i.e. housing association work, local authority housing and the "one-off" private dwelling house—a large proportion of the UK housing construction market represents a totally different situation. This is where the construction company purchases land, erects housing developments-which could be as small a two or three units or as large as hundreds—in the hope that potential custmers will buy them. This particular situation is the closest to that found in the manufacturing industries where products are created for the mass consumer market in order to satisfy a percieved customer need by the manufacturer, and are sold with a guarantee. An additional recent development in this particular part of the housing sector market has been the provision of a 15-year warranty with the house to assure the potential customer of the quality of the "product". Schemes such as "Buildmark", and more recently "Foundation 15", offer the customer a degree of assurance about the standard of the housing unit and are backed by mutual insurance societies who in turn make "quality assurance" demands upon their member construction companies (18). The objective of such schemes is obviously similar to that being sought in proposals for "project insurance" in the **non**-housing project sectors of the construction market. This particular sector of the housing market would therefore appear to have all the ideal conditions to ensure that quality as percieved by the client—who in this case is actually the end-use customer—in that—

– the producer—i.e the construction company—can totally integrate his design and construction procurement process,
– the client—i.e the end user customer—has a single contract for the design and construction of the "end product"—i.e. the housing unit, and
– the housing unit comes with a guarantee, the provision of which imposes a "quality assurance" demand on the construction company.

However, the one thing that this situation does not cater for is that of meeting the individual client/end-user's specific needs—and allowing their own value for money decisions on "design and production options" judgements—which can be achieved in the **non**-housing sector markets when the Management method is used. For example paying a lower price for a lower standard of internal finish and fitting which he himself like to upgrade at a later stage of occupation. Although in theory the end-user customer can make the same sort of choice as the consumer in the market place for the manufactured product, in reality choice is limited by location and the price more affected by current interest rates than the intrisic value of the housing unit itself—i.e. a decrease or increase in anything from to 5–10% in price can be caused by changes in the mortgage rate for borrowed capital.

Therefore, in the author's opinion, although on all the above major points the situation in the UK "speculative" housing sector presents the ideal if the quality as percieved by the client and end-user is to be ensured it does **not** allow their involvement in key "design and production option" decision-making as the project evolves. However, involvement of the end-user occupiers through participation in the design development of housing projects is currently being advocated in many parts of the world as the best means meeting "low cost" housing needs in deprived urban environments (19).

Opportunities in the Housing Sector

By taking and combining the most advantageous characteristics of the Design and Build and Management methods used in the **non**-housing project sectors, the housing sector can offer the best situation for ensuring that quality as percieved by the client/end-user is acheived. Participation—whether by low-income groups in urban or rural areas or middle-income groups in suburban areas—can only be sucessfully realised if the housing project process itself is controlled to ensure a “chain of conformance” to defined and agreed requirements from briefing to maintenance can occur. Unless this does occur, the fact that a single point of responsibility for design and construction is provided will not, of itself, be enough to ensure that quality as percieved by the client/end-user is realised—even though they have been inolved in the design decision-making. The detail model offered for the quality management of building projects (20) is the only way of ensuring that **all** the inputs are not deficient in any of the tasks carried out by any of the participants. It is important that this maxim applies equally to the “participating” client/end-user on the “customer” side as it does to the Designer, Construction Manager and Specialist Contractor involved in the “supplier” side of a housing project. This is because the quality management model proposed for building projects is essentially concerned with the functions that are always occurring and unless these are fundamentally addressed for continuous improvement, quality as percieved by the client/end-user will not occur in the final outcome—i.e. the housing development and individual unit.

Therefore, in the author’s opinion, the opportunity for the housing sector is twofold. An integrated design and construction process can be provided by the procurement contract and participation of the client/end-user can be effectively incorporated by the management of a totally controlled process—the **only** way to ensure, and assure, that deficiencies in inputs and defects in outputs do **not** occur in the total project.

6 Conclusion

To summarise, quality can only be realised in construction through controlling a totally integrated design and construction process in which the client/end-user is continually involved in “design and production option” decision-making. Forms of procurement that combine the guarantees of the Design and Build and close participant involvement of the Management methods with insurance backing that demands a “quality assured” approach by all participants are needed to support the effective management to realise such a process control. Participation in housing development should be undertaken in this way if the final outcome is to meet the client/end-user occupier’s housing needs.

References:

1 Sound Practice Committee, Quality Management-Guidance for an Office Manual, RIBA July 1990

2 Cornick. T., A Quality Management Model for Building Projects, International Journal of Project Management, Vol.6, No.4., November 1988

3 International Standards Organisation, ISO 9001–9004 Series Quality Systems 1987

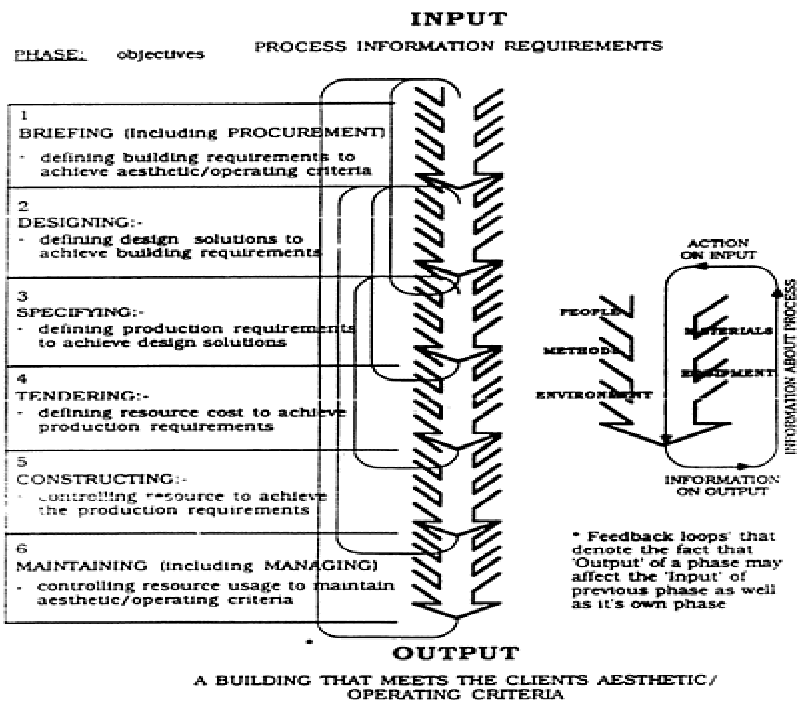
4 Architects Appointment, revised, RIBA 1990

5 Standard Form of Contract, revised, JCT 1980

6 Working Group, Quality Assurance in Building, CIOB 1987

7 Gray. C., Flanagan. R., The Changing Role of Specialist and Trade Contractor, CIOB 1989
8 Cornick. T., Broomfield. J., Grover. R., Biggs. W., A Quality Management Model for Building Projects, Research Project SERC 1986–1988
9 Bennett. J., Construction Project Management, Butterworth Management, 1987
10 Property Services Agency, Quality Assurance, HMSO 1986
11 Achieving Quality on Building Sites, NEDO 1987
12 Thinking About Building, NEDO 1985
13 Cornick. T., Pateman. J., Reducing Avoidable Costs, Kyle Stewart/Reading University, SERC/DTI 1988–1992
14 Centre for Strategic Studies in Construction, Building Britain 2001 Series, University of Reading 1990
15 Centre for Strategic Studies in Construction, Construction Management Forum-Report and Guidance, University of Reading 1991
16 Collateral Warranty, BPF 1990
17 Latent Defects in Buildings: An Analysis of Insurance Possibilities, NEDO, 1985
18 Griffith. A., Quality Assurance in Building, Macmillan 1990
19 Ospina. J., Housing Ourselves, Hilary Shipman Ltd. 1987

APPENDIX 1 **A PROCESS MODEL for BUILDING PROJECT MANAGE**



54
Design quality through land value management

I.DAVISON

Abstract
This paper discusses the conflict between the design objectives of the UK planning system and the concentration of resources in land values caused by restrictive land use allocation policies. It explores the opportunities for design improvements that might be achieved through the adoption of clearer design objectives prior to the establishment of development values and discusses the advantages of a wider application of the "builder licence" scheme for transfer of development land.

Keywords: Land Values, House Building, Design Standards, Planning System.

1 Background

Housebuilding in the UK is dominated by a small number of private companies. Four of them account for around twenty five percent of the annual production. Fifty percent of the total industry output is produced by some forty companies, each of which builds between five hundred and twelve thousand houses per year.(1) Their standard basic house designs are repeated on sites throughout the country with little or no regard for local character, traditional techniques and materials, or the nature of specific sites.

Each new development must have the permission of the local planning authority. Any significant change that the developer may wish to make to an approved development also requires permission. There are two aspects to the local planning authorities' interest: first, the establishment of the principle of housing development on the land; and secondly, the control of the appearance and detailed form of the development.

For the last ten years, local planning authorities and central government have pursued a policy intended to encourage new housing to locate within established urban areas in order to contribute to urban regeneration. This results in lower levels of development land allocation in suburban and peripheral areas than those levels requested by the house building industry. Suburban and peripheral locations are considered by the industry to have the strongest markets and greatest investment potential. Competition for these non-urban sites has increased as the industry perceives that the planning system keeps the supply of profitable development land below demand levels.

This situation concentrates the financial benefit from the allocation of development status with the landowners. Agricultural land in the UK sells for around £4,000 per hectare. Development land for housing averages more the £400,000 per hectare, an increase of more than one hundred times, created solely by the decisions of the local planning authority. Recent rises in the selling prices of new houses have been substantial but have been outstripped by the increasing cost of land for new housing development. Between 1983 and 1988, average new house prices in the UK have doubled. In the same period, the average price of building land has trebled in England and Wales.

This trend has resulted in an increasing proportion of the selling price of new houses being accounted for by the land cost. Based on 1988 figures (the latest available), in the area around London the average building plot cost has exceeded fifty percent of the average new house selling price. Nationally, the average is just below thirty percent. (Land prices have fallen in the present recession as high interest rates have resulted in a significantly smaller overall market. It is expected however that land will still represent twenty seven or twenty eight per cent of the house selling price.)

Although there is general agreement that such high levels of land cost cannot be sustained, there is no indication that the planning system will release substantially more land in areas of high market demand. These high demand areas may be seen to correlate with concentrations of more affluent and articulate existing residents. These communities are most likely to be able to mobilise opposition to new development proposals and to apply political pressure on local politicians.

The restrictive policies have not demonstrated any great success in achieving a significant increase in the proportion of new housing occurring in inner urban locations. This varies between ten and twenty per cent of the total industry output and housing developers argue strongly that this proportion cannot be increased.(2) The increase in land prices supports the view that planning policies have restricted the supply of development land in strong market areas to the extent that excess demand has generated land values which are too high to allow additional resources to fund the achievement of other planning objectives.

The planning system has other objectives that it seeks to promote throughout new housing development. These include:

(a) to pursue new housing that achieves improved design standards in terms of response to existing built and natural context;

(b) increasingly to seek new housing projects that incorporate community development plans and address ecological issues;

(c) to encourage the provision of 'affordable' or social housing within private sector projects.

This paper argues that the planning system will be unable to achieve its objectives until it addresses the fundamental problem of diverting some of the increased value of land, following allocation of development status, from the landowner to the quality of the end product. There is no likelihood of intervention through changes in taxation, which would be politically unacceptable and in any case would divert resources to central not local government, and therefore an alternative approach must be established.

2 The Hurdles to Progress

BDOR’s research for the Housing Research Foundation (3), examining planning’s aspirations for a broader approach to housing development- to improved visual design, better open space provision, more ecological sensitivity, greater contributions to infrastructure and to ‘affordable’ housing provision, has exposed a number of points in the planning system which must be addressed if those broader objectives are to be achieved.

The research is based on five case studies, in Lewisham, Tewkesbury, Hart, Rushmoor and Stockport, a range of local authority areas selected because of the wide diversity of characteristics. A surprisingly consistent set of processes, issues and problems emerged. Local differences naturally produce different patterns but the key points were being made by almost all interviewees, which included not only local authority staff from a variety of departments, but also developers, estate agents, architects and community organisations. The emphasis was on the core of the mainstream development process and identified a number of problems in achieving new housing which has the added qualities sought by the planning system.

At the same time it was clear that almost everybody was aware of the existence of many of these problems, more than willing to seek solutions and in general agreement about the form such solutions might take. This last point—the shared commitment—is absolutely central to interpreting the catalogue of ‘hurdles, which we can summarise as follows:

(a) The creation of ‘hope values’ for land which are based on market-led development and after which any change is certain to be seen as a ‘loss’ by the landowner.

(b) The lack of clear, tested and sustainable policy statements in Local Plans or other local government instruments, establishing alternative housing aspirations such as open space or better design.

(c) The consequent ‘gap’ between policy statements and the development control system which relies on an ad hoc approach to individual sites and applications.

(d) The lack of a mechanism to bring into the development process the detailed knowledge of an area held by the local community; and a consequently negative response from local people.

(e) The inconsistency of the development control process, exacerbated by planning officers general lack of knowledge of development economics and market realities.

It is important to make clear that few if any of these problems are inherent or inevitable features of the basic development process. The desire to achieve improved housing, in design quality, in affordability, or in other features, was a shared desire. This generally held wish to achieve improved housing standards (both within the planning system and within the house building industry) led the research team to identify a basis for intervention in the present development process.

3 Clearing the Way Forward

There is the need for clear policy statements establishing the basis on which the local authority will identify and seek to impose improved standards. The local application of housing improvements needs to respond to different sites, areas, authorities, developers, communities, times and markets. These improved standards are not a short-term price to be paid for the granting of development status to a site, they are the basis for better housing per se.

It was acknowledged that substantial benefits cannot be drawn from developers' profits but can only be funded from the gross land values, resulting in a net reduction in the capital gain to the landowner. The cost of achieving significant design improvements might be in the order of two or three percent of selling prices (or much higher if authorities are seeking to cross subsidise affordable housing). If developers cannot put the cost of meeting planning objectives onto the selling price, and cannot accept reduced profit margins, then the land value is the only other budget head that can bear the cost of the improvements.

Most landowners have a fairly clear assessment of the chances of having their sites allocated for development. If not in the next local plan then one after, as these plans are intended to be produced on a rolling programme. Once the prospect of planning permission is established, the landowner's hope value becomes fixed towards the top of the market price range, and at the same time, the competition for site ownership intensifies. If a landowner is convinced that the planning system will deliver substantial profits, there is little or no incentive to sell the land at something below its market value, even if the final project will be disappointingly poor design.

It also became clear that far too much of the development process is construed as confrontation, as settings in which one side wins and the other loses. The development industry—on all sides—needs to move to a negotiation pattern of 'win: win', where the achievement of wise agreements is not just acceptable to all parties but adds benefits to all.

The research team has suggested that local planning authorities must take the initiative in this intervention and establish four new steps in the development process:

> (a) Prepare area-wide 'shopping lists' of their aspirations for improved housing and include these in the formal Local Plan, which is the legally approved policy document for the area.
>
> (b) Also publish within the Local Plan an agreed mechanism—an appraisal format—against which the application of broad policy objectives will be translated to site specific applicability.
>
> (c) Produce development briefs, incorporating the agreed outcomes of the appraisal for each site, or assess development proposals on the basis of standard format briefs prepared by intending developers.
>
> (d) Ensure that development control staff, who consider specific applications for development, are integrated with policy staff teams during the production of appraisal schemes and development briefs.

In almost all of the elements, who actually undertakes the work is of far less importance than the fact that the whole approach is underpinned by agreement between different parties about content, issues, methods and mechanisms. Differences of opinion will still occur but will be focussed on those aspects which matter most and be dealt with in a context more likely to aid resolution. All of this depends on early, focussed intervention. The argument here is extremely simple. If improved standards are to be achieved then all those involved need either to get together at the earliest possible stage or, at the very least, be able to act with extremely clear guidance about the nature of questions, issues or steps to be overcome at subsequent points in any project's development. If targetted improvements are not at the centre of a scheme's development from the outset, before land value expectations become established, then they cannot be levered back in later.

4 Funding Design Improvements

The conventional method of land disposal is to convey freehold ownership from the original landowner to the developer for an outright payment of the development value before the construction begins. It is normal to have paid a deposit, usually ten per cent, at the time of contract. In the case of large sites, say ten hectares or more, the payment for the land may be sometimes be phased.

It is increasingly common for developers to enter into speculative agreements with landowners by securing an option to buy the land in the event that it is granted planning permission for development. The developers then attempt to secure the allocation of development status, paying the professional fees involved in seeking approval. Landowners sell these option agreements for non-returnable payments which may be as high as £15,000 per hectare. The option system originally enabled the developer to purchase the land, on grant of planning permission, at values substantially below the open market value. Recent agreements frequently limit the discount to less than ten per cent and sometimes specify full market value, a reflection of the high demand for scarce development land.

In these conventional models it will be seen that the land cost, a significant proportion of the gross development value, must be a major capital cost element at the beginning of the development process. This imposes a funding burden which absorbs resources that could otherwise be directed to achieving quality improvements.

We need an initiative which enables the house builder to pay for the creation of quality, in appearance, space, landscaping, materials and the technical design of individual buildings, and yet which maintains commercial profitability for landowner and developer alike. The key to this is to reduce the land capital requirement. This could be achieved by wider use of the builder-licence scheme, a system originated in the New Town Development Corporations, under which house building companies are licenced to develop parcels of land instead of having to buy the site. A development licence is granted in return for a deposit, a percentage of the eventual development value of the land. Title to the land is retained by the original landowner and transferred directly to the house purchaser simultaneously with legal completion of ownership. The beneficial impact on the builders' cash flow and capital employed of not having to find land purchase capital, provides the financial scope for achieving improvements in the quality of the development.

For an enlightened landowner, perhaps someone with a real commitment to the existing community, a builder-licence system provides the mechanism to introduce physical and social benefits to new development without sacrificing a significant proportion of the land value and without asking the developer to reduce the return on capital employed in the project. “Return on Capital” is a conventional business target, it is the product of the average unit profit margin multiplied by the turnover ratio. Turnover ratio is the annual value of sales divided by the average capital employed. In new housing schemes where the land is bought outright, the turnover ratio will normally be in the range of 1.5 to 2. Consider the following examples and their effect on funding design improvements.

> (a) In a conventional outright disposal assume a profit margin of 15%. Let us assume in this example, annual sales to the value of 1.66 times the average capital employed, giving a Return on Capital of 25%
>
> (b) With a builder-licence the capital requirement falls, as only a deposit is paid for the land. This lower capital employed, with the same turnover, will increase the turnover ratio to about 2.75. At the same profit margin of 15%, the Return on Capital becomes 41.25%, a dramatic improvement.
>
> (c) This enables the developer to fund the design improvements at, let us say, 3% of selling price, reducing the profit margin to 12% but still achieving a Return on Capital of 33%, a significant improvement in comparison with the outright purchase example.

Developers with a building licence are obliged to comply with the landowner’s design and quality controls which are far more stringent than those possible under planning legislation. These powers can require attention to detail, the use of quality materials and general care in construction. To some, this may seem a dangerously powerful influence on the freedom of the developer and designer, but the costs of achieving quality objectives can be absorbed because the developer avoids having to raise the capital for outright land purchase. It is this enhanced design control that may encourage planning authorities to consider their role in this initiative.

Planning authorities wish to have more influence on the quality of new housing to achieve their improvement objectives. Under a building licence, landowners would be free to work in partnership with the local planning authority in exercising their control over the detailed plans. This partnership would use landowner powers to influence the quality of the end product. From a planner’s viewpoint, this gives much more security. It may even give planners the confidence to allocate land under this system which would not otherwise be given planning permission, because of the environmental importance of the location.

The financial implications of this system for the landowner are fundamental but not detrimental. The conventional pattern transfers the maximum development value of the land to the landowner before development can commence. Under a builder-licence system, the return to the landowner is achieved over the life of the whole project. The value of each plot, established as a percentage of selling price, is transferred to the landowner as each individual dwelling is paid for by the new owner. This enables the landowner to share in any growth of house prices during the development period, offsetting the potential loss of interest on the capital value of the land.

With a licence, the land value is not established by open market competition (it is an agreed percentage of the selling price) and the developers do not need to pay for the land in advance of construction. It is this reduction in capital requirements and the resultant need to service the capital debt that creates the financial flexibility to pay for higher design standards or to fund social facilities or better open space provision.

The builder-licence system reverses the present relationship between land price and design quality. Competition between housebuilders for identified housing land, released within a restrictive planning allocation process, transfers the control of development to whichever company has been prepared to offer the highest price. It inevitably follows that that company then has the least amount available to spend in the creation of quality in the new development.

5 Conclusion

Planners, designers or developers who pursue design ideals must do so within the constraints of commercial reality. The owner of land which is a prime candidate for development will be confident that the planning process will deliver an inflated price and a personal fortune. There is no incentive for such owners to forego a proportion of this wealth in order to improve the quality of the development. Once the land is allocated, the planning authority has few effective powers over design standards and those that try to impose design objectives at the development control stage are often attempting to increase costs beyond acceptable commercial risks.

The first stage in overcoming these hurdles to progress must be to make clear some mutually acceptable objectives within adopted policy statements. These policies need to identify design objectives before new development land is identified, so that initial concepts of value can take account of the cost of achieving those objectives. If the policies are robust and can be enforced then prospective developers will not attempt to secure land by over-bidding in the hope of recovering land costs at the expense of quality.

The next stage is to develop a better relationship between land value, development profitability and design quality. The builder licence is one way of doing this. Until the system is improved, sites allocated in locations most acceptable to the planning system are those least likely to produce developments of outstanding design. The planning system is constrained to be preoccupied with land use location rather than the quality of the end product. Until the development control system is enabled to base approvals on the merits of the *scheme,* rather than the merits of the *site* (which in turn will promote the transference of more significant proportions of enhanced land value into the quality of development) then it seems probable that most new housing projects will demonstrate inadequate design in acceptable locations.

If the planning system wants to see continued improvement in design standards, especially in times of economic hardship, then it must work through an understanding of development economics. The system must be imaginative and create commercial opportunities. Planners, landowners, designers and developers need to work together in the interests of the built environment, not against each other in the interests of making a few people very wealthy.

The third stage will be to develop a more discerning house buying public. It seems that UK purchasers are very conservative and are certainly reluctant to pay for innovation.(4) Developers may add extra elements, such as improved insulation, more efficient heating, ecologically sensitive open space or better visual design, but today's house buyer expects this to come at the same price as the basic, standard model. It is only through enabling inproved designs to be achieved and allowing those improvements to filter through the market, that we will spread sufficient awareness to have a consumer led demand for better quality.

References

1 The sources for statistics in this section are Laing and Cruickshank, Housing Market Analysts; the Department of the Environment; and, the Halifax Building Society. Readers wishing to pursue statistical information on UK housebuilding are recommended to: Fleming, M.C. (1986) **Spon's Guide to Housing Construction and Property Market Statistics.** E & F N Spon, London.

2 The HouseBuilders' Federation (1987) **Private Housing in the Inner City**—report of an independent commission. HouseBuilder Publications, London.

3 Bishop, J. and Davison, I. (1989) **Development Densities, a discussion paper**. Housing Research Foundation, London. and Bishop, J and Davison, I. (1991) **Development Briefing**. (Interim research report) BDOR Ltd, Bristol.

4 Bishop, J and Davison, I. (1989) **Good Product, Could the Service be Better?** (Study of consumer attitudes in trade-up housing). Housing Research Foundation, London.

55
Contemporary quality control systems: case studies and lessons learned

G.T.DREGER

Abstract
Early on a Sunday morning in the Spring of 1985, ten thousand square feet of the exterior stucco cladding system on the new jail and justice center in Fort Myers, Florida pulled away from the substrate and fell to the pavement below. At the same time, one thousand miles and two states away, two luxury residential condominium complexes on Hilton Head Island, South Carolina were starting to experience the results of defective exterior cladding and other building systems failures which would later lead to multi-million dollar claims, corrective actions, and costly litigation. The diverse projects shared one major and fatal characteristic: Lack of quality control during the design and construction processes. Control of quality in building systems demands positive management applications from the programmatic phase through design and construction. This study presents three case studies involving serious quality deficiencies and major systems failures which illustrate the need for the application of comprehensive management control systems to ensure quality. Discussions of quality control methods are presented to demonstrate how proactive attention during design and construction can eliminate costly project defects and deficiencies.
Keywords: System Failures, Owner Risks, Quality Control Methods, Project Attributes, Procurement Methods, Management Information Systems, Standard of Care.

1 Introduction

Customer risk in construction has dramatically increased in recent years. The likelihood of financial exposure and cost risk occurs throughout the life of the project for the owner. Often the owner is exposed to risks as a result of the building production process greater than any other a company normally faces. The United States Business Roundtable, in an analysis of quality and cost effectiveness in the construction industry, reports that, "Owners, who pay the bills, no longer get their money's worth for construction in the United States". Tracking productivity in construction for three decades, starting in the mid-sixties, the report states that quality levels and return on investments have been falling at a steady rate, and continue to decline.

The central message of The Business Roundtable study is that the industry requires fundamental and far-reaching alterations in the way the building production delivery works, in the whole process by which structures are put together. They concluded that changes were needed in the way construction is planned, managed, accounted for, thought about and regulated.

This paper will present three case studies which are typical examples of negative impacts on building projects as a result of inadequate, or non-existent applications of quality control management systems.

2 Case Studies

The three projects presented here each share common conditions which played major roles in the ultimate lack of systems performance and untimely failures. The projects were all located in a coastal region with high winds, heavy rainfall and salt-laden atmospheres. The projects were each clad on the exterior with a cement plaster stucco cladding system. Each of the projects was intended to be of the highest quality building with projected life spans of 30 to 40 years. And finally, the projects were each designed by reputable architectural firms and constructed by alleged competent, bondable contractors.

3 Case Study One

The Lee County Judicial Complex, completed in 1984, is a US$33 million, 500,000 sq. ft (46 500 m^2) six-story concrete frame structure housing the county's courts, jails and other related judicial functions. The complex encompasses a city block in downtown Fort Myers, Florida and presents a six story facade of painted cement plaster stucco cladding as shown in the photograph in Figure 1. The facade treatment of stucco as the exterior cladding is a common material used throughout South Florida. What is not common about the facade system is the method used to secure the stucco cladding to the substrate. The system ultimately employed had not had widespread use in the geographical area and was certainly not tested as an entire system in the coastal environment of Fort Myers prior to installation on the public facility.

Fig. 1. Lee County, Florida Judicial Complex

3.1 Failure Causes

No single factor contributed to the failure of the stucco cladding system on the Lee County Judicial Center. Figure 2 depicts the conditions immediately after the wall collapse occurred. As the facts surfaced through a research and discovery process, it became apparent that the failure which cost owner over US$1 million to correct, was the result of several key conditions, which collectively produced the environment which resulted in the system collapse. The factors included (1) inadequate types of steel fasteners used to hold the vertical Z channels to the concrete block substrate, (2) excessive corrosion of the steel fasteners as a result of inadequate zinc coating, (3) an inordinate amount of efflorescence on the substrate as a result of water soluble chloride residue. The chloride build-up attributed to accelerated corrosion of the steel fasteners, and (4) two additional physical phenomena at work which contributed to the untimely failure. One was a condition known as “stress corrosion”, a form of accelerated corrosion which causes brittle fracture of steel at low stress loads. The other phenomenon is best described as “crevice corrosion”, wherein the spalled crevice produced by the shooting of metal fasteners into a cementitious substrate causes an inordinate attraction of moisture at the shank location of the fastener. The moisture in this case carried water-soluble chlorides which reacted to the shanks of the steel fasteners supporting the vertical steel “Z” channels, and literally ate them up.

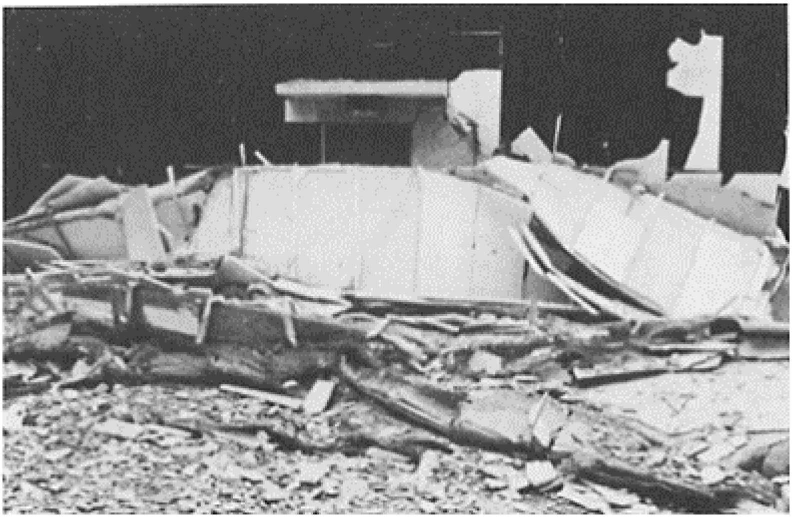


Fig. 2. Close-Up view of Failed Cladding System

4 Case Study Two

At the same moment in time and 1,000 miles away, two luxury residential condominium projects on Hilton Head Island, South Carolina were in their early stages of completion when major building problems emerged.

The first project, an eighty-eight unit US$12 million complex, as depicted in Figure 3, was barely completed when major building systems began to fail.

The primary areas of failure included:

1. Inadequate flashing systems at the exterior doors and windows.
2. Improper sealant material used as caulking compound for differing material and building plane intersections.
3. Failure of the single-ply membrane roofing system.
4. Failure of the barrel-tile roofing system.
5. In-operative electrical over-current protection for the eighty-eight air-conditioning system compressors.
6. Collapse of the masonry walls of exterior planters.
7. Erroneous use of stucco on horizonal surfaces as a water-proof barrier.

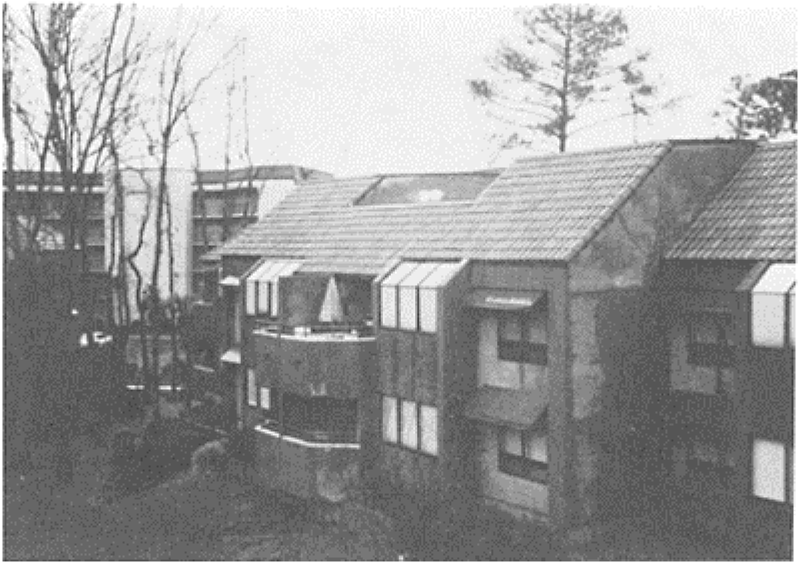


Fig. 3. 88 Unit Condominium Complex Hilton Head Island, South Carolina

All of the failed systems have now been corrected at a cost of over US$1.5 million. The owners are currently seeking recovery in the U.S. Civil Courts. An example of the poor workmanship and lack of quality control related to the roof system, stucco system, and flashing system can be seen all at once in Figure 4. Notice how the roof tiles do not extend over the eave as they should; how the eave drip-metal flashing was inexplicably omitted; and the unacceptable stucco intersection at the roof plane.

5 Case Study Three

The second project under review on Hilton Head Island is a one-hundred and forty four unit residential condominium complex with a mix of one and two story buildings, as depicted in Figure 5. The exterior is a smooth stucco cladding and the roof surface is comprised of large wood shingles arranged on a random pattern of gabled and hipped roofs. The units are considered luxury class and sell for US$350,000 to US$500,000 each.

Soon after completion and occupancy in 1985, this project too started to experience major problems which later were determined to be attributable to a lack of quality control in the design and construction processes. The major problems encountered included:

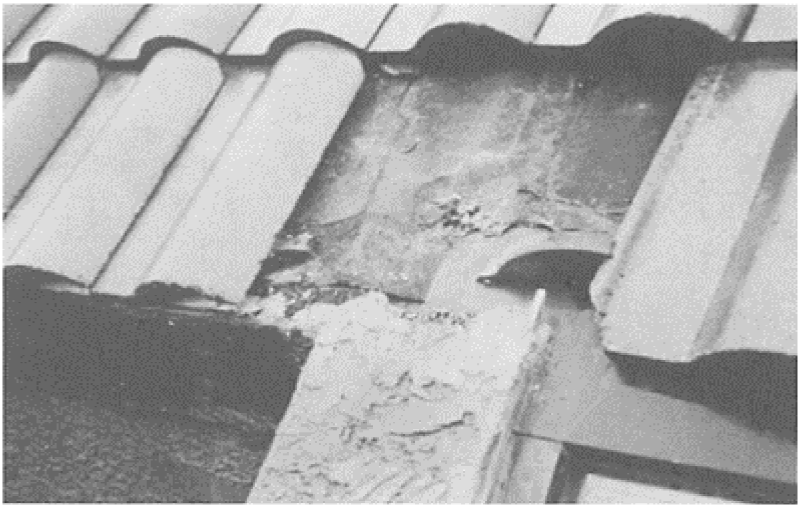


Fig. 4. Example of Deficient roof. Stucco, and Flashing Systems in 88 unit condominium project

Fig. 5. 144 unit Luxury Condominium complex on Hilton Head Island, South Carolina

1. Decay of exterior millwork.
2. Defective metal caps at chimneys.
3. Settlement and cracking of patio concrete slabs.
4. Water infiltration a wood decks and wall intersections.
5. Inadequate fire resistive separation between units.
6. Inadequate crawl space ventilation.
7. Uncontrolled water runoff from the roofs.

6 Quality Control

The management of quality in the production of buildings begins with the realization that successful projects result from mutual understandings and efforts between owners, designers and constructors. If the project is to be successful, each party must play a major role in recognizing, establishing, and orchestrating management models which define levels of quality as the project progresses throughout its discreet phases.

6.1 Program Phase

The management of quality for a typical building project starts with the programmatic phase of the project. In this initial phase the basic project attributes or inherent characteristics for the project are identified and established. Such attributes should be identified by the owner and quantified by the designer or construction manager. As quality is generally a direct ratio of cost, cost allowances should be assigned to each building system and sub-system as the project program is developed. The program should then be used as the base for budget and quality control throughout the design and construction phases. A list of typical desired building attributes suitable for quantification in the residential scale of the three case studies presented might include:

1. Length of Ownership
2. Environmental Factors
3. Useful Building Life
4. Return on Investment
5. Cost of Ownership
6. Purchase Price
7. Re-sale Value
8. Operation and Replacement Cost
9. Types of Sealants
10. Types of Roof Systems
11. Types of Windows and Doors
12. Interior Finishes
13. Water Run-Off Control

6.2 Design Phase

The quality factors attributable to the building design process should be placed in a manageable form when all desired project objectives are finally developed. The list of objectives includes not only the related attributes unique for the immediate project, but also should consider the two "constant" variables inherent in all building projects, initial cost and life cycle cost. These two indispensable elements must be clearly identified and considered at the start of the design phase along with the project attribute objectives if quality objectives are to be achieved during design.

6.3 Procurement Phase

The procurement of the construction contractor presents the owner with a variety of options related to both the contract systems employed and methods of procurement. Each variable method has associated predictable risks involving cost and quality which can be managed depending upon the systems selected and a knowledge of the potential related to each system. Owner's cost risks are usually minimized when the contract is based on a lump sum or guaranteed maximum price. Quality assurance is maximized with negotiated variable rate contracts. The contractors financial risks are most favorable when the contract system is based on actual cost plus a fee. The type of contract form selected should ensure the highest economic value and least exposure for the owner. The owner should make the choice of systems employed.

6.4 Construction Phase

Quality management in construction involves the establishment of management information systems which identify the item source, quantify the cost potential, and provide clear lines of authority and accountable responsibility. The management systems should include the following features necessary to analyze risk liability potential and manage quality during construction.

–Recognition of what exposure is involved
–Quantification of what is at stake and the determination of the economic value of the exposure
–Identification of who has the power to control the outcome
–Determination of who should assume the responsibility

Such a rationale of quality management principles is a relatively natural activity at the beginning of the project. However, unless careful management control plans are developed and implemented after the project start, the proactive offensive management objectives will be overtaken by the reactive environmental influences which permeate construction projects. Be wary of such conditions. The construction related deficiencies noted in the case studies were primarily the result of no ongoing attempt to employ management information systems or the assignment of competent personnel to control the quality of the systems which ultimately failed.

7 Standard of Care

The aggregate of problems resulting in system failures on the three projects provides a glowing example of conditions which occur when the standard of care doctrine is not applied. The standard of reasonable care, a legal basis for determining design and construction competence, is a very old concept emanating from English common law and used in the judicial arena today. Essentially, the law says that a design and construction professional is required to exercise a degree of care, skill, and diligence in professional practice equivalent to what may be reasonably required of others in that profession, given the specific time, place, and circumstances. The concept of reasonable care is constant and never changes. What changes in the design and construction industry is the technology, and the means and methods of professional applications and their achievements. The prudent owner, designer, and contractor must recognize such incremental changes and adapt management systems to accommodate the interest of each party.

As the analysis of the problem areas of the three case-study projects progressed, it became apparent that no rational attempt was made either in design or construction to apply the doctrine of standard of care.

8 Conclusion

The management and control of quality in the building project delivery process begins with the development of the program to identify, quantify, and incorporate the owners attributes and objectives into the project. As the design unfolds, careful attention must be given in the assignment of task responsibilities. During construction, reasonable attention must be focused on the assignment of responsibilities and liabilities for the competent installation of the building systems. Without the use of these basic management control principles, quality cannot be assured.

The overriding lesson learned from the three projects was that no effective management control systems were applied on a continuing basis. The wall collapse in Fort Myers was predestined as the result of failure to test the entire system on-site in the salt-laden atmospheric conditions of the coastal city. The two Hilton Head Island residential complexes failed in many ways due to the lack of applying the basic concept of “Standard of Care” as the projects progressed. All of the failed systems could easily have been prevented if management models assigning responsibility and accountability had been employed.

Visionary management techniques are not only desired but have become necessary in today’s complex and litigious prone industry. Proactive attention to even the smallest, element, such as which sealant material is most suitable, can head off costly failures and possible law suits. The dynamic shifts in specialized roles of those that produce our buildings and the continued development of new and exciting building materials and systems must be coupled with innovative management control approaches if tomorrow’s buildings are to be totally successful.

9 References

Dreger, Garvin T., AIA, Sept. 1986, **An Evaluation of the Exterior Stucco Cladding System Design,** Lee County, Fort Myers, Florida.

Dreger, Garvin T., AIA, Oct. 1990, Quality Control Using Proactive Management Techniques, in **Proceedings of the New Zealand Institute of Building, Inc.,** Building for the 90's, Auckland, New Zealand, pp. 49–61.

Failure Analysis Association, Jun. 1985, **Investigation of Fastener Corrosion on Exterior Walls, Lee County Justice Complex,** Houston, Texas.

Franklin, J.R., 1989, An Architect Looks at the Standard of Care, **Pro Net Practice Notes,** Alexandria, VA., Vol. 2, No. 2.

Ink, Stanley K., PE., Sept. 1986, **Report of Lee County Justice Center Stucco Failure,** North Fort Myers, Florida.

The Business Roundtable, Feb. 1983, A Message to Owner's Who Pay for Major Construction in **A Report on the Construction Industry Cost Effectiveness Project,** 200 Park Ave., NY, NY 10166.

56
Post-occupative quality evaluation of school buildings, a case of study

M.A.ESPOSITO

Abstract:
The goal of the project promoted by the Regione Toscana-Giunta Regionale (Region Authority) is to investigate the conformity to usage of school buildings existing in the region. The purpose is to measure the quality of location, function and structure of school buildings. A data structure is purposed for the direct collection of relevant data. The data collected from the entire region will be used to create an information system for school buildings. The information system shows the user any changes made on the territory. This helps in making future planning decision for the region. In particular this system shows school buildings whose usage conforms to the new program and those that are below acceptable quality standards. This allows the uses to make a ranking based on quality and establish priorities.

Keywords: Geographical Information System, Public Schools, Existing Buildings, Quality Evaluation, Management of Financing, Planning.

1. The context: schooling in Italy

The problem of quality and effectiveness of the school system in Italy is currently being studied, above all, in view of Europe after 1992.

A recent research project[1] shows that in spite of a very large annual budget for schooling (about 3 million liras per student with an increase of 52% on the budget for 1980) the quality level is very uneven around the country. The main problem of italian situation with respect to other countries is based on three issues:

– Existence of dropouts in middle school.
– Presence of inequality among different regions of the country.
– Lack of national standards for quality control of schooling and the support system of instruction in Italy.[2]

[1] Cen.s.i.s. (nov. 1990)
[2] Cen.s.i.s. (nov. 1990)

Studying and solving these issues is of great importance for our country. These is a need not only to check and program the pubblic money for schooling but also to guarantee a system for training teachers up to international standards.

A rising issue in the control of reforms suice we observe a tendency of the system to divide up. These may increase the geographic differences mentioned above.

Locally, efforts are made to increase the understanding of the problem of the territory, focussing on the structure and organization of the school. In contrast with the delay (registred in 80's) of national reforms mentioned above, great dynamism in observed locally where schools change rapidly with society.

This phenomenon has allowed scholls to introduce experimental programs. Such programs have started in varying proportion at different places.[3]

It is hard to monitor the effectiveness of such programs due of a lack of a national standards; a lack of flexibility of the norms and a lack of information regarding existing programs.

Innovations have Been registred in 31.2% of the high schools nation wide. The Piano Nazionale Informatica (National Computer science plan) has reported that programs were started in 41.6% of the schools in central Italy compared to only 25.4% in the north of Italy and 22.9% in the south.

Studies conducted by specialized institutes have found different approaches to school reform in Italy. Different situations are focused on local realities and geographic location. As shown by studies done in different areas of the country, innovations (also regarding national reforms) have proceeded unevenly. As a result some areas have excelled and others have not. The situation appears to be best in the central of Italy where the social issues are less conflicting and more dynamic social realty exists, (see table 1)

Table 1. Innovation in Italian school (Cen.s.i.s. data 1990)

	low innovation rate	high innovation rate
South	20.4%	4.5%
Centre	3.5%	20.4%
North	5.3%	19.0%

2. Objective of the project

The census of school facilities in Tuscany was started in 1988 with a research on a model for data collection on the territory. The model should allow a fair collection of data to be used in the region to budget financial resources for school facilities. Before the census apportioning of money was not based precisely on technical consideration, unless in emergency (natural calamity, etc.), because there are no data available or data were kept by different public board, institution or agency (like: Commune, Civil Engineers, Land

[3] see the norms of the law n°148, 5/6/90

Registry Office, etc.). In any case even if available data could not have been used by the Regione to operate a sistematic planning activity.

The models provided by the burocratic sources are rigid compared with the actual increasing variety of the problems Authority is facing. Futhermore the need of verifying how suitable different schools are, implementation of the new programs is added to already existing problems especially in the case of less innovative schools (guardianship area). In such cases schools are totally inadeguate to the education needs and often to the habitabilty standards.

The model should allow optimization for schools in the excellence area, as well as show inadequacy of schools in the guardianship area.

The lack of facilities in schools varies largely. The excellence area schools mostly need advanced tools like computers or sophisticated improvements of the school buildings (like acustic improvements). On the other hand the guardianship area schools are in need of basic facilities (like classrooms or labs).

Lately in Italy great stess has been given to environment problems. Many project have started to create a centralized information system[4]. Such information could be used by our model and made available later if necessary also in case of school buildings used differently from schools (as directed by the governament throu a Ministry: “Ministero dell’Ambiente”, “Ministero dei Beni Cultural!”, etc.)[5].

On the other hand in Italy, particulary Tuscany, historical buildings are often used as schools so that financing and restoration are not managed by the “Ministero della Pubblica Istruzione” (Ministry of Education).

Financing from the Governament does not agree with the local policy of innovation and it is often discontinous and focused on totally marginal issues. The model of the information system should be flexible for different technical programs in the region.

It semed necessary to use advanced tools for collection and analysis of data. On such technical goals is based our information system for data collection on the territory.

[4] CIPE (Comitato Interministeriale per la Programmazione Economica) (1990)
[5] Ministero della Funzione Pubblica (1990)

3. Technical goals of the project: the model

The objective of the model is to come up with a complete description of structure and usage of school buildings. Such description should allow qualitative evaluation of schools buildings and allow collection of data to be compared with others infrastructure’s data bases interactive with the school model. Besides that all data must be geographically related and refered to regional base cartography.

Comparison and evaluation are made between data collected and the standards imposed by law for public buildings[6] as well as for school buildings.[7]

New standards are introduced to evaluate the comfort of the interior of the school buildings. This way the satisfaction of users is measured using parameters not taken into account by any norm.[8]

Technical goals, determined jointly with the “Dipartimento Istruzione e Cultura” of the Regione Toscana, defines the inputs for the information system. The model was developped in two phases:

1. macroanalysis
2. microanalysis

From the analysis of possible areas of improvement made by the Regione Toscana and the relative data we found three levels refered to phase 1:

1.1 Territory to refer to
1.2 School infrastucture
1.3 System interacting on the territory.

Phase 2. includes two steps:

2.1 Entities analysis
2.2 Individuation of data classes

The first step of the project is the definition, collection and validation of data concerning school infrastructures (1.2); such data are to be collected using tools from the orderer. (see fig. 1)

For this purpose the individuation of data classes was refered to a meaningfull zoning of the territory (Italy is divided into provinces).

In phase 1 of the project the data record format has been established according to the following four modules concluded from microanalysis:

a) Spatial location
b) Functionality of the space
c) Interior comfort
d) Technical level

The peculiarity of data required specific training of the technical personnel responsible for data collection in each

[6] see the norms of the DM 27/04/78, n°384
[7] Ministero dei Lavori Pubblici, DM 18/12/75
[8] This topic is developed in a parallel degree thesis: De Santis M. (AA. 89/90) *Controllo di qualità in fase di gestione: analisi di un campione di scuole medie nella Regione Toscana,* Università di Firenze

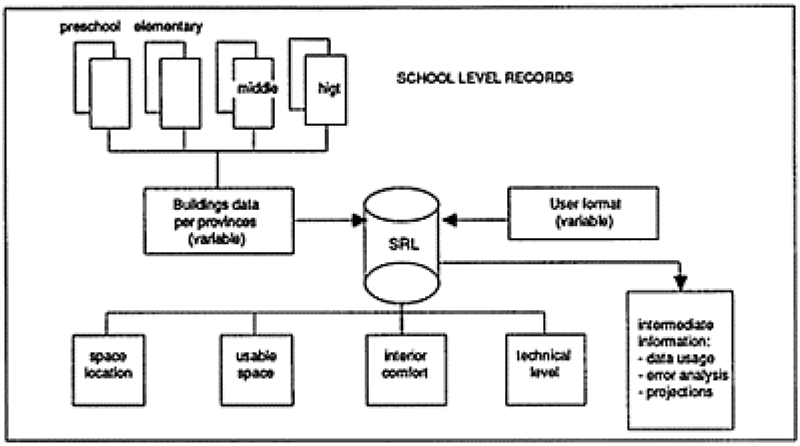


Fig. 1. Phase 1 of the project

province. This made the data collected homogenous, simplifying the task of the official data owners (Commune, Civil Engineers, Land Registry Office, Region Authority).

Through the SRL program it is possible to check the usage of data in real time. One can also perform error analysis using intermediate information and forecast data.

Data collection, one year from the beginning of the census, has covered 50% of the total region and has alredy been completed for some provinces.

Later we plan to aquire the regional base cartography through a GIS (Geographical Information System) referring to other projects started by the Regione. The geographical reference of the data, collected on school infrastructures in fhase 1, allows one to set up maps.

During the last phase of the project, different information on systems interacting with school infrastructures, is integrated with our system.

In the micoanalysis step information modules, function and data of interest for the macrolevel of systems interacting on the territory are pointed out. The goal is to merge into the GIS other data bases: regional national or external sources. We distinguish classes of data concerning:

Administrative boundaries (Town General Planning, etc..)
Transportation infrastructure
Infrastructural network (roads, highways, railways, etc.)
Antropic social and economic data
Environment.

Availability of data in the classes mentioned above leads to a more complete analysis and better planning. For istance priorities can be established on action to be taken on historical buildings based on environmental data.

The system supports studies on optimization of school location in relation to school age population, rate of population growth and trasportation facilities. The system can be used to forecast future usage of existing buildings so that plans can be made to build extra space or utilize the existing one differently.

By providing a relational data base, the GIS should allow one to monitor the system of schools in the region: to define priorities and to stimulate and control complex situation on the territory involving schools and related infrastructures.

The system can be used to integrate different functions and computer technologies of the region Authority. (Fig. 2)

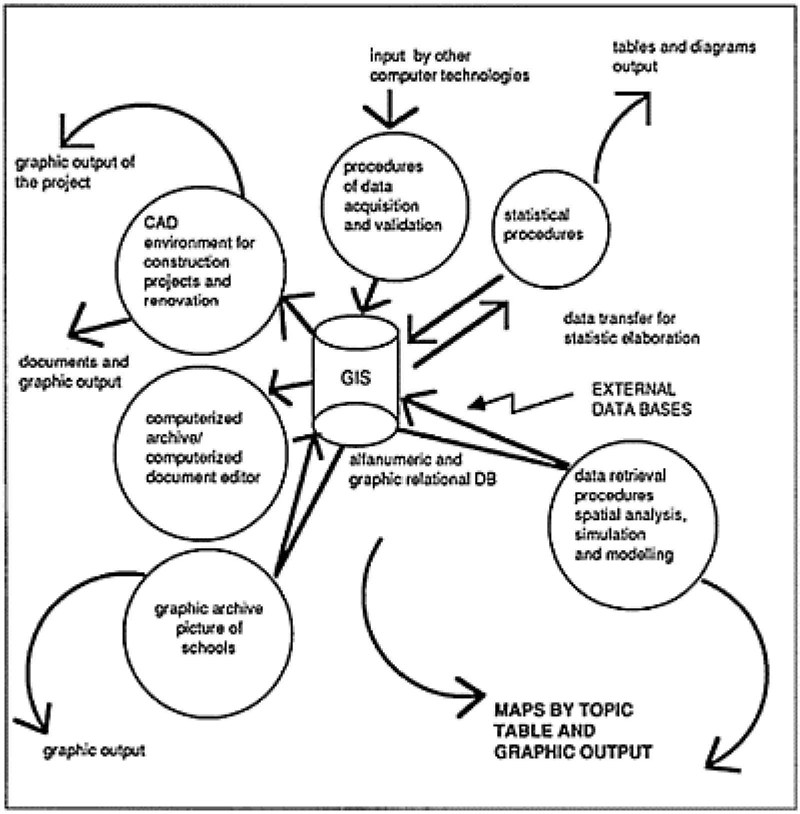


Fig. 2. Functional scheme of the final configuration of the system

4. Tools used in data collection.

Data was collected using a different set of records for each school level (preschool, elementary, middle, high). We distinguish two types of data:

General data of identification and location

Data specific to a school level.

The first field of the record is common to each school level and is the key to get a specific record. However retrievals can be made using any field of the record through specific queries.

The first field of the record contains information regarding name, location and age of each school building. Later fields contain information on quantity and quality of classrooms and other facilities. We can also find data on comfort of such spaces.

Tha data on location allows use of the data base on the part of tematic map makers. Data on quality of spaces allows one to evaluate conformity of each school to national standards, particulary for buildings dated before 1975.

Data on special facilities (gyms, parks, parking lots etc.) allows one to evaluate the quality of school and the area were it is located on the urbanistic point of view.

Data on technology used to build the school and data on its preservation allows one to evaluate the level of maintenance. This data retrieved jointly with data on comfort gives an ojective analysis of quality.

Data bases are open and updatable, particulary for data concerning maintenence or update of buildings based on new regulation (e.g. fire security, handicapped access).

5. Conclusions

The system helps evaluations on a global as well as local level. On a global level the system helps production of maps on the relation between schools and territory; for example:

– Ranking of school buildings belonging to the execellence area or to the guardianship area, or to the area not in accordance with norms (i.e. school buildings where living standards are not acceptable);
– Highlights or bad environment for school buildings;
– Visualization of user classes for different school levels;
– Maps of historical buildings used as schools;
– Etc.

On a local level the system helps to come up with project for future construction or update. For example:

– Definition of building profile (made by dimension, functionality, comfort etc.);
– Evaluation of how accessible schools are
– Etc.

Comparision of such data with data concerning experimental programs may become a very important factor on decision making.

The data base, as used by an information system geografically related may help law and decision makers at different levels:

– Region Authority for planning and programming
– Provinces and Communes for actual actions;

further the Provincial Education Offices may decide new experimental programs on a realistic view of the infrastructural support.

In conclusion the System provides to the community a tool that totally changes the traditional approach. From a-posteriori control system to a-priori support system, designed in function of projects in the sector and providing quality control on future decisions.

6. References

Cen.s.i.s. (nov.1990) **L'efficacia del sistema scolastico,** Roma.

Cen.s.i.s. (nov.1989) **Per un servizio nazionale di valutazione, studio di fattibilità,** Roma.

CIPE (Comitato Interministeriale per la Programmazione Economica) (1990) **Programma triennale 1989/91 per la tutela ambientale,** G.U. 8/9/1990, n°210, parte 1°, relativa alla deliberazione CIPE del 3/8/1990.

Ministero della Funzione Pubblica (1990) **Indirizzi di normalizzazione nell'area delle tecnologie dell'informazione nella Pubblica Amministrazione,** circ.n°51223, del 21/5/90.

DM 27/04/78, n°384, **Regolamento di attuazione dell' art.27 della L.30/03/71 n°118 a favore dei mutilati invalidi civili in materia di barriere architettoniche e trasporti pubblici**.

Ministero dell'Interne DM 08/03/85, **Direttive sulle misure più urgenti ed essenziali di prevenzione incendi ai fini del rilascio del Nulla Osta Provvisorio di cui alla L.07/ 12/84 n°818**.

Ministero dei Lavori Pubblici, DM 18/12/75, **Norma tecniche aggiornate relative all' edilizia scolastica**…

Esposito, M.A. (1989) Valutazione della qualità post occupativa, in **Controllare la qualità in edilizia** (eds R.Del Nord and M.C.Torricelli), Università di Firenze, Polistampa, Firenze, pp. 181–205

57
Comfort and new strategies for passive solar buildings

E.de OLIVEIRA FERNANDES

Abstract
The concept of passive solar buildings has evolved significantly during the last twenty years. In the early seventies, the focus was placed upon solar energy collection and storage for heating purposes only, and the dominating perspective was the substitution of conventional energy sources and equipments. The main application was in residential buildings. While centered on (solar) technologies, that approach to improve indoor environmental conditions was too far from the highly sophisticated technological approach represented by the use of air conditioning for producing comfort.

Today's quick pace of change has however contributed to make those two worlds much closer than one could imagine at first sight. The growing consideration given to different types of passive non-residential buildings, many of which equipped with some type of air conditioning system, and the fact that air conditioning systems are being themselves identified as sources of contamination for both indoors and outdoors, converge to suggest reductions in auxiliary energy systems both in terms of dimension (power) and use (energy).

This paper will discuss the implications of comfort on the strategies for building design along the ideas discussed in the previous paragraphs, with a special emphasis on nonresidential buildings.

Keywords: Comfort, Passive Solar Buildings, Building Design, Energy Conservation in Buildings.

1 Introduction

Today, the design of passive solar buildings requires much more than just having the “know how” about solar technologies.

On the one hand, solar technologies, solar components and solar systems cannot be separated from the building itself, i.e., from its architecture; and, on the other hand, the main system to be considered is precisely the building itself, i.e., its architecture, construction and operation or use all together. This perspective calls for an integration of the work of all the actors in the design process, e.g., architects, lighting and comfort engineers in particular, Oliveira Fernandes (1989).

The situation, however, is much more complex than that. In fact, the generalised lack of practice of integrated designing work is not the only factor to have a negative impact. One must recognize that the knowledge is not well enough developed and organized nor even available to support such an integrated work. Each side in the building industry needs to prove their points to the others. A lot of interdisciplinary work is to be made.

The use of passive solar technologies is quite well supported by design aids, but most are only valid for heating rather than for cooling, and they do not pay enough attention to nonthermal comfort, particularly the daylighting aspect. Besides, they have been intended for passive solar buildings where the auxiliary energy has been meant only as heating energy.

Passive cooling has not yet been addressed in too much depth and the special cases when there are needs for both heating in winter and cooling in summer has even deserved less attention.

Concerning the problem of comfort, there has been a large research effort during the last twenty years towards attaining a qualitative and quantitative understanding, but there still remains much more work to be done to deal with temperature floating conditions, warm environments, transient situations, outdoor versus indoor climatic conditions, etc.

The scope of this paper is to characterize the evolution of the concept of passive solar buildings during the last twenty years and to identify the consequences for the design activity in the nineties. It can be antecipated that there is a need for more developments in solar technologies (e.g., glazings, shading devices, insulation systems such as transparent insulation), but a greater amount of effort must be placed on the specifics of every problem that a new building design represents: better knowledge of local climatic data and better understanding of comfort criteria in order to make the overall integration of all the important issues during the design process easier and more successful.

2 Evolution of the Concept of Passive Solar Buildings

Today, the concept of “passive solar building” does not have the same meaning it used to have in the seventies. Then, they were simply called “solar houses”. The concept, as we understand it from the literature on solar energy, has evolved significantly. In the early seventies, the focus was placed upon solar energy collection and storage for heating purposes only. The dominating perspective was the substitution of conventional energy sources as well as auxiliary equipments and systems. The main application was in residential buildings. The main issue was more technological, i.e., an integration of components into an architecture that only occasionally was special. Most of the time, conventional architecture was the rule.

Although the approach was fully technological at heart, it was too far from the highly sophisticated technological approach that the use of air conditioning for providing comfort tends to represent. The main objective was not really to reach precise comfort conditions but, rather, to reduce conventional energy consumption. Therefore, the use of auxiliary energy, particularly for heating purposes, was not eliminated but just displaced.

Meanwhile, the reduction of conventional energy consumption was usually followed by drawbacks such as overheating or large temperature fluctuations. In any case, most passive solar buildings were designed accepting the implicit rule that some fluctuation of temperature and, particularly, some overheating was to be tolerated. That is why most of those buildings were residential or, at least, buildings with some low level of occupancy where occupants were allowed, when not encouraged, to interact with the systems and their controls.

As such, the guarantee of reaching comfort conditions as they are defined by current standards was not ensured. That does not mean, by the way, that the users did not declare themselves satisfied with their houses: they accepted to bear some discomfort on behalf of an option that they had consciously taken by several different reasons, with economics certainly not among the foremost. The variations in the environmental conditions should not necessarily be interpreted as sources of discomfort, at least when they were kept within acceptable bounds.

The world of passive solar buildings and the world of air conditioning systems seemed to be completely apart:

a) ideologically, the former was relying more on soft technologies, it recalled some vernacular practices and rules, and it represented a more friendly approach to the environment and nature, in general; the latter was based on systems that relied on hard energy and on a sophisticated technology.
b) Functionally, or practicaly, passive solar systems were more interactive with the user, while air conditioning systems, to some extent, tended to subdue the user.

Today's quick pace of change has however contributed to make those two rather apart worlds much closer than one could imagine at first sight: on the one hand, passive solar buildings became, above all, "buildings" rather than "diagramatic ensembles" that collect and store solar radiation; on the other hand, the overall "efficiency" of air conditioning systems became a cause for controversy as these systems were themselves identified as sources of contaminants for both indoors (olfs), Fanger (1987a) and outdoors (CFCs).

Nowadays, the general driving force for building design, from the thermal comfort perspective, became, in any case, to reduce the needs for air conditioning through two main paths:

a) reducing building loads, both internal and external, by any means. This is the role of the passive solar approach from the very early stages of the design process (urban plots, siting, orientation, openings) to the characterization of the building components (insulation, glazings, heat storing mass, etc.);
b) allowing for some fluctuation of the indoor environmental conditions, taking advantage of the large number of parameters that influence comfort.

The final objective in the nineties is no longer the simple reduction of energy consumption. Buildings are more energy efficient anyhow, and the energy prices are, at least for now, not significantly higher. Nowadays, the final objective is to integrate the energy side of the problem with a wider group of criteria such as: better quality in general; better dialogue of the user with its environment; and more responsability of Humankind regarding the global environment.

Therefore, the new allies for designers of well designed buildings, no matter what they are called, e.g., “passive solar buildings”, “bioclimatic buildings” or “buildings designed with the climatic”, are the environmentalists and the consumers themselves rather than the energy conservation people. These two groups both act as advanced sensors of the limits of human intervention regarding the respect for Nature.

3 Moderate Climates: Paradise for Passive Solar Buildings

As already noted, the very first motivation to promote solar energy in buildings was to substitute the use of conventional energy that had apparently become scarce for several reasons. The high energy prices could thus support the technological development of new devices and the logic was a piece by piece substitution.

So, it is natural that most of the iniciative originated in the Northern countries: there was a higher need of energy for comfort (and survival!); they were technologically more developed and better prepared. But, as they particularly demanded energy for heating, it is thus natural that, in the begining, much more attention was paid to active rather than to passive solar.

It is curious to notice, however, that when passive solar started to emerge, its logic was also very much oriented towards components and systems. The solar houses were in general too architecturally biased to be called real architecture. Architecture was not called to play a central role in the design process. Architectural schools and styles did not care about thermal comfort nor about the energy issue as addressed by the technical people.

Following this period, however, the role of passive solar technologies for cooling, as well as for heating, was stressed through the interpretation of regionalism in architecture and construction techniques. And, in moderate climates, vernacular architecture is characterized by massive buildings with a large variety of solutions to respond to different microclimates. In these climates, heating is not very important but it still is needed during the winter season. Conversely, cooling or, at least, heat atenuation is always necessary in the summer season.

Passive cooling, as well as passive heating, becomes a very important objective for well designed buildings. Both ask for better consideration of visual comfort together with thermal comfort. And for the latter the thermal inertia is a must.

In moderate climates, the building design process is an architectural challenge. Rafael Serra (1988a) called it the “architecture of complexity”. But, as it happens with many things in our world, it finally becomes, if successful, the architecture of simplicity, because through architecture and construction alone the building can get very close to the comfort conditions desired for both winter and summer.

Passive solar does not necessarily guarantee precise comfort conditions. It is based on the principle that some fluctuations of the indoor climatic conditions are allowed. As a matter of fact, in most regions with moderate climates, there is no generalized tradition of artificial cooling and, in some areas, the same even happens with heating. People are not used to very strict comfort conditions and, so, a positive contribution of passive solar technologies to enhance comfort conditions is already a good progress. Therefore, there is a large room for the development of passive solar concepts in these regions.

4 Auxiliary Systems in Passive Buildings

Passive solar design cannot guarantee precise comfort conditions by itself. Therefore it is usual to consider auxiliary energy for heating when solar energy, by climatic or operative conditions, is not sufficient. However, it is less interesting to think about auxiliary cooling when overheating situations occur.

In the case of underheating, the reasoning was that passive technologies were intended to collect and use as much solar energy as possible and that auxiliary systems were thought as an add-on to fully satisfay all the needs. As there was a widespread tradition of energy consumption for that purpose in the colder countries, it was possible to make economic calculations comparing the investment on solar with the savings in fuel and thus justify the investments.

When overheating occurred, it seemed more a consequence of less successful design and, therefore, in principe, it was to be considered as a problem of an average design process. A rather common example is the case of atria at high latitude locations.

In the case of cooling during the summer season, the problem is far from being symetrical to the heating problem. In first place, the range of tolerance of the human body to warmer conditions is much higher than to cooler environments. Secondly, the sun does not have direct cooling effects.

Therefore, the first approach is to avoid the environmental heat, both by insulating the walls—which is already taken care of for the requirements of the winter season—and adopting shading devices.

The natural cooling techniques can solve a number of problems but, in general, they are not very powerful. So, if there are cases of large density of occupants or if strict environmental conditions are to be provided, auxiliary cooling by air conditioning may be necessary.

A new problem then arises: an air conditioning system is a typical quasi-instantaneous system that responds to the air temperature and, sometimes, humidity. Therefore, there is a contradiction between a passive solar building with enough inertia to manage the heat fluxes and an air conditionned space were inertia may be detrimental. To go around these difficulties, the space in a building can be classified according to comfort criteria. Then, the designer can assign the type of system that is most adequate to each type of space according to two parameters: provision of comfort and economics, Oliveira Fernandes et al (1988a).

From there on, very interesting decisions can result regarding the location of such spaces in the building itself and the eventual diferentiation of their construction from the rest of the building.

5 Comfort "A la Carte"

Comfort was well studied, particularly during the last twenty years, but it still remains a very complex parameter. Comfort is not only thermal comfort, i.e., dependent on thermodynamic parameters only, but it can also be influenced by many other conditions from the environment (visual, noise) and from the person itself (phsycological conditions, among others).

Therefore, there are reasons to ditinguish "person cooling" from "space cooling", Baker (1990a). This justifies the need for a behavioural comfort model distinct from a fixed state model, Berger (1990), relying on just a few parameters, with temperature as the most important of them. In addition to the notion of comfort, the notion of discomfort has also been defined. Some contributions have been made to characterize overheating discomfort and to characterize discomfort in free-floating temperature conditions.

All this is an attempt to respond to the fact that strict comfort conditions as defined by existing standards may statistically be the most acceptable but do not represent the best environmental conditions for everybody. According to Berger, "special attention must be paid to "secondary criteria" of comfort: gradients, recent past, moment and time duration of a situation in the day, various constraints of activity, way of life, etc".

All this seems to justify that occupants will accept a wider change in environmental conditions, e.g., by introducing other compensation changes or, simply, by tolerance. Therefore, people are usually quite tolerant regarding more flexible control strategies.

So, when approaching the design of new buildings, it is a matter of identifying a series of intermediate solutions between two extremes: the total or almost total absence of indoor environmental control, such as in many parts of the globe, be it by tradition or by lack of economic means; and the buildings in which the occupants have absolutely no freedom of control whatsoever. These intermediate solutions can be simultaneously "energy conscious" and "environmentally acceptable". Passive solar buildings are a prime example of such alternative solutions.

There are many supporting pieces of evidence for this principle, the most important being:

a) The trend away from buildings without operable windows and fully controled, occupant-proof indoor environments that were typical in the 60's, and their substitution by other types of buildings which offer more humanized control strategies;
b) The degree of acceptance of indoor temperature fluctuations and some overheating evidenced by occupants (owner-occupants most of the time) of thousands of passive solar homes in the USA.
c) The preference given to natural over mechanical ventilation in general and in residential buildings in particular;
d) The importance of the contribution of HVAC systems for poor indoor air quality, as recentely identified.

This evidence shows the a wide range of arguments can be found regarding people s expectations over comfort and how a less automatic approach to comfort is evolving. Once it is accepted that comfort can be regarded in differing ways, a building can be divided into zones depending on the type and level of occupancy and on the degree of demand, each with its own climatic specificity.

This principle can of course be extended to different types of buildings, leading to the conclusion that the more precise or demanding the indoor environment is, the less reason there is for it to be a passive solar building.

6 New Strategies for Passive Solar Buildings

From what was discussed above it is possible to identify the need for two types of strategies:

a) for research: to generate the information that is not yet available to join together passive solar buildings and air conditioning systems. In what regards the research needed, one could say that a great effort must be done in order to make comfort better known and more available at the design level.
b) for the design process: to define the methodologies for the design process and to identify the criteria for evaluating the quality of every design.

7 Conclusions

Some conclusions could be drawn as strategies for comfort in passive solar buildings:

1. The better comfort is studied and known, the better the comfort objectives could be integrated into the building design process.
2. No descrimination can be claimed when several different comfort objectives and different environment control strategies coexist in the same building.
3. The decision on whether a nonresidential building should or not be passive requires a better understanding and knowledge of the comfort phenomena and the antecipation of the functions of each space—a mechanically controled environment is obviously less dependent on the type of the envelope, which anyhow should always be energy conserving.
4. Comfort in Summer asks for crucial decisions because air conditioning is not in general compatible with a passive building.
5. The degree of comfort (or discomfort) in a passive building with indoor fluctuating temperature can be objectively quantified during the design process, thus offering one more tool for decision on whether to go passive or not.

8 References

Baker, N. (1990a) Comfort and Passive Cooling, in **Workshop on Passive Cooling** (eds. E.Aranovitch, T.Steemers and E.Oliveira Fernandes), CEC DGXII, Ispra, pp. 15–33.
Berger, X. (1990a) Thermal Comfort, in **Workshop on Passive Cooling** (eds. E.Aranovitch, T.Steemers and E.Oliveira Fernandes), CEC DXII, Ispra, April pp. 35–48.

Fanger, P.O. (1987a) Strategies to Avoid Indoor Climatic Complaints, in **ICBEM,** Lausanne, (eds. A.Faist, E.Fernandes and R.Sagelsdorff), Presses Polytechniques Romandes, Lausanne, pp–23–31.

Serra, R. (1988a) Climate and Complexity in Architecture, in **Energy and Buildings for Temperate Climates: a Mediterranean Regional Approach, PLEA 88,** (eds. E.de Oliveira Fernandes and S.Yannas), Pergamon Press, Porto, pp. 3–7.

Oliveira Fernandes, E.de, Maldonado, E.A., Cortesão, C. (1988a) The Role of Passive Solar in Nonresidential Buildings in Moderate Climates, in **Energy and Buildings for Temperate Climates, PLEA 88,** (eds. E. de Oliveira Fernandes and S.Yannas), Pergamon Press, pp. 109–114.

Oliveira Fernandes, E.de (1989) The Actors in Building Design: Is There Any Reason for New Design Team Strategies? **Solar & Wind Technology,** 4, 329–332.

58

New construction technologies for residential buildings: variability in ground planning and front design with prefabricated constructions

F.W.FIGGE, W.KLINGSCH and H.E.WINDGASSEN

Abstract

In the western parts of the Federal Republic of Germany there is an increasing need of residential buildings. The reason for this housing shortage is a high immigration rate exspecially from the eastern parts of europe and from the former German Democratic Republic.

The cities and counties have to react to these facts. They are preparing a great number of areas to be developped. Housing projects which cover a greater area are normally based on architectural competitions.

There is a great demand of innovative ideas and tendencies to handle the urban architectural problems and the housing constructions. Of great importance is the fact, that the demand of a large number of flats has to be satisfied by constructions which are standardized and simplificated.

On the other hand they should be able to guaranty variability and flexibility of ground plans and front design of multi level residential buildings.

Keywords: residential housing projects, steel composite, easy assambling, prefabrication, standardization, free architectural design, internal lay out, variability, economy, earthquake resistance.

1 New ways in prefabricated constructions

While the historical efforts in prefabricated construction-systems, such as compartement units or wall-prefabrication have failed, there is still a serions demand for simplificated types of constructions to be used for different purposes and housing designs.

The steel-concrete composite technology for multi level residential buildings demonstrates a load bearing system which offers many variations to the designs as well as to the residents while the constructive elements dont vary.

HOUSING PROJECT IN WUPPERTAL

The system has been used by our group in different architectural competitions in a number of towns. And it has been adapted successfully to different functions in housing design, to different urban conditions and sociological surroundings because there is a great range of diversification and flexibility.

The construction system is made of prefabricated columns and beams and precast concrete planks. The framework is connected to a concrete staircase.

There are no load bearing walls placed in the space between the front walls. Therefore the system guaranties a high variability in interior wall positions, ground planning, front design or additional building materials.

There is a first realisation of this new technology by devellopping an area for housing constructions for Bayer in Leverkusen. High standards of construction and engineering will be fulfilled as well as a high level in architectural design.

2 Possibilities of use and constructions

Compared to the industrial goods there is a significant increase in housing costs

In relation to the personal income, technical items are getting cheaper while residential buildings increase in price. There are several reasons for this increase. One is the fact of very high ground prices, others are rising wages as well as low efforts of prefabrication and standardization in building constructions.

This situation can only be changed by a critical evaluation of the "popular" construction systems as well as a creative use of construction materials and elements.

A solution can be found by developping and using an "all purpose" construction system on a high standardized level like it has been common in the constructions of frame work buildings of the past. This construction system allows a flexible response to any changes and alternatives, in flat design and practical use.

The steel-concrete-composite system for residential buildings offers a greater range of possibilities, than usual and conventional construction techniques.

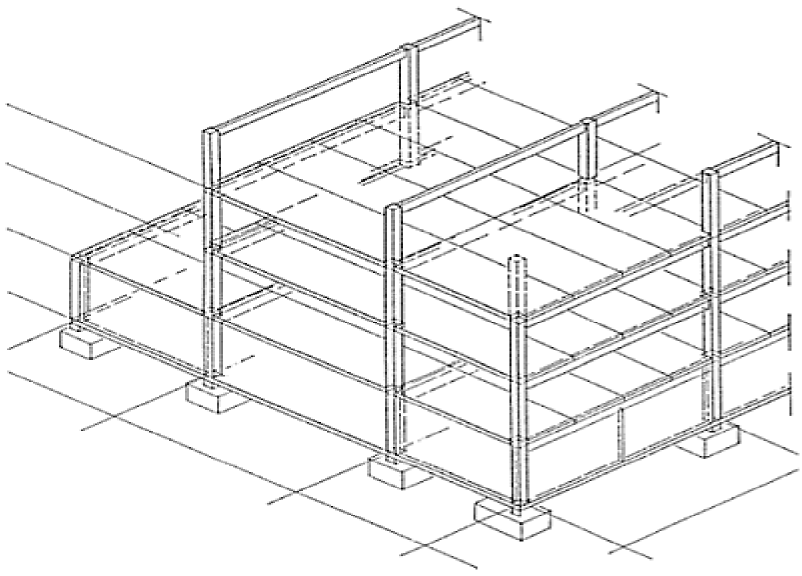
The system fulfills the following facts:

Possibilities of use:

– Compatibility to different ground plans and lay outs.
– Different ground plans in the same building
– One construction system for different types of houses and housing groups
– Adaptation to different purposes for exampel residential, administrative and industrial buildings
– Flexibility for changes in use and ground planning

Possibilities of construction:

– Integration of german industrial normes (DIN 18000)
– Limitation to only a few similar constructive elements
– Limitation to sizes and weights
– Easy handling in transportation
– Integration of plumbing heating and electric installations
– Conformity to legislation
– Diversification of designing and production
– High level of prefabrication

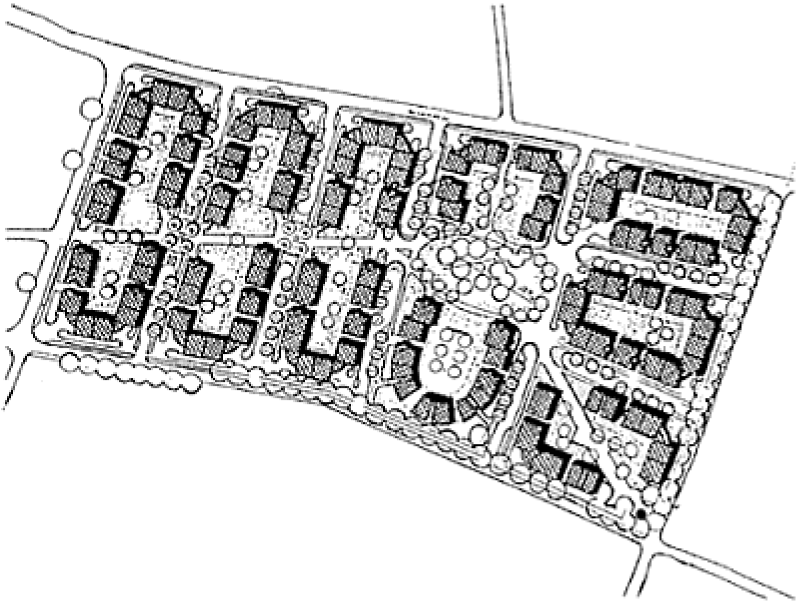


CONFIGURATION OF COLUMNS AND BEAMS

– Standardized prefabrication with a high variability of ground design and lay-outs

– industrial production—individual design.

On the following pages there are some designs witch show the construction system and its possibilities to tolerate altering architectual ground designs.

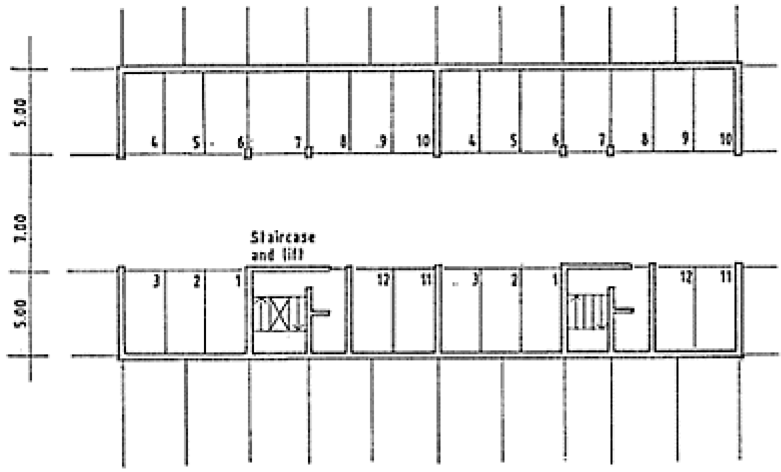


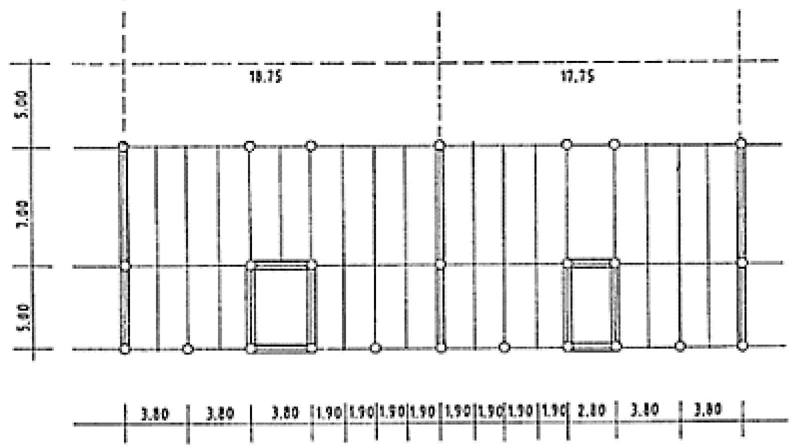
HOUSING PROJECT LEVERKUSEN-SCHLEBUSCH

The housing area ist situated in a suburb of the city of Leverkusen. Because of its size and its position in this suburban surrounding it will be come a dominant part with its some 400 flats.

LEVEL-1

Underground garage



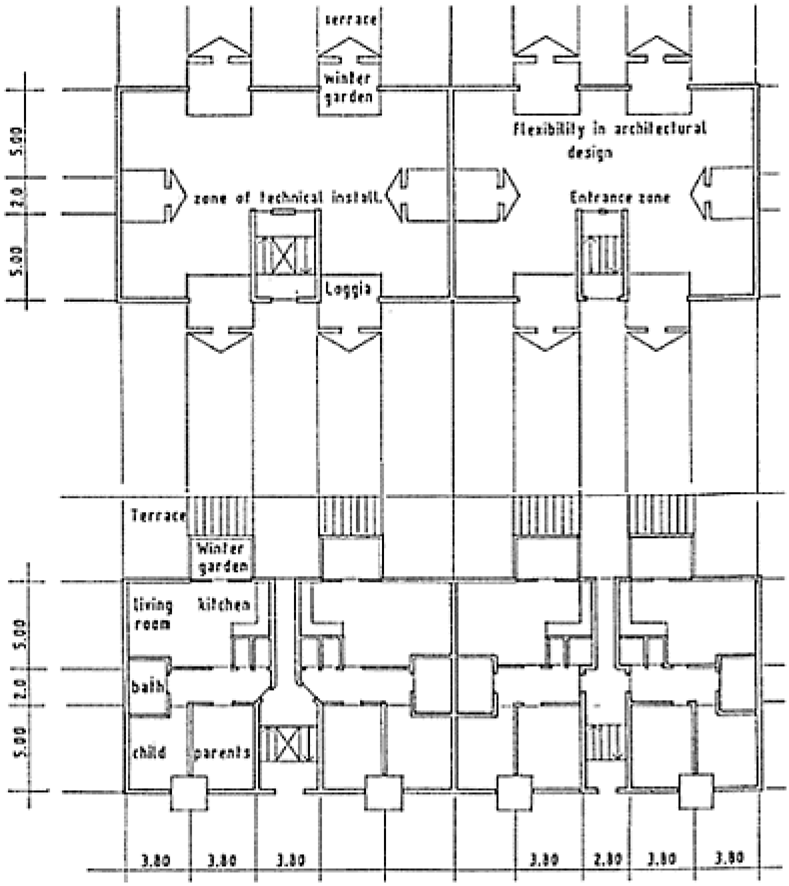


LOAD BEARING SYSTEM

The steel-concrete composite elements (columns and beams) are designed to a constructional pattern of 3,80 m/5,00 m and 3,80 m/7,00 m

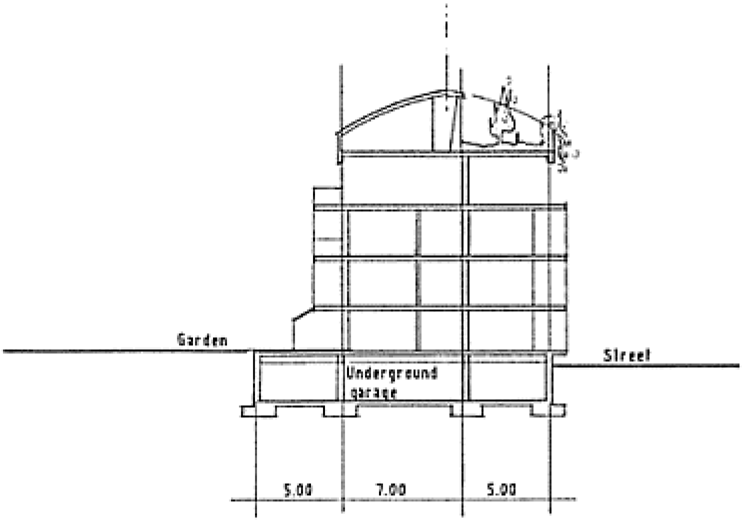
GROUND PLAN, LEVEL 0, 1, 2, 3

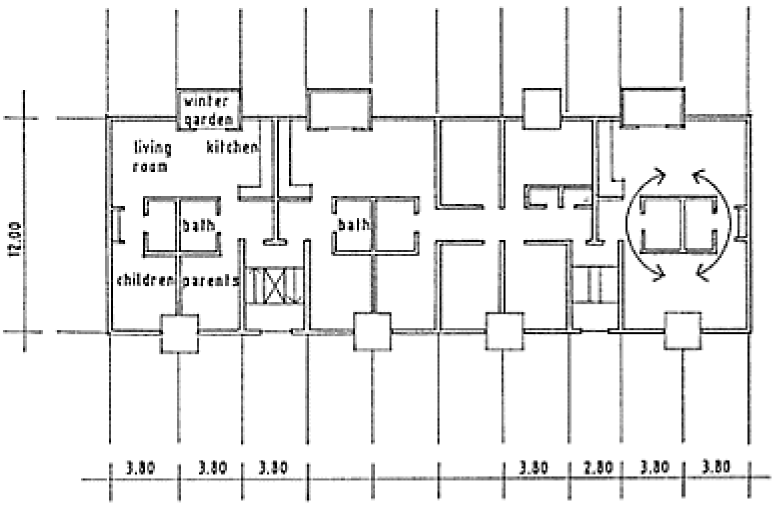
Due to only a few constructional elements like columns designers as well as residents are free to realize various room-organisations



GROUND LEVEL

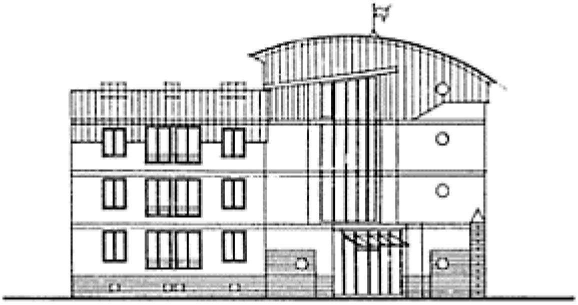
– Load bearing columns and beams
– Flexibility in wall positions
– Variability in room connections and sizes
– Variability in front design (Loggias, winter-gardens, sizes of windows)



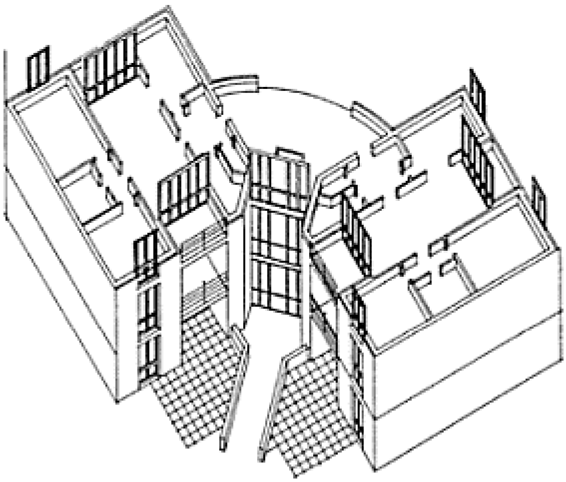


UPPER LEVEL

The connection of two buildings creates a very big flat and allows acces to two staircases



FRONT DESIGN



YARD

3.0 Constructional Realization

3.1 Requirements

Due to the minimization of vertical load bearing elements stiffness and load bearing capacity of columns as well as beams must fulfill high requirements. In principle, realization could be done by steel as well as by concrete constructional elements. However, additional design requirements may load to complications:

– minimization of cross sectional area of columns and of beams height respectively
– Integrated fire resistance
– easy handling, prefabrication and erection.

Steel as well as concrete elements cannot fulfill all these requirements.

Steel-concrete composite technology may overcome these problems and fulfill all these requirements in one type of structural elements.

3.2 Cross sectional design

Steel-concrete composite elements combine the advantages of steel elements as well as of concrete elements. Basic principle is the combination of reinforced concrete with a steel profile. Beside these standard sections a lot of individually shaped and optimized special cross sections are available, normally based on a combination of steel profiles.

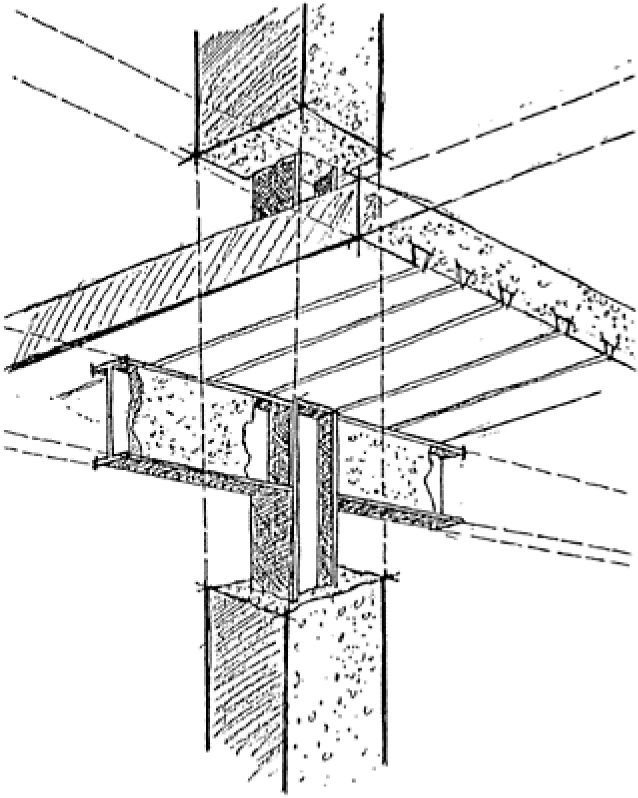
Indipendent of the type of cross section, dimensions of the structural member will differ. Under normal conditions type A will show best ratio between cross sectional dimensions and load bearing capacity. But from the aspect of fire resistance, this characteristic may be turned upside down.

3.3 Load bearing capacity, deformation behaviour

The basic principle of the load bearing capacity of steel concrete composite elements is addition of component load bearing capacity. By this principle load bearing capacity for a given external cross section dimension will be much higher than for just steel or just reinforced members. Stiffness of these elements will increase in a similar way, which leads to minimized deformations, independent of geometrically slenderness of columns or l/h-ratio of beams.

3.4 Fire resistance

All types can be designed for high fire resistance just without external claddings. This advantages reduces cost and increases durability.



CONSTRUCTION SYSTEM

In dependence of the national requirements on fire resistance in residential buildings, different cross sections are possible. If applied load is low the cross section can be reduced without reduction of fire safely.

3.5 Earth quake resistance

All steel composite structural elements show very good seismic resistance. Thus, safety of residential buildings against earth quake damage can be improved.

3.6 Construction and erection

All steel components can be prefabricated in shop including the joints for connecting beams to columns. A lot of standard solutions for joint design is available.

The elements can be handled in one day and shipped after three days after concreting. For multistorey buildings one-piece columns can be used which makes erection and on site activities very easy.

59
Functional evaluation of electronic information systems for residential and non-residential applications

A.FILLOUX

Abstract
This paper reports the main features of the work done by CSTB in the field of building automation for evaluating the quality of electronic information systems:

Functional evaluation and related test.
Ergonomy.

Keywords: Home automation, Evaluation, Simulation, Ergonomy.

1 Introduction

More or less sophisticated, many electronic information systems for residential or non residential applications are now commercialy available.

Thus, information can be transfered between equipments and a bidirectional dialogue between equipments and users can be established. At the moment, communication, safety and building management functions are rarely integrated in a single system but they can be. Then functions must be evaluated according to the different integration levels and interactions that can occur in the system.

The functional definition of an electronic information systems leads to define and identify any provided function.

According to the basic functions and the technics which are used to transmit information, the international standardization boards recognize three different systems. (Table 1)

From a user view, one can classify the functions of an electronic information system as following:

To check.
To control/to optimize.
To programm.
To display.

To alarm.

Obviously, any function of them may be activated either by remote or local control.

Table 1. Classification of systems

Class	Function	Broadcasting technic
1	Control Measurement Alarm Digital data (building technical management)	Narrow band
2	id class 1 + Digital voice and data	id class 1 + Multiplex Medium band Digital or analog data
3	id class 2 + Hifi sound Video High speed digital data	id class 2 + Multiplex Broad band Digital and analog data

In France, quality criterias for non using traditional equipments and material in building are defined by the “Commission chargée de formuler les Avis Techniques”. Those criterias are:

Compliance with standards and regulations.
Durability aspects.
Ability to use.
Quality requirements for installers.

2 Evaluation to the quality level

The aim of the evaluation procedure is to verify that an electronic information system works as the manufacturers says, provides the functions for which it has been designed and is still working when the environment is normally perturbated (usual conditions of a building environment).

So, to specify the limits of the system, some aspects have to be considered.

2.1 Compliance with standards, regulation and rules

Thermal aspects regulations.
Telecommunication agreements.
Security and safety: international standards for system.

Confidentiality of information.

2.2 Durability and reliability

The level of durability and reliability may be evaluated either from the knowledge of the reliability of elementary components, or by running long term performance tests in drastic conditions.

2.3 Ability to use

The tests that must be performed to evaluate the ability to use of a system are typically:

Climatic tests (cold, heat, humidity)
EMC test (perturbation of the environment by the system and perturbation of the system by its environment)
Test of the information process (alarms, events…)

The ability to use of the whole system is evaluated on a global aspect, with consideration to central units, satellites, sensors…in order to appreciate the ability of the system to provide its main designed functions.

3 Testing in a simulated environment

An electronic information system is a physical set whose structure can be described in relation to an inner space and an outer space, in which information are broadcasted thanks to physical links and networks.

A model of the environment interacting with the system can be proposed and the changes of environment resulting of the interaction can be simulated in a “black box” model in which information from sensors go in and commands to actuators go out.

Then, such a simulator is a software tool, that need to be interfaced with the physical electronic system in order to substitute:

The building.
The sensors anc actuators
The building occupants.

Two simulation levels can be considered:

Sequences of pre-established patterns (ON/OFF, open/close…) this simulation by discontinuous sequences is particularly dedicated to test the reliability of system and the strength of the information process. A continuous simulation mode that can be used to evaluate the level of interaction between the system and the building (thermal functions…).

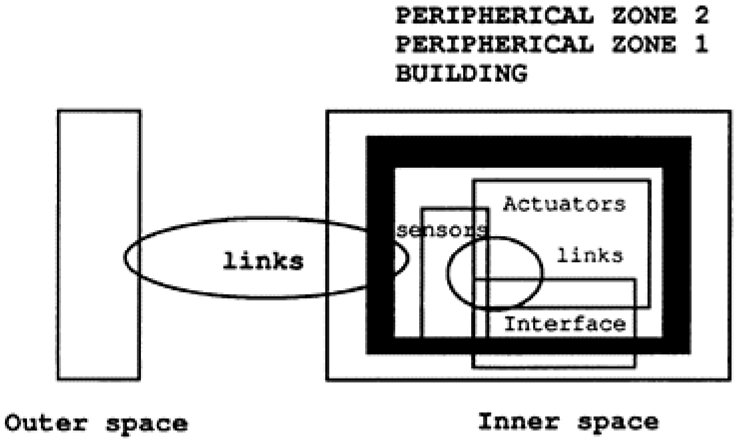


Fig. 1. Description of our electronic information system.

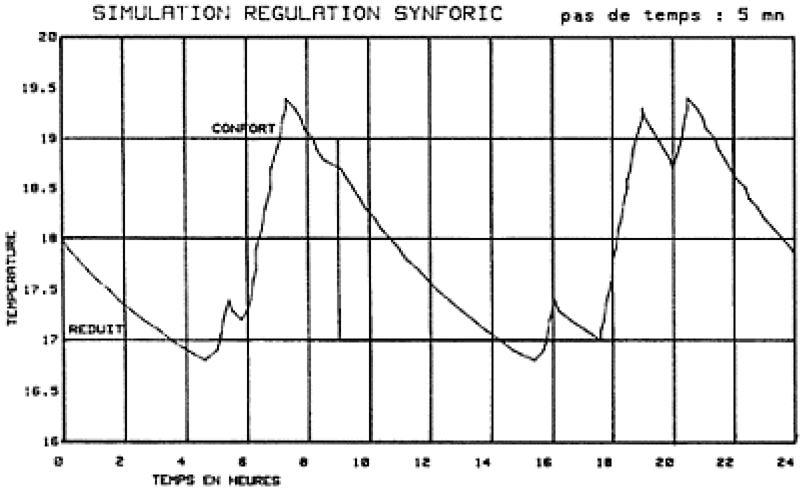


Fig. 2. Température data from SYNFORIC system. Daily simulation (CSTBât).

Test of energy management functions.

A building simulator was developed in CSTB from a thermal simulation code (CSTBât/TRNSYS) running on a HP 9000 computer (UNIX environment).

The interface between the electronic information system and the computer code is a HP 3852 acquisition system with appropriate input and output cards.

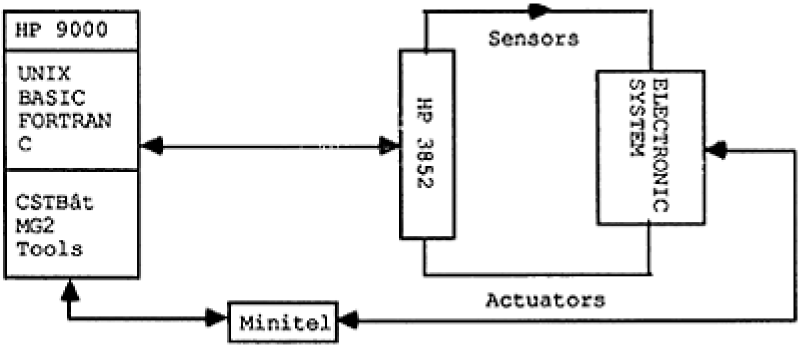


Fig. 3. Building simulation architecture.

A specific software tool is used to fit the simulator to the different systems to be tested:

Manual mode: an operator runs the system to be tested and learn to the building simulator to identify the information issued from the system. It is the initialization of the simulation.

Automatic mode: the real time simulator executes all the tasks to simulate the building and to run the set of pre-established patterns.

Semi-automatic mode: an operator is allowed to stop the simulation process to modify parameters, to add values or patterns.

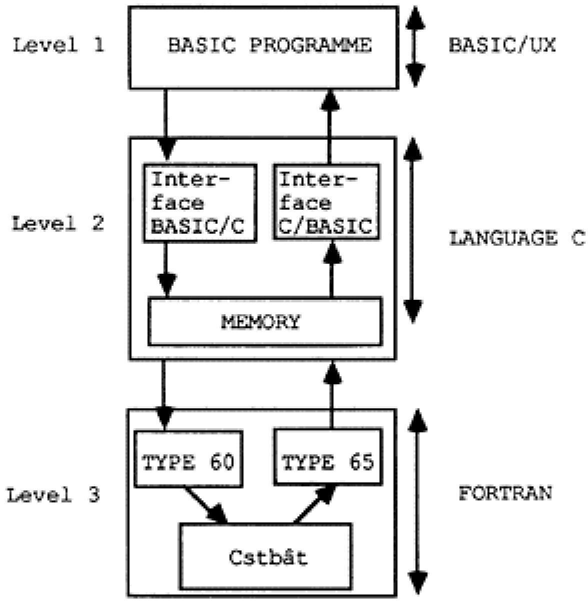


Fig. 4. Simulation process—Data transfert

4 Ergonomy of systems

It is trivial to say that the human interface of an electronic system is an important part by the influence it has on the reaction of the users facing the machine.

Most important are the consequences of a lack of ergonomy in energy management systems. In fact, one can see through the interviews of users and the analysis of their behaviour that many systems can be used correctly just after they have been put into service, but after a less or more long time, when the instructions book has disappeared, the use of automatic functions fails and the system runs in a manual mode.

For the last two years, a work has been done in CSTB, whose aim was to appreciate the level of utilisability of energy management system by ergonomic consideration.

A procedure of evaluation has been proposed. It is based on an analysis of the protocole of communication through the human interface, using a functional analysis of the system:

Structure and complexity of language.
Pertinence of symbols, words,…
Adequation between symbols and parameters.

Such an analysis is generally done at the earlier stage of the desing. It will be interactive to fit the evolution and adaptations of the system during the conception/

Furthermore, tests of usage must be performed on prototypes to validate the choices issued from the interface analysis.

Such tests have been experimented in CSTB in 1990 through an evaluation of energy management systems for demestic applications.

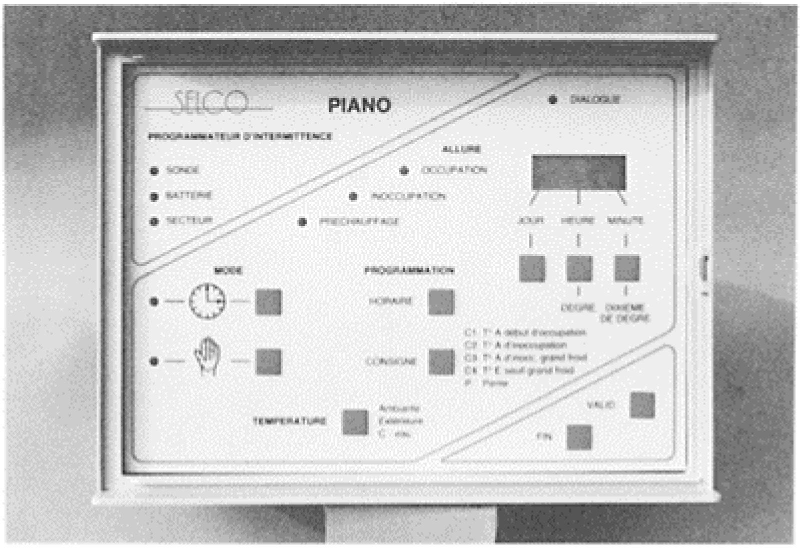


Fig. 5. Energy management system
(after ergonomic consideration)

5 Conclusion

The landscape of building environment is changing as users are considering more and more that building are not only "boxes" in which equipments and systems are installed.

Sociological and economical analysis make them consider that today's building are dedicated to protect the private life or the production tools of firms, but interacting with the inner and outer environment.

Buildings themselves become parts of global system and the evaluation of the quality of the system with the building is now necessary. Users are parts of buildings too, and it becomes obvious that the human interface with the machine is of growing importance.

So, a lot of work has been done by CSTB to take into consideration that situations; a building simulator has been developped, evaluation procedure have been established, and consideration about ergonomy was driven, but one cannot consider that this work is enough for itself. Such evaluation procedures are useful for manufacturers in the development stages of products, but in-fine, one have to evaluate the ability and the quality of systems both through experiments in real building, with real users and simulators.

Simulated method and in field experiment are complementary tools for evaluating systems.

6 References

Filloux A. and Vinot B. (1989) Domotique et utilisation rationnelle de l'énergie. CSTB report, TTA/DPE/89–776.

Filloux A. (1990) Methodologie devaluation de la qualité des systèmes domotiques et immotiques pour l'établissement d'un Avis Technique. CSTB report, TTA/DPE/90–975.

Filloux A. (1989) Protocole devaluation de l'ergonomie des thermostats programmables. CSTB report, TTA/DPE/88–680.

Colomes J., Filloux A. (1990) Evaluation de l'aptitude a la fonction des systèmes domotiques. Méthodes et moyens d'essais en environnement simulé, Partie 2, L'émulation, Congrès Scientifique International de Domotique, Rennes 27–29 Juin 1990

60
An intelligent system to control the quality of the habitat

L.FIUMMI and G.ZANNELLI

Abstract
This presentation will show several experimental-operating systems oriented to control the quality of the habitat from the comfort point of view.

The objective of such control (that of the quality of the habitat) aims at getting knowledge of the management of developed technologies so as to orient building requirements to a new space appropriation.

The work will focus on the control of new economic and managing impacts in which the present operators of the building sector are involved.

Speaking of integrated systems in buildings, starting from the design stage, causes problems within the operators' relationships.

The high specialized know-how is the critical factor.

Therefore, the role of the building operators will not have to be conventional, but specialized.

Keywords: Technologies, Information, System Integrator, Environment.

This paper constitutes a progress report of a wider research study carried out within the "Enviroment Committee" of the CNR.

1 INTRODUCTION

Given that the complexity of the system does not allow a thorough exposition of all motivations for our choices, steps, rules and norms which make up the process, we shall only present the main featuring elements which make this system applicable ***to any kind of evaluation****.*

In his lesson of Architectural Tecnology, Professor R. Giuffrè defines the environment as a place of governed transformation process of matter into consumer goods. The impact is, therefore, a reality which suddenly relates bodies which are different, and up to that moment unrelated, whose peculiarities are not always openly interactive.

Thus, comfort control is conditioned by all space and time factors which are:

related to the performance of components;
conditioned by the yield of each of these;
increased by the frequency of the actions.

Conventionally, in order to make calculations, study and define the entire process, we employed symbolical geometries according to which the phenomenon that must be observed as a whole is called **“unit”** and its components are called **“useful links”,** which divide the **“unit”** into a number of parts. The law of parameter analysis is constant in the three processes (see fig. 1). The use of symbolical geometries is applied to regular quadrangles since the square surface is one of the best utilizations of space. Calculations are done through simple mathematical operations which show the **“quality and reliability”** of the space using:

the perimetral interface (which defines the borders of the phenomenon);
the borderline data (scope of the phenomenon);
the design of the area (extension of the phenomenon).

The interface calculates the outline (contours) as a geometric element; the bordeline data analyze relations between each single factor; the design of the area refers to the **“contents”** in terms of broadness of the field **“paying area”**.

The elements of the geometry which are to be used are the following:

the sides that determine the angle;
the perimeter that geometrically limits the field and the area which represents the extension used;

therefore the operations are the following:

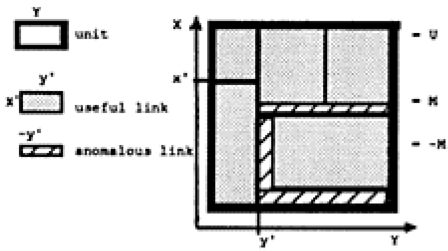
the relations between the sides; (they indicate qualitative data);
the products between the sides (they indicate the quantitative weight);
the sum (it represents the configuration).

The results represent the optimun comfort, in positive terms, and, in negative terms, the limit to the use of possible alternatives (caused, for instance, by various types of technological elements i.e. space occupied by walls). The grading index, in the interval between 0 and 1 determines the reading scale of the analysis, which is performed with an index (μ)=0 <μ> 1. Operational hurdles which determine the difference may be caused by technical, technological and performance constraints.

The three elaborations of the system () are based on the characteristic according to which the greater the difference between homologous data that make up the system, the worse will the result be. These consider the deviation as a technological possibility of optimizing the system; they have a tolerance span between the **“threshold sectors”;** they use the concept of space utilization according to which the more this space **“unit”** is subdivided (by a high number of internal borders), the more problems of technology assembling and relation there will be: the more the partitions, the greater the costs!

The flow chart provides 18 outcoming data, whose values are always between 0 and 1. All relations that link functions, by means of the (homologic) transformation which represents them, involve, on one hand the transformation law and the transforming elements, on the other the elements to be transformed and the transformed elements.

All elements belong to a binary system whose characteristics are the following; every pole is free from constraints and has, on the plane, two degrees of freedom, two poles in reciprocal ratio, have one degree of freedom and of relation (constraint), repectively three poles determine a closed system, without degrees of freedom (thus defined, as according to our goal) and three degrees of relation (constraints).



Graph of a symbolic geometry

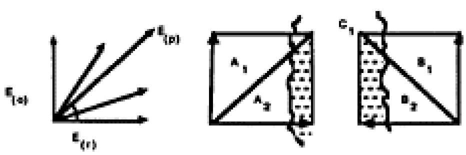
The unit represents the element, the links the components, the sides the factors

2 INDEXING SYSTEMS

Placing two points on a Cartesian diagram and joining them along the abscisse, one obtains the weight of the relation existing between the two (symbols of the interfering objects examined): on the ordinates the trends of their intrinsic characteristics are shown, whereas on the abscissae one reads what the two poles actually are.

If one applies to the two points their respective vectors (one-vertical-which expresses the intrinsic qualities, and the other-horizontal-the relation qualities) the two resultants will join on a third point.

If the figure obtained is an isosceles triangle the system is well-balanced. The relation is thus determined between an optimal **(E(o)),** a real **(E(r)),** and a possible **(E(p))** which represent the three indeces to be found in the two fields, that of the supply **(A)** and that of the demand **(B):**



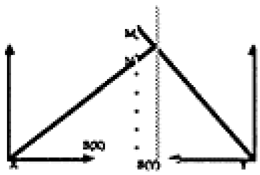
A1=field of the optimums supplied, as idea characteristics (the thing how it should be);

A2=field of the optimums supplied by the object examined (the thing how it is);

B1=field of the optimization of requirements expressed (the implementation of the demanded object, how it could be according to users' demands);

B2=field of requirements stated by users (the thing how one would like it to be);

C=field within which the acceptable requirements are under control (this space must include the vertex of the triangle which is formed by joining the bisecting lines). If in **A** the resulting angle is too small, the object would be too ideal to be used functionally. In **B,** the angle shows the quality and perfection of the technological tools used to solve the problems of user requirements and their technological implementability optimization). This gives rise to 7 postulates which determine the five discriminating hypotheses of the belonging of the fields, which are not reported for want of space. Positioning of the system with the two related polarities:

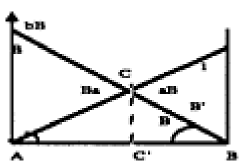


MN=increase to reestablish balance;

S(X, Y)=deviation of error value; the balance of opposites is **S(X)+S(X)=0**

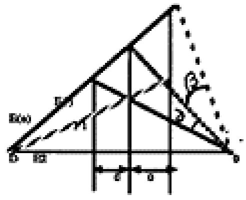
If **Y** demands more than what **X** offers in terms of performance, **M** and **N** is the unfulfilled expectation index;

if **M** and **N** are in field **X,** the availability eceeds its true possibilities of supply.



In the evaluation, **"a"** is given as indexed and **"b"** is the indexer, **"C"** is therefore indexed with the weight **"B"** poses as requested on **"A"**.

Reciprocity or influence indeces (angular evaluation), intersection indeces:



∂ (distance), is the angle or segment (○) that tells which operations should be done for the two configurations to be concurrent, and β (---) is the angle that every operation implies an increase of virtual or real costs.

3 INDEX TESTING

It has been found that the presence of non-paying spaces overloads the system, thus making the index drop, yet maintaining the same type of graph.

Whenever one faces a square unit with no internal partitions, the index is=1, which means that the space can be completely utilized and is featured as an optimal space.

The fact that often overloading it with borders, unusued space, elements to service confort, etc, and gradually increasing the number, the type of curve remains the same, proves that, the control system employed is homogeneous, regular and reliable with regard to the information provides.

As to the diagram used, there are two different possibilities and namely: in the first case the index coming out of the program is expressed as an angle included between 0 to 45°; in the second case, such index was reported on a Cartesian axis. The possibility of using the double system, allows an interpretation of the real state in relation to the optimal character of the hypothesis.

Coming now to the graph: the employable valences are on the ordinates; the straight line which is produced represents the **“quality line”** which whenever employed and emplyable valences are the same is called **“optimum line”**. In the latter case, (at 45°) the oversaturation index will be found between 0° and 45°, and the non-saturation index between 45° and 90°. Furthermore:

> **A=45°:** if there is an increase on the X axis **(employed valences)** which rappresent only the implemetation (prototype) there will be an equivalent increase on the Y axis **(employable or optimal Alences)** which represents the optimization **(archetype)**—and are will be an armonious product;
>
> **B=45°** if the object offers or tries to meet few requirements, the proposal is Utopian;
>
> **C=45°** if the object offers or tries to meet more than the allowed it will undergo a crisis.

4 The process of realizing

Technology is necessary, though not always sufficent, to improve efficacy, while an “intelligent” use of technology is necessary to make the best decisions.

Civil, industrial or residential buildings, or those destined to perform business activities, are characterized by the presence of computer technology which meets the needs of comfort and environmental safety; this adds to technology, usually at different times, which the communication needs specific for the users’ activities (ICIE, 1987).

Flexibility in a facility consists not only in the area available and organized under architectural criteria of functionality, but also in technological performances/functions.

Some authors call Intelligent Building (IB) an edifice with both hardware and software supporting the activities of those who live in it, by granting text or data analysis and information exchange through an internal network, or a network common to sevend organizations. (Supp. Modulo, 1990).

Moreover, with “Intelligent Building” we mean an edifice where the different systems are integrated to use co-ordinately its possible resources, which increases:

use flexibility;
number and quality of the services offered;
savings both in investments and operation cost.

With systems we mean both plants and services, such as heating, lighting, telephone lines, lifts, air conditioning, fire-proof net, etc.

Usually, these systems are independent on one another.

Intelligent Building represents the integration of functional areas:

control systems: active fence, control video, robbery-alarm, thief-proof alarm, fire alarm, control of entrances, parkings;

operation systems: air-conditioning plants, lighting, electric operations, lifts;

computer systems: local network (use of fast printers, access to data banks, internal communications such as electronic transmission, data and program exchange), filing (document scanner and file memorization, transmission from file to remote fac-simile machine, etc.);

communication systems: telephone, spoken-transmission, audio-conference, searcher-device, data transmission, videotel, TV and radio-diffusion, video conference, video-library.

In order to play their functions correctly inside the building, these systems need “shells” and structures with no soft-hard-wares, they should be well-planned or at least rational, attaching no priority to computer functions with respect to the environment quality.

(ICIE, 1987) We can synthetically define the processes to obtain the realization of Intelligent Buildings:

analysis of the requirements, determination of requested services and expectations of potential development;
definition of technical specifications of the requested services (subsystems);
subsystem engineering;
system integration;
bid specifications (if any distinction between the designer and the realizer of the system is made);
selection of suppliers;
wiring;
installation of the subsystems and integration equipment;
inspection;
training of the system operators (central check operators);
user education;
technical assistance and maintenance, development.

It is not easy that an architect or a project team are able to coordinate or realize an automated building, because an **integrated architectural/computerized project is, no doubt, a complex problem for professionals** (including firms, designers or manufacturers, etc.

The questions the professionals should answer in order to make clear their position about the matter, are:

which level of intelligence is required by organization for the work done?

Has the planned or built edifice the capability to contain that intelligence?

Which kind of brief must be formulated to obtain the desired results?

Who has supply this intelligence?

What will be the time interval, if any, of making changes in the organization?

Answering these questions allows the "facilities manager" to select the buildings, newly built or already existing, which meet the needs of the final users.

The complexity level of the systems included in an Intelligent Building varies according to the necessities and the particular situation of the users.

For this reason it is necessary to carefully cost-account the performance to be archivied, since this allows to specify the degree of achievable "intelligence".

Moreover, it is necessary to improve the international standards in current use (modems, multiplexera, PABX, etc.) permitting the intercommunication between different machines.

5 Management of integrated technology

When planning and realizing and project, it is important to know and manage "advanced technology" by preventing both project and realization, from evercoming our capability to "assimilate" them.

Insteated of speaking about new technologies different from the current ones for techological transformations, it seems to be more appropriate to talk about "new methods for space appropriation".

Computerized building becomes humanized building and the role of the individual as a solver becomes primary in respect of the choice of technological solutions.

The interacting components in the integration process that must be controlled in the project-phase are substantially different:

a) integration of man and environment (lighting-acoustic, microclimatic and other comforts are factors influencing both the physiological and the sociological components of the individual).

b) integration of network system (it is realized by interfaces of the communication network with three interconnected systems).

c) integration between network systems and building system (integration of building system and communication system, taking into account the technological bonds).

In order that Intelligent Buildings may be really Intelligent, they have to coexist in a favourable context.

This context is represented by Intelligent cities.

It is not the case of a mere association of more I.B., but of a whole structure integrating all infrastructural networks: water, gas, electricity and communications. In other words, more systems inside the city.

Intelligent Buildings, which at present express the need to relate technological innovations to the occupants' requirements, can find their most complete expression in this redesigning of the urban activities and function.

Planning new towns, therefore, should be inspired by "new humanism" philosophy, where man represent the fulcrum of every interventions.

The so-activated communications represent a new form of language, and language is synonimous with culture.

6 CONCLUSIONS

There are commonplace, repetitive project, and there are intelligent ones. Projects aimed at concrete solutions to problems, without maximalisms and without sloth.

The intelligent project abhors fixed formulae; at the most it adopts them, instrumentally, for its own ends, with open-minded freedom.

For the intelligent project, it is not important to seek cultural, social, economic or thecnological supremacy.

It knows how to employ all the most sophisticated things that technological research can offer today. But at the same time it can recognize the effectiveness of ancient tecnology. Its choices are not a priori choices, because the intelligent project is not intended to demonstrate any preconceived thesis whatever; it looks only for solutions to specific problems posed by enviroment, the community and users. A powerful computer is useful for calculating complex and iterative operations, however it is not only wasted, but is actually an encumbrance to simple additions. In this case the ancient mental calculation is far more effective.

REFERENCES

Giuffrè R., Salsano A. (1978) **Tecnologie hard e soft per l'autocontrollo dell'ambiente** Roma.

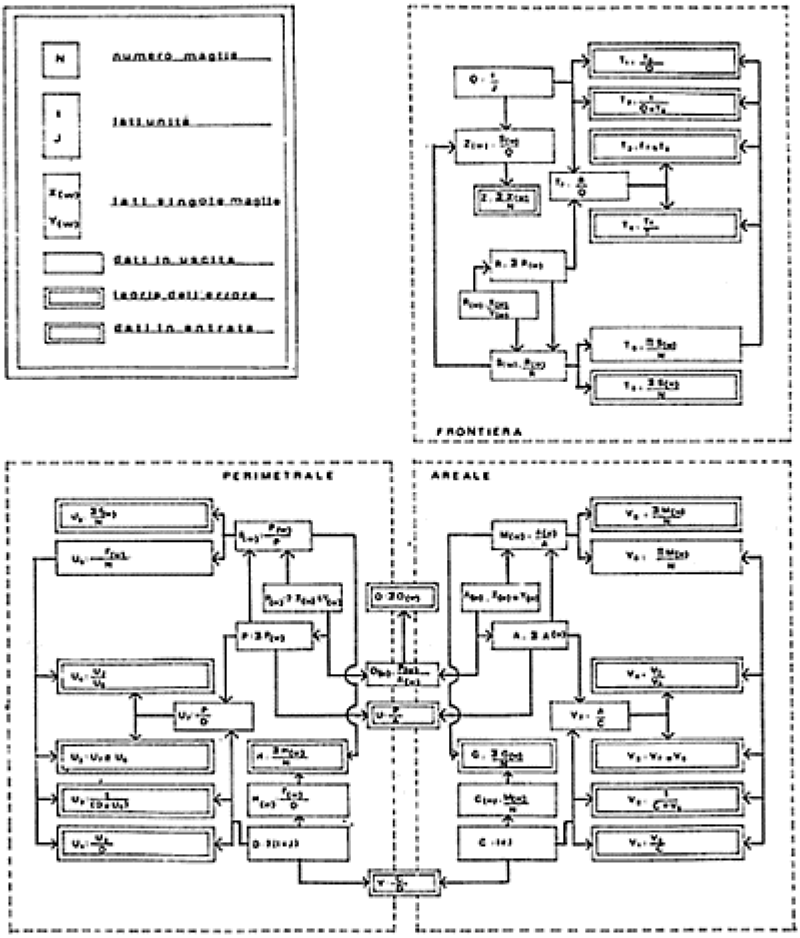
Giuffrè R. (1984) **Disegno per una tecnologia dell'ambiente**. Officina Roma.

Coperativa Ecologia (1985) **Rapporto Finale CNR PFT, Applicazioni delle procedure di valutazione di Impatto Ambientale nella progettazione di infrastrutture e reti di trasporto in Italia**. Responsabile scientifico Claudia Sorlini.

De Varda Giorgio (1985) **Telematica e manutenzione,** in Nuovo è bello, a cura di Liana Milella, Editori Laterza, pp. 137–141.

Gordon Vincent & John Peacock (1985) **The Automated Building,** Architectural Press Limited.

Giuffrè R. (1987) **Il metodo delle differenze in architettura**. Teramo.
Pagani Roberto (1987) **“L’informatica nella gestione, controllo e comunicazione dell’edificio: l’Edificio Intelligente”,** in-l’Edilizia, De Lettera, Luglio-Agosto.
ICIE (1987) **Informatica e settore delle costruzioni,** Franco Angeli, Milano.
DEGW Italia (1987) **L’edificio Intelligente,** inserto in Habitat Ufficio, n.26 giugno/luglio pp. 81–96.
Tronconi Oliviero (1987) **I primi passi del CIB in Italia,** in II nuovo Cantiere, Etas periodic!, n.6, Giugno.
ICITE CNR (1987) **Studio di Fattibilità del Progetto Finalizzato Edilizia**.
ICITE CNR (1987) **Edilizia per la ricerca**. Quaderno 1: Programmazione degli interventi, CMT Milano.
l’Arca (1988) **Il progetto intelligente,** l’Arca Ed., Milano.
Franchini, Francesca (1989) **Aspetti tecnologici degli edifici intelligent!,** in La città cablata. Un ‘enciclopedia, a cura di C. Beguinot, Giannini, Napoli, Vol. I, pp. 119–129.
I libri di Modulo, (1989) **Verso l’edificio intelligente, un nuovo modo di progettare e costruire,** Bema Ed., Milano, Supplemento a Modulo.
Garda, Davide (1989) **Il laboratories di Scienze dell’Edilizia a Berkeley,** l’Arca, aprile, pp. 1–5.
Castellano, Aldo, (1989) **Confort e salute nella casa dell’uomo,** l’Arca, aprile, pp. 6–9.
ICITE CNR (1989) Edilizia per la ricerca Quaderno 2: **Processi di progettazione, costruzione e gestione,** De Lettera Milano.
Milella, Giuseppe (1989) **Edificio Intelligente,** Modulo, pp. 856–859.
FAHRENHEIT (1989) Convegno **“Verso l’edilizia intelligente”** Bologna SAIE ’89, supplemento al n.10, “Il nuovo Cantiere”.
Muratore G. (1989) **Architettura e Ambiente** in Spazio Sport, CONI, n.3, Roma.


numero maglie
lati unità
lati singole maglie
dati in uscita
teoria dell errore
dati in entrata
FRONTIERA
PERIMETRALE
AREALE

61
Quality management practice for medium and smaller companies

L.W.FLOYD

Abstract
This Paper is divided into three parts, two of which deal with the introduction of quality systems. The third addresses some salient matters in their operation. The Paper is directed towards showing that quality management systems are tools for use in all companies irrespective of size and scope. The author hopes it will provide topics of conversation and provoke discussions.

Keywords: Simplicity, Clarity, Brevity.

1 Introduction

With the advent of the Common Market next year, many more companies of all sizes and disciplines in the Building and Civil Engineering Industry are actively moving towards the adoption of quality systems to assist them in improving their businesses. The accelerating trend in this direction has resulted in an upswing in applications to Certified Bodies accredited by the National Accreditation Council for Certification Bodies (N.A.C.C.B.). Equally, N.A.C.C.B. itself is active in the European Community in connection with similar provisions in other member countries. One of the principal aims is to establish the means whereby companies may obtain Certification which will be recognised across the various national and international frontiers.

Assuming that companies wish to obtain Certification (some do, some do not) approximately twelve to eighteen months may elapse before Assessments may sensibly occur, especially if companies are starting from cold. During this period, managements must introduce the concept of quality, its management style and compile and distribute Systems of documents reflecting their business practices which demonstrably conform with the requirements of the ISO 9000 series of Standards. Certification can only be obtained on this basis, even if the business touches minimally on the contents of ISO 9000 series.

No easy task!

The decision to adopt this course of action may be viewed by directors as costly, principally in terms of time expended by its personnel in training processes and in accumulating familiarity. No-one wishes to increase his overheads. In point of fact, many companies are actively cutting them down. In this respect, Quality Departments become vulnerable if their activities are viewed as contributing to overheads.

Accordingly, quality systems should be regarded as integral management tools attracting minimal extra overhead and as contributing positively to the success of companies' business dealings.

2 Planning the Introduction

Attention should be given to planning the introduction of a quality system. No two companies manage alike. Similarities may exist, but in the end, everyone has his own management style. Accordingly, the requirements of the ISO 9000 series should be blended into the text describing the business and not the other way round, as is the format of quite a number of Systems. It is as well to recognise this fact at the onset, because failure to do so produces a System which becomes based on the format of the ISO 9000 series and not on the natural progression of the company's business. Insufficient care in this direction results in misconceptions and even hostility when practices begin to be challenged. Traditionally, we have used our memories and our ingenuity in order to manage and supervise our work, admittedly sometimes successfully. Very few of us have used written procedures or guidelines. We have tended to press into service the experience gained from the previous contract whether or not it is really applicable. Ten years' experience in some of these situations may really equate to one year's experience ten times!

So, with these points in mind, what course of action should follow? The present difficult economic climate will mean that any increase in overheads will be frowned upon by company directors. (In many medium and small companies they are the working managers.) The adoption of quality management or, systematic management, should be viewed as a company-wide training scheme and planned as such. For many, it is the first time such training has occurred. Because it demonstrably affects everyone, it is well worthwhile drawing up a Plan for it. Provide a budget, appoint a manager to control it and measure it to see that value is being obtained for time and money expended. Directors need to be briefed, managers tutored, personnel acquainted. The effect will be cultural as well as embracing the technical and the commercial. In the U.K., the Department of Trade and Industry is prepared to assist with funding medium and smaller companies in the preparation and adoption of quality management throughout industry generally.

For the medium and smaller companies, the nomination of a full-time Quality Manager is not considered to be an economic proposition for it would serve to deprive the company of the services of an experienced line manager, which it can usually ill-afford. Equally, the appointment of a Quality Manager new to a company can prove unsuccessful because he immediately must embark on a learning curve to acquaint himself with the customers, practices, policies, principles and management style of his new employer whilst settling down to guide the production of the System. In the author's opinion, the situation may be best addressed by the nomination of a senior executive who is familiar with the directors' policies and requirements. He will outline the Plan, perhaps with a modicum of professional assistance. In the U.K., this is available from a number of sources, the services of consultants, professional bodies, trade associations, government departments and agencies being available for guidance in varying forms. The executive may wish to form a small Steering Group with the purpose of determining the scope and scale of the task, to disseminate information and to co-ordinate the various disciplines in the developing process. If the executive wishes to adopt a title for the purpose of the exercise, the term Quality System Manager would be appropriate. After all, the achievement of quality is the task of line management.

At this point, perhaps, attention could be focused on the ISO 9000 series as we are required to meet its terms and conditions. Directors must decide on the Part Number (1, 2 or 3) which best fits their businesses. The co-relation between the day-to-day business and the requirements should be understood and reflected in the System when produced. The non-existence in the ISO 9000 series of construction activities has been re-dressed in the recent C.I.R.I.A. (U.K.) publication (G.B.M.Oliver 1990) which has been well received in the industry.

The Quality Manual, often the first document to be attempted becaused it contains principles and policies (although it need not be so) should address the scope of the business and show the management and other structures as are mentioned below. The requirement to relate the manual to the ISO 9000 series is met by cross-referencing its various parts with the relevant clauses in whichever order they appear.

To summarise this first part of the Paper; plan the introduction by developing degrees of awareness. Nominate an executive to oversee the exercise. Treat it as a project and prepare a budgeted training plan. A number of videos and manuals are available from various sources. For details, please see 6. References at the end of the Paper.

3 Implemention

Implemention means the writing and compiling of the Quality System, a task which is new to nearly everyone. Rather more in the way of planning is required together with knowledge and realisation of the format of the finished product. There are differing views on the methods but it is universally accepted that simplicity, clarity and brevity are the aims to be achieved if we are not to mystify ourselves and each other with our efforts.

The preparation of a Quality System need not be too daunting a task—it is essentially an exercise where literacy and co-ordinating skills confer benefits (and this is where some professional assistance is of value as mentioned earlier). It could be convenient therefore to start with drawing up four charts (or "trees").

The Function Tree.
The Management Tree.
The Interface Matrix.
The Document Tree.

As its name suggests, the Function Tree will depict the functions undertaken by the company in the course of its business from direction/management downwards, which are to be included in the System. Do not forget to include the Quality System itself.

The Management Tree should, for practical purposes, reflect the Function Tree but it may need to show more detail.

The Interface Matrix is intended to show who interfaces with whom. By way of explanation, many activities require more than one person, or team of persons, to achieve satisfactory completion. It is essential, therefore, to show clearly in procedures, who is responsible for a particular activity and at the same time, who will interface with him to enable this activity to be satisfactorily completed. In drawing up this Matrix, confine it to functions only, (that is to say, ignore activities). One of the prototypical examples is the issue of the Architect's layouts to the following disciplines at comment stage:-

The Civil Engineer.
The Structural Engineer.
The Electrical Services Engineer.
The Environmental Services Engineer.
The Mechanical Services Engineer.

The Architect is the person responsible. He interfaces with all five Engineers in order to attract comment on his layouts, so that he can proceed to the next step.

Lastly, the Document Tree will depict all the documents in the Quality System starting with the Quality Manual at the top. It will have a small set of procedures annexed to it containing guidance on operating the System (the responsibility of the Quality System Manager). The list is completed by the set of line management procedures containing instruction and guidance on the activities in the functions mentioned above. Each activity should indicate who is responsible and who interfaces with whom. These line management procedures may be considered to be the basic component of the System, because they address the products sold by the company. Time expended is well-spent in organising their preparation and their control.

Lack of interest soon prevails when procedures are poorly produced, are difficult to read and understand. Training courses should exclude sessions where procedures have to be explained. Minimise paper production. Organise document control. Individually number each procedure. Avoid binding them into a manual. Document control of complex manuals can be punitive compared with controlling stand-alone procedures.

4 Operating the System

If the System is compiled on computer, the control of the paperwork (which management often finds irksome) is made more easy. The System which has been outlined is intended to operate with the least amount of servicing. If the key requirements are included, the System will provide for them at the proper times. The line procedures especially are meant to be used and not to serve as bookshelf items or doorstops on hot days. Personnel will become familiar with what used to be the unfamiliar. Good economic practices have their appeal—very few personnel go to work to do it wrongly. One hears that "doing it right first time" is the zenith of any System—this will bear directly on a good set of procedures.

One of the cornerstones of any Quality System is the auditing process. Managers should make good use of it because the functions and activities can be measured objectively. Although the natural focus of auditing may point to the Q.S.M., it is beneficial for managers to audit each other. The practicality of a requirement such as non-conformance and corrective action is put to the test and line management especially needs to be satisfied that the policy (as outlined in the Quality Manual) and the practices (as contained in one of the procedures annexed to the Quality Manual) really contribute to everyday business activities. At the same time as the annual audits are occurring, the Q.S.M. will request line management to review its procedures. The Q.S.M. declares the results of the whole exercise in his Annual Report to the directors.

Another cornerstone is that of Contract Review, the practical purpose of which is to check the provisions for the assurance of quality made in tenders, bids, offers, etc. (e.g. procedures, inspections, qualifications, audits, etc.) which may shortly be converted into contracts. If these provisions have been amended during the post-tender pre-contract periods, the revised requirements are recorded in these Reviews and action is taken accordingly, which may of course result in some commercial adjustments as well as technical and managerial. The ISO 9000 series requires that we deal formally with these matters and auditors will look for records accordingly. It is quite admissible to include these Reviews on the agendas of the usual meetings which occur at these times. If companies have utilized Quality Plans in their tender documents, checks on the lists of procedures will also reveal if extras are required. In British practice, the Quality Plan should not be confused with the Method Statement. The documents are dissimilar and are compiled for different purposes. On the other hand, Method Statements may contain references to procedures. The term "Quality Plan", incidentally, suffers from ubiquity. It is therefore better to use terms such as Design Plan, Inspection Plan, etc.

To conclude the Paper, the author believes that more interest will be focused on Total Quality Management in this decade. This concept develops quality systems beyond the confines of the ISO 9000 series such that all functions can be addressed. Even for smaller companies this is quite a task and it stretches administrative/co-ordinating capabilities. By taking a step or two at a time, one could make progress by adding quantity surveying (British practice), cost and cash management/technical accounting functions because there are existing interfaces with the ISO 9000 series. Examples include receipt inspection, delivery notes, quality release of components and supplies, and payments to subcontractors and suppliers. If the accounting and commercial functions are included, commercial security must not be infringed. There is obviously an increase in each of the four (4) "Trees" and in the line management procedures. The procedures annexed to the Quality Manual would remain substantially unaltered because the formation of the System is not changed. The Quality Manual would increase in size only marginally, but this may depend on the size and the capacity of the company concerned.

5 Acknowledgements

The author gratefully acknowledges the help given by Richard Grover, Oxford Polytechnic, Secretary to the E.O.Q.C. Construction Sector Committee in reviewing the Paper.

6 References

Publications

Association of Consulting Engineers (1988) **Quality Assurance; Guidance Notes with Synopses for Quality Manual and Operational Procedures,** ACE.

Building Employers Confederation (1988) **An Introduction to Quality Management for Builders,** BEG.

Chartered Institute of Building (1987) **Quality Assurance in Building,** CIOB.

Federation of Civil Engineering Contractors (1988) **Quality Assurance for Contractors; Guidance on the Introduction of a Company Quality System in Accordance with BS 5750, Part 2,** FCEC.

Foster, A (1985) **The Application of BS 5750 Quality Systems to Building Services,** Building Services Research and Information Association, Bracknell, Technical Note TN 2/85.

Gregory, D.P. (1989) **A Guide to Quality Assessment,** Building Services Research and Information Association, Bracknell, Technical Note 1/89.

Grover, R.J. (1987) **Quality; A Shared Commitment—Quality Assurance in Building and Construction,** British Quality Association.

Institute of Quality Assurance (1989) Building and Construction Special Issue. **Quality Assurance,** 15, No. 4.

Oliver, G.B.M. (1990) **Quality Management in Construction; Interpretations of BS 5750 (1987)—'Quality Systems' for the Construction Industry,** Construction Industry Research and Information Association, Special Publication 74.

Royal Institute of British Architects Indemnity Reserch Ltd. (1989) **Quality Assurance: Quality Systems in Building Design Firms 150 9001 1987—Guidance on assessment, and notes for firms,** RIBAIR.

Royal Institution of Chartered Surveyors (1990) **Quality Assurance; Guidelines for the Interpretation of BS 5750 for use by Quantity Surveying Practices and Certification Bodies,** RICS.

Sadgrove, B.M. (1988) **A client's guide to Quality Assurance in Construction,** Construction Industry Research and Information Association, Special Publication 55.

Technological Institute (1989) **Implementation of Quality in Construction; Experience in the 80's/Challenges in the 90's,** Technological Institute, Taastrup, Denmark.

Videos

Construction Industry Research and Information Association (1989) **Quality Assurance in Construction,** CIRIA Special Publication 63.

62
Housing quality: technical and non-technical aspects

G.FRANCESCATO

Abstract
Most technical personnel involved in managing and implementing quality standards hold a view of quality that is at variance with that of the general public. This paper takes as a point of departure the **systemic** and **transnational** approaches proposed by the author at the CIB 89 Congress in Paris. An analysis of the papers read at that congress is presented in order to identify congruence or divergence with these approaches. Implications for a publicly meaningful concept and application of housing quality are discussed.

1 Introduction

In any established field, discipline or profession, there is a tendency to privilege the execution of tasks specific to its praxis over the monitoring of its underlying perspectives and world-views. Although "state-of-the-art" reviews are often undertaken (as is the case in this symposium), ordinarily they emphasize techniques, methods, findings, or general issues rather than basic assumptions.

This tendency is normal and unsurprising. However, if a field is to remain vigorous and relevant, it should balance such trends by regular re-examination of its basic conceptual assumptions in response to continuing change in the world. Introspection becomes an especially critical need in post-industrial society, in which, as is often noted, change occurs at an ever accelerating pace.

Consequently, this paper seeks to contribute to a reflection on the **concept of quality** itself. It briefly examines the problem of **defining** quality and its attendant difficulties; distinguishes between quality **measurement** and quality **assessment;** summarizes a conceptual framework for quality assessment based on **systemic** and **transactional** approaches originally presented at the 1989 CIB International Congress in Paris; and analyzes the corpus of papers presented at that congress in order to identify possible elements of congruence with, or divergence from these approaches. Finally, the paper discusses implications of this analysis for a **publicly meaningful** concept of housing and building quality.

These issues may seem abstract, academic, and removed from the realities of economic considerations, management strategies, construction techniques, standards and codes, which properly occupy center stage in this symposium. They are not. The concepts that underlie the formulation of policies and programs have a powerful effect on their effectiveness—and thus on the housing and building likely to emerge from their implementation.

2 What is quality?

Not unlike other useful concepts, quality, in any area of human activity, has eluded precise definition. This is not surprising, because quality, as a term, acquires meaning only within a system of values which vary greatly among persons and groups—and over time. Complex and far-reaching consequences stem from this simple observation. For the purposes of this discussion, the most important effect is that the experts involved in developing, managing and implementing quality standards hold views of quality that, by-and-large, are at variance with those held by the general public.

It is not difficult to determine the reasons for this state of affairs. There has been a general tendency in the industrialized world to conceive quality in economic or technical terms that lend themselves to measurement of **objective** aspects. But the public conceives quality in terms of **global appraisals** based on **perceptions** of aspects of quality—and perceptions are, by definition, **subjective,** even though certainly affected by objective factors. In psychological terms, global appraisals may be viewed as attitudes, that is as composites of cognitive, affective, and behavioral intentional aspects, all of which mediate between objective quality indicators and global quality appraisals (Francescato, Weidemann, and Anderson, 1989).

Moreover, the objectivity of expert assessments is mostly illusory. As everyone else, planners, engineers, architects, and researchers are also influenced by subjective factors such as professional and political ideologies, perceptions, goals, and expectations (Saegert, 1989).

3 Measurement and assessment

It is important to distinguish between quality **measurement** and quality **assessment**. Measurement is generally straightforward; it simply involves the identification of variables related to quality (whether by hypothesis or by empirical findings) and the utilization of technically appropriate data collection and data analysis methods. Measurement, though easier and simpler for objective factors, is also feasible in the case of subjective aspects.

However, assessment is more problematic. To assess is to evaluate **performance** against a **criterion** or a number of criteria. This presents difficulties because both performance and criterion can only be defined by a value-based judgement; they are not empirically verifiable. Indeed, the term “performance” connotes not just any behavior but a **goal-oriented-behavior,** that is, behavior rendered meaningful by the existence of a criterion that specifies when a goal has been attained. But “performance” and “criterion” are interrelated and can be viewed as two faces of the same aspect, linked together by a shared convention, in fact a “code” of values.

As is well known, values are seldom made explicit in quality assessments and in policies, decisions and programs founded on such assessments. This makes it impossible to determine whether confidence can be placed on the experts' or investigators' conclusions. **Publicly meaningful** quality assessments can only be achieved if the value system underlying performance and criteria is shared by both experts and public.

4 Systemic and transactional approaches to quality

Systemic and transactional approaches to environmental assessments have been discussed in greater detail elsewhere (e.g., Francescato, 1989). However, it is useful to summarize here a number of relevant points.

First, one of the tenets of systems theory is that any system is subject to the control and monitoring of a management subsystem. But definitions of quality, methods of performance evaluation, establishment of criteria and monitoring strategies are too often the product of the expert or scientific management subsystem, that is of those involved in the **scientific and professional** areas of decision making, not of the **public and political** management subsystem.

Second, it is useful to consider that the distinction between a system and its environment is essentially a linguistic and taxonomic artefact. A system's environment is in fact only a higher-hierarchy system within which a system is contained and, more important, to which it is connected.

These two considerations suggest that, in addition to continuing the present course of research, there is a need for gaining a better understanding of the role played by subjective factors in the experts' work and for grater congruence between the professional and public value systems. Moreover, a concerted effort must be made to link technical aspect of quality, such as thermal comfort, interior space performance, soundproofing, air quality, etc., to other subsystem with which they are intimately bound up, such as those in the social, cultural, economic, and political realms.

Likewise, the transactional perspective now emerging in the human sciences may provide some useful insights. First, this approach proposes that analysis be shifted from the components of a system to the system as a whole, and that the **changing relationships** among aspects of this whole be the focus of study.

Second, while change among relationships is often the result of efforts at achieving goals, the goals themselves are frequently in a state of flux due to a variety of external factors.

Finally, any complex system tends to have multiple "customers", that is, "multiple goals at work in the same transactional configuration".

Again these observations lead to the conclusion that it is desirable to develop approaches that would conceive building quality as an "event" (cf. Altman and Rogoff, 1989), as a confluence that changes over time of all the factors impinging on it, technical and non-technical, objective and subjective.

In addition, the multiple goals of all those who act in the system, from the politicians and the developers to the planners, designers, experts, and the general public, ought to be simultaneously analyzed so as to achieve a better understanding of how they can be brought to mutually support each other or, at the very least, to minimize mutual conflicts.

5 Quality for building users

The title of this section echoes the theme of the 1989 CIB Congress, held in Paris. An examination of the papers presented at that congress was conducted to ascertain convergence or divergence with the perspective and approach advocated here.

5.1 Method

The large number of papers presented at the 1989 CIB Congress precluded performing a content analysis of the proceedings. Because keywords were not standardized, it was also impossible to conduct a keyword analysis in lieu of content analysis. Instead, the papers were examined against eight questions intended to address the issues discussed in the preceding sections. Table 1 summarizes these questions.

Table I—Aspects of CIB 89 Papers Examined

VARIABLE	QUESTION
A	Is what is meant by "quality" made explicit?
B	Is the focus on assessment rather than on measurement?
C	Are performance criteria explicitly stated in terms of values?
D	Is there an emphasis on "expert" management systems?
E	Is there an emphasis on "public" management systems?
F	Are both expert and public management systems considered?
G	Is there consideration of changing relationships over time?
H	Are the multiple goals of system customers considered?

A process of stepwise elimination was used to remove from the sample papers that addressed specialized sub-themes (these could not reasonably be expected to concern themselves with global quality). Thus, volumes I and II of Theme II (Lifespan of Buildings), and volumes I and II of Theme III (Constructing Quality) were not considered. This proved to be a somewhat imprecise procedure, as a small number of papers in these volumes did in fact deal with global quality (e.g., Di Giulio), but inclusion of these papers would have inappropriately skewed the data distribution.

Further, even Theme I, User Comfort, included specialized sessions devoted to energy, security, etc., so that only session I–I, Architecture and Spatial Organization: Overall Quality, could be truly considered to address the issues discussed here. However, for comparison purposes, analyses were conducted for the entire sample of papers in Theme I, as well as separately for those in session I–I.

5.2 Results

Tables II and III present the descriptive statistics for all cases in Theme I, after 25 cases which were judged not to address the theme (User Comfort) were removed from the analysis. Affirmative answers to the questions in table I were coded as 1, and negative one as 0.

Table II—Means and Standard Deviations for Theme I N=132—Yes=1.00; No=0.00

Variable	A	B	C	D	E	F	G	H
Mean	.11	.17	.13	.88	.13	.09	.11	.11
St Dev	.32	.37	.34	.33	.34	.29	.32	.31

Table III—Frequency Distribution of Positive Answers: Theme I N=132

Variable	A	B	C	D	E	F	G	H
Count	15	22	17	116	17	12	15	14
Percent	11	17	13	88	13	9	11	11

Tables IV and V display the statistics for a smaller sample consisting only of the papers in session I (Architecture and Spatial Organization: Overall Quality) of Theme I (User Comfort), after 13 cases that were judged not to address the session subject were, again, removed from the analysis. The same codes were used as in the previous sample.

Table IV—Means and Standard Deviations for Theme I, Session I (Architecture and Spatial Organization: Overall Quality) N=17—Yes=1.00; No=0.00

Variable	A	B	C	D	E	F	G	H
Mean	.47	.71	.47	.65	.47	.24	.41	.35
St Dev	.51	.47	.51	.49	.51	.44	.51	.49

The results show that the papers in the larger sample (Theme of User Comfort) strongly diverged from the viewpoint proposed in this paper. For example, only 11 percent of the presentations explicitly defined

Table V—Frequency Distribution of Positive Answers: Theme I, Session I (Architecture and Spatial Organization: Overall Quality) N=17

Variable	A	B	C	D	E	F	G	H
Count	8	12	8	11	8	4	7	6
Percent	47	71	47	65	47	24	41	35

what their authors meant by "quality", 13 percent stated what assessment criteria were used, and just 9 percent addressed "public" views of quality, while fully 88 percent relied solely on "expert" judgements.

Even among the smaller sample, which was intended to treat issues of architectural and spatial organization in terms of overall quality, less than half of the papers defined what was meant by "quality", what assessment criteria were used, or took some account of the public's perceptions of quality, and 65 percent still emphasized the views of experts.

Still fewer papers acknowledged the complexities introduced by change over time and by the multiple, and possibly conflicting, goals at work in quality assessments. Only 11 percent in the larger sample, and just 41 percent and 35 percent respectively in the smaller sample, addressed such issues.

5.3 Discussion

CIB Congresses are well-attended, influential gatherings. At the Paris event, more than 300 papers were presented within the general theme of "Quality for Building Users Throughout the World". Therefore, the perspectives that emerge from such a meeting constitute an indicator of the "state of the art" in the field.

Yet, only less than half of all the papers in the 1989 CIB treated issues that could be construed to address global building quality, and indeed fewer than 6 percent were classified within the scope of the term "overall quality" by the congress organizers. The results presented above, further significantly reduce the proportions of the presentations that even acknowledged, let alone fully dealt with, dimensions related to the perspectives outlined earlier in this paper.

In light of these observations, it is difficult to escape the conclusion that most of the research being carried out takes a narrowly technical view of quality, one that is directed to measurement of single, discrete aspects of quality, rather than to performance assessment based on explicit criteria, and one that is, in any event, more concerned with satisfying the concerns of the experts than those of the general public.

This conclusion should not be interpreted as a criticism of the utility or technical quality of any single study. Nor should it be construed to imply that the type of work reported at the 1989 CIB Congress should be discontinued. Obviously, as in any complex field, experts and technical knowledge can make important contributions to the solution of specific problems.

But, while the type of research examined here is clearly necessary, it is the thesis of this paper that it is not sufficient if the goal is indeed to deliver overall quality to the users of buildings in all parts of the world. In other words, a better balance must be reached between the “expert” perspective and the “public” perspective of quality. Greater attention must be paid to those aspects of quality to which building users attribute particular importance. Because these aspects are likely to change over time and vary across population groups and geographic location, greater sophistication is called for in developing and implementing appropriate theoretical frameworks and research methodologies.

6 Implications for housing quality

A publicly meaningful concept of housing quality is likely to have significant implications for all the areas listed in the topical matrix of this Symposium.

Housing policies are driven by both quantitative and qualitative goals. But these goals are interrelated, as shown by the European experience with housing reconstruction in the aftermath of World War II (U.N. Economic Commission for Europe, 1973). This experience has demonstrated that, as the public’s view of acceptable quality changes, it inevitably affects the attainment of quantitative goals. In the general climate of economic growth and increasing affluence that Europe has been experiencing, policies aimed at providing sufficient number of dwellings of satisfactory technical quality have often resulted in vacancies and housing abandonment (e.g. van Kempen, 1986).

The housing market is also directly affected by public views of quality. Indeed, conceptual frameworks and methods of market analysis have been constructed which regard prices that the public is willing to pay for the “service bundles” provided by housing as a reflection of public quality constructs. The so-called “hedonic index” is an example of such an approach (Mendelsohn and Struyk, 1975).

Public concepts of quality are also likely to influence management strategies and practices, both at the project delivery and at the post-occupancy levels. Management tends to be driven primarily by concerns with time and capital efficiency. But these efficiencies are, in turn, affected by risk levels—and risk increases in direct proportion to the lack of congruence between management’s and the public’s views of quality.

In sum, reliance on technical and expert judgements and concentration on research and application instruments designed for the purpose of measuring technical quality is likely to have, at best, only a limited effect on the provision of housing of publicly satisfactory quality. At worst, such an emphasis can misdirect policies, programs, plans, and management strategies and risk repeating mistakes that have already proven politically and economically unacceptable in a number of countries.

The plea of this paper is not for discontinuation or de-emphasis of research in technical aspects of housing and building quality, but rather for a better balance of technical and non-technical aspects and for privileging public over expert views of quality.

7 References

van Kempen (1986) High Rise Housing Estates and the Concentration of Poverty. **The Netherlands Journal of Housing and Environmental Research**. 1, 5–26.

Mendelsohn, R. and Struyk, R.J. (1975) **The Use of service Flows Data in Measuring Housing Quality**. Washington, D.C., The Urban Institute.

Francescato, G, Weidemann, S., and Anderson, J.R. (1989) Evaluating the Built Environment from the Users' Point of View: An Attitudinal Model of Residential Satisfaction, in Preiser, W.F.E. (ed.) **Building Evaluation**. New York, Plenum.

Saegert, S. (1987) Environmental Psychology and Social Change, in Stokols, D. and I.Altman (eds.) **Handbook of Environmental Psychology** vol. 1. New York, Wiley.

Francescato, G. (1989) Planning and Design Aspects in the Quality of Multifamily Housing: The U.S. and European Experience, in **Quality for Building Users throughout the World**. Paris, International Council for Building Research Studies and Documentation (CIB).

Altman, I. and Rogoff, B. (1987) World Views in Psychology: Interactional, Organismic, and Transactional Perspectives, in Stokols, D. and I.Altman (eds.) **Handbook of Environmental Psychology** vol. 1. New York, Wiley.

U.N. Economic Commission for Europe (1973) **Housing Requirements and Demand Current Methods of Assessment and Problems of Estimation** Geneva, United Nations.

63
Total quality control in a building construction company

J.le GALL

Abstract
The Thirty Golden Years which have contributed in discrediting our Constructor's professions in the eyes of younger people, have also mollified the power of reaction of our companies in front of the development and evolments of the market.

In order to catch up at top speed, the T.Q.C. is a very efficient system indeed, but its industrial expansions are not well adapted to construction work. The fact of preparing methods and specific tools is a very important operation which reaches out to the know-how it self and, on a more difficult level, to one's professional and individual behaviour.

Together with the first fields of application, one must also develop side—measures such as motivation of the managerial staff, communication, training, security and especially the Quality/Innovation tandem.

At the end of this "catching up phase", the panorama of the construction industry will be altered beyond recognition.

Keywords: Development/Evolution, Anticipation, Know-how, Behaviour, Methods, Tools, Starting-up, Practical Use, Communication, Training, Quality-Innovation Tandem, C.I.M., Industrial Tailor—made product.

1 /The general background

1.1. A far too slow reaction to obvious issues.

"EVERYTHING IS ON THE MOVE HENCE, EVERYTHING MUST BE ON THE MOVE".

Pretty obvious indeed! and one may add:

"ALL THAT IS LEFT IS INTERDEPENDENCE! GONE IS INDEPENDENCE!".

Both these statements can apply to our business organizations, our structures, our ways of management and operation, our production,…

We have come to the point where we have to face constant questioning and permanent anticipation. Nothing will be done tomorrow in the way it is done today.

Intellectually speaking, most of the leading men and executive staff agree on these two points. But on the other hand, the matter is quite different when it comes to facing the consequences and materializing them.

1.2. From industry to building construction and civil engineering works: rashness in predictions.

Thirty or forty years ago in the industrial field, the word "quality" gave a precise definition of the target. Even today, in these sectors, through the quality of the finished product it focusses ones attention on the creativity and competitiveness of the industrial manufacturer who is usually in direct contact with his market and its requirements and needs. A finished product which the client can actually "see" in most cases before having decided to buy it.

In Industry, quality techniques have rested on mass production and hence statistic inspection and management systems, on a limited number of "processes", on procedures which were rather easily devised and applied, on long lasting production lines, and steady locations, on permanent working teams, on adequate solid training conditions…

In short, fair conditions allowing one to set up an internal quality inspection system and all its applications.

Such foundations were solid enough to cope with any future developments which were the normal consequences of technological, commercial and sociocultural evolutions… From an inner and well polished quality inspection, one switched over to a dynamic operator-control, to a participating management activity and to partial and total quality control which were the prelude to modern answers with their "straight line" hierachy, such as "empowerment" (generalized sharing of power) now being experimented.

Very few of these conditions appear in the context of Building Construction and Civil Engineering which has just recently been put on the tracks of T.Q.C. But all the same, one of the methodologies often put forward by "specialists" is, more or less, to reproduce the above described itinerary, start off from a different point and accelerate the whole procedure!

Pressing on and jumping various stages is necessary and quite feasible. Consequently, you have to rely on the experience of other industrial sectors, but you also have to re-think the whole operation and adapt it to present day condition and environment. It is a major and highly complicated task, rarely dealt with in today's European contruction world.

1.3. Scope of the endeavour

In France, the Building Industry is slowly emerging from a paternalistic taylorism based on a "job-site history" unique in its kind among other industries.

It is entangled in confusing vital and conjunctural complexities which are the result of the incongruous accumulation of its historical past.

To the variety of adapted “products” which must be materialized, of the know-how and environmental conditions which must be kept under control and to its nomadism one must add the remoteness of needs and market, the complicated and constraining accesses to the market, the number of participants and the very strong subdividing of action.

To top it all, our “plant” is often on the move, our staff, and all the more our production personnel, comes and goes. As a matter of fact, during the “Thirty-Golden-Years” (!?) we certainly saw to it that they be underqualified, set aside and that their stamina be broken. Our relationship with clients, architects and sub-contractors were mainly based on disputes, but in those days we could still indulge in such luxury because of the adaptability of prices and the scope of demand.

Anyhow, considering “it didn’t work out too badly” high ranking nostalgic people still dream of repeating their by gone achievements with the help of methods and operational systems which have hardly been altered.

The road which is to lead Building Construction and Civil Engineering to Excellency through total quality control is still badly staked out and methods and tools must yet be better defined; there are numerous obstacles and no true solutions!

Let us learn our lesson from the captains of industry who were on the job before us, but let us also learn how to interpret it and use it. We shall need a fair amount of creativity, but the stakes are high. Those who will continue refusing the obstacle will take important risks, often deadly ones.

1.4. The Building Construction Company

Building Construction and Civil Engineering have of course many things in common. There are also great differences which backfire on to their management methods, their ideas and their ways of operating.

“Public” Civil Engineering, in particular, might accept the prediction of industrial methods in a somewhat easier way.

Building Construction has a more specific regional form of organization meant for small or average size sites, and several levels of consolidation. It is no longer the more management of a project, but it is not yet the management of a production line.

A large Building Construction Company is the addition of variable sized profit centers which all owe something to the name “P.M.E.” (Small and Average Size Company).

It is this particular case which will now be the subject matter of this report.

1.5 Why now?

The question was systematically put to us before 1988, but less and less now, since the European Single Market is no longer an image beyond the horizon.

Why now? Because:

The market has simultaneously become narrower and more demanding since the client himself is more technical and his requirements have become more global.

The supply has risen above the demand and competition has become very aggressive.

Regional and national borders are fading away as far as both supply and demand are concerned.

The new technoligical ressources increase the competitiveness of those who are the first to know how to apply them.

People have new ways of acting and business organizations and management systems must be able to integrate them very quickly.

The needs/supply complexity can no longer be managed empirically.

As from now, only THE VERY BEST will survive provided of course they remain so.

The aim of today's approach is in fact only the up-dating of our means of operation and production so as to adapt them to a rapidly developing environment which we have not taken into account for some time.

Yet another consequence of the "Thirty Golden Years"!

And we have resisted as long as the market has allowed a majority of us to keep our head above the surface. All this is gone and done with now! All the more since the "bathtub" has become larger and since new swimmers come and create bigger waves.

So, our endeavours, which are barely called **"QUALITY",** mean nothing else but making operational all actions which will allow us to catch up with all the time we have lost in terms of management of our companies. Once the catching up operation is over, and within the permanent contest of **"ECONOMIC WARFARE",** we shall have to keep developing our creativity and our excellent competitiveness through mere mobilization and through the willpower of our staff, and also through the daily optimization of our methods and means of operation. Last but not least, through our capability of anticipating the development of the market and of its upstream major issues, needs and requirements.

We shall then have become "professionals"!

2 /Means of application

2.1. Definitions and basic principles

In order to facilitate the design and application of our methods and tools, we usually subdivide quality demand into three main chapters:

a—The improvement of Quality for the benefit of the CLIENT. Such improvement must be compulsory, from the basic analysis of needs and the preparation of demanded or not demanded offer, all the way to the contractual delivery of the implemented Project and its facilities. Including of course a good and efficient relationship during all the period of contractual and bilateral work.

b—The improvement of Quality for the benefit of the CONTRACTOR, in other words the permanent increase of his competitiveness and professional ability to his "excellent" operational actions on site, allows for an immediate "Client Quality" at lower cost.

c—The improvement of the Quality of living conditions for the Contractor's MEN who are on the job and for those of his partners (the "Grand Contracting Company") within the design and materializing of our answers to the existing needs is also a milestone.

To reach this aim, we must motivate and mobilize our men even more so that both their productivity and creativity, whether individual or "in team", reach the very top level.

For each of these chapters we believe that action must be divided into two main topics:

a—First topic—"KNOW-HOW": technical activities meant to optimize and unite (synergia) the work of the numerous internal and external participants in each project or profit center. The keywords are: methods, strictness and rigour, scheduling, modelization and formalization of repetitive tasks, detection and solving of problems, use of systems and tools for inspection, supervision and prevention, quality regulations and procedures,…

b—Second topic—"BEHAVIOUR": management and sociocultural actions aiming at forwarding the company's leadership and management options toward more modern lines better adapted to the new commercial, technical, programming and especially social data of their environment.

Along this line, keywords are: liability and responsibility, participation, solidarity, operator-control, team work, the right to error, communication, consideration, training, partnership, mesh-type relationship,…

2.2. How to start up

Every time operations are launched with "great care", they usually start up on the basis of "site quality" or "quality circles"!

In both cases, experience mostly shows the coming to life on the short or long term, of limitations or even helplessness in the ranks of the most motivated "actors".

Such is the consequence of a far too literal understanding of the various industrial patterns. A job-site is not a workshop and a construction company is only one of the "dramatis personnae", many of whom stand halfway along the line. In both cases, all efforts are too important as compared to the results, since internal environment has not been sufficiently prepared and since external environment acts more like a hinderance than anything else.

We have come to the conclusion that the following principles should govern any commencement:

A "topdown" move of the hierarchy.

An upstream to downstream move in terms of interventions.

A quick and total involvment of the company so that all the staff concerned share equal responsibility in the face of Quality.

A fast extension's to "down stream" environment of suppliers and service suppliers.

A tactful intervention on the upstream environment so as to minimize any upstream hinderances and lack of Quality.

Always keeping in mind of the client the following issue, which is still not quite well understood:

the CLIENT is always the one who has to FOOT THE BILL of any LACK OF QUALITY.

No Contractor could possibly face any losses equivalent to lack of Quality expenditures if they were not "payed" by the client himself.

2.3. The various cases to be dealt with

Each case is a special case: the men in charge of quality are aware of it.

But on the other hand, one can class them in families, hence specific methodologies.

There are four major families:

The profit earning centre

The major building site

The functional centralized department

The operational centralized department.

The "centre of profit-making-family" which we have chosen as the launching pad for our issue is in fact a "full package" because it also deals with centralized departments and building sites.

Last, experience has shown us that our efficiency is at its highest level for centres manned by 100 or 200 people.

2.4. Stages of application to a centre

There are two major stages:

The approximately six month long preparatory phase which amounts to a record of facts and to the operational schedule for the performance phase.

This performance phase (18 to 24 months) must lead the centre to a first stage of optimized and coordonated operations: said stage is more or less equivalent to the one which allows the centre to apply for the Quality Assurance Agreement type E.N. 29001.

a —The preparatory phase

In short:

– the initial feeler-meeting between Manager and Staff,
– the basic "Go" given by the Manager,
– the first work performance diagnosis from the leading men of each central department.
The two members of the Quality team then acquire good "knowledge" of the entity.
– the duplicate report (objective report on actual data, and the first "impression") is presented to the Manager who will forward to the executives for joint analysis.
– the "irreversible" decision of getting the whole operation off the ground after the Manager-to-Staff consensus.
– the setting up and commissioning of a leading Quality team.
– the detailed diagnosis now regarding the two issues, know-now and behaviour.
– through mainly individual conversations, it implies one third to half of the personnel. It gives detailed results on the initial diagnosis, analyses the mechanisms of internal links and tackles the external relations. It is completed by a first estimate of the non-quality costs which allow a shared understanding of the economic and commercial stakes.

– the last resulting report is the balance of facts and of priority actions which have to be launched. Not only at the job-sites but also at the departments of the centre.
– the reports on actual facts and on the program of priority actions which will be fathered by this project after being validated and adapted by the leading group and approved by the Manager. They are submitted in a one day meeting, first to the executive staff and then to all the personnel (High Mass).

b —The actual performance phase

Proper work will now begin. It will take a long time, demand a good deal of determination, harship, good and proper planning. All our empirical, "verbal" and cultural assets will have to stand for trial!

We deal with the matter in two different ways:

– Through pin-point actions and permanent operations in terms of direct responsibility of the leading quality team. It is in charge of pumping life and animation into the work groups which will, if so be, solve major problems. In specific alloted time lags of course: 3 months or so for solving each problem. It will carry on with the detection and processing, and in a well prepared environment, it will bring about the "spontaneous" birth of permanent groups bent on improving Quality (another way of saying "Quality circles"). The "solutions" will pave the way for structured operations.
– Those of well structured operations boosted by Quality control specialists, which will involve all the personnel of the centre, from the Senior Executive Officer all the way down to site labour along three main lines:

"Management"

The Manager will give a more and more accurate and quantified definition of his policy and of the means of information and assistance to decisions which will allow him to "re-act" to and quickly anticipate any outside developments (market/ressources). With his staff he will pin-point his organization, all the feasible development patterns and he will foster communication programmes, permanent training periods, partnership schemes and network's, and major research and development operations for the future of his centre.

Them he will have fathered the important chapters of the "Quality Manual" and of the project of his company (the development programme).

Centralized Departments.

On the basis of facts and activities, each department will formulate its most repetitive tasks and will study its internal relationships (internal analysis of client to supplier attitudes) and its external ones. The department will define the procedures (repetitive tasks) and will negociate them with the various clients and suppliers.

It will set up its own quality data, its own preventive and inspection systems. Thus it will put in place an operational Quality program which we call n° "0", subject to a 6 month testing period and to alterations to become Quality Action Programme n° "1".

Production Departments

Two or three basic-sites will be chosen to compile a dossier which we call: Quality Operational Programme for Building Sites".

The aim is to help the site supervisor involved in producing and materializing the tools and procedures which he will use everyday to lead and monitor the building site, the means of prevention and the methods of operator-control development.

As for preceding cases, N° "0" Quality Programme will be tested on various testing sites. The centre will then have at its disposal a N° "1" Q.O.P. which will be forwarded to all site-supervisors so that when a site has to be mobilized, they will be in a position to pre-formulate the Quality programme and all the corresponding methods and tools.

c —Final Aim

After such a long but compulsory itinerary, the centre will have given birth to its own Total Quality Control System, it will have to apply it and keep it active and alive. It will then be in a position to offer Quality to each of its clients and, if the case be, it will be entitled to Quality Assurance E.N. 29001 Agreement.

3 /Major side-measures

They are indispensable in terms of the swift economic development of the issue.

3.1. Motivation of senior and executive staff

It is a prime condition magically confirmed by all Quality Specialists. Let us only recall the following points:

– The absorbtion of "Quality Investment" is directly proportional (in terms of percentage and swiftness of return) to We Manager's conviction and example attitude and to that of his staff.
– On the other hand the degree of Quality Investment (the cost) is in inversed ratio.
– The failure hazards are mainly due to such lacks in conviction and example. A failure in the field of "Quality" usually leads to demotivization and important backpeddling within the centre.

One must nevertheless emphasize that the endeavours of the executives and staff to adapt themselves to the situation, especially in terms of "behaviour", are, at times, quite impressive. The "modern" managment philosophy and approaches are often at the antipodes of those, which have been successfully applied a few years ago. The man in charge of internal Quality control or the external consultant must be sure of the initial level of motivation (or take measures to be sure indeed) before accepting the responsibility of launching a Quality Operation. If not, the man-in-charge would be suicide prone or not accountable for his own actions.

3.2. Communication

Most of our first analyses show that bad internal communication is the prime element of “non quality” in a centre to the great astonishment of the Manager.

Thank god the personnel is not informed of internal and external communications which present ressources could generate!

The action of informing become number one issue, even for Building Construction Companies.

Hence, the responsibility and interest of the Manager is to be the driving-force of progress in this specific field.

The amazing development of micro-computers has put factual and economic means at our disposal. The first companies capable of using them in a proper way will be at “Top-Level”.

Nevertheless, there must be a major protection shield: front line information and communication, prepared by the Mother Company. The extraordinary potential must not generate a smallish Tower of Babel!

3.3. Permanent training programme

Yet another “MUST”, which is the consequence of obvious speedy development. Capacity and Know-How are quickly becoming more and more obsolete. All the more, when one holds a high rank.

This is not really felt deeply in France. The executive staff must become aware of this issue as early as possible, if not, they will dig their own graves including that of their Company!

At the other far end of the line, the problem is even more acute: whether they have volunteered or not, there are less and less people to train. Whereas it is a strategic issue and in spite of the numerous public addresses, the repolishing of the Building Construction Industry remains a brilliant slogan! Any action along this line would be, and are in fact, taken with shyness. They are certainly not up to the stackes.

Red Alert!

3.4. Innovation

Within our methodology, Quality and Innovation are two complementary and indissociable topics which we put under the heading “PROGRESS OPERATIONS”.

To paraphrase the Japanese, and also because we are convinced, we say that what our companies need to be and remain excellent is,

– systematic, step by step daily progression (KAIZEN): it is the preferential terrain of “Quality” approaches.
– periodical up-the ladder type progression due to a technological forward thrust and an innovation and research policy.

The total of these two rhythms of progression gives the ideal tempo to the progression of the company. Moreover, quality actions contribute to the mobilization of creative capacities within the company. They also allow us to detect products, processes or procedures which are "out of breath" and have done their time. They cannot be kept alive except through costly and desperate surgery.

Within a company, the Quality-Innovation synergy is most probably one of the major criteria of the perenniality of its top-level.

4 /The probable consequences of a generalization of the T.Q.C.

We have drawn up a list of a few of them:

4.1. For the company

Until they have caught up with their environment, our business organizations and companies are going to be sorely tried indeed. The necessary changes will be too swift for their normal "biological" pace. It is the critical phase which must be handled with utmost care always keeping in mind that one must rush ahead but not too far and with too great a haste.

Internal resistance is strong. The medical treatment meant to release the brakes will be information and training in "massives" doses.

4.2. For all the working channels

It is obvious for any careful and impartial observer that, in most case, the present way channels are operated is miles away from all the criteria which could lead to total excellency.

There again, one has to catch up with lost time. And be quick about it too, otherwise all the channels will fall into the hands of international groups "far more in the picture" than we are. But without blind rashness, step by step, otherwise the damage will be severe in certain professions.

In most sectors of industrial activities, there is a strong binary "purchaser to vendor" relationship which is a short cut and which eliminates a maximum interface loss of pressure. It will not be the sole and only solution, but, it will be one indeed. It has to be quickly codified so as to test it, check its effects and work value and avoid: it being used thoughtlessly.

4.3. Heading towards a real Building Construction Industry

Several attempts have already been made in the past. Once again, with a far too superficial imitation of industrial cases. It resulted in a few short-lived successes then a temporary switch back to what is called the traditional lines of work.

The new environmental data, the amazing ressources which are now at our disposal, the starting up of Total Quality Control by most of the actors lead us to believe that this time there is a long term success ahead for the Building Industry.

In the coming years, a few of us will become "building producers" by developing efficient integrated computer assisted production methods which will give our clients the **"Industrial-tailor-made-product"**. In other words, meet their requirements as best we can, consolidate our profit-earning and give our personnel the desired standard of life at the office.

If we fail, others will succeed in our place.

64
Economy and quality in building services and utilities—research programme in Brazil

O.M.GONÇALVES

Abstract
This paper presents research programme developed in the Civil Construction Engineering Department of the Escola Politécnica of the University of São Paulo, focusing quality and economic aspects of these systems in residential buildings. Concerning the economic aspect the programme involves research works related to the water and energy conservation such as: study of user's behavior related to water supply and drainage systems, development of models to determine the water and energy demand consumption and evaluation of the system components. In relation to the quality aspect we are developing studies on Quality Assurance of the components of water supply and drainage systems. These studies comprise not only the documentation but also quality audit programmes.

Keywords: Building Services, Quality, Economy, Water Conservation, Energy Conservation.

1 Introduction

The Civil Construction Engineering Department of the Escola Politécnica of the University of São Paulo comprises in the Building Services area the sub-systems of the building which goal is to support the performance of the users' activities in residential, commercial, industrial and institutional buildings in relation to: water supply and drainage, energy supply (electricity and gas), thermal and acoustic comfort and fire protection and safety.

Considering the systemic character of building services they must not be studied in an analytical and reductionist way. The utilization of the system approach and consequently of the performance concept is extremely important in the design, execution, operation and maintenance of the building services systems considering the user's and the building's demands.

Building Services study presents problems which can be divided into further two main branches:

Characterization of the demands in which the system is submitted;
Characterization of the system itself, of its elements and components in order to support properly the imposed demands.

Thus, in the Building Services research area studies have been developed approaching the suitable model definition in order to determine the demands depending on the intensity of utilization. Once these demands and the specifics fenomena of each system are known, the behavior of the elements and components of the system is evaluated, in order to suggest new technologies economically and technically more suitable.

In the case of the residential building section the study is directed on the water supply and drainage systems and on the energy supply systems (electricity and gas). Research has been developed in these two systems focusing chiefly two fundamental aspects:

Economy—considering water and energy conservation as well as suitable dimensioning procedures;
Quality in building systems focusing the assured quality of these systems components.

We present, as follows, some topics that are being developed concerning the subject in question and related to the residential building area.

2 Determination of the demands in residential building systems

Brazil is a country of continental dimensions where population is spread, in different ways, in regions which differ not only in climatic parameters but also in distinct levels of social and cultural conditions. It can be said, keeping the right proportion, that this situation is similar to that occurring in the United States of America or in Europe, as a whole.

To determine the demands of a certain system (design flow-rates and design electric currents) is important that the employed dimensioning model take into account the real behavior of this system considering the diversities of each region.

Our viewpoint is that the most appropriate models must be “open”. They must have general characteristics in relation to the intervening variables but must also have a specific character in relation to the particular characteristics of each design situation.

2.1 Design flow-rates in water supply systems

We developed an “open” probabilistic model to determine the demands (design flow-rates “Qp”) in water supply systems. The most direct relationship between the user and the building water supply system occurs when he is performing activities related to the use of water and the sanitary appliances system. Therefore, the flow-rates that occur in the system depend basically on the following factors: users' activities, building characteristics and characteristics of the group of sanitary appliances.

We can also shorten the influence of these various factors expressing them by:

Intensity of the utilization of the group of sanitary appliances;

Unitary flow-rates of the sanitary appliances.

The intensity of the utilization of the group of sanitary appliances depends on the following variables:

Discharge duration of a sanitary appliance denoted by **t;**

Time interval between the start or the end of consecutive discharge of a sanitary appliance denoted by **T;** the random variable **T** depends on several factors: type of building, users characteristics, population, spacial organization, type of appliance and number of appliances available.

Number of sanitary appliances installed downstream from the considered section, denoted by **n**.

The unitary flow-rates of a specific type of a sanitary appliance will be denoted by **q**.

We can present on Table 1 the depending relationships between the factors that influence the design flow-rates and the intervening variables that willbe used in the "open" mathematical model.

In Gonçalves & Graça [1988] and Gonçalves [1986] [1989], a guideline to use this model can be found.

Table 1. Dependence relationship between influence factors and the variables employed in the model

Factors	**Variables**	**Intensity**			**F–R**
		t	T	n	q
Users	Type of building	D	D	IN	D
Activities	Users characteristic	D	D	IN	D
Building	Population	IN	D	IN	IN
Characteristics	Spacial Organization	IN	D	IN	IN
Charact Group	Appliance function	D	D	IN	D
Sanit. Applianc	Number of appliances	IN	D	D	IN
		rv	rv	dv	rv

D=depend

IN=independ

dv=deterministic variable

rv=random variable

F–R=flow-rates

Researches are being developed, applying the "open" model as a reference, in order to set the parameters of the intensity utilization and of the unitary flow-rates, using field measurement to design specific situations.

In the case of hot water supply systems Ilha [1991] developed a research in residential buildings in which values, to set the referred parameters, were obtained. Two significant housing types were considered in São Paulo city: dwellings of two bedrooms and one bathroom and dwellings of three bedrooms and two bathrooms. This kind of measurement required the development of a device that could store within a time interval the flow-rate occurrences. This device, called "ARTE" has been used in field measurement in 5 dwellings.

The outcome is presented on Table 2.

Table 2. Parameters of the intensity utilization and unitary flow-rates in hot water supply systems

		shower	lavatory	kitch.sink
unit.flow-rate	μ	0.106 *	0.059	0.049
(l/s)	σ	0.020 *	0.040	0.032
discharge	μ	465.00	32.00	25.00
duration (s)	σ	359.00	36.00	38.00
number	μ	0.75	0.83	16.18
of uses (3 h)	σ	0.29	0.66	10.71
peak period (h)		2	2	3
temperature		45°C	44°C	47°C

(*)—flow-rate of hot and cold water mixture

Table 3 shows a decrease of the medium unitary flow-rate values, compared to those reccomended by the Brazilian Standard Association (NBR-7198) today. This decrease represents energy (electricity and gas) conservation and a cut in costs in the design and in the dimensioning of hot water supply systems.

Table 3. Hot Water unitary flow-rates (l/s)

	Shower	Lavatory	Kitch.sink
NBR-7198	0.120	0.100	0.250
Ilha [1991]	0.064	0.059	0.049

The behavior of the components of the drainage supply building systems must be evaluated taking into consideration the efective reductions of the design flow-rates in building water supply. A research work was developed in this same direction (Oliveira [1991]) studying the behavior of the horizontal pipes related to the water flow in the drainage systems in residential buildings using the software developed by Prof. J.Swaffield (UK) and L.Gallowin (USA).

We present, as follows, researches which are being made related to the demand of the energy supply systems in buildings.

2.2 Demands in energy supply building systems

In the area of energy supply building systems demand profile is being studied along specific design situations the aim being to equate the following problems likely to occur in large brazilian cities. The first one is the electric power demand profile in the residential segment which is unbalanced and at the peak period, (between 5:30pm and 8:30pm) it can reach values 1.7 higher than the medium values (heating of water for higienic purposes is one of the principal causes). The substitution of electric power by gas (NG and LPG) in the water heating system is the second one (the supply of natural gas is rising in some large cities).

Prado[1990] developed studies in low-cost housing analysing the electric power demand with the substitution of the electricity by the gas in water heating. The typical water heating equipment in this type of housing is the electric shower.

Field measurements have been carried out in 130 housing units, what represents statistically this type of low-cost housing in São Paulo city.

Figure 1 shows the economy obtained in the electric supply system with the energetic substitution. The electric demand is 5.5 kw when the electric shower is installed and it is 1.2 kw when the water heater is gas fired.

Ioshimoto [1990] developed studies to establish the demands in gas supply systems in residential buildings: dwellings of two bedrooms and one bathroom and dwellings of three bedrooms and two bathrooms.

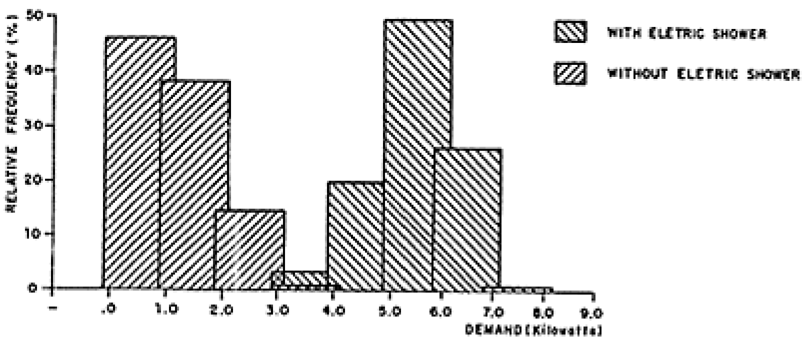


Figure 1. Electric energy demand in low-cost housing in São Paulo—Prado [1990]

Field measurements have been carried out in 23 buildings during 4 months period. In this study the curves of simultaneous factor **(Fs)** depending on the total flow-rate **(Qi)** of all installed equipment have been defined for some levels of failure factors—Figure 2.

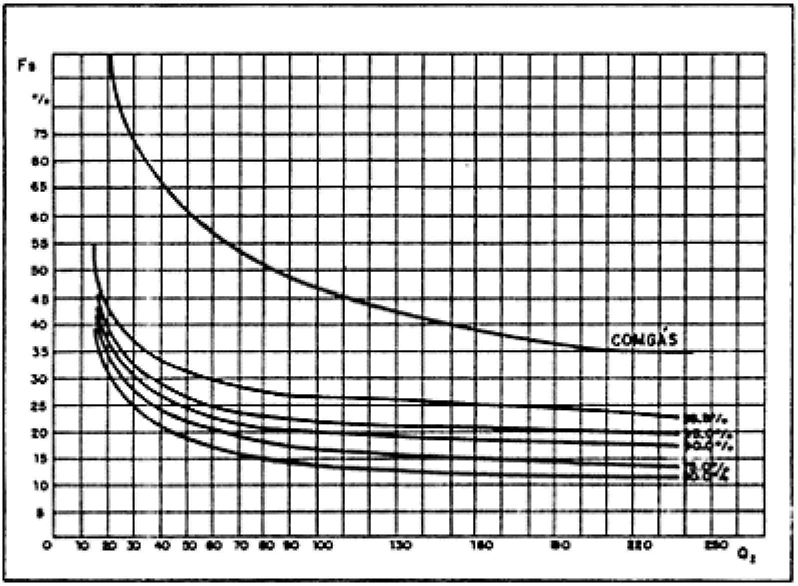


Figure 2. Simultaneous factor **(Fs)** versus Total flow-rate **(Qi)**—Gas supply System

Thus the design flow-rates **(Qp)** of the gas supply system components can be calculated, for specific design situation, by the following expression:

Qp=Fs.Qi

It can be observed in Figure 2 that the values of **Fs** obtained by Ioshimoto [1990] are lower than the proposed ones by the Gas Company Standardization—**COMGAS**.

We present, as follows, studies related to the Quality Assurance Programme.

3. Quality Assurance Programmes of components of building services systems

We are working on the proposal of Quality Assurance models evaluating the implementation in the manufaturing sector, of components of water supply and drainage system in buildings (PVC pipes and fittings).

The considered Quality Programme is one of the ones proposed by ISO called “Third Part Certification”. The general directives of the programme shall be established by the Association of Manufacturers of the resin/compounds and the pipes and fittings transformers. An independent institution will provide the necessary technical support to help in providing useful information for the programme. Once the general directives have been established, these will have to be relayed to all the members of the programme.

The audit shall be carried out at three levels:

Resin/coumpound manufacturers;
Pipes and fittings manufacturers;
Service contractors, there being a random check.

The independent institution will be responsible for the administration of the programme. The following are the steps of the Quality Assurance Programme:

(a) Preparation of Technical Standardization including:

Technical specification of product procedures for the handling, transport, storing of products and the procedures for designing/installing the system;
Experimental methods to control delivery of raw material during the manufacture of the products and to characterize, over a long term, the performance of the raw material and the products;

(b) Preparation of the documents related to the technical and functional aspects of the Quality Assurance Programme, including:

Documents determining the **duties and responsibilities** of the members of the Programme (raw material supplier, transformers and audit institution);
Documents to be used by the **audit institution;**
Documents to **accredit** firms wishing to participate in the Programme;

(c) Development of quality audit activities including:

Quality audit of **manufacturers of resin/compound;**
Quality audit of **manufacturers of pipes and fittings;**
Quality audit in the **installation of the system components** (random check);

(d) The Programme Institutional Laboratory

In order to develop the Quality Programme a laboratory structure will be necessary, structure this, that will support the activities suggested in the documents that constitute the standardization. The basic concept of this laboratory is its independent structure, and it is constituted by:
Laboratory equipment of the companies members of the Quality Programme which will be used at the activities of the quality audit institution to be duly authorized by the respective companies;
Laboratory equipments acquired cooperatively by the companies members of the programme installed in neutral place and managed by the quality audit institution. This independent and neutral laboratory can be included in the government programmes of industrial quality.

The Quality Assurance Programme is being implemented, and the first results are positives.

4. Final remarks

In our viewpoint the adoption of "open" models to determine the design demands in building services systems is suitable and permits the representing of the users' behavior mainly in countries or regions of continental dimensions and cultural diversities. The use of simplified methods—"close"—is adequated just in cases where the characteristics are specific and the design situation are clear.

In relation to Quality Assurance Programmes the application of the "Third Part Certification" (ISO) is suitable, and good results can be obtained when applied in the building services system components.

5. References

Gonçalves, O.M. (1986) **Formulação de Modelo para Determinação das Vazðes de Projeto para ○ Dimensionamento dos Sistemas Prediais de Distribuição de Âgua Fria**. Tesis presented to obtain PhD title at Escola Politécnica of the University of São Paulo.

Gonçalves, O.M. (1989) **Influence of the users' behavior in determining the water flow-rates in water supply systems in buildings**. Paper presented at the 16th CIB-W62 Seminar, Gavle, Sweden.

Gonçalves, O.M. and Graça, M.E.A. (1988) **Design flow-rates in water supply systems in buildings with large sanitary areas—a queueing theory approach**. Paper presented at the 15th CIB-W62 Seminar, Edinburgh, Scotland.

Ilha M.S. (1991) **Estudo de parâmetros relacionados com a utilização de água quente em edifícios residenciais**. Tesis presented to obtain Master Degree at Escola Politécnica of the University of São Paulo.

Ioshimoto, E. (1990) **Formulação de Metodologia para Análise de Projetos de Sistemas Prediais de Gás Combustível**. Tesis presented to obtain PhD title at Escola Politécnica of the University of São Paulo.

Oliveira, L.H. (1990) **Estudo do escoamento em condutores horizontals dos sistemas prediais de coleta de esgotos sanitários de edifícios residenciais**. Paper presented at the Civil Construction Engineering Department of the Escola Politécnica of the University of São Paulo.

Prado, R.T.A. (1990) **Demanda de energia e projeto de instalaçðes elétricas em habitaçðes de interesse social**. Paper presented at the Civil Construction Engineering Department of the Escola Politécnica of the University of São Paulo.

65
Quality management in the building firm

P.GOSSELIN

Abstract
The present lecture particularly refers to the "Guideline for the Drawing up of a Quality Manual", designed on initiative of the BBRI within the framework of the party "Qualité et Execution" ("Quality and Execution") of the Belgian Construction section in the EOQ (see appendix 2—composition of the working party).

Keywords: Building, Quality Assurance, Quality Manual, Quality Management.

1 Introduction

"The quality is a notion known at all times but considered rather subjectively until the last years. Nowadays, the customer—the client—demands more and more quality performances in all fields. Expressions like quality product, quality service, quality of the environment, quality of life, etc., are used more and more frequently."[1].

The client wants to get the level of quality that offers him the most advantageous compromise between, on the one hand, the satisfaction of his own needs and of the user's requirements (term, reliability, performances) and, on the other hand, the price.

Quality can be defined as "the totality of characteristics" of a building "that bear on its ability to satisfy stated or implied needs"[2].

For the building firm and the various trades it is composed of, that means:

1° the satisfaction of the client and users

– by meeting the requirements taken into account for the construction
– by applying a fair price (purchase price, operation and maintenance costs)
– by delivering within the agreed-upon terms.

2° the satisfaction of the collectivity (general interest)

– in accordance with standards and regulatory requirements
– in accordance with environmental considerations.

3° <u>the satisfaction of the firm</u>

– by applying costs producing profit
– by motivating all the members of the firm to act for quality.

The building sector is different from other industries because of:

– the uniqueness or low repetitivity of the work
– the numerous activities linked to the installation of a building
– the number of partners involved.

Consequently it is essential for the building enterprise to introduce quality organization. It is not quality that is expensive but “subquality” or “overquality” (fig. 1). The organizational system aiming at giving confidence in quality should involve the whole firm and not only one person or one department.

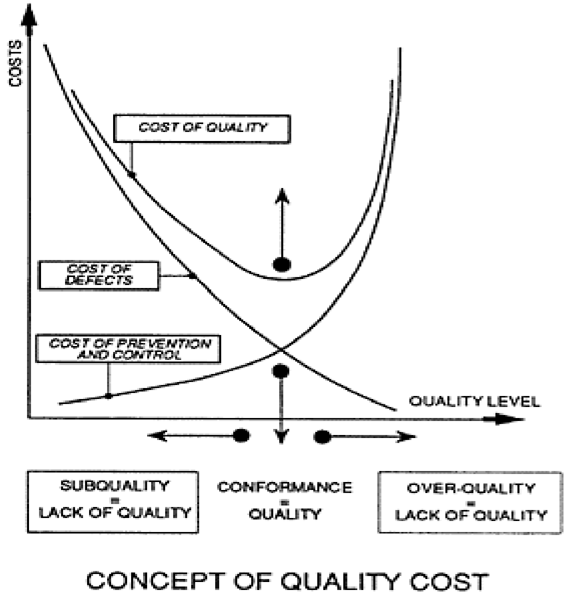


Fig.1. Concept of quality cost.

[1] Recommendations OQC 84 AFCIQ.
[2] ISO standard 8402.

2 The contractor and the quality

2.1 Construction cycle

The client (public or private) is the individual or legal entity that, for miscellaneous reasons, wishes the erection of a building work. According to his own requirements and those of the building users, he defines his programme with the possible help of outside advisors. The designer conceives the project complying with the requirements of the programme. Plan, technical specifications and bill of quantities make it possible to describe the future construction work precisely. The contractor uses the necessary means to carry out the activities and respect the level of performance required. Thanks to the acceptance and management of the construction, the total quality of the latter can be assessed. Consequently, it is essential that each partner got organized to ensure that the construction will meet the requirements, that the total quality of the work will be satisfied.

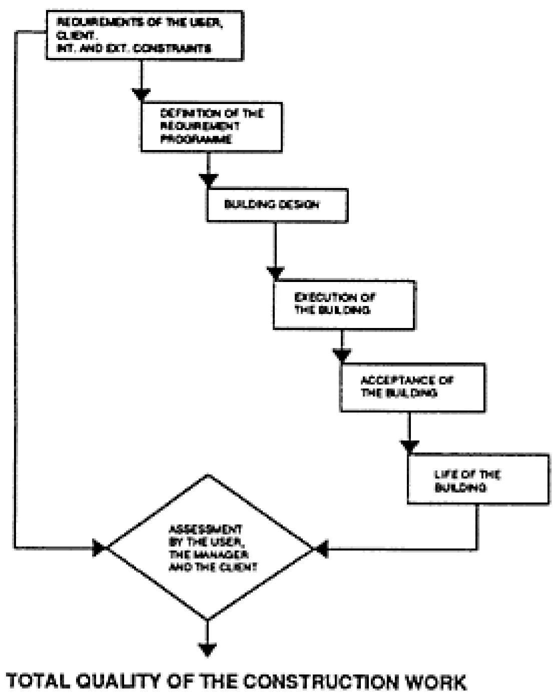


Fig. 2. Total quality of the construction work.

2.2 Quality assurance

a) The client and quality assurance.

Quality assurance and its principles have been introduced in the army, then in the aerospace and the nuclear industry. The aim was to impose rules for quality assurance as well as quality organization for complex and high risk programmes. Nowadays, those rules apply more and more to all kinds of human activities, in particular to the construction. They have to be modulated according to the construction to build. The client is in charge of defining clearly his requirements in a programme[3] and the levels of quality desired. In some cases, he imposes quality organization in the technical specifications; in other cases, he demands that the firms prove they apply a system ensuring quality. The client refers either to the "quality manual" of each partner or to the quality assurance programme specific to the building site and introduced by the firm itself to give confidence (assurance) in the quality of the work carried out (fig. 3).

b) The contractor and quality assurance.

The aim of the enterprise is to ensure that the quality required is satisfied before, during and after the execution. In order to achieve this, the contractor draws up a quality manual (fig. 3) which defines the quality system introduced within the firm. Moreover, there are general organizational, technical and specifically site procedures.

1° At the moment of the price bid: a QAP (Quality Assurance Programme) proper to the construction to build is elaborated and defines the provisions

– specific to the firm (quality manual)
– specific to the building site

introduced to meet the quality required, assure and verify it is really achieved.

2° At the time of the execution: the competence and the qualification of the personnel are not adequate to ensure a priori the proper execution of the work. A person, as competent as can be, is never secure from a mistake and especially from a neglect.

[3] The guide for the client (with the RPS method)—CSTC publication Quality in the construction.

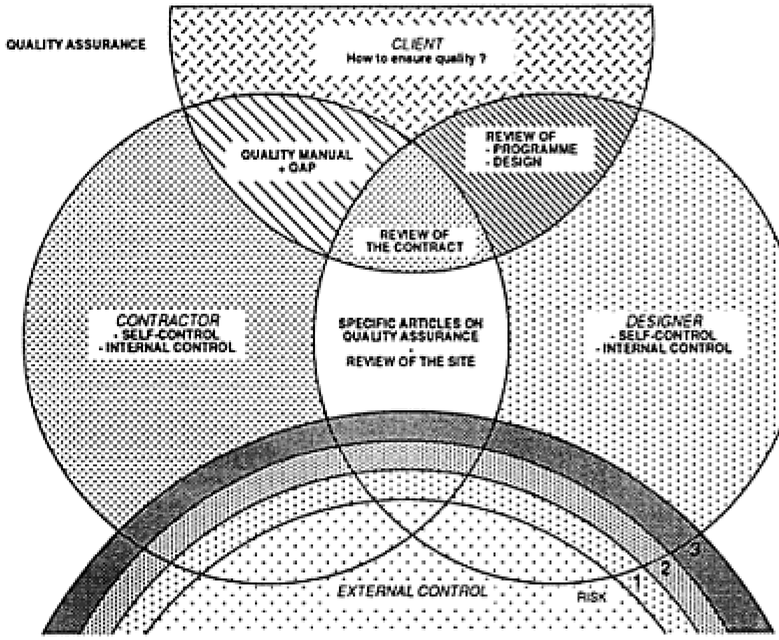


Fig. 3.

So control is necessary throughout the firm and can be divided into 3 categories:

– self-control, which is the backbone of the quality system of the firm
– internal control, which makes it possible to avoid any drift
– external control, sometimes required in the technical specifications.

It is the contractor who controls the quality of what he has carried out (fig. 4). He is responsible for the efficient evolution of control and surveillance. He has to motivate the personnel to self-control and give them the necessary means in that regard (equipment, training,…). He has to look to it that everyone acts both as a customer and a supplier of the work he is in charge of. The methods ensuring the results and the programme of checking activities are the subject of procedures described in the quality manual for the whole firm and in a QAP (Quality Assurance Programme) for each building site. The identification of conforming work, the processing of non-conformances and corrective actions are part of the follow-up and control of quality within the firm.

3° At the moment of the work acceptance: a synthetic report certifying the conformance of the construction must contain:

– the synthetic note
– the list of execution documents (actually used)
– the follow-up document
– the non-conformance cards
– the certificate of compliance.

For smaller sites, the synthetic report is limited to the main requirements of the construction.

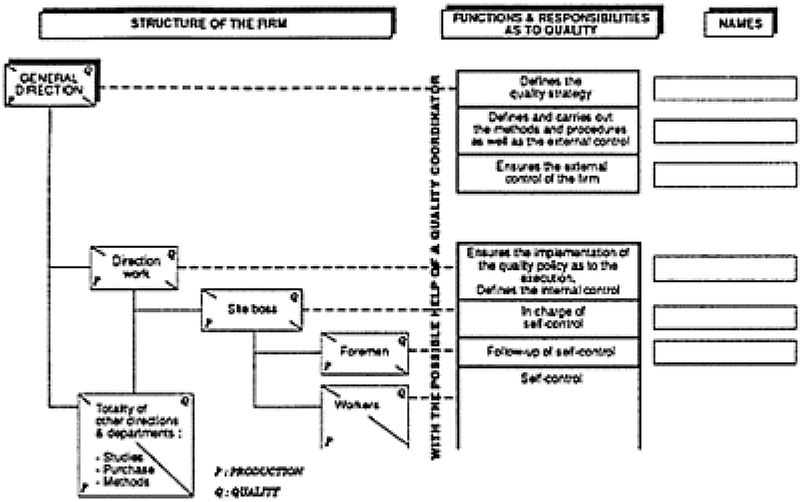


Fig. 4.

3 Quality manual

3.1 Why a quality manual?

a) In 1989, the Centre Scientifique et Technique de la Construction (Belgian Building Research Institute) started an enquiry on “Quality-Contractors” among 2,079 enterprises accounting for the biggest Belgian businesses in the building sector. It revealed that nearly 15% of the turnover is absorbed by costs resulting from lack of quality (fig. 5):

– repairs
– noncompliances
– accidents
– litigations
– lack of productivity.

Similar studies carried out in other sectors show that this percentage is not exaggerated.

Quality and responsibility go hand in hand. Everyone, from the client, over the designer to the contractor, contributes to the quality of the end product. That is why the contractor must use every possible means to make the client confident.

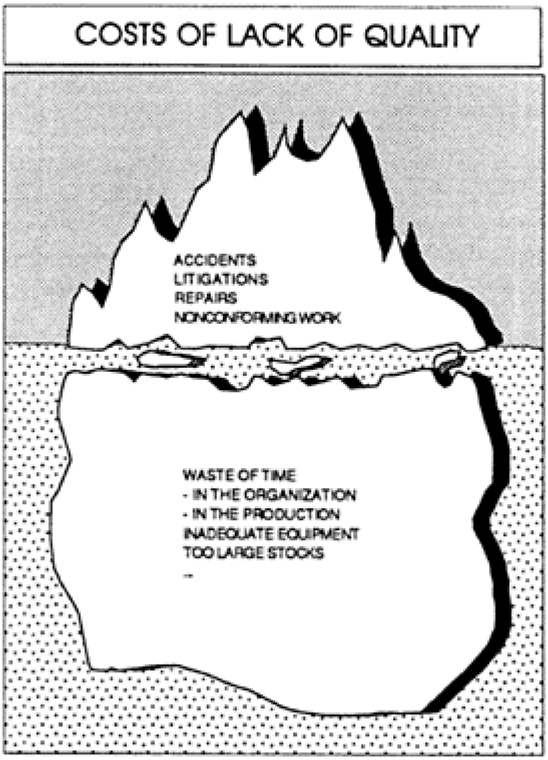


Fig. 5. Costs of lack of quality

b) The quality manual defines the provisions introduced by the firm to ensure the quality of the work required. It reflects the quality system of the company. The client must not trust the firm unreservedly. The quality manual ensures him his requirements will be met. It results in an improved openness.

The quality manual is only compulsory if the technical specifications require it (referring to the European norms EN 29001, 29002 and 29003, approved as Belgian standards).

Nevertheless, it would be most desirable for contractors concerned about quality activities to introduce a quality system and to document it in a quality manual.

Certification of quality systems in building companies progressively appears in European countries. Firms can only be certified[4] if they have a quality manual and implement it.

Consequently, it is not enough to draw up a quality manual, with the possible help of an external consultant, it has also to reflect the real situation in the firm.

Several months are necessary for the personnel to adapt to self-control, to implement new quality management methods.

[4] Law of 20th July 1990 (published in the Moniteur belge on 22nd August 1990).

3.2 What is a quality manual?

It is a document describing the whole of organizational provisions as to:

– the firm structures
– the general procedures ruling the obtainment of quality
– the general provisions applicable to all the activities of the firm in the field of quality
– the specific missions of operational services.

This document is drawn up by the company for its own use. It can also be used to convince the customer that the firm has elaborated a quality system.

It must be put into practice and not remain simply theoretical. It has to reflect what happens in the company.

4 Quality management

Quality management comprises all the means the company implement to reach the objectives its quality strategy aims at (fig. 6). It does not involve one person but everybody. It requires a precise definition of the procedures and tools being part of the quality system of the enterprise.

The assurance that the contractor supplies a work of quality to the client (i.e. meeting the customer’s requirements) must materialize in predefined and systematic actions.

To get confident, the client can ask for proofs that quality assurance is really implemented. So, for more and more common activities, articles of the technical specifications specific to quality assurance progressively appear

– either on a global basis for the whole project
– or typically for certain risky types of work.

The contractor faced with that type of technical specifications can only justify his discount validly if he has introduced a quality system. His quality manual in accordance with the norm EN 29001 or EN 29002 or EN 29003 will reflect the actions of quality assurance he carries out within his company. That is why one to two years are necessary for the contractor to implement a quality policy. It is in fact impossible to change a type of management in a shorter time, especially as each person of the firm is involved.

Each one has to consider himself as a customer and a supplier (fig. 7). Everybody has to feel responsible for the work he carries out, which requires training at first of the staff and leaders and afterwards of the various departments of the company. One of the backbones of quality management is undoubtedly self-control. With the help of simple and effective procedures, each one controls himself and puts a mark when checking his own work. The latter makes it possible to give the guarantee to the other partners that the predecessor (previous activity) has been carried out in accordance with the requirements.

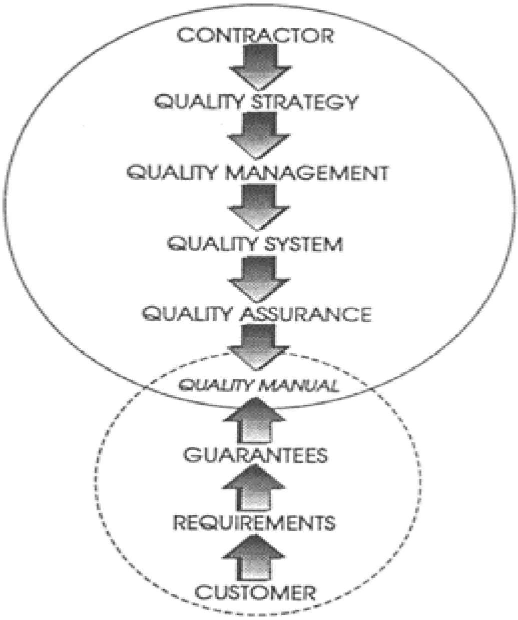


Fig. 6.

If for all that self-control, some nonconformances appear, the contractor will see to it to make them good. Defects or errors are not hidden but managed to avoid them in the future.

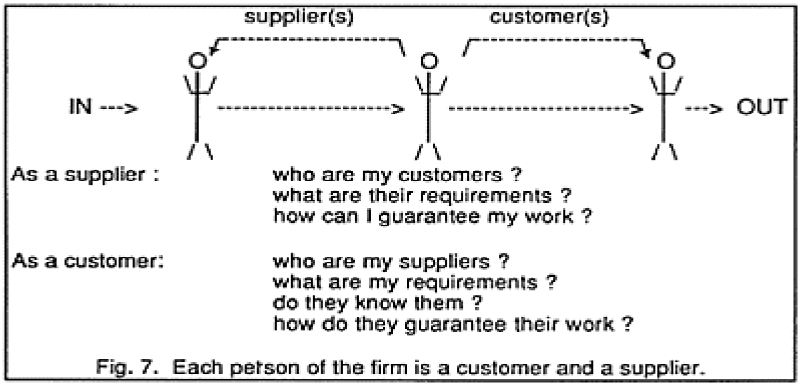


Fig. 7. Each person of the firm is a customer and a supplier.

According to the type of component, its function in the whole building work, the requirements, the limits accepted,…nonconformance can be managed. A nonconforming product, element or implementation does not mean immediate reject or throw away or demolition (fig. 8).

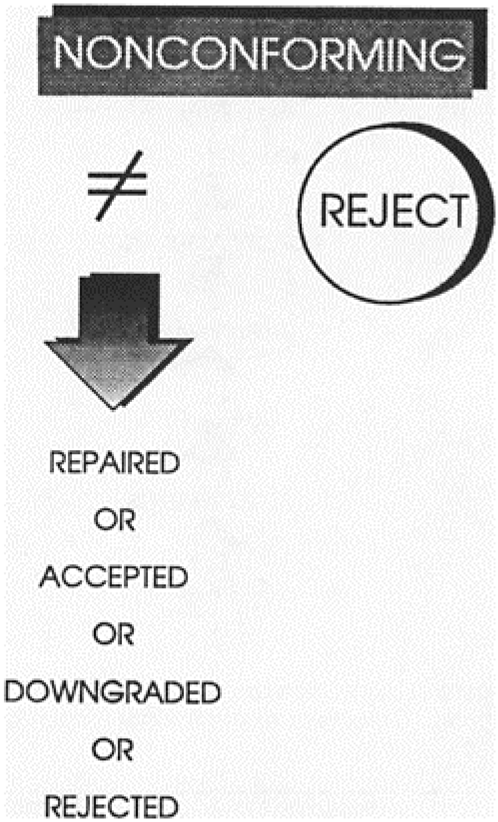


Fig. 8.

Conclusion

At dawn of the certification of quality systems that will be ruled by the law dated 20th July 1990, the building sector and especially contractors have to get trained to that new type of management. Our neighbour countries have already got over to certification.

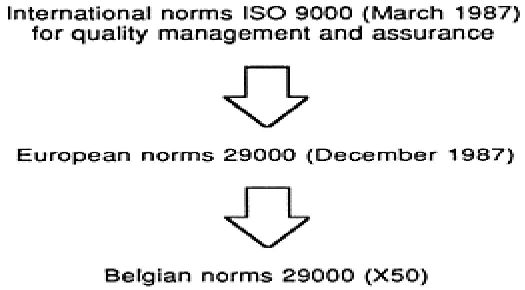
We should not wait until we are faced with quality assurance articles from technical specifications enforcing a quality system within the firm.

From now on choose your counsellors and get trained to be among the first to manage the quality of your work.

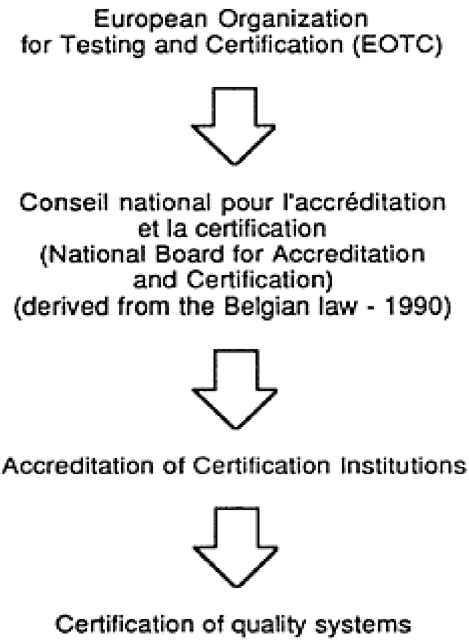
Your firm can only benefit from it!

Appendix 1 REGULATORY CONTEXT

1° QUALITY ASSURANCE



2° CERTIFICATION (in the making)



Appendix 2 WORKING PARTY "QUALITY MANUAL"

Quality Manual
—1st edition—September 1990—

Working party

Messrs M.CNUDDE, BBRI
A.DE RO, Bureau SECO
P.DECLERCK, DECOMO S.A.
V.FAVIER, FAVIER S.A.
H.MOTTEU, BBRI
A.PELEGRIN, F.E.G.C.
J.-P.RENUART, AIB -VINCOTTE
A.VANDAMME, PIETERS-DE GELDER N.V.
M.VREULS, TRACTEBEL S.A.
PH.GOSSELIN, Animating Secretary, BBRI

That party has been created on initiave of Rik DECLERCK, chairman of the group "Quality and Execution" of the Belgian Construction section in the EOQ (European Organization for Quality).

66
Quality assurance in UK housebuilding

A.GRIFFITH

Abstract
There is a growing requirement within the U.K. building and construction industry for improved performance and quality in building. There is also a much greater emphasis being given to developing managerial methods designed to ensure its accomplishment—Quality Assurance (Q.A.). Whilst quality assurance is only now beginning to pervade across the construction industry, it has been applied within the U.K. housebuilding sector for many years. Independent housebuilding registration schemes such as the long-standing National House-Building Council (NHBC) Warranty scheme has been joined recently by a new initiative, 'Foundation 15' from Municipal Mutual Insurance Ltd. Despite these schemes, the new-house purchaser is frequently faced with problems of performance and quality in the new house. This paper highlights the need for quality assurance in housebuilding, briefly reviews the two housebuilding registration schemes, and draws upon research studies to identify why problems occur and how they may be overcome. Keywords: Housebuilding, Registration Schemes, Quality Assurance, Performance, Quality, Quality Assurance (Q.A.)

Introduction

The Need for Quality Assurance

In recent years there has been a rapidly growing interest within the building and construction industry for the greater promotion of Quality Assurance (Q.A.)—formalised managerial methods designed to plan, monitor and control the achievement of quality [1]. The emphasis on quality assurance, thrust upon the building industry by B.S. 5750, the U.K.'s national standard for quality assurance has pervaded the thought of all who procure, design and construct buildings. As the origins of formalised quality assurance lie in manufacturing and engineering industry where benefits have been realised for many years, the development and application of formal independent (third party) quality assurance schemes within construction has been slow to emerge. In general, the introduction of B.S. 5750 has led to much ambiguity and indeed controversy surrounding the true applicability of Q.A. systems to building and construction given the unique nature and characteristics that exist within the industry.

Whilst there is considerable scepticism and reluctance in some quarters, others are recognising quality assurance as a managerial concept of considerable worth in a constantly changing industry. Clients, customers and indeed the general public are becoming more discerning in their perception of the construction industry, have ever increasing expectations of its services and products and, above all, are demanding improved performance in buildings, better quality and greater value for money.

The Framework for Quality Assurance

Within the U.K. the principles of quality assurance have been developed and encapsulated in B.S. 5750 which forms the document now used as the basis for the application of quality assurance to many different industries including building and construction. B.S. 5750 develops an industry wide framework within which individual companies in all sectors of building and construction can develop their own quality assurance systems to fulfil their own operational needs whilst meeting, if they so wish, the requirements of individual or sector based quality assurance registration schemes. Recognised quality assurance registration schemes such as those marketed by the British Standards Institution (BSI), Yarsley Quality Assured Firms Ltd (YQAF) and Lloyds Register of Quality Assurance (LRQA), and others, provide such services across a wide range of construction industry.

Housebuilding

Whereas registrations schemes across the construction industry are a relatively recent introduction, sector based quality assurance registration schemes within housebuilding have existed for many years. The most successful of such independent registration schemes is that offered by the National House Building Council (NHBC). For over fifty years the NHBC has provided for the voluntary registration of housebuilders to promote higher standards of new housebuilding across the entire sector, and to provide a measure of protection for the house purchaser against defect and damage to their new home. The NHBC's provision of the housebuilding registration scheme has, in recent years, been challenged by the introduction of a new independent registration and guarantee scheme from Municipal Mutual Insurance Ltd, one of the U.K.'s foremost home insurers.

Both schemes seek primarily to uphold the very highest standards of performance and quality in U.K. housebuilding- It is unfortunate therefore, that despite such highly structured, clearly formalised and well intentioned quality assurance schemes, research studies conducted throughout the last decade have highlighted that problems of performance and quality are often all too common and remain unresolved.

Quality Assurance in Housebuilding

Housebuilding is virtually unique in its level of commitment to formalised quality assurance. It is currently the only sector of U.K. building and construction industry that provides the purchaser with a legal guarantee of the building's performance and standard of quality, backed by insurance against building defects and damage.

Two quite separate schemes provide such protection on 'new' built houses, these being;

1 National House-Building Council (NHBC), '*Buildmark*' warranty scheme [2].
2 The Municipal Mutual Insurance Ltd (MMI), '*Foundation 15*' guarantee scheme [3].

The National House-Building Council (NHBC) 'Buildmark' Warranty Scheme.

The National House-Building Council (NHBC) is a long standing, housebuilding regulatory body. The NHBC provides for the independent and nationwide assessment and registration of housebuilders financed through levies paid by the individual housebuilders subscribing to the scheme. The NHBC sets standards for new homes in addition to those requirements specified by building regulations and local authority planning and building control. The overall aim of the NHBC is to set nationally recognised standards for building performance and quality in all new houses and to guarantee their design and construction against building defects as a protection for the purchaser. It achieves this through the following measures;

(i) Setting minimum standards of performance, quality and workmanship with which housebuilders must comply as a requirement of their continued registration as an NHBC approved and registered housebuilder.
(ii) Continuing improvement of the Council's minimum performance and quality standards to meet the ever changing requirements of the housebuilding industry.
(iii) Type approval of design and inspection of quality and workmanship for houses under construction on site.
(iv) Provision of a ten-year warranty on the completed house under the Council's 'Buildmark' scheme.
(v) Impartial conciliation and arbitration of disputes between the housebuilder and purchaser over problems that may arise during the warranty period.
(vi) Promotion of research into any aspect of housebuilding which could affect or seek to improve standards of quality in housing.
(vi) Dissemination of information and research to the housebuilding industry and to the public through NHBC publications.

The NHBC, known prior to 1973 as the National House Builder's Registration Council (NHBRC), was founded in 1936 gathering its membership and support from professionals in building, architecture, surveying and engineering in addition to representatives from building societies, the construction industry's unions and Government. Since its founding, the Council has evolved to a situation today where well in excess of ninety percent of all new houses built in the U.K. are regulated by the NHBC. Almost all private housebuilders are registered with the Council. The principal reason for the virtual total acceptance of NHBC requirements is that unless a new house has been NHBC certified for standards of quality and workmanship, it is almost impossible to finance the purchase as the scheme is well supported by the major building societies and banks. The NHBC certificate covering a new house is a pre-requisite of securing a mortgage and forms a condition of contract between the financier and purchaser.

‘Buildmark’

‘Buildmark’ is the NHBC’s sign of commitment to the pursuit of quality in housebuilding. Its symbol is a display to purchasers that their new house is protected for two years against minor deficiencies and defect and for ten years from major defects causing structural damage to the dwelling. If defects should occur, the two-year warranty ensures that the builder will carry out rectification, free of charge. Should defects occur outside the builder’s period of liability, the NHBC will, at their own expense, rectify the defect under the ten-year guarantee. Buildmark is also an assurance to the purchaser that the housebuilder is reputable, having been assessed, registered and deemed competent to build by the Council, and that the house has been independently inspected for building defects during construction on site.

Warranty Scheme

The extent of protection afforded by the NHBC’s ten-year warranty is in addition to any contractual, statutory and common law rights, that the purchaser may have against the housebuilder. The cover is ‘in—addition’ because, under the Council’s scheme, the housebuilder warrants to the purchaser that the house has been built, or will be built, on the following terms [2]:

(i) In accordance with the NHBC requirements
(ii) In an efficient and workmanlike manner, and of proper materials, so as to be fit for habitation

The nature and extent of cover given under the warranty depends upon when the difficulties arise, and, therefore, problems may be categorised into one of three types;

(i) Problems arising whilst the house is under construction
(ii) Problems arising during the initial Guarantee Period,
(iii) Problems arising during the Structural Guarantee Period.

As will be seen subsequently, the greater proportion of deficiencies and defects in performance and quality occur when the house is under construction or during the Initial Guarantee Period when it is the responsibility of the housebuilder to make good, within a reasonable time and at his own expense, any defects or damage which arise as a result of the builder not meeting the minimum standards specified by the NHBC.

The Municipal Mutual Insurance (MMI) ‘Foundation 15’ Guarantee Scheme

Municipal Mutual Insurance Ltd

Municipal Mutual Insurance Ltd, a member of the Association of British Insurers (ABI), is an independent insurance company who are committed to the pursuit of better quality and improved performance within the housebuilding sector. MMI have recently introduced ‘Foundation 15’, a fifteen-year guarantee scheme applicable to new houses built by approved housebuilders registered with their scheme, Like NHBC, MMI provide for the independent assessment and registration of housebuilders financed through registration fees paid by the individual housebuilders themselves, and provide a guarantee to the house purchaser against building defect and damage

MMI seeks to achieve this through the following;

(i) Setting minimum standards of performance, workmanship and quality for housebuilders within its ‘Foundation 15’ Technical Manual.
(ii) Requiring registered developers and builders to comply with the requirements as specified by the Scheme’s Certificate and Technical Manual.
(iii) Inspection of work in progress on site and approval of the completed dwelling.
(iv) Conciliation and arbitration between the builder and the purchaser when difficulties arise.
(v) Provision of ‘foundation 15’, a fifteen-year guarantee against defect and damage.

‘Foundation 15’

‘Foundation 15’, as the name implies, is a guarantee scheme protecting the house purchaser against *defect and damage* to a new property for a period of fifteen years. The ‘Foundation 15’ scheme, like the NHBC’s ‘Buildmark’ scheme is supported by building societies and financial institutions and forms part of the contractual procedure between the purchaser and the mortgagee.

‘Foundation 15’ provides cover at three stages;

(i) During construction—protection against defects when construction is not completed in accordance with the scheme’s requirements.
(ii) First Two Years—responsibility assumed by the builder to correct any damage or defects apparent. If the builder fails in his responsibility an insurance claim to the scheme may be made.
(iii) Up To Fifteen Years—MMI insures against more serious damage *(major damage)* and defects. These generally relate to the ‘structure’ of the new home.

Whilst ‘Foundation 15’ is a relatively new innovation, introduced in 1988, Municipal Mutual Insurance Ltd, one of the U.K.’s most prominent and respected insurance companies, have in fact, a long history of serving the public in the home insurance market and are fully supportive of maintaining the highest possible standards within the housebuilding industry. Many developers, financiers and particularly the public, recognise, ‘Foundation 15’ as a worthy alternative to NHBC’s ‘Buildmark’ and, as such, the scheme is developing rapidly.

Achievement of Quality Assurance in U.K. Building

Both the formalised quality assurance schemes within the housebuilding sector, NHBC's 'Buildmark' and MMI's 'Foundation 15' have sought to raise awareness for and strive towards the achievement of better quality, workmanship and performance in U.K. housebuilding and provide the buyer with some degree of guarantee against problems that may occur when purchasing a new home. Such schemes aim to control, more consistently, the levels of workmanship on site, the quality of materials and components used and the long-term performance of the completed dwelling by:

(i) Setting minimum standards of performance, quality and workmanship with their schemes to augment existing building regulations and planning and building control.
(ii) Assessment of house designs (type approval) before work commences on site.
(iii) Monitoring the construction process as the development phase and construction work proceeds and issuing certificates (under the schemes where appropriate).
(iv) Taking active steps to have the builder rectify any deficiencies and defects during the construction phase.
(v) Ensuring that the builder assumes responsibility, as specified by the scheme to rectify any defects occurring within the builder's liability period, (currently two years) and also provide a service of conciliation and arbitration between purchaser and builder where difficulties ensue.
(vi) Handling enquiries and claims presented within the terms and conditions of the warranty or guarantee periods.

Such provisions should, in theory, contribute considerably to the pursuit of improved quality in housebuilding. Realistically however, the success of such schemes, indeed success in all quality assurance schemes, can only be measured in terms of the real 'achievement' of quality and the elimination of problems experienced by the purchaser throughout all stages in the housebuilding and purchasing process. Despite the valiant efforts of the registration (quality assurance) schemes within housebuilding, problems do occur, the nature, extent and implications of which are perhaps only truly appreciated by the purchaser who experiences them.

Quality in Traditional (Masonry) Housing

Although quality in housebuilding is, as in other sectors of construction, not easily quantified and certainly not always directly measurable, a number of research studies [4], [5], [6], [7] have addressed the issues and problems surrounding building faults, defects and damage. The Building Research Establishment study, 'Quality in Traditional Housing' [4], examines performance and quality in masonry housing through the detailed investigation of *building faults and defects*. A survey of 1725 houses drawn from both the public and private sector in England identified over 900 different faults classified into over 100 group types. Almost one-half of these faults were judged to have originated on site (classified as problem with workmanship), one quarter originated in the design process and one-quarter attributed to deficiencies in building materials and components.

The proportion, one-quarter, of fault types, attributed to inadequacies during the design process were thought to be direct infringements of the Building Regulations or disregard for codes and standards cited in the Building Regulations. A further twenty per cent infringed codes and standards not specified in the Building Regulations and over one-half of the fault types attributed to either ignorance or conscious infringement of other authoritative documentation.

As the study did not focus exclusively upon private sector speculative housebuilding a housebuilders registration scheme would not be applicable and therefore, would not have been an influence in the level of quality achieved. What was clear however, is that particular aspects had influenced the problems that arose, the most readily identifiable being: inadequate information, poor communication, poor care in workmanship; and a lack of site supervision. Such problems affecting performance and quality in housebuilding are certainly not unique to housebuilding as similar findings emerged from the 1987 Building Economic Development Council/Building Research Establishment, (Building EDC/BRE), study entitled ‘Achieving Quality on Building Sites’ [7] which focused upon quality in the general building sector.

Quality in Timber-Framed Housing

The vast majority of the U.K.’s national housing stock, built using non-traditional construction (forms of construction other than masonry), uses timber-framed technology. The application of timber-frame, in the form in which it has developed in recent years, may be said to be an engineered structure and therefore, demands considerably different design criteria and site practices from those needed for traditional masonry construction. It is through recognising these differences that doubts have, at some time, been expressed at the performance, quality and long-term reliability of timber-framed construction. Any concern for timber-frame has been perhaps falsely encouraged by the inadequate performance and quality of other non-traditional construction forms used in the 1960’s and early 1970’s. Technologically, “modern’ (post 1960) timber-framed housing has little in common with timber-frame construction preceding 1960.

Preliminary (pilot study) research has been conducted in Scotland [8] where over the last decade a considerable proportion of new private sector housing has been built using timber—framed construction. The Study highlights that whilst there is clearly no evidence to suggest that major problems of performance and quality have occurred, there is some evidence that the problems that do arise tend, in the main, to result from “workmanship” aspects.

A sample of one hundred and eight dwellings, that had been built to the specification and requirements of an independent housebuilding registration scheme, identified that twenty-six percent had a performance or quality related problem of some type, with over half of these representing simple and avoidable snagging items. The more detailed examination of three randomly selected dwellings revealed a total of ninety-five building faults categorised into fifty-four fault types. Subjective interpretation of the origin of each fault was made from which it is suggested that forty-six percent of all faults result from possible inadequacies in the level of site workmanship and its attendant aspects. It is likely, in reality, that more than half of all faults originate from this source since an undetermined proportion of faults may be subsumed within the subjective category of 'design or workmanship'. In attempting to categorise the degree of severity of building faults it was concluded that almost two-thirds of fault types were of a minor nature which could be classified as snagging items. One fifth were problems which might give rise to a defect if left untreated in the long-term and the remaining proportion (13%) were thought to be problems of a more serious nature which had a great likelihood of leading to a defect if undetected or left untreated. It was also highlighted by several houseowners that there had been some reluctance by the builder to rectify defects during the period of builders' responsibility. This had led to some defects being untreated for some considerable time and therefore, might have worsened the effects of what may only have been minor building faults.

Obviously, studies such as those described cannot accurately present the true and overall picture due to their small and non-statistically valid sample size. They can only give a superficial and subjective insight into isolated pockets of activity within the field. What it can do however, is to provide some indication as to the type of problems that arise and how and why some problems of performance and quality in housebuilding may occur, particularly when other circumstantial and subjective evidence is drawn from observation and discussion.

Essentially, of course, such studies show that despite the contribution of the independent registration (sector based quality assurance) schemes, problems remain in the construction of both traditional and non-traditional housing forms. It is essential to recognise that problems arising from workmanship are, of course, not intrinsic to any particular construction form but it must also be recognised that the effect of defects can be more serious in some designs than in others.

Problems of Quality in Housebuilding Identified

Practical quality assurance in housebuilding, as with all forms of construction, is dependant upon four broad aspects, these being:

(i) Adopting the appropriate design
(ii) Using appropriate materials and components
(iii) Implementing 'practical' quality assurance in the management of construction on site (site activity)
(iv) Informing the building occupier on the most effective and efficient use of the building

Appropriate Design and Materials

Relevant research studies indicate that few performance and quality related problems emanate directly from the 'design' stage although unclear or missing project information is frequently cited as a design related cause of communication problems. This is especially so where specifications fail to show quality related requirements. Likewise, only a small proportion of quality related problems can be directly linked to material and components, through, for example, their misuse or incorrect specifications.

Site Activity

There is conclusive evidence that quality problems directly related to 'site activity' or 'workmanship', and associated aspects, occur most often. Around one-half of all problems that the owners of new houses face are as a direct result of inadequate workmanship. Problems can range from mere snagging items to more serious building defects and damage and whilst some may be minor, 'any' problem is important to the new house owner seeking rectification.

The main influences upon problems surrounding quality linked with inadequate workmanship in housebuilding can be summarised as follows:

(i) The inadequate definition of quality assurance policy within the housebuilder's organisation at all hierarchal management-levels—differences between the theoretical requirements of the independent regulatory quality assurance schemes and implemented practices.
(ii) Inadequate specification for quality communicated by management to the operative at the workplace—lack of workable practices on site.
(iii) Clear yardsticks for monitoring and checking quality on site are not provided—regard for quality assurance as a remedy rather than a preventive mechanism.
(iv) Poor operative/managerial feedback mechanisms—lack of working relationship and constant liaison.
(v) Poor standard of workmanship (craft skills)—frequently due to psychological factors such as low morale or poor conditions etc.
(vi) Disregard for quality in preference to speed and cost determinants—importance of quality in the long-term misperceived, consciously outweighed, accent upon meeting only the barest minimum specified requirements.
(vii) Lack of practical integration of the site activity with the independent quality regulatory processes, (local authority building control, independent registration schemes inspection and approval mechanisms), infrequent inspections and poorly structured independent supervision.
(viii) Inadequate supervision by first-line supervisors (foremen) and site managers (agents)—increasingly crucial as general operatives rather than trade specialists are often employed.
(ix) Difficulties experienced by the homeowner in seeking rectification of problems under recognised guarantee schemes both with the housebuilder and subsequently with the independent registration bodies—inadequate consumer relations.

Use of the Dwelling

Houseowner education is a further problematic area. It is clear that a considerable proportion of problems experienced by the new home owner is in the effective and efficient use of the dwelling. Home owners manuals, though not common, can be of considerable benefit in informing the owner of how to take care of the house, specifying its operating characteristics, and providing advice on minor self-maintenance. Such aspects could reduce many of the problems that arise in the first two years of ownership. Frequent complaints during the initial period of occupation surround such issues as surface condensation, shrinkage cracking, drying-out staining, and other snagging type items, where better homeowner education and builder-owner liaison could alleviate problems that might occur. More information could be given by the builder to the purchaser regarding the guarantee schemes themselves. Both the NHBC and MMI have new homeowner handbooks describing not only the details of their guarantee schemes but informing the owner on claims procedures should misfortune arise and defects and damage occur.

Seeking Improvement

Inadequate quality in U.K. housebuilding, as in other sectors of construction industry, is not a problem of lacking technical knowledge and skills. It is also not a problem of lacking quality assurance registration schemes, since two well founded independent registration schemes currently exist which are doing much to uphold the high standards currently being achieved. Clearly problems are arising within the construction process itself which fails to truly integrate the design and construction phases with the vital independent regulation processes provided by building control and the independent registration schemes. Housebuilding registration bodies must strive more to make their approval and inspection processes during construction more rigorous and provide a more positive and effective link between the housebuilder and purchaser. As recognised in the brief review of research studies, problems of quality result, in the main, from simple and often avoidable workmanship and supervisory errors during construction. Housebuilders themselves must focus upon the practical implementation of quality assurance within their organisations to ensure that quality assurance is accepted as a challenge and a commitment and not merely a burden of meeting the very basic requirements. Housebuilders should also liaise more fully with the regulatory bodies and the home owner to ensure that avoidable problems do not go unresolved. Improvements in housebuilding quality standards is clearly a case of not changing the system but encouraging greater teamwork towards pulling together what are currently the loose-ends in a very workable system.

References

[1] GRIFFITH A Quality Assurance in Building (1990) Macmillan Building and Surveying Series Macmillan Education, ISBN 0–333–52724–0

[2] NHBC 'Buildmark'—Ten year new house warranty (1988) Scottish Edition National House-Building Council
[3] MMI 'Foundation 15'—New Home Guarantee Scheme Details and New Home Owner's Handbook (1989) Municipal Mutual Insurance Ltd
[4] BRE Quality in Traditional Housing Volume 1: An Investigation into Faults and their Avoidance (1982) HMSO, ISBN 0–11–671350
[5] BRE Common Defects in Low-Rise traditional Housing (1982) Building Research Establishment, ISBN 0–85125–337–7
[6] BRE Timber-framed Housing—A Technical Appraisal (1983) Building Research Establishment Report
[7] BUILDING Achieving Quality on Building Sites (1987) EDC Building Economic Development Council, National Economic Development Office (NEDO) NEDO, ISBN 0–7292–0839–7
[8] GRIFFITH A Current Building Performance in Timber-framed Housing (1989) Heriot-Watt University, Un-published Report

Glossary of Terms

The following terms, referred to in the text have explicit definitions and meanings and are described in the documents referenced. For further information those documents should be consulted.

'Buildmark'—is the Trade Mark of the NHBC Combined Warranty and Protection Scheme.
Defect—A defect in the house resulting from a breach of any of the NHBC's Requirements caused by the Builder, his architect, engineer, sub-contractor or some other agent employed by him or acting on his behalf (NHBC)
Defect—a failure to comply with the Requirements in respect of a New Home. (MMI)
Defect—a shortfall in performance as a result of a building fault (BRE)
Demage—damage to the Home cause by a defect (NHBC)
Damage—damage caused by a defect (MMI)
Fault—a departure from good practice as defined by criteria in Building Regulation, British Standards and Codes, the published recommendation of recognised authoritative bodies, and (for faults of site origin) a departure from design requirements where these were not themselves at fault. (BRE)
'Foundation 15'—MMI Ltd New Home Guarantee Scheme
Major Damage—Ground movement or damage affecting the structural integrity or structural stability of the New Home requiring complete or partial rebuilding or extensive repair work (MMI)

67
The assessment of quality in special needs housing

R.W.GRIMSHAW

Abstract
The following paper reviews the progress that has been made in developing a methodology for assessing the quality of hostel provision for the single homeless in the United Kingdom in respect of the needs of the residents. The work has evolved from a multi-disciplinary study sponsored by the Department of the Environment and carried out by the author and a colleague between 1985 and 1988. The original research showed a lack of fit between the spatial attributes of the buildings and the way the space was used: this paper reviews the progress that has been made as part of a doctoral thesis into the development of a hierarchical methodology which can be used to evaluate and compare the quality of the environment in a wide range of hostel types.

Keywords: Hostels, Homelessness, Post-occupancy Evaluation, Housing Need, Environmental Quality

1 Introduction

Between 1985 and 1988, the author, in conjunction with Dr PL Garside, carried out research sponsored by the Department of the Environment, to evaluate the provision of hostels for the single homeless in the United Kingdom. The research examined the inter-relationship of design, funding and management and was concerned with assessing the quality of the buildings provided in relation to their purpose. The project studied twenty-five hostels in five different local authority areas, with hostel types ranging from direct access to long stay hostels, and varying in size from four to one hundred and sixty beds. The final report was published in 1991[1]

It became clear during the work that whilst there existed well tried methodologies[2] to collect and analyse the data on the physical environment and its effect on occupants, there was no reliable method of comparing the individual hostels apart from the making of unacceptable subjective judgements. The author has worked on developing a methodology for making such comparisons which quantitatively assesses the fit of the building to the needs of the residents. This paper will describe the research evidence on the lack of fit between buildings and occupants and review the basis on which the methodology has been developed.

2 The Research Evidence

2.1 Types of Hostel Accommodation

Hostels for the single homeless are an example of housing developed to meet a special need and, by definition, provide only temporary accommodation for an identifiable group: they are not meant to be permanent homes. This implies that the experience of living in a hostel changes the resident in some way which makes that person better able to cope with normal life when they leave. Hostel accommodation provides much more than just shelter; if that was all that was required then permanent accommodation would be the answer and hostels would be redundant. Although the provision of permanent accommodation must be the ultimate goal of all those who help the single homeless, hostel accommodation provides a temporary respite whilst other problems, whether social or economic are addressed.

Two clearly identifiable types of modern hostel provision were identified in the research. The first, called the domestic model, housed up to 10 residents and was usually provided in a refurbished family house, with a spatial layout closely following that of a family dwelling. The second, called the cluster model, covered larger hostels of up to thirty beds dealing with direct access and shorter stay residents. These hostels were usually new build and the internal space was divided into room clusters of up to ten beds with some communal facilities being provided in the cluster but with central services and staff facilities.

2.2 The Role of Social Communal Space

Although the hostels studied covered a wide range of provision a common feature of all was the provision of social communal space, with a clear assumption that the resident groups would use this space for social interaction and that such interaction constitutes an essential part of the rehabilitation process. This is fundamental to the philosophy of hostel provision[3]. It is stated in the Shared Housing Supplement and has been implicit in the development of more acceptable forms of institutional care since the report of the Nuffield Foundation in the 1940's[4]. It is now a feature of many types of residential building from old peoples homes to hospitals[5].

The social communal space provided was of two types: space where specific essential tasks could be carried out, like kitchens, and space for non-specific social activities, usually in the form of a lounge. The arrangement of space in the hostels implied that the latter was expected to be used rather as a nuclear family would use similar space and was furnished accordingly.

2.3 Evidence of Lack of Fit

The research clearly indicated a lack of fit between the buildings and residents, which challenged the assumptions on which the hostels were designed. Although the provision of social communal space is seen as an essential part of the rehabilitation process, the overwhelming evidence from the research was that non-specific social communal spaces are not used for social communal activities except under exceptional circumstances. Table One summarises the research evidence which was collected using a combination of observation, interviews with residents, and interviews with staff using Zeisal's methodology. It can be seen from this table that only four hostels used the space in the anticipated way. In fourteen cases the space was used as a television lounge only and in seven cases the space was totally unused.

Table One: Summary of Research Results

Use of Non-specific Social Communal Space		
	No. of Hostels	Percentage
Used for social activities	4	16
Used for non-social activities	14	56
Unused	7	28

The non-use of the space is a particularly graphic indication of the lack of fit between the residents needs and the spatial provision, especially as this space is provided at the expense of private space. Indeed two examples were found where the designer had consciously made private bedrooms small to force residents out into the communal space provided. The watching of television has also been shown to have a negative effect on social interaction and is used by people who have difficulty with social contact as an avoidance mechanism[6]. In both cases the residents are clearly rejecting the supposed benefits of social interaction.

Even in the cases where the space was used as designed, special factors were involved. Three of the properties were short-life housing and the people occupying them had been selected because they were existing cohesive groups which would require minimal supervision. They had therefore already established a strong group identity rather like that of a family and could use communal space comfortably. The other case was a hostel for Asian women where the cultural background made the communal use of space more acceptable and where staff took a paternal role in controlling the use of communal space.

On the other hand where communal space had a specific purpose, like the preparation of food in a kitchen, the space was used even if meals were taken back to private rooms for consumption. Residents seemed much more willing to spend time in these areas for informal social contact, implying much more willingness to identify with space which they had a reason to use.

3 Implications of the Research Findings

These findings have fundamental consequences for hostel design and question the underlying assumptions on which the spatial designs are based. They suggest that hostel design and possibly the design of special needs housing in general, much of which makes the same assumptions about the value of social communal space, is based on a lack of understanding of the needs of the users. It can be argued that there is a requirement for a method of assessing the fit between the users of special needs housing and the buildings they occupy, which can be used as an aid by both managers and designers. Such a method should allow for the making of meaningful comparisons between accommodation catering for different levels of need within the same generic categories. This was a problem in the research in question where the evidence from each hostel was clear, but the making of comparisons between the hostels was impossible because the range of provision was so diverse.

4 The Development of a Methodology

4.1 The Meaning of Homelessness

In terms of housing research the single homeless are a valuable group to study for two reasons. The first is that by definition they have lost, for whatever reason, two of the main foundations of civilised life: their home and their family. Therefore, any provision of accommodation for them must address some of the most fundamental assumptions we have about the role of the home and the family in our lives. The second is that the provision of hostel accommodation, which is by definition temporary, implies that the environment within the hostel plays a part in the rehabilitation process which enables residents to cope with self-contained living in the future. Any methodology which can address the relationship between the resident and the hostel environment must have a much wider application in evaluating the environment/behaviour question in general.

4.2 The Research Base

The methodology for differential evaluation has been developed from two bodies of existing research. The first is the work which has been carried out by environmental psychologists into the relationship between behaviour and environment and particularly the latest work carried out using transactional analysis. The second is work being carried out into facilities management which has used supply and demand models to address the question of post occupancy evaluation techniques.

Much work has been carried out by environmental psychologists which suggests that the concept of the ‘home’ in western society is very complex and that it is central to the development of our individual identities, bridging the gap between the internal self and the external world. Comprehensive references would be too numerous to quote in a short paper but the work of Altman, Sommer, Lawrence, Dovey and Cooper are worthy of mention.

Sommer[7] has developed the concept of personal space which extends into the external world around us and is important in defining the self. Altman[8] has incorporated this concept into his theory of privacy as a mechanism for regulating access to the self and Clare Cooper[9] has shown how the home is an important ingredient in the presentation of our self image to the world. Lawrence[10] has researched the link between the physical form of the home and our mental perception of it and Dovey[11] has shown that the qualities which go to make up a ‘home’ can be isolated from the physical form itself.

In more recent work, Altman et al.[12] have shown that the home environment can be seen as a transactional unit which provides a framework for interaction between people space and time. This is valuable because it provides a model which avoids any suggestion of determinism in the relationship between environment and behaviour and because it allows for dynamic change. This model and the work quoted above have been used as the basis for developing the detailed questions which form part of the proposed methodology.

Becker[13] in his Orbit 2.1 study looked at the post occupancy evaluation of office space, in the context of facilities management, by isolating 14 key variables which are the most important for decision making but looking at them in the context of a supply and demand model. The buildings are the suppliers of space within which an organisation’s activities take place, and the organisation, made up of its groups, sub-groups and individuals, provides the demand for space. The advantage of this model is that it separates the needs of the users of space from the attributes of the space itself and by evaluating supply and demand across the 14 variables a picture can be drawn up not only of the fit between buildings and the activities which take place within them but also of the areas in which supply and demand do not equate. If supply and demand balance then the buildings are working efficiently; if demand outstrips supply the buildings are failing to supply the right amount and quality of space and if supply outstrips demand then resources are being wasted by oversupply of space and services.

Although developed specifically for the office environment, the supply and demand principle provides a useful method for evaluating the fit of any buildings to their users and has been adapted to provide a framework for handling the data collected within the methodology.

4.3 A Hierarchical Framework

Although the above point to the away in which individual buildings can be evaluated, it does not provide a framework for addressing the problem of buildings with different attributes and different client needs. To do this we need to go back to more fundamental work on motivation and the satisfying of needs. A number of models exist but two have been particularly useful to environmental designers: Leighton’s scale of ‘essential striving sentiments’ and Maslow’s ‘hierarchy of human need’.

Whilst Leighton’s scale[14] is more comprehensive than Maslow’s[15] it is not ordered in any fashion making it difficult to assess the relative importance of the elements. On the other hand, Maslow’s scale whilst attempting to assess the same factors underlying all human needs, places those needs within a hierarchical structure arguing that the weaker needs can only be satisfied if the stronger more basic needs have been taken care of. This is valuable because it allows for an assessment of the relative importance of different levels of need.

Some of the needs, especially the more basic ones, are more physiologically based, some are more sociological and the weakest or more intellectual are more psychologically based. Fred Steele[16] has taken Maslows list and has identified the spatial implications of each level of the hierarchy and the sociophysical mechanisms involved in addressing them. Steele's interpretation is shown in table 2 and provides the basic mechanism for constructing the methodology for assessing the quality of hostel environments.

Table Two: Human Needs and the Sociophysical Mechanisms that Afford Them

Need	Steele's Interpretation	Sociophysical Mechanism
Physiological	Shelter Security	Shelter Access to services
Safety	Social Contact	Privacy Territory Defensible space
Belonging	Symbolic identity	Communal setting Symbolic aesthetics
Esteem	Growth, pleasure	Personalisation Control
Actualization	Growth, pleasure	Choice Development
Cognitive	Growth, pleasure	Formal aesthetics

Source: Lang[17]

This hierarchical approach is particularly valuable in dealing with special needs housing in general and the single homeless in particular, because of the variance in the levels of deprivation. With the most needy, especially the growing number who have been living on the streets, it cannot be assumed that any of even their most basic needs are being met. The range of provision in hostels for the single homeless is from the very basic direct access hostel which cater for the most deprived through to long stay hostels where the residents are close to independent life. Steele's development of Maslow provides a framework within which hostels making different provision within this spectrum can be evaluated because the relative importance of different client needs and expectations can be evaluated.

5 The Structure of Data collection

In considering lack of fit as a supply and demand problem, Maslow/Steele provide a structure for considering the demand side of the equation by furnishing an accepted definition of human need. In the proposed methodology data is collected on a checklist which is structured under Maslows six categories and is designed to assess how well the hostels supply the physical aspects of that need. Within each of the six sections the questions are addressed to the spatial implications identified by Steele, dealing with specific issues which the research has identified as being important.

The first section deals with basic shelter and security and poses questions on the provision of beds, heating, bathroom facilities and the provision of adequate meals or facilities on which to cook meals. It also addresses internal and external security and resident access to different parts of the building.

The second section deals with privacy provision within the hostel and the ability of residents to establish their own territory to which they control access.

The third section deals with belonging and the provision for social contact both within and outside the hostel. The former this deals with type and layout of communal space and physical evidence of a group identity. The latter examines the location and the identity of the hostel within the local community. This section also looks at the question of institutional features.

The fourth section deals with questions of the ability of the individual to express his/her own identity by personalising space and controlling the quality of their immediate environment. It therefore poses such questions as the ability to put up posters, have personal possessions in the hostel and the control of heating and ventilation in private space. In cluster hostels it deals with the autonomy of the clusters from the central administration.

The fifth and sixth levels of the hierarchy are the highest intellectual pursuits and are less spatially identified with the home. They are primarily of psychological concern and are connected with a settled and stable life. Such stability is not connected with the single homeless in hostels whose needs are more basic and therefore the checklist does not extend to these concerns.

At all levels the questions are designed to address the problem of fit and the way space is being used, whether it is private or communal.

6 Weighting and Balance

The weighting and balance of the information collected is still under detailed consideration but the philosophy behind the scoring has been identified. It follows two principles: the first is that different hostels are dealing with different levels of need and therefore a series of target scores can be expected. For example, direct access hostels must be concerned with the basic physiological and safety needs of the residents as the first step in rehabilitation and would not be expected to be dealing with esteem and belonging. On the other hand, small domestic model hostels which are medium or long stay and whose residents will shortly be ready for independent life, should be addressing all of the first four levels of need.

The second principle is that the basic needs must be adequately catered for before the higher needs can be addressed and that failure to do so will detract from the whole quality of the provision. Thus, a hostel which fails to provide for the privacy needs of residents by providing shared bedrooms cannot score highly no matter how well it caters for personalisation and symbolic aesthetics.

7 Conclusion

Although this work is incomplete, it is believed that it represents an important step forward in the development of quantitative post occupancy evaluation techniques for special needs housing in particular and housing in general. It is based on an assessment of the importance of the spatial aspects of the home and the family to human identity and its hierarchical structure allows comparisons to be made between buildings which cater for different levels of need. Its use will allow post occupancy evaluation information on the fit between the building and the needs of its users to be fed into future housing design

References

1 Garside P1, Grimshaw RW and Ward FW (1991) **No Place Like Home: The Hostels Experience,** London, HMSO
2 Zeisal J (1981) **Inquiry by Design,** Cambridge, CUP
3 Housing Corporation (1989) **Shared Housing Supplement,** London, HC
4 Nuffield Foundation (1947) **Old People: A Report of the Survey Committee on the Problems of Ageing and The Care of Old People,** London, OUP
5 Willcocks D, Peace S and Kellaher L (1987) **Private Lives in Public Places,** London, Tavistock
6 Parke Rd (1978) Childrens Home Environments, in Altman I and Wohlwill JF (eds) **Children and the Environment,** New York, Plenum Press
7 Sommer R (1969) **Personal Space: The Behaviourial Aspects of Design,** Englewood Cliffs NJ, Prentice-Hall
8 Altman I (1975) **Environment and Social Behaviour,** Monterey, Ca., Brooks Cole
9 Cooper C (1974) The House as Symbol of Self, in Lang J et al. (eds) **Designing for Human Behaviour,** Stroudsberg Pa., Dowden Hutchinson and Ross
10 Lawrence RJ (1987) **Housing Dwellings and Home,** Chichester, J Wiley
11 Dovey K (1985) Home and Homelessness, in Altman I and Werner CM (eds) **Home Environments,** New York, Plenum Press
12 Altman I, Werner CM and Oxley d (1985) Temporal Aspects of Homes: A Transactional Perspective, in Altman I and Werner CM (eds) **Home Environments,** New York, Plenum Press
13 Becker F (1988) Orbit 2.1, **Facilities** 6 (3)
14 Leighton AH (1959) **My Name is Legion: Foundations for a Theory of Man in Relation to Culture,** New York, Basic Books
15 Maslow AH (1954) **Motivation and Personality,** New York, Harper and Row
16 Steele F (1973) **Physical Settings and Organisational Development,** Reading, Mass., Addison-Wesley
17 Lang J (1987) **Creating Architectural Theory:** New York, Van Nostrand Reinhold

68
The use of ISO 9002 as a basis for development and implementation of certifiable quality management systems for contractors

H.GUDMUNDSSON

Abstract

There is a growing interest for cerfication of contractors' Quality Management Systems on basis of the ISO 9000 series. The paper describes a model for developing a Quality Management System on basis of the ISO 9002, the demands to a system from the ISO standard, the role of management and employees in the developing process. The paper gives some guidelines based on experiance gained from a Danish pilot project.

ISO 9000 series, Contractors Quality Management System, developement and implementation.

1 Introduction

This paper describes the development of a quality management system conforming to ISO 9001 or 9002. 6 Danish contractors are working towards a certification of their Quality Management Systems in collaboration with the Danish Standard Institution and the Danish Technological Institute. The project is partly financed by the Ministry of Industry and Commerce as a pilot project, and the results will be publicised for the benefit of the building industry in general.

It is today a growing trend that contracts carry a clause demanding that contractors have a formal and documented quality systems. To meet this clause the ISO 9000 series are often used as a reference.

In Denmark the contractors can have liability for hidden faults limited from 20 to 5 years, provided they have a documented Quality management system. This created problems as the systems differ and they are therefore difficult to audit for the buyer.

The need for a common standard for Quality Management Systems and a third party audit certification of these systems has therefore become more pressing. The problems thereby created are that the certified systems tend to be bureaucratic, as the certification bodies demand systems that are too complicated for small companies and the certification process itself is expensive.

2 The content and implications of the ISO 9000 series

The ISO 9000 gives guidelines for a purchaser and a supplier to the selection of which of the standards in the series is most relevant to the contract and what specific adoptions have to be made.

Risk costs and benefits for both parties should be appraised and taken into consideration, when determining the extent and the nature of the information necessary in order to provide the adequate confidence in the achievment of the intended quality.

When the standards are used for certification this bilateral situation is not present. The certification body can not take the individual contract into consideration but must assume that the Quality Management System shall comply with the specifications of the most demanding contract.

This is especially a problem for subcontractors who have a big variety of contracts extending from a simple foundation for a one-family-house to a complicated industrial powerplant.

The contractor will therefore need to have a very flexible system taken the needs of a wide range of contracts into account.

The certification body must also accept that a contractor does not have a singular system but systems adapted to each individual contract, but deriving from a basic system. This calls for flexibility and competence from the certification body in auditing the contractor as he must evaluate the contractors compliance to the system in relation to each individual contract.

The ISO 9000 lists a number of factors to be considered as fundamental when selecting the appropriate model for a product or a service:

– Design process complexity
– Design maturity
– These factors deal with the difficulty of design and with the extent to which the total design is known and proven either by performance testing or field experience.
– Production-process complexity.

> This factor deals with the availability of proven production processes, the need for development of new processes, the number and variety of processes required and the impact of the processes on the conformance of the product.

The ISO 9000 also lists some 8 quality systems elements to be taken into consideration such as:

– the adequacy of the quality system
– the capability to achieve product conformity with specific requirements
– the complexity and innovation required to design the product
– the complexity and difficulty of producing the product
– the past performance of the supplier (contractor).

As can be seen from the above the ISO standard recommends that the complexity of each product and production process should be considered when designing the quality system. This is especially important in the construction industry as contractors often are involved in complicated civil construction works where faults often are costly, as well as house building using traditional design and proven production processes, where faults are easier to repaire.

3 The role of management

The quality problems in the construction industry are rarely caused by lack of knowledge nor by the use of unknown technic or material in the building process.

The faults are mostly due to ineffective quality management, insufficient work instructions and lack of using already accessible knowledge

The quality system should therefore especially take this into account and deal with problems such as organisation structure, responsibility and authority, education, jobtraining and instruction.

There are six common causes for a companies failure in developing an effective quality management system.

– the management has not made up its mind to develop and implement the system
– the necessary resources quantitative and qualitative are not allocated
– the task and objectives the mangement sets for the development projekt is not defined
– the developing and implementing process is neither analyzed nor planned
– the company neither knows its weak nor its strong sides
– the management does not involve itself in the process.

It is important that the management sets the objectives for the quality system and its implementation in the company and commits itself to quality. If the first try is not successful and is abandoned, it will be more difficult the second time.

4 The role of the employees

One of the main problems in using the ISO 9000 series is that it is written by quality management specialist for other quality management specialist but most often used by non specialists who may have experience in quality control and therefore think in control measures and not in quality management systems.

This problem should be taken into consideration before starting the quality development programme either by giving the task to properly trained employees or if there are none in the company by starting a training programme giving the leader of the project training as a quality system auditor.

It is not advisable to hire external consultants to do the job completely. The development and implementation of the system should be done by the contractor. On the other hand an external consultant should be used as a sparring partner and to motivate and inspire the contractors project workers and at the same time keep the momentum in the developing process.

If the company completely relies on external consultancy the expertise and insight in the companies' problems leaves with the consultant and the motivation factor will be smaller as the resulting system will be a system created by outsiders and therefore not tailored to the contractors real needs.

Care should be taken to involve as many of the people who will be affected by the system as possible and to inform all employees of the process.

5 The process of developing the system and the content of the system

When the quality programme is planned there are two possible main routes to take:

– develop a system for the companies own sake
– develop a system that will make it easier for the certification body to audit.

In the case of the the contractor selects the second route, the system will be built around the framework of the ISO 9000 series, if the objective is only to get the certificate this method can be used. But it can be more difficult to get a system that is suitable for the contractor and will produce the intended results.

If route one is chosen the company will most probably get an effective quality management system as well as one that can be certified.

To do this the company should work out a programme with the following elements:

1. register and analyze the companies existing quality system and identify the weak and strong sides of the company
2. work out a programme for the quality development project. The programme should include elements such as time table and milestones, training programme, budget, identification and allocation of personnel engaged or affected by the programme
3. registration and analyses of the production process for example in form of a flow diagram
4. identification of problematic areas for priority of engagement
5. appointment of working groups to draw up procedures, this will be a repetitive process
6. compile the procedures into a quality manual
7. implement the system through information of personnel
8. revise the system in accordance with the experience gained under the implementation process.

The system should include the following elements which could be documented in the quality handbook:

– company quality policies and objectives signed by the top management
– the organizational structure with definition of responsibility and authority
– administrative and operational procedures
– work instructions
– controlprocedures and methods
– quality specifications

6 Discussion

Managing quality is a management task and the quality sy- stem is a management tool to solve that task. It is therefore important that the quality management system is designed to solve the companies problems, it should in-crease earnings by reducing failure costs and provide confidence to the management and the buyer in the construction satisfying the requirements for quality.

In some cases the management is only interested in getting a certification for advertising purposes, i.e. doing the right thing but for the wrong reason. This will often lead to frustrations in the developing and the implementation process and reluctance from personnel to use the system as these systems tend to be bureaucratic.

There are few simple rules that are important to follow

1. The management must decide that it will develop and implement a quality system, and commit itself to quality and the quality development programme. The management must set up objectives for the programme and follow up on the achievment.
2. The programme should be described as a project with budget, milestones, timetable and training programme for affected personnel.
3. The execution of the project can with advantage be subdivided into three phases

   – a preliminary phase including planning activities identification of problems, establishing working groups, identification of problem areas for priority of work, setting preliminary quality objectives and policies.
   – a development phase, including registration of processes, documentation of procedures organisation structure, information of personnel, editing of the Quality Handbook
   – implementation phase, implementing and revising the Quality Manual, which will be an iterative process

4. The system must be continually supervised and evaluated by management.

The Danish project has shown that these simple rules are fundamental and even though following them does not guarantee success the probability of pulling through with success is greater.

The project is not finished but already now experience shows

– that a quality development programme is costly but beneficial to the companies involved
– it has been of great value for the motivation and the progress of the work to collaborate with the other contractors.
– it was important for the project workers to confer with the external consultant to confirm that they were on the right track
– the contractors using one person doing all the work compared to contractors using working groups had it easier in the description phase but discovered problems in the implementation phase as their information regarding procedures in the different departments was not accurate and the procedures therefore were not always relevant to the actual situation.

The companies agree that the project has made it easier to develope the Quality Management System and the system is working in all of the companies. One is already certified and two have started the certification process.

7 References

ISO 9000 Quality management and quality assurance standards—Guidelines for selection and use
ISO 9002 Quality systems—Model for quality assurance in production and installation
Gudmundsson, Halldor (1991) Anvendelse af ISO/DS 9001 til udvikling og indførelse af certificerbare kvalitetstyringssystemer i entreprenørvirksomheder.

69
Sources of quality failures in building

Y.HAMMARLUND and P-E.JOSEPHSON

Abstract
Success in quality management requires familiarity with quality-related costs. During the introductory phases of the building process, there are many opportunities to influence the final characteristics and the production costs. The opportunities decrease gradually during the process. During the construction phase they are negligible.

Due to defects and noncompliance with requirements, quality problems are generated during the building process. The range and characteristics of failure costs in Swedish housing are discussed in this paper. It has been found that these costs are equivalent to about 10 % of the total production cost. The opportunities to influence failure costs are different from those for production costs. During the design phase, one third of the failure costs can be influenced whereas, during construction, half of the costs can be affected. Material defects and improper use of the building account for one fifth of the failure costs.

Keywords: Quality, Quality Costs, Quality Failure Costs, Quality Failures, Failure Costs, Costs, Housing, Construction Management, Quality Management, Building, Construction.

1 Introduction

Buildings and structures are usually constructed with the intention of being used for a long span of time. The responsibility for their erection and their use is divided among a multiplicity of agents; clients, designers, contractors, property managers, tenants and public institutions.

The way in which the responsibility is distributed among the agents is of great importance in the effort to improve quality in building. The responsibility concerns the design of the structures; their capacity to satisfy the needs of the tenants. It also concerns obtaining the intended features and characteristics and preserving them.

It is of great importance that responsibility is distributed among the agents in accordance with their actual ability to control the process and/or result. Current opinion on how these abilities to influence turn out is greatly diversified, as it has been founded mainly on subjective grounds.

Nowadays in Sweden there is considerable interest in the quality aspects of building. Systematic efforts in collecting information on quality-related aspects are being carried out. It is now possible to throw further light on the extent to which the agents of the building process can influence quality in building.

2 The Building Process

The development of a building or other structure follows a course which shows common traits. Building processes represent such courses. They cover the period of time from the initiation of the building project until the finished structure is ready to use.

During the building process, there occurs a progressive defining of the structure. This follows the well known course illustrated in Figure 1. The figure is based on the assumption that complete documentation exists before the start of construction. The opportunity to influence the final characteristics of the structure, as well as production costs, becomes gradually decreased.

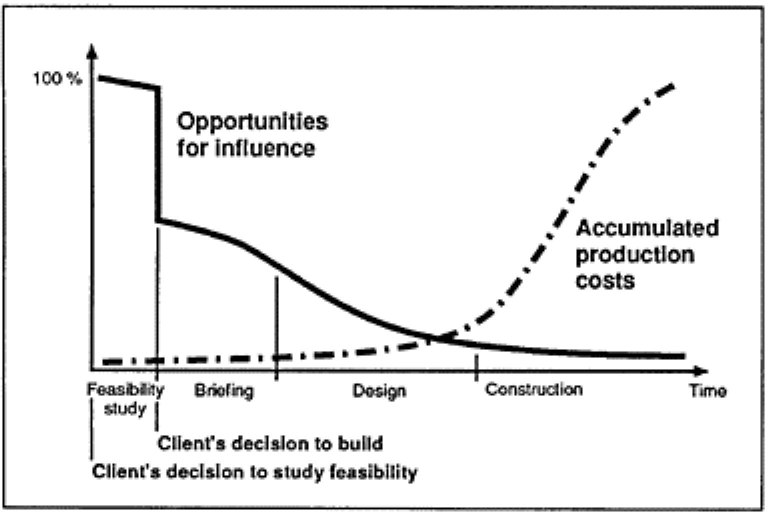


Figure 1. Opportunity for influence versus production costs during the building process.

When a decision is made to carry out a specific building project, the type of structure to be built and the basic characteristics and standard requirements it will have are established. Other requirements for carrying out the project, for example budget and time restrictions, are decided. A considerable part of the final characteristics of the structure and, accordingly, of the production costs are thus established at this point.

The opportunity to influence the final characteristics of a building is still great in the briefing phase, however it becomes progressively less during the design process. During the production phase, the chance to influence the characteristics of the structure and, accordingly, the resources needed, are limited.

The production cost of the project is equivalent to the basic investment in the structure. Production cost rises by gradual stages; in the early phases, feasibility study, briefing and design, such cost is limited. The greatest intensity is reached in the construction phase, when the major part of production cost is incurred.

A building or other structure is expected to be servicable for a long time. For this to be so, it must be properly managed. The costs that are related to such management, to maintain the structure and otherwise facilitate its use, rise during the lifespan of the structure to an amount many times greater than the original investment.

3 Quality-Related Costs

The building process normally involves a wide network of companies, authorities and individuals. The construction of buildings and other structures is usually the result of a complicated interaction among the foregoing. The risk of disruptions of many kinds is obvious. A far from insignificant part of the work taking place during the building process is to avoid and/or compensate for different types of disruption.

One type of disruption comprises noncompliance with specified or intended requirements for production and usage. The cost of preventing such disruptions or compensating for them when they appear is termed quality costs.

In the International Standard, ISO 9004:1987(E), quality related cost is defined. From the point of view of a business, operating quality costs are defined as, “those costs inccurred by a business in order to attain and ensure specified quality levels”. Operating quality costs include prevention and appraisal costs and failure costs (or losses).

Prevention costs constitute, according to ISO 9004, “cost of efforts to prevent failures”. These prevention costs include costs for all measures taken to make it possible for those involved to avoid nonconformaties or failures.

By appraisal costs is meant, in ISO 9004, “costs of testing, inspection and examination to assess whether specified quality is being maintained”. Appraisal costs can be understood as those incurred in order to determine whether those involved have worked adequately on all occasions.

Prevention and appraisal costs are investments made to avoid failure costs.

Failure costs (or losses) can be either internal or external, according to ISO 9004.

Internal failure costs are defined as, “costs resulting from a product or service failing to meet the quality requirements prior to delivery (e.g. reperforming of service, reprocessing, rework, retest, scrap)”. Internal failure costs are, thus, costs that the business has incurred, before the product or service is accepted by the customer, caused by the failure of those involved to do the work adequately on all occasions.

External failure costs are, “costs resulting from a product or service failing to meet the quality requirements after delivery (e.g. product service, warranties and returns, direct cost and allowances, product recall costs, liability costs)". This category of failure cost covers costs caused by the failure of the inspection system to catch failures prior to delivery.

Successful quality management requires that quality-related costs are held to a level at which a company's utilisation of resources is optimal. This further requires well planned prevention and inspection activities. These activities must be based on understanding of the size and nature of the cost components mentioned. The magnitude and character of failure costs in Swedish housing will be discussed next.

4 Costs of Internal Quality Failures

Relatively few investigations of quality-related costs have been found in the literature. Ball (1987), Van den Beukel (1989), BRE (1983), Burati and Farrington (1987) and Hansen (1985) are some examples. When such information has been presented, information about the investigation methods was usually lacking.

At the Building Economics and Construction Management Department of Chalmers University of Technology, in cooperation with FoU-Väst (R&D-West), a group of eight construction firms, a study has been carried out. Its aim was to clarify the extent and character of internal quality failures in construction. The main results of the study are presented in Hammarlund et al (1990a) and Augustsson et al (1989), which also includes references to previous studies. The primary objective of this study has been partly to identify situations in which preventive measures have the greatest effect on quality-related costs, and partly to stimulate all agents in the process to actively take effective measures in meeting quality goals. This has been accomplished by mapping and analysis of internal failure costs identified at construction sites.

The main study comprised 20 months continuous monitoring of the activity at one site, a community service building produced as a package deal. A full-time observer stationed on the site conducted the follow-up. Twenty-one shorter studies, each spanning three weeks, were carried out to test validity. They represented different types of building; buildings of various sizes, at different stages of construction, under different types of contract, at different times of the year etc.

As previously noted, ISO 9004 is formulated from the company's viewpoint in the definition of internal failure costs. Here, however, we are concerned with quality failures that occur at the building site during the construction process, regardless of who is responsible for the cost. By quality failure was meant deviation from what was intended. In the study, no judgement was made about whether the intended, the planned solution or the production method chosen, was actually the best possible. The research method is fully described in Hammarlund et al (1990b).

The main result of the study is presented in Figure 2.

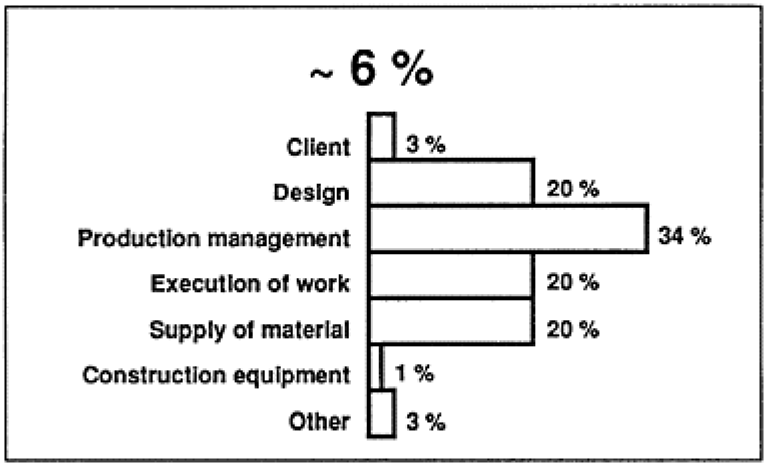


Figure 2. Costs of internal quality failures.

It can be shown that the costs for correcting quality failures amounts to approximately 6 % of the production cost. (The time required to rectify the errors corresponds to approximately 11 % of the total working-hours). A large part of the failure costs, approximately 1/3, can be ascribed to failures in site management. Somewhat smaller portions of the failure costs, approximately 1/5 each, can be ascribed to failures in design, workmanship and material deliveries. Other causes of the failure costs are of subordinate significance.

Defective workmanship, defects in products, insufficient work preparation, inadequate construction, incomplete planning, disturbances in personnel planning, delays, alterations, failures in setting out and coordination failures constituted, in order of precedence, the most frequent failure types.

In order to achieve the aim of the study it has been important that the people in the industry find the results presented realistic. This consideration has characterized the organization of the study.

Josephson (1990a, 1990b) discusses the research method used and the validity of the results. One conclusion is that the results presented are not extreme. They give a reliable picture of the type, volume, origin and causes of the quality-related failures.

It should be noted that the study comprises only a part, although probably the greater part, of the internal failure costs of building. Costs of failures corrected before information or deliveries had reached the site, were not studied. Examples of such failures are those that occurred and were corrected in the briefing or design phases, as well as failures occurring and corrected in materials or machines before the deliveries.

5 Costs of External Quality Failures

Costs for external failures in the construction process consist of cost associated with the counter-measure of failures appearing after final inspection, regardless of who takes the responsibility. Examples of this kind of failure are inadequate function, presence of moisture, mould or radon, rotten windowframes and water damage.

Some international studies on defects and omissions in buildings have been found in the literature. BRE (1975), CSTC (1976), and STATT (1989) are some examples.

Determining the frequency of external quality costs is more complicated than that of internal quality costs. To trace the costs for this type of failure to the time of actual construction, one must take into account interest rates and changes in the value of money. This procedure can be understood as comparable to ascertaining the magnitude of a fund for financing measures to correct future failures. Some information already exists for determining the size of such a fund.

At the reqest of the Ministry of Housing in 1981, the National Swedish Institute for Building Research performed a survey of exceptional maintenance-costs for buildings built 1955–1979. The demand for exceptional maintenance can be understood as external quality failures. The study has been presented in Sjöström et al (1982). The Institute was later entrusted to perform a survey of the technical status of existing Swedish buildings and other structures including, among other things, the need for repair work and maintenance (Tolstoy, 1984). The survey comprised, with some exceptions, all buildings, which were heated during the main part of the heating period. The survey was performed as a sample survey. All the items of the sample were scrutinized by professional inspectors.

Tolstoy says that the costs for exceptional maintenance in 1983 amounted to three billion Swedish crowns. This is equivalent to 3 % of the production value for Swedish building in that year. It may be noted that defects in German bulding reach the same figure, 3%, according to STATT (1989).

When the costs for exceptional maintenance are traced back to the time of the actual construction, a value of 4% of the production cost is found. The basis for the calculation is then 4 % real interest rate. Information from the Swedish National Accounting system for 1955–1979 is used.

In Bergström (1989), the sources of the costs for extraordinary maintenance are dicussed. Based on several studies, including the abovementioned, averages are given for the different sources of the external quality-related costs. The results are presented in Figure 3.

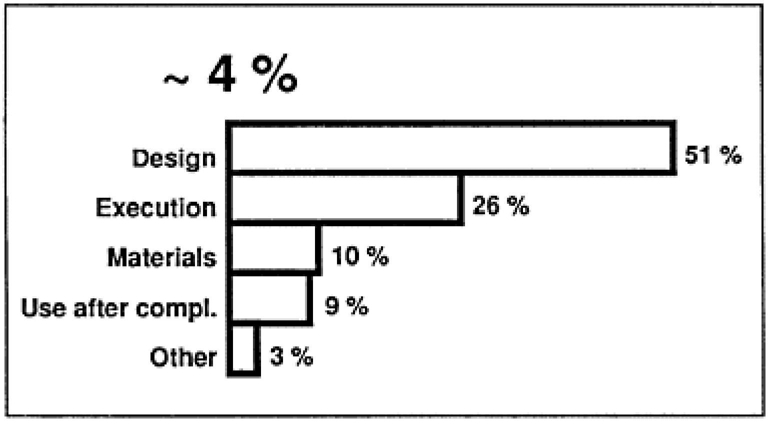


Figure 3. Costs of external quality failures

Half of the external failure costs have their sources in the design phase, and one quarter are in the execution of work. Failure of materials accounts for 10%, about the same figure as for improper use of the building. According to Bergström, the Swedish findings corresponds reasonably well with international experience.

6 Sources of Quality Failures

Identification of feasible choices for reduction of failure costs presumes knowledge of their origin. When the range and characteristics of internal and external costs are known, their sources may be determined. Based on what has been presented earlier in this paper, the sources can be calculated and, hence, the opportunities for influence. The results are presented in Figure 4.

It can be seen that the failure costs in construction, of the type dicussed in this paper, are equivalent to about 10 % of the total production cost.

The opportunities to influence them are different from those for production costs. During the design phase, one third of the failure costs can be influenced, while during construction half of the costs can be affected. Material defects and improper use of the building account for one fifth of the failure costs.

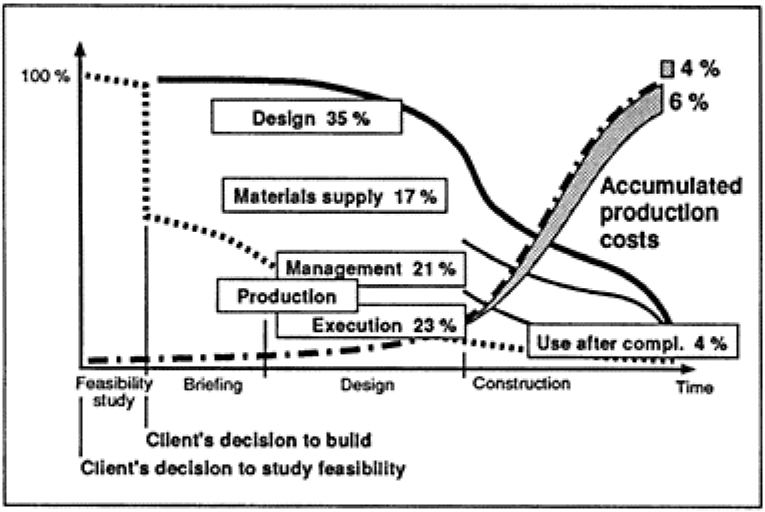


Figure 4. Opportunity of influencing quality failure costs in the building process

7 Conclusions

The figures presented in this paper are not necessarily true mean values for Swedish housing. Since the aim is to motivate the agents of the building process to quality-consciousness, the determination of mean values is neither required nor meaningful. The figures, however, reflect what is normal as it has been perceived by the agents. The results have to a large extent been applied in practice. They have functioned as catalysts for starting a large number of quality improvement programs in the building sector.

Further studies are being carried out in Sweden at present. At Chalmers University of Technology, a project is in progress, with the objective of gaining a deeper understanding of basic phenomena behind failures and disturbances. Within CIB a large project is being carried out, which comprises an extensive study on defects and deficiencies in existing Swedish buildings and other structures.

8 References

Augustsson, R., Hammarlund, Y., Jacobsson, S., and Josephson, P.-E. (1989) **Kvalitet i Byggandet—Kvalitetsfelkostnader,** Report 21, Department of Building Economics and Construction Management, Chalmers University of Technology, Gothenburg, Sweden.

Ball, P.L. (1987) The economics and assurance of quality in construction, Conference paper, **Quality: A Shared Commitment,** EOQC, London, UK.

Bergström, S.G. (1989) Byggfelsstudier inom SVR, Journal article, **Väg—och Vattenbyggaren,** no 7, Sweden.

Van den Beukel, A. (1989) **Quality Cost,** Committee on Housing, Building and Planning, Economic commission for Europe, Economic and Social Council, United Nations.

Building Research Establishment (BRE) (1975) Building failure patterns and their implications, Journal article, **The Architects' Journal,** feb 1975.

Building Research Establishment (BRE) (1983) **Quality in Traditional Housing, Vol 1: an Investigation into Faults and their Avoidance,** Department of the Environment, Building Research Establishment, London, UK.

Burati, J.L., and Farrington, J.J. (1987) **Costs of Quality Deviations in Design and Construction,** Construction Industry Institute, Source Document 29, U.S.

Hammarlund, Y., Jacobsson, S., and Josephson, P.-E. (1990a) Quality Failure Costs in Building Construction, Conference paper, **CIB W 55/W 65 International Symposium,** University of Technology, Sydney, Australia.

Hammarlund, Y., Jacobsson, S., and Josephson, P.-E. (1990b) Quality observer—a new role at the construction site?, Conference paper, **CIB W 55/W 65 International Symposium,** University of Technology, Sydney, Australia.

Hansen, R. (1985) **Kvalitetssikring og kvalitetskostnader,** Hovedoppgave, Institutt for Anleggsdrift, Norges Tekniske Hogskole, Trondheim, Norway.

ISO 9004 (1987 (E) Quality Management and Quality System Elements—Guidelines, International Organization for Standardization.

Josephson, P.-E. (1990a) **Kvalitet i Byggandet—en Diskussion om Kostnader for Interna Kvalitetsfel,** Report 25, Department of Building Economics and Construction Management, Chalmers University of Technology, Gothenburg, Sweden.

Josephson, P.-E. (1990b) Quality in building construction—a discussion on costs of internal quality failures, Conference paper, **Nordiskt seminarium om kvalitetsstyrning i byggprocessen,** Laboratory of Building Production Technology, Technical Research Centre of Finland, Tampere, Finland.

Reygaerts, J., Gasper, M. and Dufordoir, C. (1976) 1200 problémes, Journal article, **CSTC-Revue,** no 3, Centre Scientific et Technique de la Construction, Belgium.

Sjöström, C., Svennerstedt, B., and Tolstoy, N (1982) Vad kostar det att åtgärda skador och fel i bostadsbeståndet?, Journal article, **Väg—och Vattenbyggaren,** no 10, Sweden.

STATT (1989) **Rationellt byggande—metoder, hjälpmedel och maskiner,** Utlandsrapport från Sveriges Tekniska Attachéer, STATT 8906, Stockholm, Sweden.

Tolstoy, N. (1984) Är kostnaden att åtgärda skador och fel i husbeståndet for hög?, Journal article, **Väg—och Vattenbyggaren,** no 11–12, Sweden.

70
Multicriteria evaluation methods: attractive tools for the support of decision making on building projects

R.E.C.M.van der HEIJDEN

Abstract
Multicriteria evaluation techniques are important tools for the support of decisionmaking on alternative building plans. Some of the main techniques are described and their applicability is discussed. The application of one of the techniques in the context of retail planning is shortly described.

Keywords: Multicriteria Evaluation, Planning and Building, Decision Support

1 Introduction

Essential for fields such as civil engineering and town and country planning is the development of alternative plans for building projects and a systematic evaluation of these plans. Decisionmakers pursue specified goals and are supported by data and information on the attributes of plans, the likely impacts, possibilities for realization, etc. Hence, an important part of this process concerns the generation of alternatives and the so called ex ante evaluation of these alternatives.

The evaluation activity is typically characterized by matching the subjective and often biased information on aims of different participants in the decision process on the one hand and factual information on the alternatives on the other hand. In particular with respect to the planning of building programmes this matching process is politically loaded: it copes with issues of large financial investments, with impacts on the environmental quality, with changes in socio-spatial functioning, with a lot of uncertainties, etc. Consequently, decisionmaking on building projects has become subject of public discussion.

Due to this growing interest in the nature and outcome of the process of evaluation and decisionmaking, much progress has been made with respect to the development of concepts and methods for the systematic support of decisionmaking. Research basically focus on

a. the methodology of generating alternative plans
b. the measurement of impacts of alternative plans
c. the development and application of evaluation tools
d. the integration of a-b-c in decision support systems.

In the past decade, the Faculty of Civil Engineering has developed a tradition in learning students to apply multicriteria evaluation approaches in the context of their work. This tradition started with reserach on multicriteria evaluation techniques by Voogd, who published this work in the early eighties (e.g. Voogd, 1983). After his departure from the Faculty, the approach continued to be teached and applied with success.

This paper discusses the applicability of some main operational approaches to multicriteria evaluation and is structured as follows. Section 2 discusses some main issues related to multicriteria evaluation analysis. Section 3 presents an overview of some main techniques. Section 4 then shortly illustrates one of these techniques.

2 Issues in multicriteria evaluation analysis

The development of spatial plans or large building projects, requires the integration of the variety of information on: functional design requirements, cost/benefits of investments, spatio-functional mix, environmental impacts, technical requirements, organization of realization, legal procedures and so on. A number of issues are relevant for the application of multicriteria evaluation methods in this multidimensional evaluation context.

a. An important aim of the analysis is to find the best alternative from a set of alternatives given a set of evaluation criteria. However, there is a tendency to exaggerate the importance of this aim. The same importance should be attached to the group of following aims:

– structuring and reducing information
– structuring the choice set
– incorporating qualitative differences among alternatives in their evaluation
– creating a systematic overview of advantages and disadvantages of alternatives
– making judgements and their influence on decisions explicit
– reducing uncertainties.

Multicriteria evaluation analysis should be considered as a tool for ordering decision processes and not for taking decisions. The interaction between the analysis and the decisionmaking is therefore important and might be realized successfully in a decision support environment (Bahl and Hunt, 1984; Van der Heijden, 1986, 1990).

b. In terms of research the main activities focus on the specification of alternatives, evaluation criteria, the measurement of evaluation scores, and the measurement of differences in criteria priorities. In other words: a focus on the specification of the evaluation matrix. In that context the researcher necessarily communicates intensively with decisionmakers. Mutual acceptance and trust is essential for a successful multicriteria evaluation. The reseacher should become involved in the decision problem to get familiar with the ins and outs. A ‘clean technical engineering’ approach focusing on the solving of a specified problem by some clear technical procedure, is less effective.

c. With respect to the specification of criteria and measurement of evaluation scores, it generally is impossible to quantify all differences between alternatives. However, quantifying is certainly not always desirable, because it causes the exclusion of ill-measureable impacts/attributes from the evaluation process, although they might influence decisionmakers implicitly. Moreover, from a technical point of view quantification is not necessary, as will be illustrated in section 3. This implies that qualitative, organizational, legal, environmental etc. aspects of building programmes and spatial plans can be incorporated in the evaluation process explicitly. The evaluation of building plans and projects is then based on a mix of qualitative (ordinal) evaluation data and quantitative (ratio) data. This influences the choice of the evaluation technique.

d. In terms of the measurement of evaluation scores, more attention should be paid to the problem that assessments of future impacts of alternative plans or projects (the increase of the number of visitors, the change in investments in adjacent areas, the shift in the use of particular facilities, etc.), should be expressed as a ratio with the autonomous or trend development (Van der Heijden, 1986) to avoid misleading absolute evaluation scores, neglecting the relative position to the future impacts of the zero-option.

In the next section, some main multicriteria evaluation techniques will be memorized, focusing on the incorporation of qualitative information in the evaluation process (for more details: see Voogd, 1983).

3 Some methods

The multicriteria evaluation techniques to discuss here start with the specification of an evaluation matrix E with scores E(k, r) for K alternative plans (k=1,…, K) on r criteria (r=1,…, R).

The most frequently applied evaluation approach is the **(weighted) summation technique,** calculating an appraisal score S(k) for each alternative k as follows:

$$S(k) = \sum_{r} w(r).E(k,r) \qquad (1)$$

where w(r) is the weight attached to criterion r. This technique assumes that all scores and weights are measured on a ratio scale, that the scores all have the same direction and that they have been standardized. The alternative yielding the highest appraisal score is the ‘best’.

The assumption on the measurement scale of the data limits the applicability of the technique. Nevertheless, in practice the technique is often applied for evaluating qualitative data too, by interpreting ordinal evaluation data and ordinal criteria priorities in terms of values of some unified ratio scale (e.g. ranging from 0 to 1 or 0 to 10). These operations are generally quite arbitrarily and subject of discussion.

Further, there is a substantial problem with the weighted summation technique, wich can be illustrated as follows. Assume 4 students looking for a house to live as a group. They define 6 criteria and find 3 alternatives. Together they specify the evaluation matrix presented in Table 1 and decide to give equal weights to the criteria. Next, each of them tries to choose the 'best' aternative.

The first student standardizes the evaluation scores between 0 and 10, applies the approach of summation of the scores (Table 2) and concludes that C is the best choice.

Student 2 approaches the choice problem by translating the scores to a scale with scores best, moderate, and worst. In her view, given all criteria weighting equally, the alternative that scores best on the largest number of criteria is the best choice. Table 3 shows that alternative A is chosen by her.

Student 3 applies another standardization rule than student 1 in that all scores per criterium are subdivided by the maximum score, thus yielding scores with a maximum of 1.0 (Table 3). Note that the direction of the scores is such that a lower score is a better score! Applying the summation technique results in choosing alternative A.

Finally, student 4 accepts a decision rule based on the view that alternatives do/do not exceed particular thresholds. The results are presented in Table 4 (included is information on the accepted thresholds). Then, the student simple calculates frequencies and decides to choose alternative C.

This example illustrates that different views are valid for evaluating even simple problems and that these different evaluation approaches yield different results. However, one approach is not evidently better than another. This particularly refers to the issue of dealing with qualitative information and dealing with information in a qualitative (awareness of uncertainty!) way.

A second technique focus on the evaluation of a pure qualitative evaluation matrix. This **qualitative permutation technique** (Paelinck, 1977) is based on the transformation of ordinal data into data on a binary scale and an additional calculation of frequency scores.

Table 1: Evaluation matrix

		alternatives			
criteria		A	B	C	
a.	price per individu	200	250	225	df1/month
b.	mean surface private	9	9.75	11	m2
c.	distance to university	1.5	3	2.5	km
d.	noice level by traffic	40	55	47	dBA
e.	distance to shops	500	400	375	m
f.	atmosphere	−	++	+	

Table 2: Translated evaluation matrix student 1

		alternatives		
criteria		A	B	C
a.	price per individual	10	0	5
b.	mean surface private	0	3	10
c.	distance to university	10	0	3
d.	noice level by traffic	10	0	5
e.	distance to shops	0	7	10
f.	atmosphere	0	10	5
Total		30	20	38

Table 3: Translated evaluation matrix student 2

		alternatives		
criteria		A	B	C
a.	price per individual	best	worst	mod.
b.	mean surface private	worst	mod.	best
c.	distance to university	best	worst	mod.
d.	noice level by traffic	best	worst	mod.
e.	distance to shops	worst	mod.	best
f.	atmosphere	worst	best	mod.

Table 4: Translated evaluation matrix student 3

		alternatives		
criteria		A	B	C
a.	price per individual	0.80	1.00	0.90
b.	mean surface private	0.18	0.11	0.00
c.	distance to university	0.50	1.00	0.83
d.	noice level by traffic	0.72	1.00	0.85
e.	distance to shops	1.00	0.80	0.75
f.	atmosphere	0.20	0.00	0.10
Total		3.40	3.91	3.43

Table 5: Translated evaluation matrix student 4

		alternatives			
criteria		A	B	C	
a.	price per individual	1	0	1	<225 df1
b.	mean surface private	0	0	1	>10 m2
c.	distance to university	1	1	1	<3 km
d.	noice level by traffic	1	0	0	<40 dBA
e.	distance to shops	0	1	1	<400 m
f.	atmosphere	0	1	1	not bad
Total		3	3	4	

The technique starts with the specification of all the possible rankings (permutations) of the K alternatives. Since in general there are more than 2 alternatives, each of these hypothetical rankings consists of a number of preference combinations (e.g. alternative B better than alternative A; alternative D better than B; etc.). The qualitative permutation technique focus on the comparison of the hypothetical rankings with the empirical rankings as expressed in the evaluation matrix. The extent to which a hypothetical ranking corresponds to an empirical ranking can be checked for each criterion. The results of this comparison are expressed in a new matrix with R (the number of criteria) rows and U (the number of permutations) colums. Each cel (u, r) expresses the total frequency of correct rankings. A score of +1 is given to an empirical preference combination that corresponds to the hypothetical preference combination. A score of −1 is given when the rankings are opposite and a score of 0 is given when both alternatives are equally rankordered.

Finally, these frequency scores can be weighted, assuming some weight set for the criteria. By applying the weighted summation approach, for each hypothetical ranking an appraisal score can be calculated. The ranking with the highest score is the ‘best’.

The application of the qualitative permuation technique is difficult when the number of alternatives becomes large. The approach is therefore particularly attractive in the search for alternative scenarios for building, when a limited number of global ideas exist on plans or projects and the information is not easily quantifyable.

The final technique to be discussed here, the **Evamixtechnique** (Voogd, 1983) focus on the simultaneous evaluation of qualitative and quantitative evaluation data.

In the first step the evaluation matrix is subdivided in a qualitative (X) and quantitative (Y) evaluation matrix and the evaluation scores are directed into one direction. Further, the weights attached to the criteria (w(r)) are standardized to sum to 1.0. Then the quantitative evaluation scores are standardized as follows:

$$e(k,r) = \frac{E(k,r) - \min E(k',r)}{\max E(k',r) - \min E(k',r)} \qquad (2)$$

with k, k′=1,....., K and r=1,....., R

In the second step, for both evaluation matrices separately, dominance scores are calcultated for each combination of alternative plans (k, k′). For the qualitative criteria, the dominance scores are calculated as follows:

$$X(k,k') = \sum_{r} w(r) \cdot \text{sign} [e(k,r)-e(k',r)] \quad (3)$$

$$\text{with sign} = \begin{cases} + & \text{if } e(k,r) > e(k',r) \\ - & \text{if } e(k,r) < e(k',r) \\ 0 & \text{if } e(k,r) = e(k',r) \end{cases}$$

For the quantitative criteria, the dominance scores are calculated as:

$$Y(k,k') = \sum_{r} w(r) \cdot [e(k,r)-e(k',r)] \quad (4)$$

In the third step, the qualitative dominance matrix and the quantitative dominance matrix are both standardized, in order to make them comparable, according to the rule:

$$X'(k,k') = X(k,k') / \sum_{k} \sum_{k'} X(k,k') \quad (5)$$

$$Y'(k,k') = Y(k,k') / \sum_{k} \sum_{k'} Y(k,k') \quad (6)$$

In the fourth step, the overall dominance scores for each combination of plans (k, k′) are calculated:

$$t(k, k')=W(1).X'(k, k')+W(2).Y'(k, k') \quad (7)$$

where W(1) is the sum of the weights attached to the qualitative criteria and W(2) the sum of the weights of the quantitative criteria.

Finally the overall appraisal score for each alternative plan is calculated by means of equation

$$S(k) = \sum_{k'} t(k,k') \qquad (k \neq k') \quad (8)$$

The alternative with the highest appraisal score is 'the best'.

4 Illustration

In this section the evaluation process will be illustrated on basis of evaluation data for alternative plans for changing the shopping structure in the Maastricht region, The Netherlands (for details: Van der Heijden, 1986). Within the region 38 mutually exclusive shopping centres were identified, 27 within the municipality of Maastricht and 11 in adjacent municipalities. The research project focused on the analysis of the performance of the shopping system, the generation of alternative plans, the specification of adequate impact evaluation criteria and the application of multicriteria evaluation techniques to support final decisionmaking on the alternative plans.

The analysis of the actual shopping system performance resulted in information on a variety of attributes of shopping centres and opinion scores by consumers with respect to choice range, price, parking facilities and atmosphere. Further a consumer questionaire provided information on expenditure flows. A turnover-to-floorspace ratio per branche per shopping centre was calculated.

Next, a combination of some models was used to assess the performance of the system assuming no changes in the shopping structure. A multi-attribute preference model for consumer choice of shopping centres was used to forecast expenditure distribution additional to a forecast of the spatial choice set of consumers. Moreover a model was specified and applied assessing retailer reactive behaviour to changes in turnover.

The information resulting from these two analyses provided sufficient information to identify a number of planning-relevant problems related to specific shopping centres. These problems were mainly understood in terms of a lack of investments in facilities due to a lack of economic viability. This led to the specification of 8 alternative plans for particular shopping centres in terms of extension or reduction of floorspace, improvement of the accesibility and improvement of atmosphere.

Next, these plans had to be evaluated systematically. That means a number of measurable criteria had to be defined and evaluation scores had to be calculated. A variety of evaluation criteria corresponding to the variety of interests was defined and their scores calculated. Moreover, the time-dynamic impact values were expressed as a ratio with the expected trend performance of the shopping system (zero-option). Impact values where forecasted for a period of 10 years.

The multidimensionality within the criteria was specified in terms of (a) retailer interests, (b) consumer interests and (c) public interests. Each type of interest was analyzed and operationalized by defining a number of evaluation criteria. It is not possible in this paper to present the equations on basis of which the evaluation scores were calculated. Therefore we will only describe and shortly comment the indicators. Note that 3 shopping centres are mentioned specifically due to the focus of the plans on the central district of Maastricht.

Retailer interests:

The following indicators (turnover-to-floorspace: TF) focus on what happens with the 3 shopping centres within the Maastricht central district in the context of each plan, as well as on the impacts of the plans on shopping centres not included in the plan.

1. the average yearly proportional shift in TF ratios for shopping centre ‘City’, as compared to the trend.
2. the average yearly proportional shift in TF ratios for shopping centre ‘Oud-Wyck’, as compared to the trend.
3. the average yearly proportional shift in TF ratios for shopping centre ‘Heer’, as compared to the trend.
4. the average yearly proportional shift in TF ratios for shopping centres not included in the plan, as compared to the trend.

The following indicators 5 and 6 produce information on whether a lower TF ratio due to a plan is permanent rather than incidental. Indicators 7 and 8 focus on whether a plan will increase the violation of normative TF ratios.

5. the average frequency of TF ratios for the shopping centres included in the plan that are lower than the trend TF ratios.
6. the average frequency of TF ratios for the shopping centres not included in the plan that are lower than the trend TF ratios.
7. the average frequency of TF ratios for the shopping centres included in the plan that are lower than the normative TF ratios.
8. the average frequency of TF ratios for the shopping centres not included in the plan that are lower than the normative TF ratios.

The planning team might be interested in changes in te service area of shopping centres. These changes might indicate a loss of attractiveness for consumers. Indicators 9 and 10 focus on this effect within the primary service area, indicators 11 and 12 within the so called secondary service area.

9. The average yearly proportional shift in the shortest distance expenditure proportion for shopping centres included in the plan, as compared to the trend.
10. The average yearly proportional shift in the shortest distance expenditure proportion for shopping centres not included in the plan, as compared to the trend.
11. The avarage yearly proportional shift in expenditure proportion of consumers living within a distance of 3.0 km from the shopping centres included in the plan, as compared to the trend.
12. The avarage yearly proportional shift in expenditure proportion of consumers living within a distance of 3.0 km from the shopping centres included in the plan, as compared to the trend.

The retailer reaction model calculates autonomous changes in floorspace during the forecasting period. Indicator 13 quantifies these changes for shopping centres not included in the plan, since they may have consequences for the attractiveness of these centres. A comparable indicator for centres included in the plan is senseless.

13. The average yearly proportional shift in total floorspace for non-daily goods of shopping centres not included in the plan, as compared to the trend.

Consumer interests:

Retail plans may bring about changes in the nature of consumers’ knowledge of the shopping structure. More knowledge might imply consumers to include a larger choice set in their spatial shopping behaviour. This is expressed in the following indicator.

14. The average yearly proportional shift in familiarity with shopping floorspace, as compared to the trend.

Indicator 15 and 16 present a simple measure of availability by focusing on the presence of shopping facilities within a particular threshold distance.

15. The average yearly proportional shift in the shopping floorspace consumers have access to within a distance of 3 km from the residential dwelling, as compared to the trend.
16. The average yearly proportional shift in the shopping floorspace consumers have access to within a distance of 6 km from the residential dwelling, as compared to the trend.

Indicator 17 expresses the accessibility to the nearest shopping centres. The notion of attractiveness may be operationalized in terms of some objective variable (e.g. number of shops) or some subjective evaluation value.

17. The average yearly proportional shift in the local access to shopping centres within a particular threshold distance, expressed in terms of the tradeoff between the attractiveness of a shopping centre and the costs of bridging the distance, due to a plan as compared to the trend development.

Public interests:

Indicator 18 focuses on whether the (in) equity in the gap between actual and normative TF ratios in different shopping centres is increased due to a plan. Indicator 19 focuses on the possibility that (in) equity in the distance that consumers living in different residential areas have to travel is increased. For the measurement of (in) equity indicators are used, suggested by Gaile (1977).

18. Equity in the average difference between the actual and normative TF ratios for all shopping centres, for the development according to the plan, as compared to the trend.
19. Equity in the average distance travelled from residential zones to the shopping centres in case of plan implementation, as compared to the trend.

Indicator 20 is introduced since planners being interested in reducing the mobility within the planning area.

20. The average yearly proportional shift in distance travelled by consumers, as compared to the trend.

The final three indicators refer to evaluation information from sources additional to the model simulations.

21. A value for the expected direct public investments related to the realization of the plan.
22. A value for the net amount of land that becomes available for land use functions other than shopping

Table 6: Impacts of 8 retail plans for the Maastricht central district in terms of indicator values

indicator and directions		plans							
		1	2	3	4	5	6	7	8
retailer interests									
1	(+)	0.980	1.005	0.989	1.012	1.003	0.978	0.986	0.996
2	(+)	2.261	1.046	2.410	0.919	2.112	2.211	2.344	2.132
3	(+)	0.899	1.091	0.938	0.932	0.879	0.866	0.906	0.854
4	(+)	0.964	1.007	0.974	0.878	0.852	0.959	0.971	0.886
5	(−)	1	1	1	1	2	3	3	4
6	(−)	2	1	3	3	3	2	2	3
7	(−)	4	4	4	1	3	3	3	2
8	(−)	2	1	1	3	3	2	2	3
9	(+)	1.904	0.807	1.714	1.085	1.294	1.563	1.356	1.181
10	(+)	0.956	1.008	0.969	0.858	0.826	0.952	0.966	0.865
11	(–)	1.105	0.950	1.007	1.020	1.032	1.028	1.019	1.032
12	(–)	0.719	1.002	0.719	0.965	0.949	0.862	0.877	0.939
13	(+)	0.996	1.000	0.998	0.984	0.980	0.995	0.997	0.984
consumer interests									
14	(+)	0.996	0.976	0.974	1.047	1.021	1.005	0.983	1.020
15	(+)	0.999	0.998	0.987	1.030	1.081	1.001	0.990	1.014
16	(+)	0.998	0.998	0.987	1.023	1.010	1.003	0.991	1.010
17	(+)	0.973	1.003	0.982	0.876	0.860	0.976	0.985	0.891
public interests									
18	(−)	0.999	1.000	0.999	0.997	0.996	0.997	0.998	0.996
b	(−)	1.000	1.000	1.012	0.718	0.714	0.976	1.012	0.847
c	(−)	1.012	0.999	1.009	1.007	1.009	1.011	1.009	1.011
d	(−)	1.014	0.999	1.010	1.003	1.013	1.015	1.012	1.015
e	(−)	1.010	0.999	1.008	1.005	1.007	1.009	1.008	1.009
f	(−)	0.986	1.014	0.977	0.652	0.623	0.971	1.007	0.768
19	(−)	1.004	1.000	1.003	1.032	1.035	1.004	1.003	1.026
b	(−)	1.000	1.000	1.000	0.985	0.977	0.992	0.992	0.985

c	(−)	1.002	1.000	1.001	1.022	1.022	1.002	1.001	1.015
d	(−)	0.998	1.000	0.999	0.990	0.998	0.998	0.999	0.989
e	(−)	1.003	1.000	1.002	1.025	1.026	1.002	1.002	1.018
f	(−)	1.000	1.000	1.046	1.046	1.008	1.008	1.008	1.038
20	(−)	1.002	0.999	1.001	1.040	1.042	0.999	0.998	1.030
21	(−)	1	2	3	1	2	1	1	4
22	(+)	2	4	3	1	2	2	3	2
23	(+)	2	1	2	3	4	2	2	4

Table 7: Results of the multicriteria evaluation in terms of rank order figures

plans:	1	2	3	4	5	6	7	8
weight set 1: no special emphasis								
ranking:	3	7	5	8	1	4	6	2
weight set 2: special emphasis on retailer interests								
ranking:	2	6	1	8	3	5	4	7
weight set 3: special emphasis on consumer interests								
ranking:	5	8	7	2	1	4	6	7
weight set 4: special emphasis on public interests								
ranking:	1	6	3	8	7	2	4	5

business, due to the plan.

23. A value for the degree to which the inter-regional attractivenees of the central district of Maastricht as shopping area is increased.

The choice of the evaluation technique is determined by the mixed nature of the evaluation data. Some of the indicators yield information that should be interpreted at an ordinal level, while other indicators are at a ratio level. In particular, the indicators 21, 22 and 23 are ordinal. However, the indicators 5, 6, 7 and 8 may also be interpreted in that way. The remaining indicators are interpreted at a ratio level.

The evaluation analysis, using the Evamix-approach, consisted of a series of calculations based on the evaluation matrix on te one hand and varying weights on the other hand. Several strategies were applied to attach weights to each of the included criteria:

– weight set 1: no extra weight is put on criteria related to whatever interest group;
– weight set 2: extra weight is put on criteria related to retailer interests (criterion 1–13);
– weight set 3: extra weight is put on criteria related to consumer interests (criterion 14–17);
– weight set 4: extra weight is put on criteria related to public interests (criterion 18–23).

The results of the analysis have been summarized in Table 7. These results are a starting point for further (public) discussion on the alternative plans.

5. References

Bahl, H.C. and Hunt, R.G. (1984), Decision making theory and DSS design, **Data Base,** 15, no. 4, 10–14

Gaile, G.L. (1977), Effiquity: a comparison of a measure of efficiency with an entropic measure of the equality of discrete spatial distributions, **Economic Geography,** 53, 265–282

Paelinck, J.H.P. (1977), Qualitative multiple criteria analysis: an application to airport location, **Environment and Planning,** 9, 883–895

Van der Heijden, R.E.C.M. (1986), **A decision support system for the planning of retail facilities: theory, methodology and application,** Dissertation, Eindhoven University of Technology, The Netherlands

Van der Heijden, R.E.C.M. (1990), Spatial plan evaluation in a decision support environment: a dutch case study, **Delft Progress Report,** 14, 122–133

Voogd, H. (1983)**, Multicriteria evaluation for urban and regional planning,** Pion, London

71
Licensing housing contractors—quality control by government

V.IRELAND

Abstract
This paper describes the role of a government body in New South Wales, established by statute, called the Building Services Corporation. It has the objectives of improving the quality of domestic buildings by licensing contractors, disciplining them if necessary and administering a comprehensive insurance scheme. Defective work is thus repaired and owners can be compensated for unreasonable trading by the contractor.
Keywords: Licensing, Housing Contractors, Domestic

1 The Housing Industry In New South Wales

New South Wales is the largest state in Australia with a population of over 5 million, almost one-third of that of Australia.

The majority of housing is provided by the private sector (95%). Government only provides housing for those who cannot afford it themselves and members of this group are encouraged to purchase in time.

Private housing is commissioned by one of:

1. Custom built cottages by the owner engaging an architect or a design service to produce a set of drawings of the proposed house which are then put out to tender among a group of building contractors, or a price negotiated with one contractor.
2. The purchase of a predesigned 'project home' which has been erected and displayed for inspection with prices specified—one of a number of designers is chosen and the building contractor is invited to provide a precise price now that the actual site is known: thus adjustments are made for footings, site works and any variations to the standard display home.
3. Owner-builders: a system whereby owners can take out a licence to construct their own home, either largely by themselves (all except electrical, plumbing and drainage) or by the use of licensed tradespeople.

The contractor responsible for construction of the cottage in 1. and 2. also requires a licence.

Many people live in multi-unit dwellings, however these are normally purchased after construction.

2 Characteristics Of The Industry

A number of factors are described to outline the factors influencing a housing contractor.

2.1 Fluctuations in Turnover

Housing activity in Australia varies by more than—40% to +60% from the moving mean over a 20 year period. This is in association with demand, which is affected by availability of finance. The speed of adjustment of building activity to changing conditions has been more than 30% in a year. If the annual percentage changes in total demand exceeds five percent, new supply will be unable to match demand (Anderssen, H. and McEvoy, J, 1990).

2.2 Intense Competition and Low Profits

Volume building contractors in the housing sector, with the majority of their houses marketed as Project Houses (1.0 point 2) have quite low profit margins (5–7%) in stable times and usually operate at a loss in fluctuating periods. Therefore their operations have to be well planned and run smoothly otherwise the small profit disappears.

2.3 High Degree of Subcontracted Work

Most of the work is done by specialist subcontractors and suppliers for the medium and larger contractors. The smaller contractors (3–6 cottages per year) maintain a small permanent workforce, mainly of carpenters.

2.4 Fixed Price Contracts

Almost all building contractors offer fixed priced contracts of 13 or 26 weeks to complete the construction of the cottage. Furthermore, they often do so without having firm agreements with specialist contractors and suppliers who do the work. Therefore the risk taken is fairly significant.

2.5 High Profits on Capital

Because of the low outlay of the plant and equipment, the lack of need for a joinery factory and the existence of progress payments for work completed/the general contractor can make quite a high profit on capital invested, notwithstanding the risks. The high possible profit is one of the key factors responsible for attracting people to the industry.

2.6 Largely Uninformed Purchasers

The group of people who commission the general contractor to build are largely uninformed, as the majority are in their 20s and early 30s, have not commissioned a home before and include a ‘romantic’ element in the action. The ‘romantic’ element is associated with marriage and setting up a new home together. Consequently many are very trusting towards the building contractor, not questioning many of the contractors recommendations. An extreme example of this is a case of a couple who paid 70% of the contract value as an up-front deposit before work commenced. When the contractor went into liquidation all of this was lost. When questioned why they did this, the only answer provided was that the contractor said they must.

2.7 Role of Contractors Associations

There are a number of contractors associations involved in the industry whose role, among other things, is to promote the interests of their members. This group includes both associations whose members are general contractors and those whose numbers are specialist or trade contractors.

Some associations propose practices (standard forms of contract, representation of their members) which are not designed to protect the consumer and by which the unwary consumer can be harmed.

2.8 Overall View

While the situation previously described in this paper suggest a badly organised industry this is not generally the case. The majority of consumers receive a quality product at a very competitive price.

3 The Building Services Corporation

3.1 Objectives

The Building Services Corporation is a statutory authority established to be responsible for licensing both general and specialist contractors who construct domestic buildings.

The objects of the Corporation are:

a) to promote and protect the interests of owners and purchasers of dwellings and users of water supplies, sewerage systems, gas, electricity, refrigeration and air conditioning; and

b) to set, assess and maintain standards of competence of persons doing residential building work or specialist work.

For the purpose of attaining its objects, the Corporation may:

a) bring about under this act the resolution of disputes which may involve residential building work, or specialist work, that is defective or incomplete or in relation to which there may have been unfair conduct; and
b) complement the work of industry organisations, public authorities and education institutions in promoting standards; and
c) insure under this Act residential building work against its not being completed or its being defective; and
d) give general advice and guidance to the public.

3.2 Complaints

When a complaint is received by the BSC from a consumer the following steps occur:

a) The consumer is questioned on whether the complaint has been made to the licensee: if not the BSC will not deal with it.
b) If the licensee refuses to act to rectify or complete the work a BSC inspector visits the site and conducts an inspection.
c) If the inspector considers the complaint justified the contractor is contacted by the inspector and verbally requested to rectify or complete the work.
d) If the verbal request is not successful a notice of defective or incomplete work is issued which includes an instruction to rectify within a period.
e) If (d) is not effective a Notice to Show Cause (why the licensee should not be disciplined) is issued.

3.3 Disputes Resolution

In 1989 there were 74,731 units of building work insured and 7,837 complaints received. Thus 90% of work was completed without complaint.

Of the 7,837 complaints received only 222 Show Cause hearings were necessary. Resulting from this were the following actions:

*	No further action	6
*	Cautions/reprimands	27
*	Suspensions/cancellations/disqualification	74
*	Monetary penalty	154

In 1989 the profile of complaints was as shown in Table One.

Table One: Complaints profile of the Building Services Corporation in 1989

BUILDING COMPLAINTS PROFILE			
RECEIVED:	6,789	FINALISED:	7,244
BUILDING TYPE:			
New Dwellings	54%	Alterations/Additions	24%
Town Houses/Units	12%	Swimming Pools	10%
CAUSE:			
Workmanship	60%	Contractual	20%
Other	20%		
TRADE RESPONSIBILITY:			
Carpenter/Joiner	28%	Wall/Floor Tiler	16%
Bricklayer	12%	Concretor	11%
Painter	10%	Plumber	8%
Roof Plumber	8%	Roof Tiler	7%
DEFECT:			
Leaking Showers	4%	Contractual	9%
External Water	18%	Structural	8%
Faulty Installation	8%	Unsatisfactory finish	8%
Non-structural	24%	Other	21%

There is a time limit applying to complaints. Complaints about general defects must be lodged no later than three years after work starts. Complaints about major structural defects much be lodged no later than seven years after work commences.

3.4 Discipline

The BSC has the power to cancel licences for periods up to a permanent cancellation. In addition it may impose fines up to $5,000. These may be imposed both on the company and the qualified supervisor. In 1889 seventy four companies or individuals were permanently disqualified.

The Corporation has made it a practice to take decisions on the cancellation of a licence by the full corporation only: thus while the Show Cause hearing is conducted by one or two corporation members, or one member and an Associate, the decision on cancellation is taken by a full Corporation meeting considering the transcript of the Show Cause hearing.

Decisions on fining members can be made by one or more Corporation members.

The case for the Corporation is presented by the Corporation's legal officer. The licensee may, and usually is, defended by his/her own legal representative. The General Manager has power to warn the public of dealing with a problem contractor.

3.5 Prosecutions

A number of prosecutions for illegal work occurred during 1989. These are shown in Table Two.

Table Two: Prosecutions for illegal work

PROSECUTIONS COMMENCED (Informations laid)		**393**
*	Building Work	184
*	Trade Work	173
*	Plumbing, Gasfitting & Draining Work	36
*	Electrical Work	N/A
PROSECUTIONS FINALISED		**393**
*	Fines imposed by Local Court	292
*	Dismissed by Magistrate	7
*	Offences proved, no penalty	30
*	Withdrawn by BSC	45
*	Electrical Work	N/A

The maximum fine for illegal operation is $10,000.

3.4 Licensing

The BSC has introduced licences in 1990 for the following categories:

* Full builder's Licence
* Full Builder's Licence endorsed for a particular type of building work (eg swimming pools, structural landscaping, kitchen renovations etc)
* Restricted (trade) Licence including 'labour-only'
* Restricted (trade) Licence including 'labour-only' endorsed for a particular type of trade work (eg cladding, paving, timber decks, etc)
* Plumbing, Gasfitting or draining Contractor's Authority or Licence
* Electrical Contractor's Certificate of Registration.

The Contractors licence is gold, the Qualified Supervisor's licence blue and the certificate of Registration is yellow. All licences are credit card size.

3.5 Fees

Licence fees applying in 1990 were as shown in Table Three.

Table Three:

Type of Application	New	Renewal	Restoration
	$	$	$
Contractor Licence			
Building Contractor:			
Individual	300	200	300
Partnership	500	225	325
Corporation	600	300	400
Other construction or specialist contractor			
Individual	120	100	150
Partnership	175	150	200
Corporation	200	175	225
Qualified Supervisor Certificate			
Building Supervisor	100	60	110
(1 year)			
NOTE: "Building" includes work in relation to inground swimming pools, garages, carports, screened enclosures, structural landscaping, kitchen renovations, bathroom and laundry renovations.			

3.6 Insurance

1. Comprehensive protection is automatically provided for:

a) insured building work the cost of which exceeds $1,000
b) residential building work the cost of which exceeds $1,000, being renovations to bathrooms, kitchens or laundries, whether or not specialist work is involved, if all the work is done by the holder or an appropriate licence, even if building approval is not required; and
c) compulsory owner builder insurance

2. Comprehensive protection is provided as an option) for:

a) insured building work not requiring a building approval.
b) optional I.O.B. work when the beneficiary is a successor in title to the owner.

3. Comprehensive protection is provided for owner builder work under certain conditions.

Maximum payments
The normal aggregate liability of the Cooperation under this Scheme in respect of a claim made under any combination of heads of claim is limited up to a maximum of $60,000.

3.7 Industry Assistance

Approximately 10% of the Corporations' budget is currently donated to assisting the industry.

4 Actions Of A Central Authority

A central authority, such as the Building Services Corporation can considerably positive influences on an industry. A number of these are outlined in this section, many of which the Building Services Corporation in New South Wales does.

4.1 Monitoring Poor Construction

The monitoring of the main and recurrent aspects of poor construction has considerable value. Such a report is shown in Table One however an even more comprehensive reporting and analysis can be made. This requires a clear classification of defects and accurate reporting by inspectors.

4.2 Manual of Construction for Key Defects Areas

The analysis and report resulting from 4.1 will then allow detailed manuals to be developed for key defects. Such manuals can include tried and tested methods of construction and be given wide publicity. Such manuals are particularly necessary when dealing with many small companies.

4.3 Manual of Key Points of Supervision

An accompanying manual to that envisaged in 4.2 of appropriately detailed steps of supervision in order to achieve the quality desired, is also desirable. The small companies constructing houses and the lack of internal training makes this necessary.

4.4 Monitoring Levels of Activity

The levels of activity of the domestic market can have a very strong influence on the liquidity of building companies. Both periods of low activity, and periods of high activity can be damaging.

Periods of low activity do not allow the companies enough cash-flow to cover overheads. However, possibly unexpected, periods of high activity can be very harmful due to the methods of tendering of this sector. Projects are won on the basis of fixed price contracts. In periods of high activity the cost of labour rises rapidly and hence profit margins disappear. Companies must quickly realise they are taking-on too much new work and desist from tendering.

4.5 Education and Training of Licensees

Obviously very significant work can be done here to assist the industry in achieving quality of technical performance.

Furthermore, many building company managers could considerably improve in their dealings with purchasers. As 'experts' in the industry some managers can become arrogant in their dealing with consumers, which leads to deteriorating relationships.

5 Conclusions

The existence of a central licensing authority can considerably assist the housing sector of the industry due to the unique position of such an authority to impose standards and raise revenue to assist the implementation of quality enhancing mechanisms.

72
Consumer protection and quality through standards for the UK house building industry

R.W.JOHNSON

Abstract
For more than 50 years NHBC has been the consumer protection body of the private house-building industry. It fulfils this function by setting minimum standards for quality in construction, by inspecting homes as they are built and by offering the Buildmark to protect home-buyers from serious loss.

The governing Council represents those interested in improving the standards of private sector house-building. Of its members, two thirds represent the building societies, consumers, architects, surveyors, town planners and the unions; one third are house-builders.

NHBC has a register of member builders. An NHBC builder agrees under the terms of his membership to build his homes to NHBC's technical standards and to submit them to inspection. After paying his fees he is then able to offer the Buildmark to his purchasers.

More than 27,000 builders belong to NHBC. Membership is essential since new homes cannot normally be mortgaged without the Buildmark. As a result, more than 90% of new homes are covered by the scheme. Nearly four million households have received the protection since the original Ten Year Warranty was introduced in 1965.

An example of NHBC participating in a topic of national interest to the private-sector house-building industry is the NHBC contribution towards providing practical guidance for the construction of houses where there is a risk of methane/landfill gas emission.

Keywords: NHBC, Buildmark.

1 Introduction

This paper describes the development of NHBC during the 50 years since its formation. An outline of the governing structure, its financing, together with the four primary functions of NHBC and how they form the envelope of consumer protection to the private home-owner are presented.

The paper also illustrates how NHBC is influencing a topical issue, the landfill gas/methane issue, which has political, environmental, social, economic as well as technical implications, not only for the home-owner and developer, but also for local approving authorities and central government policy.

2 The Development of NHBC

NHBC was founded over 50 years ago and as the following illustrates, there has been consistent growth, both in the proportion of private-sector housing with NHBC cover, and the extent of cover provided.

> 1936—A group of responsible builders founded the Housing Improvement Association, a voluntary registration body to control building design, workmanship and materials in private-sector housing. Eventually the Association became known as the National House Builders Registration Council. The members provided a two-year warranty on new homes.
>
> 1939–1945—During the second world war, there was a suspension of house building and hence the scheme was prevented from developing.
>
> 1951—Only 4% of new homes were protected by the scheme. There were 653 Registered Builders.
>
> 1963—The proportion of new homes protected had risen to 26% and the number of Registered Builders increased to 1,700.
>
> 1965–1968—The UK experienced a building boom, resulting in an increase in the number of firms entering the house building industry. Many were inexperienced in construction and quality in the industry declined.
>
> The Government had to consider the most appropriate method to raise quality in construction. The Government concluded self-regulation in the industry would be the most effective way to improve and maintain quality.
>
> In order to support NHBC in its role of self-regulating the industry, both the Government and the Building Societies Association recommended that mortgages (loans) should only be advanced on new homes if they were covered with the NHBC Warranty. The warranty period was increased from two to ten years. The constitution was amended to represent the whole industry, instead of a builders' organisation.

Since house-builders would experience difficulty selling their houses without an NHBC Warranty, house-builder registrations rapidly increased so that by 1970 over 98% of new homes were covered by the scheme.

1968–1970—The NHBC extended into Scotland and Northern Ireland. In Scotland 70% and Northern Ireland 98% of new homes were protected with NHBC Warranty.

1970–1980—The NHBC Technical Standards were totally revised and new Standards introduced which dramatically affected defects in foundations, flat roofs and generally improved the quality of new homes.

Similar NHBC schemes launched in parts of Australia, Canada and forty states in the United States, as well as Eire and the Netherlands.

The financial limit of cover progressively improved, as well as NHBC becoming approved as an Insurance Company.

1980–1990—Continued growth of NHBC.

In 1981 Queen Elizabeth II opens the two-millionth house and in 1986 Queen Elizabeth the Queen Mother opens the three-millionth house registered with NHBC.

Under the 1984 Building Act, the NHBC becomes an Approved Inspector, thereby permitted to check plans and inspect construction to ensure compliance with the Statutory Building Regulations.

The subsidiary PRC Homes Ltd. formed. Many state-owned prefabricated reinforced concrete homes had been sold to private homeowners, which, it was later discovered, had major structural faults. The 1984 Housing Defect Act was passed in order that home-owners could obtain grant assistance to repair their houses. The Government and the Building Societies Association asked NHBC to arrange expert vetting of the repair schemes and to provide a warranty on repairs.

The NHBC Warranty Scheme during this period was extended to include renovated buildings. The warranty protection period is currently limited to six years.

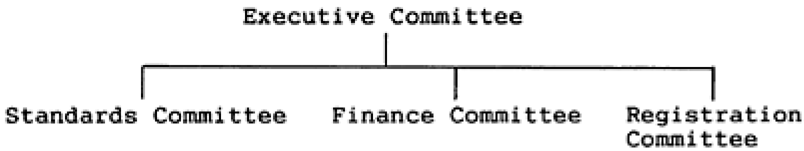
In order to promote quality in construction, the Pride in the Job Campaign was launched. Private housing sites are assessed each year and one hundred site agents are chosen for awards. Certificates are given to the site team. From the top one hundred two are chosen as the UK winners.

1990—The NHBC continues to develop new services as part of its consumer protection role for the private house-building industry, including a growing interest in European Standards and the opportunities the single European market provides.

3 The Governing Structure and Financing of NHBC

The NHBC is governed by its Council. The Council Members are nominated by groups who are interested in improving the quality of new homes. They include Building Societies, Consumers, Architects, Surveyors, Town Planners, Trade Unions, Lawyers and House-Builders.

The Council functions through a committee structure.



All the committees report to the Executive Committee which sets NHBC overall policy.

Separate committees exist for Scotland and Northern Ireland.

The Council policy is implemented by the Chief Executive and his staff.

NHBC employs over 800 staff. About 500 to 600 are technical staff—the majority forming the site inspection teams.

NHBC is financed privately through the builder or developer. When a builder or developer becomes registered with NHBC, an annual membership fee is charged, together with an inspection fee/insurance premium for each home which is built. These costs are passed onto the purchaser but the affect upon the price of a home is very small—about 0.4% of the total cost of the home.

4 The Envelope of Consumer Protection

The four primary functions of consumer protection are:-

(a) Builder Registration
(b) Technical Standards
(c) Site Inspections
(d) Ten-year Warranty

The four functions are all interrelated and are necessary to form an envelope of protection to the private home-owner. Each function is described in detail and to conclude it will be seen that each function is mutually dependent upon the others.

(a) Builder Registration

The NHBC maintains a National Register of House-Builders and Developers. When a House-Builder or Developer applies to join the National Register, financial and other references will be taken up. For builders, arrangements will also be made for an interview with NHBC technical staff to discuss and assess technical ability. Past and current work will be taken into account. The obligations of membership and NHBC procedures will also be explained.

Great care is taken to check any connection between applicants and firms already on the Register or previously deleted from it. The applicant may have to accept responsibility for any claims received from purchasers of homes built by a connected deleted company.

When investigations are complete, applicants will normally be offered conditions of registration. An application may, however, be deferred if the applicant cannot show proof that he can achieve satisfactory standards.

The number of applications for membership grows each year. There are over 27,000 members currently registered. They account for more than 90% of all houses built for sale in the United Kingdom.

The National Register comprises two types of member:

House-Builders—who are entitled to build houses either for sale direct to the public or for developers.

Developers—who are not entitled to build houses themselves but must employ a registered House-Builder as a main contractor.

Members of the National Register pay an annual membership fee. They also pay a registration fee for each home they build. This latter fee includes elements to cover the cost of inspection and also a single insurance premium for Buildmark cover.

To encourage the good House-Builder and Developer and to penalize the not so good, a "no claims discount" system is operated for dwelling registration fees. Fees payable are related to the length of time a member has been on the Register and the cost of claims against him. This cost is compared with the national average and is taken into account in assessing the fee to be paid. Discount steps can be gained or lost for good or bad record.

In order to improve standards and to reduce the cost of claims, incurred by a small minority but borne by the whole industry, the NHBC imposes sanctions on problem builders.

If builders fail to correct defects pointed out to them by NHBC field staff, they face disciplinary action. Surcharges may be imposed or, in extreme circumstances, the builder may be deleted from the Register. This in effect means that the company is no longer able to build homes for sale, since houses are not normally mortgageable without the NHBC Buildmark cover. About 40 builders are deleted from the Register each year.

The NHBC has an Inspection Audit team, part of whose brief is to inspect the sites which are causing concern.

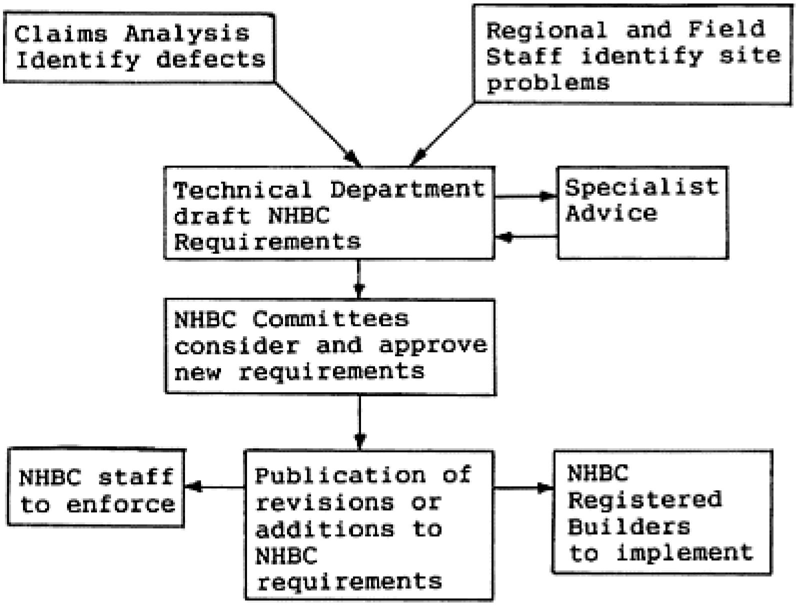
(b) Technical Standards

NHBC is continually striving to maintain and improve the standards of house-building and thus reduce the number and severity of defects in new homes. It is much better for purchasers not to have to claim against the warranty. The house must also give good service for many years, long after the warranty has run out and the original purchaser has moved on.

So NHBC sets standards which must be met by all its member builders. They are minimum standards and many builders exceed them. But they are designed to ensure that all new homes, whatever they cost, will be structurally sound and have a long and reliable life.

All NHBC Registered House-Builders receive the NHBC Standards which is continually improved and revised.

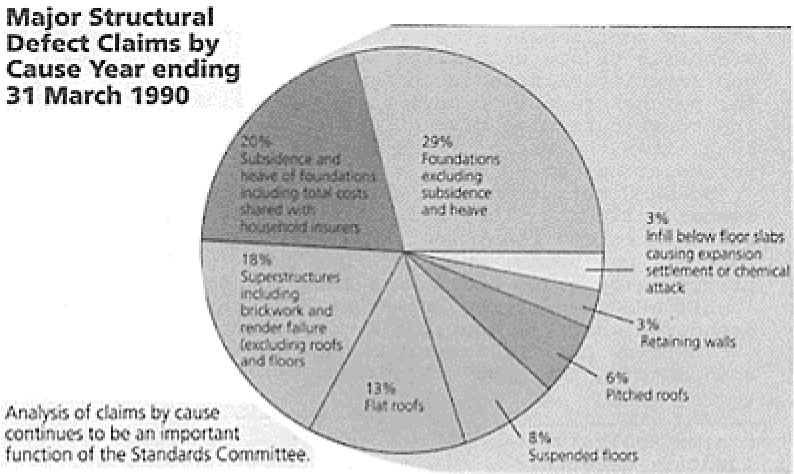
The flow chart illustrates the process for developing and amending the NHBC Standards.



An important aspect is the claims analysis in order to detect the source of claims. It may be a specific construction method, the inadequate durability or strength of a construction material, or a developing trend of failure identified by the claims analysis which can be arrested by an amendment to the NHBC standards.

The pie chart below illustrates the principal causes of Major Structural Defect Claims for the year to 31st March 1990.

The total cost of claims per year fluctuates between five and eleven million pounds.



Applying the information obtained from the claims analysis new sections or amendments to existing clauses are drafted and submitted to the NHBC Committees for approval. The agreed text is then incorporated within the NHBC Standards and distributed to the Registered House-Builders and NHBC Technical Staff.

(c) Site Inspections

NHBC has a field staff of over 500 inspectors who inspect new houses under construction. In England and Wales their inspections now have two functions. They visit sites on average every three weeks, to ensure that NHBC's standards are being met. In addition on sites brought to NHBC for Building Control they also inspect at critical stages of construction to see that the Building Regulations are being observed. (The Building Regulations are designed to protect public health and safety.)

NHBC Inspectors identify and see corrected a great many faults which could later lead to trouble and to claims against the warranty. But they cannot be expected to pick up all faults as their time on site is limited and construction can progress a long way during the period before their next visit. The warranty remains the safety net for undetected faults.

Inspection is principally aimed at preventing defects which the purchaser cannot see, or cannot be expected to recognise. It does not relieve him of the responsibility of a careful inspection before taking over the keys.

NHBC's style has always been to be practical and persuasive. Research has shown that the great majority of faults result from errors in design or specification and experience shows most site workers want to do a good job if they can. So wherever possible NHBC staff work with builders, to eliminate faults rather than adopt an officious or bureaucratic attitude. But with those few builders who are not interested in good site practice and building standards, NHBC Inspectors have to take a tough line.

(d) The Ten Year Warranty

The fourth primary function in providing protection to the private home owner is the NHBC Warranty.

NHBC is an approved Insurance Company and if the three other functions are unable to intercept a defect in the construction of a house, then the warranty safety net provides the insurance funds to rectify the damage caused by the defect.

The current extent of the warranty is as follows:

(1) The builder goes out of business before the house is complete and after the purchaser has signed the contract of purchase.

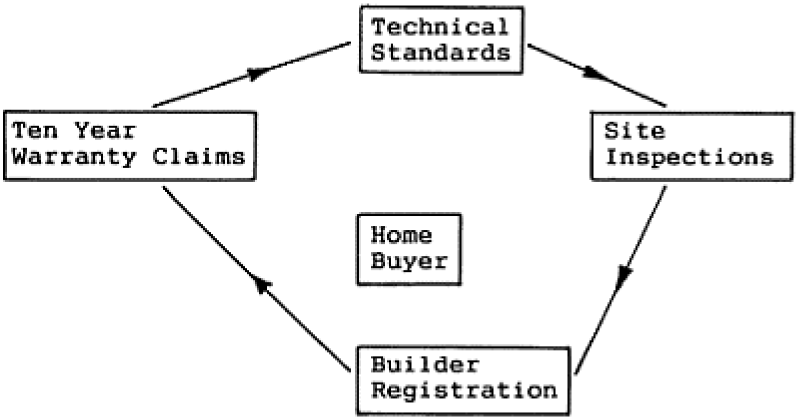
NHBC will pay up to £10,000 or 10% of the purchase price to enable the building to be completed.

(2) If the builder goes out of business after the house is complete but during the first two years.

NHBC will remedy all defects arising from failure to comply with NHBC standards.

(3) If a major structural damage occurs within the third to the tenth year due to a defect in the structure NHBC will rectify up to the market value of the property

The four functions are interrelated:-



Therefore the starting point in consumer protection is the knowledge that the builder is an experienced, competent house-builder. The purchaser is also protected with the Ten-year Warranty which in turn provides claims analysis information for the compiling of the standards. The standards form the basis of the site inspections by providing the Registered House-Builder with up-to-date technical information for the prevention of defects.

5 Private Sector Housing on Sites where there is the Potential for Landfill Gas/Methane Emissions

As NHBC has grown and gained respect it has been possible for NHBC to contribute towards resolving national issues which are commensurate with its role as a consumer protection body and the promotion of quality in the private house-building industry.

One area where NHBC is exercising considerable influence is the landfill gas/methane issue. The emergence of the problem, the national implications and the NHBC involvement is briefly described below.

During the early morning of 24th March, 1986 an explosion occurred, completely destroying a bungalow at 51 Clarke Avenue, Loscoe, Derbyshire, England. Subsequent investigations for the public enquiry revealed that the explosion was caused by methane gas generated in a nearby landfill site migrating through fissures in the underlying rock strata and service trenches. The gas collected in a void beneath the property. The time switch for the central heating system ignited the pilot light, causing an explosion.

There is in the order of 30,000,000 tons of waste to be disposed of per year and over 90% is deposited in waste tips.

A Government Agency undertook a survey which indicated there were approximately 1,400 landfill sites in the United Kingdom which required remedial measures and there were buildings within 250m of the boundary of a landfill site.

The Loscoe incident highlighted the need to ensure the waste management industry in the UK is controlled by technical standards, backed by legislation. The setting in place of technical guidelines for the industry following the Loscoe incident has taken place with considerable rapidity. The Environment Protection Bill will provide the legislation to support the control of waste management.

However, there are many thousands of existing landfill sites, some still in operation, many closed and capped, others now built over. As well as possible contamination of ground water and the associated health hazards due to contamination of soils, some of these sites emit harmful and potentially explosive gases. The majority of the existing landfill sites are situated in urban areas, where there are existing homes over or adjacent to the landfill sites.

This raises political, economic, social and technical issues which are currently being addressed.

NHBC officials have been kept informed and consulted by central Government throughout.

Therefore, it has been possible for NHBC to contribute to those aspects affecting private-sector housing. It was decided at the outset that unlike many other technical issues, NHBC would not prepare its own standard but provide the resources and expertise to assist central and local Government prepare national guidelines.

In retrospect, this has been considered a prudent decision because it enables the UK Government to prepare a series of measures covering all aspects of the contamination/landfill gas/methane issue with NHBC providing the necessary support and advice for guidance related to the private house-building sector.

The following are the primary areas of NHBC involvement:

(a) Submission of evidence to the House of Commons Select Committee.

(b) Financing research into the origin of methane and its affect upon the construction industry.
(c) Chairmanship and membership of research steering groups.
(d) Liaison with Local Government Associations to examine and possibly draft guidelines for the assessment of development land adjacent to or over former landfill sites.
(e) Participating in the development of government guidance documents for the construction of buildings built upon land where gas emissions are occurring.
(f) Meeting Government Ministers to explain the plight of the home-owner and house-builder.
(g) Joint research project with the UK Building Research Establishment to assess the performance of gas-prevention methods and remedial work, by constructing an experimental house upon a gassing landfill site.
(h) Liaison with European and overseas research establishments and engineering practitioners who are similarly involved with the issue.

6 Conclusion

To conclude, by self-regulation NHBC protects the homebuyer by promoting higher standards of housebuilding, preventing defects and providing Buildmark ensures the homebuyer does not suffer serious financial loss because a builder has failed to comply with NHBC Rules and Technical Requirements. In addition, NHBC is making an increasing contribution towards influencing Government policy and technical guidance on issues affecting the private house-building industry.

73
AVT—new possibilities of facade lining using acrylic resin saturated natural stones

W.KLINGSCH

Abstract
Modern architectural concepts tend to increasing application of natural stones for facade lining. Quality requirements on material strength and durability lead to strong restrictions in selections of natural stones. With the new technique of Acryl Resin Saturation (AVT-technique) material quality can be increased significantly. New types of natural stones can be used for facade lining and will support requirements of advanced architectural concepts (more colours, different surface structures, high durability, reduced material thickness).

Key-words: Facade Lining with Natural Stones, Acrylic Resin Saturation, Saturation Technique, Material Properties, Quality Assurance, Aspects of Architecture, Statics, Economy.

1 Requirements and present situation

The international architectural scene shows an increasing tendency to natural stones for facade lining. Two basic quality requirements must be fullfilled by those materials:

– defined material strength by reasons of statics and construction,
– high durability of the natural stone materials.

By both requirements selection of applicable natural-stones is severely restricted. Very often, these requirements lead to a limitation of appropriate stone material to the group of granites. Though there is a wide field of different colours of these stones, these restricted selection may cause a more or less monotonous optical impression of natural stone facade lining.

Application of non-granitic natural stones may lead to statical and constructional problems due to thicker plates. In addition higher porosity of these stones will reduce durability.

A new technique which was developed during the last years may give new impulses to facade architecture: AVT-natural stones.

2 The concept of AVT

2.1 Definition

AVT is the German abbreviation of Acrylic Resin Saturation of natural stones.

With a special saturation technique it is possible to saturate natural stones completely. This saturation technique was developed for preservation and protection of monuments where it is under application since more than 15 years with excellent success. By modification of this saturation technique it is now possible to adapt this high quality to natural stones for facade lining.

2.2 Saturation procedure

For saturation procedure natural stone material may be handled as block or cut into sizes due to architectural or constructional design concepts. Natural stone will be saturated by the following steps:

– Evacuation of gases and fluids within the pore system of the stone by autoclaving,
– diving of the material into liquid acrylic resin,
– complete saturation of the evacuated stones by liquid acrylic resin under high pressure,
– polymerization of the acrylic resin within the volume of voids of the stones.

After that procedure, the natural stone plates are ready for facade lining.

2.3 Influence on material properties

Within a wide research programme the following main parameters were tested in comparison between original and AVT modified natural stones:

– density,
– compression strength,
– water absorption,
– abrasion,
– freeze-thaw resistance,
– bending strength,
– load bearing capacity at anchoring bolts pressure.

For practical application, the main parameters are strength against bending, anchoring bolt loading and durability (resistance against weathering). Effectivity of AVT depends on the mineral make up of the natural stones in general and on the porosity characteristic in particular. By acryl resin (AR)-penetration open porosity will be sealed which reduces water absorption and increases durability. By the same effect matrix strength is increasing.

Figures 1–4 will explain the micropore interaction within natural stone matrix and acrylic resin by electron microscope analysis (SEM).

Comparison between figures 1 and 2 shows the complete penetration of pore system by AR as well as the cladding of the mineral particles. This explains as well increasing of durability as material strength. Figure 3 shows the good surface contact between acrylic resin (AR) and mineral basic material along the pore surface. By X-ray spectroscopy AR penetration can be identified: The carbon peak is missing with the mineral basic material. Table 1 summarizes the results of comparison test between an original sandstone and its AVT-modification. These results illustrate the possible capacity of AVT-treatment on strength and durability.

As a main advantage AVT-natural stones don’t show any measurable ageing effect. AVT allows transformation of natural stones with proper basic qualitiy but critical ageing into high permanent quality (tuff, porphyry, shelly limestone, slate, marble and others).

3 Prospect

3.1 Architecture

A lot of attractive natural stones could not be used up to now for facade lining because of their low strength and/or critical durability. By AVT-method many of these stones will now reach a high quality level to be used in facade lining and even in application to tall buildings. In architectural concepts multiple new colours and new surface structures for facade lining with natural stones will overcome the restrictions of today. Even typical local stones of low strenght and durability can be used now as a high quality material.

AVT treatment normally does not influence the original colour or any other optical characteristic of the stone. In some cases, depending on the mineralogical structure of the material, the original colour may be slightly intensified by AVT treatment, comparable to a wet surface after raining.

3.2 Construction

AVT natural stones can be used with a minimized material thickness. Reduction of thickness may reach 50 % or more, compared to the original material.

Thus, reduction of dead load of the facade lining will influence the structural details as anchorage in a very positive way.

3.3 Safety, durability

Statistical investigations comparing the quality of mechanical material properties and their regularity showed that scattering of material quality of original stone material will be decreased significantly by AVT treatment. In addition, the critical moisture dependency of mechanical properties will be eliminated as indicated in table 1. With a water absorption ratio of about 0%, durability is increasing to a high quality. Table 1 shows the significant reduction in mechanical and freeze-thaw abrasion as well.

3.4 Economy

AVT treatment means an additional cost factor on the one hand. On the other hand, however, there are reduced costs by the reduction of the material thickness due to increasing strength. With the reduction of dead load for facade lining there are, in addition, decreasing costs for the anchoring system. It opens new possibilities to use local stones to reduce costs of material as well as of transportations.

Results of a detailed cost-benefit analysis for a real project are given in Table 2. Compared are facade linings in traditional granite, with original sandstone and AVT-sandstone respectively.

Each thickness of Table 1 was defined by statical analysis for the building due to the strength of the material. The difference between costs of sandstone with or without AVT treatment may not be decisive, but for a plate thickness of 50 mm problems with the available anchoring system occurred which may lead to smaller dimensions of the plates and thus, to an increasing of the costs for assembling.

But independent of the basis costs for cladding given in Table 2 AVT-sandstone will have a much higher quality in durability and will reach the quality of granite as miminum.

4 Literature

AVT (1987) **Patent Specification** DE 3505427 C2 Germany, 1987

Spelsberg, P. (1989), Sommer, M. (1990), Klingsch, W. (1990) **Research Reports** “AVT-Investigations”, Institute for Building Materials Technology and Fire Safety Engineering, Wuppertal University, Germany.

Table 1: Comparison of material properties for a type of sandstone (“Zeiler Grünsandstein”, Germany)

Parameter	Dimension	Original Sandstone		AVT-Modified Sandstone	
Density	g/cm^3	2,3	(100%)	2,4	(104%)
H_2O-Absorption	M-%	5,8	(100%)	0,1	(2%)
Mechanical Abrasion	mm	3,8	(100%)	2,1	(56%)
Freeze-Thaw Abrasion	g	1, 3	(100%)	0,32	(25%)
Compression Strength	N/mm^2				
dry		63	(100%)	124	(199%)
wet		24		106	
Bending Strength	N/mm^2				
dry		11	(100%)	41	(371%)
wet		4		48	

ABR[1)]	N		
dry		300 (100%)	1200 (400%)
wet		130	910

[1)] ABR: Anchorage Bolt Resistance

Table 2: Cost Analysis for a Facade-Project

Material	Thickness of Facade-Plates	Total Costs
Granite	40 mm	210%
Sandstone	50 mm	110%
AVT-Sandstone	25 mm	100%

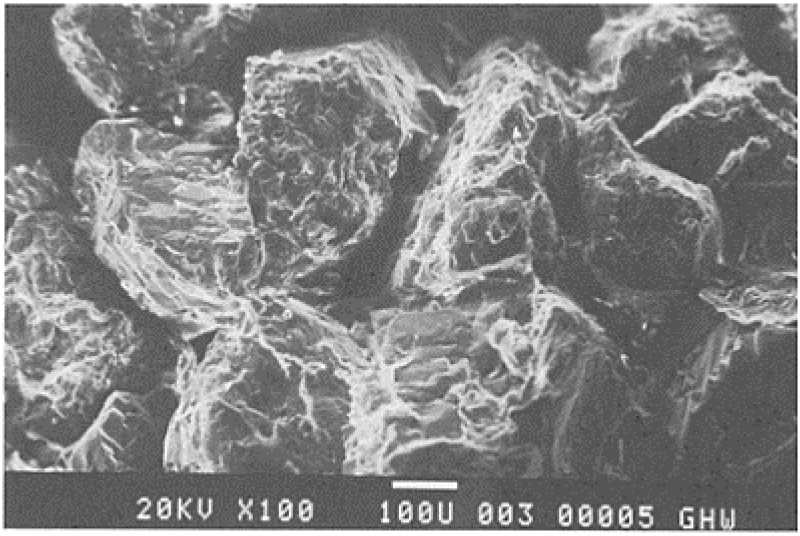
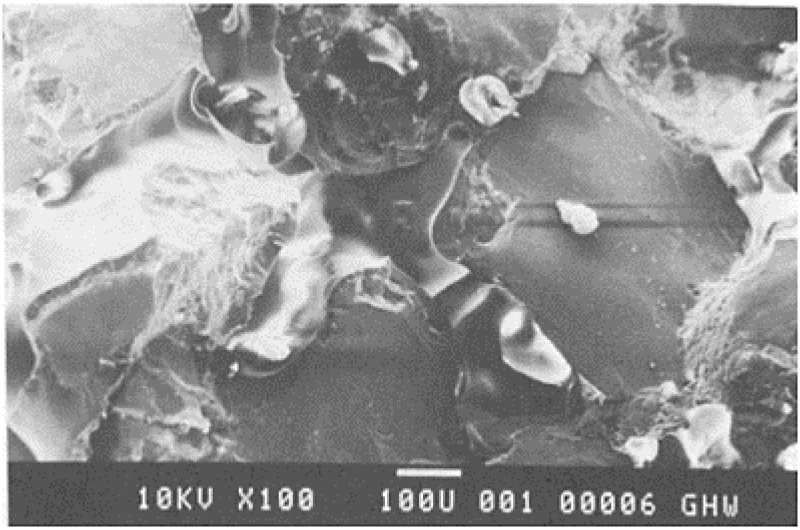


Fig. 1 Original Sandstone (unsaturated) SEM photography, scaling factor 100

Fig. 2 AVT-Sandstone (Acrylic Resin Saturation) SEM photography, scaling factor 100



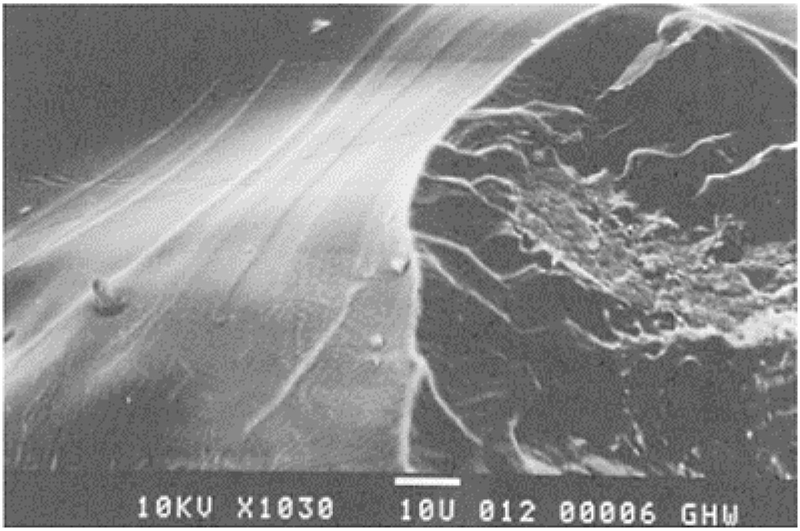


Fig. 3 AVT-Sandstone (Acrylic Resin Saturation) Detail of a Pore of Core Area filled with AR, SEM photography, scaling factor 1030

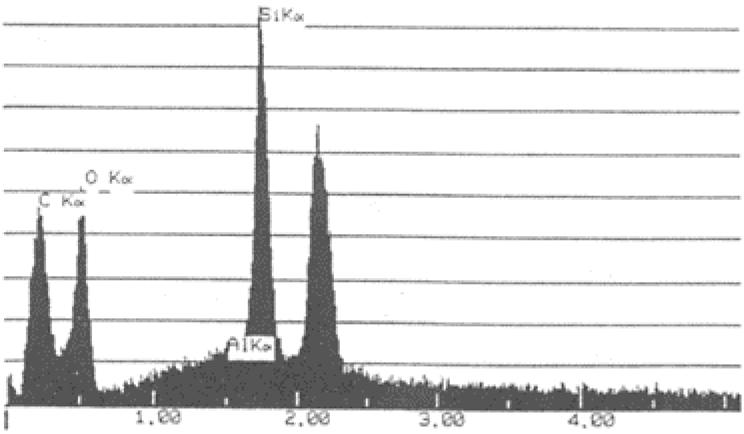


Fig. 4 AVT-Sandstone (Acrylic Resin Saturation) X-Ray Spectral Analysis

74
Quality in building industry, the Finnish research programme for improving quality of end products and quality management

T.KOIVU

Abstract
"Quality in building technology" is a research programme initiated in November 1989 and financed by the Technology Development Centre and the Technical Research Centre of Finland. The aim of the project is to improve the premises or culture of overall quality in the building sector.

The programme is divided into five projects in such a way that both quality of building products and quality management in building process form a comprehensive structure for implementing correct and sound practice in the Finnish industry. The first sub-project is the coordination of the actual research work. Its aims are to create useful terminology for quality assurance applicable also in the European markets and to take care of relations with other countries. The second and perhaps most difficult sub-project is the systematization of requirements. Its aims are to implement the performance concept to the standardization and approval of products, and to create a system to assess specifications and requirements in a building project so that the end product will perform correctly as a whole.

The third sub-project is concerned with the improvement of quality assurance in the building process and industry. The purpose of the sub-project is to define the interactions between quality systems and the various parties involved in the process and to improve cooperation between them. The resulting instructions for quality management in a building process should make it easier for the companies in the building industry to develop their quality management.

In the fourth sub-project, models of quality management systems for different types of companies are created and implemented. The guidelines for writing systems for clients, designers, construction and manufacturing companies are derived from the ISO 9000 standard and the results of the sub-project 3.

The fifth sub-project tries to use the created systems in pilot projects. The costs and benefits of the systems, experience and feedback are essential already in the de-velopment stage, so the pilot projects are to be performed almost simultaneously with the other sub-projects.

1 Introduction

1.1 Premises

The most important premise at the start of this programme was to produce a comprehensive definition of the term *quality* which would satisfy all parties of the building trade. Compared with other industries builders to consider a wider range of aspects when talking about quality. In a typical building project the needs of the end user are hard enough to determine, let alone his needs and expectations during the lifetime of the building. Thus in this project quality is understood as “verified conformance with the defined requirements” /7/. Requirements are defined in terms of instances or persons. This project emphasises the usage requirements and those of the customer or end user.

Other premises are numerous, the most important being of an international nature. The building sector as a whole will be affected by the liberation of capital, labour, products and services expected by 1992. This will manifest as changes in regulations (directives, sector agreements) and unifying standards. The new regulations will alter the ways of specifying and classifying the quality of building materials and components. The development of standards forms a good basis for unifying specifications of individual parts of buildings between nations, but there is no systematic way to ensure that the end-product from the user’s point of view will function as a result of the individual components fulfilling their respective requirements for the intended use.

Recent improvements in quality management and assurance systems, and in the standardization of their use and evaluation, are bound to affect the companies trading on the international construction-product and building-industry markets. In Finland the development of quality systems is well under way in some of the largest construction and building component production companies. However, it is essential to guide the development of the quality assurance (QA) systems in order to determine correct apportionment of responsibilities and authorities in a project that will assure the quality of the end product. This should result in clarified methods of quality management and rules of cooperation of the parties involved, in a given project, and these should resemble as closely as possible practises on the European markets. Control operations by official authorities during projects will be fewer in future, which should be taken into account when redistributing liabilities.

The premises for the project have two main lines of emphasis, summarized in Figure 1. The first is on the design phase of the building process, where it is essential to express the requirements and demands of the end-user are clearly enough to give correct boundaries to the design and planning. The other concerns actual QA techniques and how to implement them.

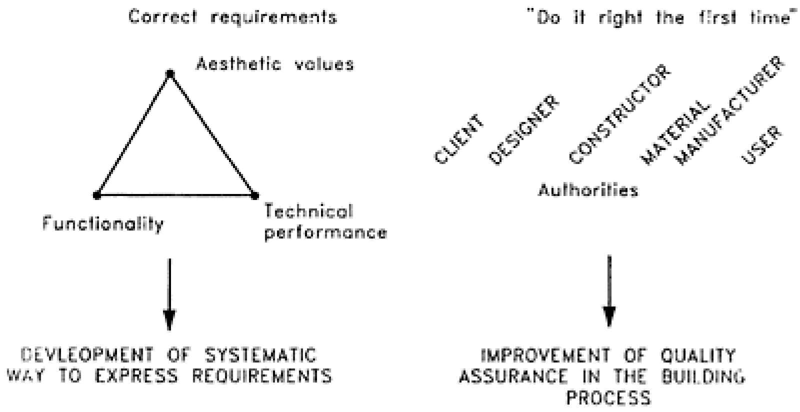


Fig. 1. Main aspects of the research programme /6/.

1.2 Quality assurance in today's Finnish building industry

The concept of QA may be very young in the Finnish building industry, not to mention quality management and Total Quality Control (TQC), but high requirement levels in Finnish standards and the extensive inspection operations have a long tradition that has formed a solid foundation for the implementation of QA systems. However, the ideas behind quality management and the implementation of relevant techniques still require a considerable amount of research and development.

Some companies in the Finnish building industry are well on the way to developing QA systems. The most advanced systems are naturally found in companies representing material and component manufacturers. Half a dozen manufacturers have applied for certificates in accordance with the Finnish translation of the ISO 9000 standard, SFS-ISO 9000. These certificates are issued by the Finnish Standardization Association, which is the only certifying body in Finland.

In the construction sector companies have taken steps to implement quality management also. The Association of the Finnish Construction Industry has started a project which aims to implement the Norwegian model /10/ for quality system development (see section 2.4).

In the design sector the development of QA systems has not gained popularity except perhaps in some of the largest companies. The designers, especially architects, find it difficult to overcome the problems involved; typical design offices are very small, with less than ten em-ployees, and have very little resources for research and development. However, the Association of Finnish Consulting Companies has taken steps to help member companies overcome these problems by handing out information and helping in establishing contacts.

2 Projects of the programme

2.1 Objectives and structure of the programme

The objective of the programme is to produce methods, systematics, databases and support systems with which to

– define correct requirement levels can be defined in the design and planning of a construction project and
– attain adequate confidence that a building will satisfy the given requirements.

The programme comprises five projects and their coordination. Each project has a various number of sub-projects, each with its own budget and organization. All in all, the programme should take three years to complete. Below is a short description of each project. The organization of the research programme is set out in Appendix 1.

2.2 Project 1: Terminology

The first project of the programme entails the compilation of a set of quality-related terms for the construction industry. Various international terminologies form the basis for this compilation. So far the Finnish building industry has lacked a common language /8/ to describe quality. For example, *"quality system"* has more than a dozen definitions. Many on-going research projects in Finland constantly produce new terms so the need for harmonisation is clear.

The aims are first of all to create a small set of terms for researchers involved the projects. This small pilot study will be filled in with detailed definitions as the work proceeds. At the close of the programme, a complete terminology will be published as part of the final report.

The first phase includes an inventory of authorised terminologies, both Finnish and foreign, a collection of definitions from different companies and associations, characteristic analysis and the formation of concept systematics, and finally the actual definition of some twenty terms. The definitions will be given to the researchers in the various projects of the programme.

The Building Information Foundation is responsible for the project and its final result. The Technical Terminology Centre is acting as consultant and the working group comprises seven different representatives of the Finnish building sector.

Having a set of terminology is essential for the building and use of various support and decision-making systems concerned with quality management. Wherever possible, it should be developed with international cooperation. The principle of the work is to apply the ISO 9000 standard to the construction industry, supplemented with terms relevant to Finland. Thus the "clients" of this project are the industry as a whole and research scientists from other projects in the programme.

2.3 Project 2: Requirement systematics

The basis for this project is performance concept, which has gradually become the most accepted approach in expressing requirements for buildings or their parts. Performance is defined as "The ability of a building or its component to perform its function in its intended use" /4/. However, as yet there is no specified method for using this approach.

As indicated earlier, documents such as the Building Products Directive, its Interpretative Documents and Eurocodes will affect each national standardization scheme. Now is the time to coordinate standardization and approval systems work with methods for defining and expressing requirements and specifications in building projects.

The aim of this project is to create a structure which will assist in the making of requirements and specifications by systemizing the expression of the performance property values of products. The project is divided into four blocks as follows:

A) The development of "product systematics". The systematics could be described three-dimensionally as shown in Figure 2. The x axis is the division of the building into a hierarchy ranging from the building to the material level. The z axis is the list of properties which must be considered in the definition phase of each project. The y axis represents the performance requirements and their evaluation.

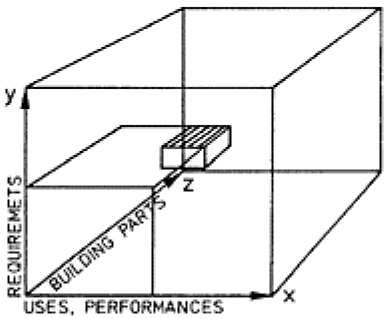


Fig. 2. Three dimensional aspects of defining the performance of a building.

B) The development of product and instruction labelling systems for different product groups. The purpose of the instruction labelling system is to tell the manufacturer how his products should be evaluated or tested according to the performance criteria and what kind of environment can be expected for end-use of the product. The product labels tell the customer how the product he is buying has complied with the performance tests and how it will perform under the use he intends.

C) The development of national databases according to product systematics.

D) A study of how the systematics work in the making of a building product model in the design phase.

Because the end user is seldom the one paying for the project, finding the right quality profile for each building necessitates compromise between economical resources and the design solution. The systematics are an effort to help designers and the client define the needs and aims for each project. They do not tell the customer how to get the best value for his money, but rather what product is best suitable for his use.

2.4 Project 3: Improvement of quality management in the construction process

The need to improve quality management at the project level was recognized very soon after QA measures had been implemented at the company level. Various institutes around Europe have published guides to management of quality in building projects, but none have so far gained wide international acceptance. This is mainly due to the differences between countries in the delegation of responsibilities within the building process /2, 3/. Finland also has its own tradition concerning the responsibilities of client's representatives, architects, structural, HVAC and electrical designers, builders, subcontractors and material and component manufacturers. A new concept of organizing building design and construction was recently developed in Finland under the name Construction Technology 2000 /3/. The new process might be regarded as an open building process, in which the specifications of a building or its part are given in a pre-tendering phase to the contractor with a statement of performance requirements. This allows the manufacturers and contractors to implement the results of their research and development. The system is created to motivate manufacturers to develop new methods and products.

The aim of this project is to improve the quality management of projects. The idea is to ensure that the qual ity systems of different parties involved fit together. The underlying principle is shown in Figure 3.

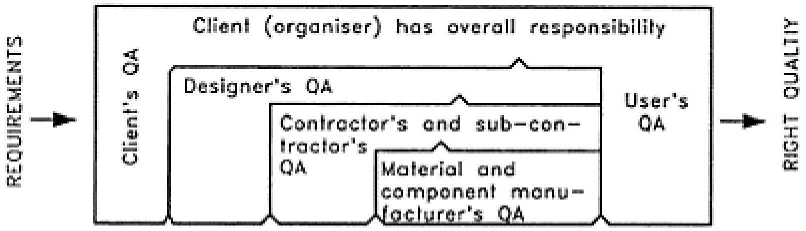


Fig. 3. Principle of fitting quality systems together in the Finnish construction industry /11/.

The project is divided into three blocks, the first of which aims to establish a framework for managing quality in the building process. The main issue under consideration the modelling of dependencies of QA-related information. This should result in the determination of dependencies between the process, product specifications and QA elements in the process. The tools of conceptual modelling /1/ will be used for this task.

Once the framework and principles of quality management have been determined, next step will be to create techniques and quality management tools for implementing the principles. A number of these tools already exist, but their systematic use from the viewpoint of quality management is deficient. Thus new tools have to be implemented, for example, the use of QA system element “corrective actions” will be dealt with at the project level. The results will be documented in a set of instructions for the client or his representative.

The second block will study the relationship between control measures implemented by government authorities and QA. In Finland, safety and few other essential requirements for buildings are strictly controlled by government authorities /5/. Each project, from its design to handing over is subject to inspections by the municipal authorities. The objective of this block is to find ways of minimizing the need for such inspections by giving the companies more responsibility over their own work.

The third and last block of the project aims to establish a QA system model for companies representing professional clients or consultants, who take overall responsibility for the organization of a project. Here two major aspects must be considered. First, the aim of a project is always the end product, its quality is the main objective. Second, the company or party taking overall responsibility has its own client-supplier relationships which determine the scope of the party’s quality system. The actual development work will be carried out in the same manner as in Project 4 (see below).

2.5 Project 4: Improvement of quality assurance in companies

The aim of the fourth project is to develop or take into use different types of model for quality systems. The models are applied to each sector of the building process, i.e. the designers, construction companies, subcontractors and component and material industry. Their purpose is to help companies develop their own quality systems /9/, facilitate and accelerate research and development, and save costs. The models are integrated for compatibility according to the principles set in the third project.

The models should help companies obtain an internationally accepted certificates. Thus one of the major aims is to improve the international competitiveness of these companies.

Development of the models will be done by an independent research organization in cooperation with a group of companies. Each of the companies will simultaneously work on their own QA systems. The research organization will act as a primus motor and develop a frame for the QA systems, which the companies will then utilize.

The first stage will comprise state-of-the-art study of the QA used by various sectors of the building industry across Europe. Some of this work has already been done at the programming stage and by various associations representing the different sectors.

Development of the model will be launched by analysing important issues concerning the QA of each particular sector. This will include an evaluation of motivations behind company operations and a determination of client-supplier relationships.

The third stage of the project will produce methods for ensuring that important key functions can be carried out properly. Existing “right ways” of operating will form the basis for QA procedures. Missing procedures will be developed where necessary, tested and documented and attached to the QA systems.

The model for construction companies already exists. The Norwegian model (Norges byggforskningsinstitutt, NBI) was translated into Finnish as a part of the research project. The actual development work is programmed by the Norwegian system itself, and the only task linking these two projects will include the incorporation of QA systems developed according to the NBI model into the principles of project 3.

2.6 Project 5: Taking the systems into use

The last project will test in practice the systematics and methods created in the earlier projects. The pilot projects will start at an early stage so the feedback is received simultaneously with the development work.

One of the aims of this project is to establish cooperation with the universities in order to train undergraduates in the use of the systems and systematics created in the programme.

3 Conclusions

So far very few actual results in terms of, e.g., savings in quality costs have been achieved in the programme. Designing of the programme alone and picturing the overall scheme or infrastructure of quality in the Finnish building industry was a tedious task. The Finnish approach emphasises the user's needs. In stating "quality is verified conformance to the requirements", one must remember that requirements derive primarily from the user's needs. The essential requirements, as stated in the Building Products Directive, also need fitting in the systematics.

The other main part of the approach is gaining sufficient confidence that the requirements of a project will be met, all the way from the design to the demolition of a building. As stated in the various projects, quality management must be implemented at the project and company level.

Forming an overall, nationwide open approach is expected to take three years and 3 million ECUs. One of the premises for a research programme of this nature is that the Finnish construction market is of the right size and that the industry has a long tradition in making "open systems", which set out rules for the industry as a whole. New ideas are fast assimilated providing the industry has a chance to be involved in the research itself. This is the case in this programme.

4 References

/1/ Björk, Bo-Christer. STEP—Information Interchange Standard for Product Information. Valokynä (1990)1, pp. 20–30, (volume not mentioned, in Finnish).

/2/ Cornick, Tim. Quality Management for Building Projects, A Master List of Strategies for the Construction Industry. CIB W88 Working Commission for Quality Assurance 13.-14.6.1990, Oslo.

/3/ Hirvensalo, Reijo & al. Construction 2000—Aimed Design and Construction Process. Helsinki 1990, Rakentajain Kustannus. 71 pp.

/4/ ISO 6241. Performance standards in building—Principles for their preparations and factors to be considered. International Standardisation Association, 1984. 10 pp.

/5/ Maljonen, Juhani & al. Liabilities in Construction. Helsinki 1990, Ministry of Environment, Report 1/1990, 93 pp.
/6/ Saarimaa, Juho et al. Quality in Building Technology, the Research Programme (draft), Technical Research Centre of Finland, Espoo 1990. (in Finnish).
/7/ Saarinen, Eero. Quality Assurance in Contracting Companies. Helsinki 1990, Finnish Association of Construction Industry, 47 pp. (in Finnish).
/8/ SFS Handbook 50. Handbook for terminology work. Principles and methods of applied terminology science. Finnish Standardisation Association and Centre for Technical Terminology, 1989, 41 pp.
/9/ SFS ISO 9000. Quality Systems. Standard Series. Finnish Standardization Association, 1988. 93 pp.
/10/ Sjøholt, O. The Norwegian Model for Establishing Quality Management in Building Enterprises. Building Research and Practise, The CIB Journal (1989) 5 pp. 289–293 (volume not mentioned).
/11/ Wätte, Staffan & Cassel, Per. Using Quality Systems in Construction. Stockholm 1989, Sveriges praktiserande arkitekter (SPA), 137 s. (in Swedish).

Appendix 1.

11.2.1991		PROJECT 0: COORDINATION |	MOTTO OF THE PROGRAMME: QUALITY=VERIFIED CONFORMANCE WITH REQUIREMENTS	
PROJECT 1: TERMINOLOGY	PROJECT 2: SYSTEMATIZATION OF REQUIREMENTS	PROJECT 3: QUALITY MANAGEMENT IN THE BUILDING PROCESS	PROJECT 4: IMPROVEMENT OF QUALITY ASSURANCE IN COMPANIES	PROJECT 5: TAKING SYSTEMS INTO USE
Quality terminology is in accordance with international ones (ISO8241, EOQC.ETC.) Interpretations for builders AIM: Common language for building industry regarding quality	Systematic ways to express user performance requirements and to evaluate properties of products includes designing a framework for the systematics, piloting it with actual products, reorganizing databases and product model. AIM: Better definition of user needs, user satisfaction	Instructions and guidelines for project managers, definition of responsibilities and liabilities model of QA system for project management companies AIM: Smoother process, fewer defects, user satisfaction	Models for QA systems for companies AIM: Better competitiveness, less defects	Pilot projects, education and training AIM: Making the overall sceme known and living
				reality

75
Quality management profiles and financial performance in UK house building companies

D.A.LANGFORD and A.C.NDILI

Abstract

This paper reports the results of a study into the relationship between Quality Management and Financial Performance in the UK house building industry. It concludes that companies with a strong commitment to quality tend to perform better than those who do not. Additionally the factors making up a quality profile were separately analysed and firms which were aware of the importance of marketing, had a keen sense of the value of R & D, had developed an organizational structure to control quality independently of production and had a defined policy on quality and adopted quality control techniques out performed those who did not.

1. Introduction

The issue of 'quality' has become a watchword of the construction industry during the late 1980s and early 1990s and many organizations have perceived 'quality' as one vehicle to help survive the ravages of the UK recession of the early 1990s. The expression of this movement has been the willingness of designers and constructors to seek out quality assurance accreditation under BS 5750 and to offer warranties for the final product. This process has further developed so that constructors are now marketing services which gives a maximum guaranteed price, guarantees the project duration, the quality of the finished product and provides a guarantee against defects for the first 25 years of the buildings' life (Building Magazine 17 May 1991).

In many organizations this approach has led to the introduction of Quality Management programmes which sought to instil the concept of 'quality' into the whole construction process. This paper investigates the impact of such techniques upon the financial performance of companies in the speculative house building industries in the UK.

What is meant by Quality?

Construction is a task which involves the fulfilment of both functional and aesthetic criteria and so quality is a term which can be applied to the environment, or a particular building, that acknowledges both functional and aesthetic characteristics. So 'quality' is a concept which combines function and aesthetics. Obviously aesthetic quality is difficult to evaluate particularly in a pluralist society where common values are scarce. Lesniskowski (1982) notes that in the pluralist era "tendencies are to the subjective" and that the loss of communal aspirations has led to a "cult of the personality". In architecture 'the pluralist stage is the time to judge individual achievements rather than the general quality, beauty of individual buildings rather than the beauty of cities individual attitudes rather than general social greatness." Thus in the pluralist epoch there is no general quality and quality may only be found in individual works. These concepts are mirrored in the way house building firms have approached quality.

Most have introduced quality management schemes since clients, be they corporate, commercial or private individuals, have sought quality in their products. At the level of the housebuilding industry quality of the individual house is the focus of quality and design improvements. Yet better technical quality in the product (the house) have gone hand in hand with the creation of soulless private housing developments bereft of public services built on the fringes of major cities. This new emphasis upon quality management has been purposive. As quality replaces price as a major factor in shaping client choices then designers and constructors seek to respond to these new market conditions by presenting the products as high quality and the firms which make them as having a strong commitment to quality management.

Such shifts in organizational values are, of course, not philanthropic and the introduction of quality management schemes required investment of capital and managerial commitment.

The Research Study

The question surrounding the influence of stimulated quality management to a small research project (Ndili 1990). The research set out to find out whether those firms who had adopted a vigorous approach to quality management had been financially more successful than others. Data was collected from 37 companies who major business is private housebuilding with an output ranging from 100–10,000+units per year. The data was collected in two themes:

The level of quality consciousness in firms
and
How financially succesful they were.

The financial data was obtained from the companies annual reports for the period 1988–89 and the annual average profit as a percentage of annual turnover in these years. This data was classified into three levels of performance by using a box plot technique. The classification was as follows:

Average profit/annual turnover %		Financial performance
3.4–10.9	–	Low Financial performance
11.0–15.9	–	Medium Financial performance
16.0–28.5	–	High Financial performance

The quality consciousness of companies was tested by questionnaire. In the literature survey undertaken prior to the empirical research some seven variables were identified. They were:

1. Business policy and philosophy
2. Marketing functions
3. Quality control techniques
4. R & D/Education and training
5. Corporate culture
6. Organizational structure and efficiency
7. Quality policy

(Note: Variables 3 & 7 were consolidated when the data was analysed.)

A questionnaire was then constructed using between 4 & 11 questions in each section with a total of 40 questions. Each question contained 3 possible responses and these responses were graduated to indicate an increasing commitment to quality management. Some examples from the questionnaire can illustrate the point:

Quality Control Techniques

1. How often do you update quality information from sites:

		Score awarded against each response
a)	every two weeks or less	(3)
b)	every three to five weeks	(2)
c)	every six weeks or more	(1)

What proportion of customer complaints are analysed?

a)	All	(3)
b)	Most	(2)
c)	Some	(1)

The data collected was converted into three classifications of quality management by using a box plot. This gave the following score ranges and quality profiles:

Score range

40–90	– Low quality management profile
91–110	– Medium quality management profile
111–120	– High quality management profile

This data was then tested to seek correlations between quality management profiles and financial performance.

Results

The two independent variables (Quality Management and Financial Performance) were tested for association using correlation co-efficients and chi-squared tests.

These tests were selected as the variables comply with the conditions set by non-parametric statistic tests as the variables are independent and the data nominal in form.

The calculation displayed the following outcomes:

1. Test of Association

High Quality management profiles was correlated with High Financial performance at a level of significance of less than 1%.

2 Chi-squared test Totals	Low Financial Performance (FP)	Medium FP	High FP	
Low Quality management profile (QMP)	6	4	0	10
Medium QMP	4	11	6	21
High QMP	0	3	3	6
Totals	10	18	9	

Degrees of freedom=4 chi-squared total 10.57 at 5% significance the probability value=9.488 for 4 degrees of freedom

Therefore the null hypothesis was rejected and the association between the Quality Management profile and financial performance was accepted.

The sub-variables, identified in the development of the questionnaire, were then tested to partial out the elements of the quality management profile which influenced financial performance.

Some 4 of the 7 variables were positively correlated to financial performance; they were:

marketing awareness (correlation co-efficient 0.368,

$r \leq 0.05 P \leq 0.05$

research and development awareness

(correlation co-efficient 0.447,

$r < 0.01 p < 0.01$

organizational structure (correlation co-efficient 0.424,

$r < 0.01, p < 0.05$

quality policy and use of quality control technique

(correlation co-efficient 0.493

$r < 0.01, p < 0.05$)

Conclusions

The research sought to examine quality management profiles and its connection to financial performance in house building companies. The literature examined as part of this work suggested that customer orientation rather than an emphasis upon production and the adoption of the concepts of quality management are characteristics of successful house builders.

Companies emphasising an awareness of marketing, research and development and those with a highly responsive organizational structure with attention to a quality policy supported by a battery of quality control techniques performed better.

To sum up, those firms which adopt and implement quality management techniques in company planning and activities and where the quality concept is embedded in the company culture then financial performance will be improved.

Limitations of the Research

It is accepted that it is difficult to separate out the 'quality' function since its presence may be symptomatic of good management in other areas of the firms activities. Moreover financial performance may be shaped by external factors over which the firm has no, or little, control. Factors such as land values, interest rates, inflation have not been considered but have been assumed to influence the sample in uniform ways. Regional and local differences in their impact may partially invalidate this assumption.

Future Research

This rolling programme of research into the housebuilding industry is expected to be extended in the near future. It is hoped to explore the relationship between technological innovation in the housebuilding industry and financial performance which will add to the already completed work in the field of marketing behaviour and financial performance.

References

Building Magazine Issue 20 Volume CCLVI 17 May 1991

Lesniskowski, W.G., Rationalism & Romanticism in Architecture McGraw Hill 1982

Ndili, A.C., Total Quality Management Profiles and Financial Performance of Medium sized private house building companies in the United Kingdom, Unpublished MSc thesis, Bath University 1990

76
Efficacy of spaciofunctional standards

V.MANFRON and P.ZENNARO

Abstract
On complex building systems, as for residential use, the quality of the generated system often differs from the generating system. That is noticeable on the existing regulation systems active on our Country (environmental, spaciofunctional, technological and guide-line).

Paying attention into spaciofunctional system, the above mentioned regulation systems are concerning about adequate quality levels to be guaranteed, but analysing the field we find that the regulation in force results sometimes effective, sometimes redundant, sometimes inefficient, sometimes useless.

The study case assumed is the public residential buildings realised in the last decade in the Veneto Region. We put our interest on the above mentioned topics with regard to promote a bigger congruence between the aim of the regulation and real results.

Keywords: Quality Evaluation, Public Housing, Spaciofunctional System.

1 Introduction

Facing up the theme of the buildings quality and in particular of those assigned to the residential uses, there are some preliminary considerations to be set that can lead us to the correct comprehension of the phenomena that are linked to it, both according to the technological lay-out of behaviour in use and to the spaciofunctional lay-out, intended as a suitable answer to the user's requirements.

A building system is made up with the organic connection of components that are more or less complex. In the composition of these elements every builder is worried about supplying a quality degree that is suitable both to the specific requests by the regulations in force and to its productive requirements. In both cases, at any rate, the purpose seems to be an attempt to providing a product that guarantees acceptable quality levels by the end-u-sers. As far as the quality levels are concerned, the normative apparata try to impose with methods that are more or less coercive certain performances showing the prearranged quality levels that don't always find a real correspondence on the inside of this framework. The builder is forced to move among the normative impositions, the users demands and the market necessities; this forces him to develope a final product elaboration system that guarantees from one side to the other that nears as much as possible the users and production demands.

Therefore we are in front of a rather interesting methodology of problem solution little by little while the innovation contents increase the adopted process for the buildings construction is less and less similar to the classical one that starts from the problem identification and, following all the intermediate phases, reaches a final synthesis; the adopted procedures are assimilable more easily to the “landing” theory, to the progressive approach. This procedure is adopted when one has to come to a well-known objective, but if such an objective is so far-off that it can not be known in his wholeness, the reaching it goal and then knowing it can be pursued through progressive approaching. In the beginning a goal is fixed that one is able to know it is pursued because known, then from the first one a successive goal is fixed and one reaches it and so on as far as one reaches the goal originally fixed or at least one gets close as much as possible.

2 Qualitative deficiencies

The building is the result of the interconnection of subelements (technical elements, technological unities) that can all have a satisfactory quality degree thanks to the fact that each of these ones is often an industrial product with particularly careful quality controls, but the final result is seldom optimal. Such a qualitative bewilderment is due to the fact that the building is not overall projectable from the quality point of view, or from the designer one, or from the building contractor, or from the makers of components. The last ones in fact have to introduce on the market field objects that can be considered of a good level in their own life, but they can loose this prerogative when they are put near to others in the formation of block groups.

Fundamentally the limit of the quality success in building is just this one. The single components are not always controllable according to their approach to other parts, because the verification is not carried out in function of that particular organism of which they will be an integral part, but in reference to an “ideal” building. The building is usually projected as an aggregation of components that often get worse the laying out performances. To this it must be added the fact that, as we have said above, the quality request is satisfied, in the built element, not as an objective fact, but as a problem solution approach.

Moreover it must be added that if a particular quality degree is requested by the users, the designer, with the instruments at his disposal, usually supplies suboptimal answers because of the limits imposed by the regulations, that are not always fitted, and of the limits connected with the lay-out approach that is expressed through seeking attempts at the right solution.

Therefore our user makes use of a flat that originally has already some limits linked to the adopted technology and this often conditions the performances of the environmental project. Moreover the solution offered by the designer pays for the above mentioned limits: in substance there is a double landing, one referring to the productive apparatus, the technological landing, and the another belonging to the project that involves, as mentioned, also an environmental landing.

Now we proceed to examine the problematics on which the designer has main capacities to influence: those concerning with the quality of the spaciofunctional project.

3 Spaciofunctional quality

When we talk about spaciofuntional quality we mean, with Turchini (1) that one "which measures the fitting of artificial spaces to the expected use, in other words to the users ractivities".

In accordance with this definition it is possible to subdivide these performances on the basis of blocks or parts of it distinguishing those relating to the dwelling block, to the flat, to spacial ambits or to service spaces.

For a dwelling block the requested performances are the following:

– constitution and dimensioning;
– people and things accessibility;
– physical handicapped persons accessibility;
– assistance transports and special motor vehicles accessibility;
– non interference zone between accesses and vehicular roads;
– supply of permanent furnishing;
– supply of installations;
– protection against falling;
– protection against intrusion and burglary;
– protection against insects and harmful animals;
– protection against fires;
– a system of emergency exits;
– cleanliness and maintenance;
– cleanliness of floored zones;
– aggregation of real property units of the dwelling block;
– flexibility of the dwelling blocks.

As far as the flat is concerned the requested performances are the following:

– constitution and dimensioning;
– furnishing;
– accessibility;
– practicability;
– supply of equipments;
– supply of permanent furnishing;
– supply of installations;
– tranquillity;
– privacy;
– protection against the risk of electrocution, explosures and fires;
– protection against falling;
– easy circulation and safety safeguard;
– protection against intrusions;

– protection against insects and harmful animals;
– lighting;
– cleanliness and maintenance;
– flexibility.

The performances list for the spatial ambits and for the service spaces are similar, and their exact elencation is deferred to (2).

The efficacy of the spaciofunctional regulation can be therefore valuated on project; this means that the satisfaction of the performance lists previusly exposed, in the planning phase, should correspond, this is the goal of the regulation, to satisfactory conditions of use from the user's point of view. Afterwords we will also see that the verification on project reveals that the normative apparatus is not exactly fitting to the objectives.

4 The study case

In our particular case if the accomplishments of the last tenth years are analyzed, a very interesting period in the italian ambit for the application of the law 457/78 that has planned over biennial periods a series of residential proceedings with state subsidy, we can control if the assumptions of the performance regulations, relative to the spaciofunctional project, have been real.

Analyzing the interventions realized through this plan, also called ten year plan for the house, in the Venetian region we have managed to get a series of very interesting information.

The results that come from this research can be compared in fact to fundamentally four basic proceedings or to their aggregation, as mentioned on (3) for the environmental system:

1 – all high results, that is completely supplied performance;

2 – all low results, non supplied performance;

3 – results that are distributed on a Weinberg curve, that is supplied or non supplied performance;

4 – results that marks a log-normal distribution (the so called Gauss' curve), that is an average supplied performance;

5 – other distributions derived from the sovrapposition of points 1–3, 2–3, 3–4;

6 – in addition to this proceedings, compared to a lecture of the performances in use, there are a series of results that follow indifferent proceedings, or better, that are not compared to any of the above mentioned cases.

To this results a preliminary statement must be made, that has a relevant importance in their decipherment.

The analyzed interventions have been realised in the presence of some changes of regulations, for example on the restriction of power consuption, or on security. Other rules have been unchanged, others have been introduced, for example the recent regulation on the matter of the exceeding of the architectural barriers for physical handicapped persons. To this situation the ambit of the self-regulation that every designer sets to himself in the project phase must be added.

This means that the whole of the regulations applied to the investigated interventions has not been constant and therefore their efficacy has lent the side to some defaillance. This effect is compared to the data gathered from the enquiry that has proved that:

1 – some regulations are always effective, see figure 1;

2 – some regulations are sufficiently effective, see figure 2;

3 – some regulations are ineffective, see figure 3;

4 – some regulations are either effective or ineffective, see figure 4;

5 – some regulations are redundant, see figure 5;

6 – some regulations are useless, see figure 6.

If we transfer what we have just assered in the graphics we realize that we have to go back to the proceedings gathered from the analysis of the behaviour in use of the enquired intentions.

In fact the first case, efficacy of regulations, is reproduced in the following graphic:

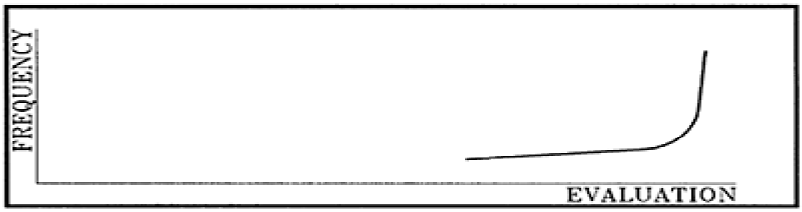


Fig. 1. All high results.

Here the constitution, the dimensioning and the accessibility of people and things for the dwelling block and for the flat here included.

The second case is reproduced into the following graphic:

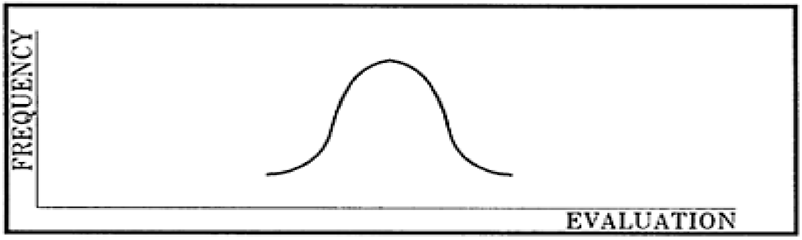


Fig. 2. Results that marks a log-normal distribution (the so called Gauss' curve).

In this one for example the flexibility for the dwelling block and the practicability for the flat are included.

The third case is represented by the following fig. 3; In this one the accessibility of assistance transport and special motor vehicles for the dwelling block and the supply of permanent furnishing for flat are included.

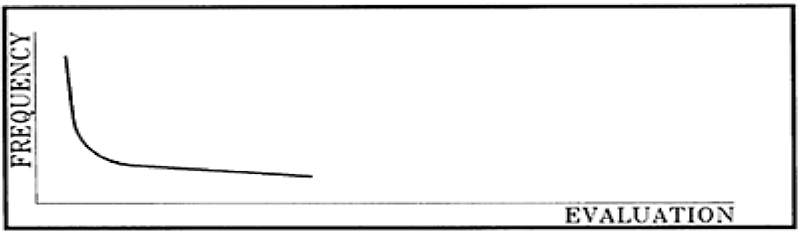


Fig. 3. All low results.

The forth case is pointed out by the following graphic

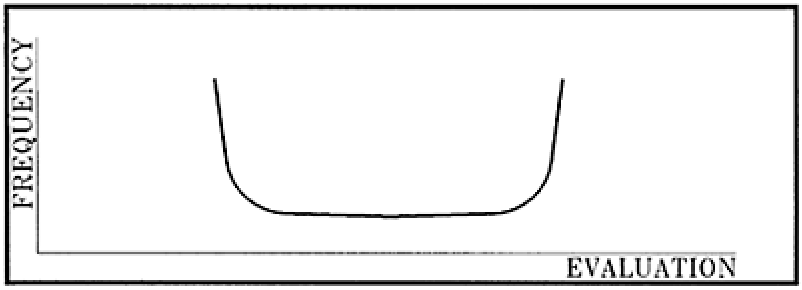


Fig. 4. Results that are distributed on a Weinberg curve.

In this one we can notice the accessibility of persons ha. ving a physical handicap for the dwelling block and the easy circulation and safeguard of safety for flat. The fifth case is represented by the following graphic:

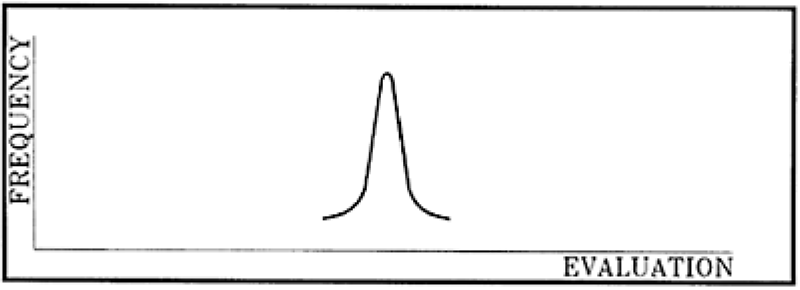


Fig. 5. Results that marks a very narrow log-normal distribution

Here the protection against fallings for the dwelling block and the illumination for the flat are included.

The sixth case is pointed out by the graphic represented on fig. 6; in this one we can notice the accessibility of people and things for the dwelling block and the installing equipments for flat.

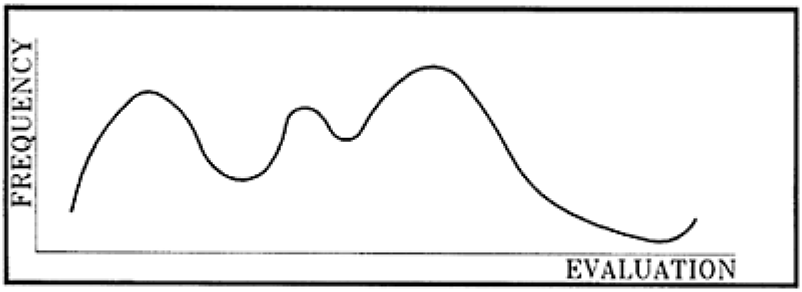


Fig. 6. Indifferent proceedings.

The reasons of the above mentioned behaviours seem to lie in the relationship among regulations, product and behaviour in use.

The link among these three moments is formed by the process of alternation to the satisfaction of the user's requirements.

This process that guides the insiders in the sector presents itself not always simple. This is the case in which the regulation is scantily effective or incident in a negative way. Let us explain a little.

If some regarding considerations have to be done we must say that the described situation is typical of non homogeneous system of regulations, that are formed by the adding of tested and effective regulations and regulations that are still stage of "landing". It can be an example the quoted law on the restriction of energetic consuptions that limits itself to its specific objective without taking into one consideration the effects that the modification of the used technologies, in order to satisfy the regulation, induces on the behaviour of the buildings when they are in use.

5 Conclusions

Therefore if sometimes we are in the presence of a damage deriving from the application of some regulations, the product provided at the present time has at any rate a quality degree sufficiently fitting to answer the requirements of the users, thanks to the capability of the production sector to reduce in positive some effects of the regulations that could negatively condition some phases of the process.

Therefore we consider that encouraging a better balance between the ends of regulation and those of the building can be a qualifying objective of the whole process.

Even in this case, unfortunately, the bewilderment betwe-en the strictness of the object legislative apparata and the dynamism of the market that proposes continous modifications, comes up again. The regulative field in force, then, tends to produce more and more object ties progressively deviating from the logic of the performance, logic that probably could be that one able to provide the best results in the next future.

As far as the ambit of intervention of the spaciofunctional regulation is especially concerned it is necessary to see again some performance formulations of the same correcting the effects above all in the ambits in which, as we have seen, the rules application affects in a redundant way, otherwise it is useless or scantily effective.

Therefore, if the spaciofunctional quality is that one which measures the degree of fitting of the space ambits to the fixed use, the designer intervention can assume an importance level sufficiently decisive according to the final product quality. From this aspect we can also point out that the “landing” operation as regards the users requirements can positively concluded only when all the operating regulative systems are assembled in a unique place, included those ones linked to the productive and planning sectors with the aim of guaranteeing the best quality.

References

(1) Turchini, Giuseppe, Qualità edilizia e qualità architettonica, in **Archi e colonne,** n°3–4, 1985.
(2) AA.VV., **Organismo abitativo e alloggio.** Franco Angeli editore, Milano, 1985.
(3) Manfron, V. and Zennaro, P., Seuils d’access et niveaux de qualité dans le système environnemental, in **Quality for building users throughout the world, XI International Congress,** Paris, june 1989.

77
New approach to a rational framework on liability and insurance requirements in all phases of construction projects

A.T.MASCARENHAS

(*) Civil Engineer, Senior Research Officer at Laboratório Nacional de Engenharia Civil (LNEC)—PORTUGAL

ABSTRACT

This document deals with the principles, aims and guidelines that should govern the setting up of integrated regimes of guarantees—liability and insurance—for damage cover in construction projects. Ways to implement these regimes are discussed as well as types of insurance to be adopted and requirement; to be complied with.

I INTRODUCTION

THE NEED, SUPPORTED BY FACTS IN EEC COUNTRIES, FOR MEASURES IN THE CONSTRUCTION SECTOR THAT MAY ENHANCE THE SOCIO-ECONOMIC AIMS OF CONSTRUCTION, TOGETHER WITH THE URGENCY OF ADAPTING THIS SECTOR TO THE RULES AND MECHANISMS OF THE SINGLE MARKET, CALL FOR A NEW APPROACH TO A NUMBER OF THE MATTERS INVOLVED. FOLLOWING THIS LINE, IN THIS PAPER ARE SUGGESTED THE MAIN CONCEPTS AND THE FRAMEWORK FOR THE ESTABLISHMENT OF INTEGRATED REGIMES OF GUARANTEES—LIABILITY AND INSURANCE—FOR DAMAGE COVER TO BE APPLIED IN CONSTRUCTION PROJECTS, THE NECESSARY OPERATIVE MEANS AND REQUIREMENTS TO BE FULFILLED FOR THEIR IMPLEMENTATION.

AS A MATTER OF FACT, INCREASING NEED HAS BEEN FELT FOR GUARANTEES OF COVEP FOR DAMAGE THAT MAY ARISE FROM DEFECTS OR DISFUNCTIONS IN THE ACTIVITY OF THE AGENTS INVOLVED AND/OR OWING TO OTHER POSSIBLE EVENTS THAT MAY OCCUR DURING THE OVERALL CONSTRUCTION AND EXPLOITATION PROCESS OF BUILDING AND OTHER CIVIL ENGINE BRING WORKS. FURTHER TO A WAY TO PROTECT THE PRIVATE INTEREST OF THE PARTIES IN VOLVED IN THE CONSTRUCTION PROJECTS, SUCH GUARANTEES BASICALLY APPEAR AS A

PUBLI INTEREST TOOL, GIVEN THE IMPORTANCE OF THE SOCIO-ECONOMIC ASPECTS CONCERNED.

THUS IT MATTERS TO DEFINE THE CONTENTS OF THESE GUARANTEES FOR DAMAGE COV IN THE LIGHT OF SOME BASIC PRINCIPLES AND GUIDELINES THAT MAY AS SUCH AS POSSIBL CONTRIBUTE TO ACHIEVING SOME ESSENTIAL AIMS, AND MINIMIZE THE OCCURENCE OF HARMF SITUATIONS AS IS THE CASE WITH LITIGATION.

SO, IT IS INESSENTIAL PURPOSE OF THIS PARER TO INTRODUCE A BASIC FRAMEWORK TO DEFINE INTEGRATED REGIMES OF GUARANTEES FOR DAMAGE COVER TO BE APPLIED IN ALL STAGES OF CONSTRUCTION PROJECTS, FROM PROMOTION TO EXPLOITATION, WHICH SHOU CONSISTENTLY AND RATIONALLY HARMONIZE ASSIGNMENTS OF THE DIFFERENT AGENTS INVOLV IN THE PROJECTS AND LIABILITIES FOR DAMAGES INHERENT IN THEIR ACTIVITIES, AS WEL AS TO PROMOTE THE SAFEGUARD OF INTERESTS OF THIRD PARTIES OR OF PUBLIC NATURE.

II BASIC ASSUMPTIONS AND MAIN PRINCIPLES IN THE STUDY OF GUARANTEES FOR DAMAGE COVER IN CONSTRUCTION PROJECTS

1. A REFERENCE SHOULD FIRSTLY BE MADE TO SOME BASIC ASSUMPTIONS AND MAIN PRINCIPLES TO BE TAKEN INTO ACCONNT IN THE FORMULATION OF REGIMES OF GUARANTEES FOR DAMAGE COVER IN CONSTRUCTION PROJECTS.
2. ON THIS CONCERN, THE FOLLOWING BASIC ASSUMPTIONS AND MAIN PRINCIPLES ARE POINTED OUT:

(1) INEVITABILITY OF UNCERTAINTIES THAT ENTAIL RISKS IN HUMAN ACTIVITIES, PARTICULARLY IN THE VARIOUS PHASES OF CONSTRUCTION PROJECTS (INCLUDING EXPLOITATION);
(2) SAFEGUARD OF ECONOMIC INVESTMENTS IN CONSTRUCTION PROJECTS;
(3) RIGHT OF INJURED PARTIES TO COMPENSATION FOR LOSS AND DAMAGE PRODUCED BY OTHERS;
(4) PROTECTION, PARTICULARLY OF THIRD PARTIES, AS RE. GARDS RISKS DUE TO THE PROJECTS;
(5) ASSUMPTION BY FACH PARTY OF THE ONUS CORRESPONDING TO THE RISKS INVOLVED IN ITS OWN ASSIGNEMENTS AND ACTIVITIES—SHARE OF RISKS AND LIABILITIES;
(6) NEED FOR IMPLEMENTATION OF SHORT TERM COMPENSA. TION PROCESSES FOR DAMAGE SUFFERED, FOR EXAMPLE BY MEANS OF THEIR SEPARATION FROM THE LIABILITY ASSESSMENT PROCESSES BUT, IN THIS CASE, MANTAINING THE RIGHT OF RECOURSE;

(7) NEED FOR CARRYING OUT THE CHARACTERIZATION OF THE RISKS INVOLVED IN CONSTRUCTION PROJECTS AS WELL AS FOR THEIR CONTROL AND REDUCTION DOWN TO AN ACCEPTABLE SOCIO-ECONOMIC LEVEL (NAMELY AS RE. GARDS RISKS DUE TO NEGLIGENCE);
(8) IMPORTANCE OF INSURANCE OPERATORS TO PROVIDE POLICIES FOR PROPERTY AND LIABILITY INSURANCE, AS GUARANTEES FOR DAMAGE COVER.

III NEED OF GUARANTEES FOR DAMAGE COVER

3. CREATING SUCH CONDITIONS AS NECESSARY FOR ITS BEING POSSIBLE, IN A NATURAL AND QUIET WAY, TO FACE THE RISKS ASSOCIATED WITH POSSIBLE OCCURENCE OF DIFFERENT LIKELY TYPES OF EVENTS THAT MAY PRODUCE DAMAGES DURING AND AFTER THE CONSTRUCTION PROCESS, IS MOST CERTAINLY THE SUITABLE DECISION TO BE TAKEN BY THE AGENTS INVOLVED IN CONSTRUCTION PROJECTS.
4. THE EVOLUTION OF SOCIETY, NAMELY IN THE FIELD OF EDUCATION AND INFORMATION, WILL MAKE THOSE AGENTS FULLY AND DEFINITELY AWARE OF THE ADVANTAGE OF DOING SO DE PER SE, PARTICULARLY FOR REASONS OF SELF-PROTECTION.
5. IN AN INTERMEDIATE STAGE OF DEVELOPMENT AND WHEN THE SOCIO-ECONOMIC INTEREST IS CONSIDERABLE AT NATIONAL LEVEL, IT MAY BE UP TO THE STATE TO CONCEIVE AND, EVEN BY LAW, IMPLEMENT A REGIME OF GUARANTEES FOR DAMAGE COVER THOUGHT SUITABLE TO PROTECT THAT PUBLIC INTEREST.

IV AIMS OF INTEGRATED REGIMES OF GUARANTEES FOR DAMAGE COVIER IN CONSTRUCTION PROJECTS

6. SO, IN PRINCIPLE, A REGIME OF GUARANTEES FOR DAMAGE COVER WILL BE INTENDED FOR GOALS MUCH BEYOND THE MERE PROTECTION OF THE PRIVATE INTERESTS OF THE PARTIES DIRECTLY INVOLVED IN THE CONSTRUCTION PROJECTS.
7. THOSE GOALS, IN THE CASE CONCERNED OF CONSTRUCTION PROJECTS, WILL BASICALLY CONSIST OF THE FOLLOWING:

G_1 – *TO PROTECT THE SAFETY OF INVESTMENTS IN CONSTRUCTION, AGAINST THE UNIVERSE OF UNCERTAINTIES ALWAYS EXISTING THROUGHOUT THE ENTIRE CONSTRUCTION AND EXPLOITATION PROCESS, BY CREATING CONDITIONS TO ACHIEVE—SAVE FOR MOST EXCEPTIONAL SITUATIONS—THE FOLLOWING SPECIFIC OBJECTIVES:*

(O_1) – *To assure completion of works in due time, inspite of the possibility of occurence of deterioration scenarios in course of its execution—suitable and timely resolution of these situations;*

(O_2) – To assure the operationality in use during the lifetime for seen and in accordance with the set of functional requirements prescribed—prompt and effective intervention being ensured in case of disfunction;

G_2 – *TO CREATE A FURTHER DYNAMICS FOR PROMOTING QUALITY ASSURANCE IN CONSTRUCTION PROJECTS, THE FOLLOWING SPECIFIC OBJECTIVE BEING PARTICULARLY IMPORTANT:*

(O_3) – To provide a more effective intervention in the sphere of reduction and control of risks inherent in defects or disfunctions resulting from ommissions and faults in the construction process and/or in exploitation;

G_3 – *TO ENSURE IN GENERAL, AN EFFECTIVE COUNTERPART OF THE LEGAL AND/OR CONTRACTUAL LIABILITIES TAKEN, i.e. THE RIGHT OF PARTIES INJURED TO COMPENSATION FOR LOSS AND DAMAGE, THE MAIN OBJECTIVE BEING:*

(O_4) – To guarantee indemnity to third parties for loss and damage resulting from the construction projects.

V CONCEPTUAL BASES

8. REGIMES OF GUARANTEES FOR DAMAGE COVER WITH THE ABOVE OBJECTIVES MAY BE ACHIEVED IN ACCORDANCE WITH THE FOLLOWING GUIDELINES:

i_1 – *DECOMPOSITION OF THE OVERALL CONSTRUCTION AND EXPLOITATION PROCESS INTO PHASES, IN ACCORDANCE WITH ADEQUATE CRITERIA (viz. PROMOTION, DESIGN, CONSTRUCTION, EXPLOITATION) (*);*

(*) In practice, subphases of the phases mentioned can be considered.

i_2 – *IN EACH PHASE, CLASSIFICATION OF THE AGENTS INVOLVED IN THE OVERALL PROCESS AS:*

A_1 – Principal Agent(s)

A_2 – Secondary Agent(s)

A PRINCIPAL AGENT IN A GIVEN PHASE BEING THE ONE (INDIVIDUAL OR CORPORATION) THAT PLAYS A MAIN ROLE IN THAT PHASE AND IS BOUND IN A FIRST LEVEL TO THE CORRESPONDING OBLIGATIONS;

A SECONDARY AGENT IN A GIVEN PHASE BEING ANY OTHER THAN THE PRINCIPAL AGENT (S), INVOLVED IN THAT PHASE OR IN PRECEDING PHASES OF THE CONSTRUCTION PROJECT;

i_3 – *BINDING THE PRINCIPAL AGENT (OR PRINCIPAL AGENTS) IN EACH PHASE, TO AN OBJECTIVE LIABILITY (STRICT, INDEPENDENT OF FAULT) FOR SOME OR ALL TYPES OF DAMAGES OCCURING IN THE PHASE CONSIDERED AND THAT CAN BE RELATED WITH HIS (THEIR) ACTIVITY, WITHOUT PREJUDICE OF ANY RIGHT OF RECOURSE AGAINST OTHER AGENTS (SECONDARY AGENTS IN THE PHASE CONSIDERED);*

i_4 – *RECOGNITION OF THE SUBJECTIVE LIABILITY (WITH FAULT) FOR DAMAGE OF SECONDARY AGENTS IN EACH PHASE;*

i_5 – *THE OBJECTIVE LIABILITY MAY BE FULL OR PARTIAL DEPENDING ON ITS REFER RING TO ALL TYPES OF DAMAGE OR TO SOME TYPES ONLY; THE FOLLOWING TYPES OF DAMAGE CAN BE CONSIDERED:*

t_1 – *Property damage in construction works, components or equipments;*

t_2 – *Physical damage to third parties (persons or property);*

t_3 – *Imaterial damage (without physical evidence).*

9. CONSEQUENTLY A REGIME OF GUARANTEES FOR DAMAGE COVER SET UP IN ACCORDANCE WITH THE ABOVE LINES WOULD LEED TO THE FOLLOWING RESULTS:

R_1 – *IN EACH PHASE SHORT TERM COVERAGE OF THE TYPES OF DAMAGE COMPRISED IN THE OBJECTIVE LIABILITY ASSIGNED TO THE PRINCIPAL AGENT (S);*

R_2 – *POSSIBILITY OF TRANSFER OF THE TOTAL OR PART OF THE CHARGES INVOLVED IN THAT COVERAGE, TO THE SECONDARY AGENTS AFTER THE LIABILITY ASSESSMENT PROCEDURE;*

R_3 – *COVERAGE OF DAMAGES OTHER THAN THOSE MENTIONED, ONLY AFTER THE WHOLE LIABILITY ASSESSMENT PROCEDURE.*

10. IN ORDER THAT THE OBJECTIVE (O_1) CAN BE ATAINED—WHICH IS THOUGTH OF GREAT IMPORTANCE—THE TYPE OF DAMAGE t_1 REFERRED TO THE CONSTRUCTION STAGE MUST ALWAYS BE COVERED BY THE GUARANTEES OF OBJECTIVE LIABILITY TO WHICH THE PRINCIPAL AGENT(S) (CONTRACTORS AND BUILDERS) IS (ARE) BOUND.

11. THE REGIME OF GUARANTEES FOR DAMAGE COVER TO BE ADOPTED SHALL THEN FIT INTO THE RANGE OF OPTIONS ABOUT THE EXTENT OF OBJECTIVE LIABILITY, TO WHICH THE PRINCIPAL AGENT(S) IN EACH PHASE IS (ARE) BOUND.

VI IMPLEMENTATION

12. THAT REGIME WHICH, IN PRINCIPLE, IS TO CONCERN ALL PHASES OF A CONSTRUCTION PROJECT INCLUDING EXPLOITATION, MAY THUS DEVELOP THROUGH THE ESTABLIS MENT OF SUCCESSIVE COMPONENT REGIMES OF GUARANTEES FOR DAMAGE COVER FOR THE VARIOUS PHASES, IN ACCORDANCE WITH THE LINES ALREADY SET FORTH.

13. THE MOST PRACTICAL AND EFFICIENT WAY TO IMPLEMENT THOSE COMPONENT REGIMES WOULD BE BY MEANS OF A SYSTEM OF INSURANCES; THE LATTER WOULD COVER THE OBJECTIVE AND SUBJECTIVE LIABILITY OF PRINCIPAL AGENT (S). AND THE SUBJECTIVE LIABILITY OF SECONDARY AGENTS, REFERRED TO DAMAGE OCCURING

IN THE VARIOUS PHASES, TAKING IN THE COPRESPONDING COMPONENT REGIMES.

14. THUS, IN EACH PHASE OF A CONSTRUCTION PROJECT, THE PRINCIPAL AGENT(S) IS (ARE) TO UNDERWRITE A SET OF INSURANCES WHICH MUST COMPLY WITH ITEM 3 AND MOREOVER WITH THE FOLLOWING CLAUSES:

(1) – GUARANTEEING (SHORT-TERM) COVERAGE, INDEPENDENTLY OF ASSESSMENT OF

LIABILITIES, FOR DAMAGE FALLING WITHIN THE CONTENTS OF HIS (THEIR) OBJECTIVE LIABILITY—ASSESSED DAMAGE INSURANCE (ADI);

(2) – RIGHT OF RECOURSE OF THE INSURER AGAINST OTHER AGENTS INCURRING IN SUBJECTIVE LIABILITY FOR DAMAGE;

(3) – GUARANTEEING COVERAGE OF DAMAGE TO THIRD PARTIES FOR WHICH HE (THEY) IS (ARE) LIABLE, WHEN THIS IS NOT INCLUDED UNDER ITEM (1)—THIRD PARTY DAMAGE INSURANCE (TPDI).

15. ON THE OTHER HAND, SECONDARY AGENTS THAT MAY INCUR IN LIABILITY FOR DAMAGE OCCURRED IN A GIVEN PHASE SHALL UNDERWRITE AN INSURANCE FOR THAT (SUBJECTIVE) LIABILITY—*ASSESSED LIABILITY INSURANCE (ALI).*

VII LINKAGE WITH LIABILITY LEGAL REGIME

16. THE IMPLEMENTATION IN CONSTRUCTION PROJECTS OF INTEGRATED REGIMES OF GUARANTEES FOR DAMAGE COVER IN THE WAY PROPOSED DOES NOT ENTAIL, AT LEAST THEORETICALLY, THE SIMULTANEOUS REVISION OF THE LIABILITY LEGAL REGIME IN FORCE FOR CONSTRUCTION AGENTS;

17. NEVERTHELESS, SUCH A REVISION SEEMS MOST CONVENIENT, ESSENTIALLY FOR TWO REASONS:

(i) – In the light of present actual conditions, need of an adequate and general framework, for better fitting in the liability of agents involved in construction projects, trying to achieve a more effective and fair sharing of liabilities, in accordance with the parts played by those agents;

(ii) – Advantages, in terms of rationality and efficiency, of non-existence of dissonance but reaching to harmony between the legal liability of the agents and the exigences to them about guarantees for damage cover which may sistematically, as is proposed in this paper, be required for instance under the form of insurance;

18. MOREOVER THE GUIDELINES SUGGESTED HERE FOR DRAWING UP THE INTEGRATED REGIMES OF GUARANTEES FOR DAMAGE COVER IN CONSTRUCTION PROJECTS, CAN BE USED TO PROVIDE THE BASES FOR THE REVISION OF THE LEGAL LIABILITY REGIME IN FORCE.

III OBLIGATORY INSURANCE, APPLICATION SCOPE AND IMPLEMENTATION

19. A DECISION AS TO THE APPLICATION SCOPE—TOTALITY OR PART OF THE CONSTRUC TION PROJECTS—OF INTEGRATED REGIMES OF GUARANTEES LIKE THOSE PROPOSED IN A GIVEN SOCIETY, AND AS TO THE WAY IN WHICH THEY WILL BE APPLIED (VOLUNTARY APPLICATION, ADMINISTRATIVE OR LEGISLATIVE ENFORCEMENT), WILL DEPEND ON A JUDGEMENT WHICH OUGHT TO TAKE INTO ACCOUNT THE GOALS TO BE ATTAINED AND THE PREVAILING SOCIO-CULTURAL, TECHNICAL AND ECONOMIC ASPECTS;
20. LEGISLATIVE ENFORCEMENT OF A REGIME OF GUARANTEES FOR DAMAGE COVER FOLLOWING THE GUIDELINES STATED WITH A LARGE RANGE OF APPLICATION USING THE SET OF INSURANCES REFERRED TO, HAS SOME SPECIFIC IMPLICATIONS, FOR INSTANCE, THAT SOME MEASURES MUST A PRIORI BE FORESEEN TO IMPOSE COMPLIANCE WITH THE FOLLOWING BASIC REQUIREMENTS:

a_1 – *Availability of necessary policies in the insurance market, in conditions of socio-economic feasibility, supported by a factual study of the existing risks;*

a_2 – *Incentives to promotion and practice of quality control at several levels of construction projects (limitation of the amount of premiums, allowances, etc);*

a_3 – *Acceptance by insurance operators, in reasonable terms, of creativeness and technilogical innovation in construction projects, at least for not impeding them.*

REFERENCES

(1) CONSEIL INTERNATIONAL DU BATIMENT—Post-Construction Liability and Insurance. Documentation CIB-W87 (1987).

(2) MASCARENHAS, A.T.—General Bases of Integrated Regimes of Guarantees for Damage Cover in Construction Projects. Paper, CIB W87, 6th Plenary Meeting, Lisbon, 1990.

(3) MASCARENHAS, A.T.—Garantias Face aos Riscos na Construção. ITE, LNEC, Lisboa 1990.

(4) KNOCKE, J.—Post-Construction Liability and Insurance Systems-England and Wales. National Swedish Institute for Building Research, Bulletin M85:13.

(5) BORGES, J.F.—Garantia de Qualidade na Construção. LNEC, Lisboa, 1987.

(6) BORGES, J.F.—Ethics in Building. Joint-Committee on Structural Safety. LNEC, Lisbon, 1986.

(7) Project de Rapport de Synthése sur les Problèmes d’Assurance RC dans le domaine des Risques Liés a l’Acte de Construire. Comitê Européen des Assurances (CEA), Paris, 1985.

(8) TRIGO, J. Teixeira e BACALHAU, J.E. Gaspar—O Desafio da Qualidade na Construção de Edifícios. VII Coloquio da Qualidade, Associação Portuguesa para a Qualidade Industrial, Lisboa, 1980.
(9) FERNANDES, A.—Qualidade dos Materiais e Componentes da Construção. Memória n° 672, Lisboa, 1986.
(10) MASCARENHAS, A.T.—Utilidade Sócio-Económica, Segurança Estrutural e Garantia de Qualidade. ITES, LNEC, Lisboa, 1985.

78
An integrated decision making environment for cost vs quality control

K.MATHUR and D.McGEORGE

Abstract
The vast majority of the methods and techniques in the construction industry relate to the control of cost, time, the performance of individual components, or an individual activity in a long and complex process leading to the creation of the built-environment. This paper proposes a paradigm which looks at the overall quality of the total built-environment. It suggests a *Quality Profile* needed to monitor quality throughout the construction process. The achievement of overall quality will only be possible, the paper suggests, by changing a fragmented design process to an integrated one based on coordination, communication, and consensus of the team members. The role of information technology and other computer technologies (AI, neural networks, hypermedia, etc) that will be used for a decision support environment, which would make this new approach possible, is discussed.

Keywords: Quality profile, Integrated design, Decision support systems, Knowledge-based systems, Information technology.

1 Introduction

In dealing with such general terms as economics and quality in the context of the built environment, it is important to provide a problem statement. Any proposal for a process or method addressing these issues must, for example, be clear if this applies to an individual component of the building and the time scale of its applicability. Any new technique that improves work efficiency for a site operation or office procedure can be claimed to improve quality and lead to economic solution to the problem. The totality of the problem of providing a client with an economical solution to his housing (shelter) requirements over a period of time is apparently much more complex. This was highlighted over two decades ago by the Building Performance Research Unit of the University of Strathclyde (Markus, 1972). It is typical of a complex problem that it cannot be solved at the level at which it is stated and that there is no perfect solution.

BPRU offered no comprehensive solutions, but only a philosophy and a framework for dealing with the complexities of the built environment so as to best satisfy the needs of the users of the built environment and to best utilise tools and techniques at hand. We have considerably more and powerful tools today than 20 years ago, and the prospects of using 'intelligent' computer tools which would access enormous information sources within the next decade are very real.

It would appear, however, that the construction community opted to deal with miniscule parts of the total problem and the research community has been content with supporting parsimonious tools. We seem to be working out of context of any framework and chasing unstated goals. Have we been seeking some magic formulae and methods to achieve economical solutions and total quality without identifying the benefactors and their desires for 'quality' and the price they are willing to pay for it. It is important first of all to analyse the problems in addressing the subject of economics and quality that have beset the construction community and to identify clear goals for the next generation of problem-solving methodologies. These tools, based on recent developments in hypermedia technology, associative information networks, neural networks, knowledge based systems, should provide a good decision support environment for the construction team charged with the delivery of the complete built environment, and not to be confused with specific techniques for individual parts of the process or the product.

2 Success and quality

Is the term quality as commonly used, a measure of the successful outcome of the construction process.[1] The word quality would most certainly evoke different responses from the participants[2] in the construction process. For example, an architect would perhaps think of the building form and the internal spatial environment; a speculator-client in terms of marble floors and granite cladding; and a builder may look at the details of finishes and completion time. Ironically, for the occupiers all this would be meaningless if their basic requirements are not satisfied. In some extreme cases buildings were never occupied, or pulled down after after a brief occupation. This highlights the glaring difference between a building and other artifacts. The success of a building project, for most developers, is attributed to low capital cost, high profits, good quality building finishes, completion on time, or its initial marketability. What is obviously a complex analysis of measuring different success factors, is branded as 'quality' of the finished product.

In order to understand and discuss quality further it is necessary to understand the motivation and perspective of each of the participant in the construction process.

[1] Construction Process is defined here to include all activities in the life of a building—from inception to demolition. The process thus includes design, the physical construction, and maintenance of the building. Retrofitting or rehabilitation may be done once or twice in the life of a building, and these are part of the Construction Process.
[2] Participants: The architect, builder, construction manager, engineers—civil, structural, mechanical, electrical, etc. and the client.

3 The goals

Each of the participants in the construction process works towards a goal and has his own perception of the success of the project vis-a-vis this goal. The building process is a lengthy process that affects many people. There are thus many stakeholder (Armstrong, 1985) in this process of change of the built environment brought about by the construction of a new building. The stakeholders are both users and producers of the building. The producers, including developers, designers, marketing managers, designers, specialist consultants, builders and contractors, all have a stake in the construction process since their aims are inter-dependent and often in conflict. All these stakeholders have an interest in the success of the project, but these interests, and consequently, their objectives, are different. Some of these objectives are discussed below to highlight the motivations in carrying out the project.

It should be noted that these objectives are temporal and elusive by nature and inevitably will be coloured by the bias of the observer or commentator. Also they represent a fraction of the totality of the multiple objectives of the complete process.

(a) Architectural style. The architect's motivation might be to develop a distinctive architectural style, to follow a doctrine ('proper' architecture), or adopt a certain position such as *'form follows function'*. The aim may be to create something new, either based on some style or convention (mutation) to bring diversity and variety. How these architectural positions would benefit scores of users over many decades of use, beyond aesthetic appeal, is difficult to assess.

(b) Profit. The developer's aim is to sell the building before or after completion at a profit. The client as the owner or occupier may also like to assess the salability of the building in the short and the long term. The profit margins depend on market forces and, for a new building, are quite unrelated to the intended use. It might be fair to say that a large proportion of the building stock is purchased based on a few visible attributes such as size, cost, general appearance and finishes. This speaks very little of the suitability of the building for its intended use, ease and cost of maintenance and operation, and ease (flexibility) of rehabilitation and retrofitting.

(c) Budget and time-frame. The completion of the construction project within allocated budget and time require difficult and complex management operations, and these are important goals on their own. The motivation is to increase profits, or minimise losses. The success depends partly on the design, communication (production documents) and the flow of information. The successful attainment of these goals are not for occupant's long term benefit.

(d) Construction quality. This usually refers to the quality of the finished product. The quality of visible materials—fittings and finishes—is a matter of budget, but the quality of other materials such as concrete and of fabrication may not reveal until much later when the defects begin to occur. These quality issues depend on site operations, and 'buildability' is the primary concern of the builder, which in turn also depends upon the design.

(e) Utility. The ultimate aim of the construction process is to make the building useful to the occupier. This is in stark contrast with the developer's aim of speedy capital recovery. Much investment is made in the visible, decorative elements to attract buyers or tenants, but these may have little utility. In the long term we must find a balance between utility and aesthetic qualities.

In the entire construction process we fail to see any real motivation to achieve a built form that provides quality for the owner/occupier. The majority of goals and motivations set during the construction process seem only to serve some selfish, usually profit oriented interests. Many of these goals work against each other, and do not contribute to the global project objectives. Can one individual or organisation (or system?) monitor and control client's objective: value for money?

4 Design and quality

It has been argued and generally accepted that the early design decisions play the most significant role in determining the overall quality of the built environment. Overall quality implies the achievement of desired quality for a stated period of time at an acceptable cost. In most cases there is a notional limit on the capital expenditure and the designer's task is provide an acceptable design within the budget limit. Clients who desire a built-form but have no budget restraints are rare. The paradigm that would be most acceptable is where the client is constantly apprised of the cost implications of design modifications as the process moves from inception to scheme design. In this recursive process a cost estimate of the proposed design is needed and, depending on the design satge, this may be based on unit rates or an elemental estimate. With some exceptions, in most design decision-making situations, the cost modelling is not an integral part of the evolution of design. If the stated cost exceeds budget limit, steps are taken to cut down cost, such as to reduce floor areas or use less expensive finishes. The design of the building structure and other building services are just as segregated as the cost analysis.

Design procedures that provide, in isolation, the optimum design for the building structure, or engineering services and the accurate cost estimates serve only to improve upon the design solution at hand, but do not help to search for better solutions. It is well known that there may be several, perhaps hundreds of other solutions which are unsearched and some of which may provide better overall solutions. It is thus not the limitation of the existing tools for the analysis and design of individual components and cost. We do not as yet have the process and indeed the tools for searching the entire solution space and performing cost-performance trade-offs.

Brandon (1984) provided a framework for, and a possible approach to this cost-performance trade-off. The approach was illustrated with two design variables, and one can see the enormity of the problem when other significant variables enter the cost map in the search for a solution.

Cost is only an indicator of the amount of money the client can expect to pay for the product either as the initial capital or over a period of time if running costs can be estimated. It has eclipsed the question of value. Cost has also been conveniently adopted as a synonym for quality—and the client is expected be prepared to pay more for better 'quality'.

For the client quality is surely a comparative measure of money well spent. Indeed, for individual components of the building, such as fixtures and finishes, where cost would increase proportionately with better 'quality', the client can choose these to suit his budget. One cannot, however, easily justify a more expensive structure (say with excessive spans), or building orientation and fenestration that gives rise to excessive heat gains (losses), or services not well integrated with the structure and the envelope. Do we have the measures to justify to the client that his money has been well spent in the choice of the basic structure, services, envelope and the spatial size and layout, which are all interrelated.

Cost modelling techniques today seem mainly to be concerned with estimating the cost (usually the first cost) of a given design and the cost advisers role seems to be one of finding alternative cheaper (or more expensive) components. If during the construction process the actual expenditure exceeds planned budget, a cost-cutting exercise is undertaken. Cost advisers, at no point in the construction process, explicitly address the issue of the overall quality of the built environment.

5 A quality paradigm

Irrespective of the problem-solving strategies, heuristics and procedures, the designer must terminate the process. It would be reasonable to assume that the designer terminates the process when he/she believes that a good design (final solution) has been achieved. A good design could be one for which all performance requirements have been satisfactorily met with (cost and construction time limits being two of them); conflicts, if any, have been resolved; and the design meets with client's approval (the satisficing paradigm). Even if this definition of good design is accepted, considering the vastness of the solution space, one would never know, in the design of most buildings, if such a final solution was optimum (best possible), or even anywhere near the optimum. Indeed very few buildings are required to carry out an environmental impact analysis—its impact on the physical, social, and cultural environment.

If the search process has to terminate when the desired quality has been achieved, we must define quality beyond the satisfaction of primary performance criteria. Buildings are different from other artifacts that we use, so is the meaning of building quality. Consider the following:

(a) Quality is temporal. Building quality is not something which can be judged at a single point in time and thereafter accepted without challenge (Powell and Brandon, 1985). As a building matures and adapts itself to the environment, the quality may improve or deteriorate. This relates not only to the building hardware but also to the ability to accommodate new functions (flexibility or loose-fit). A building, a symbiosis between man and the built-hardware, is a dynamic homeostatic balance (Markus, 1972). It is desirable to have a robust balance. Building quality should thus be stated and evaluated over a time-frame specified in the brief.

(b) Quality must be evaluated in-place. The performance of each individual sub-system must be evaluated in relation to its interactions with others. The sum of parts, each one independently an optimum solution, is unlikely to provide an optimum whole, since some parts may be antagonistic to one another and would not combine synergistically.

(c) Quality evaluation is a process. Quality cannot be evaluated by looking at the finished product. The design goals and constraints are dynamic and evolve as the process progresses. The final product should be judged in view of these evolving criteria. The complex balancing act, particularly at the early design stages, among conflicting criteria adds to the quality. The care taken in this process must be graded by keeping a record of the design criteria and rationale used. A finished product is often hidden behind a decorative mask. Another product without such frills may have put in greater care for the total solution and the built-environment.

(d) Quality is by consensus. Since the stakeholders have different goals, compromise and coalescence would reflect that all aspects have received due weightage in aggregating performances. This reflects a product of overall quality. A shift in professional attitudes may be necessary since architectural qualities (of space and form) may carry an unduly high weightage when the architect is the dominant member of the design team. Consensus must be based on cost and benefit and the trade-offs needed for an overall optimum. This is an approach to greater rationality in decision-making, and such team work must be monitored to control quality.

(e) Quality is relative to cost. There is a level of cost in relation to accommodation below which a building of quality just cannot be provided. At the same time spending more money on a project may be encouraging waste and inefficiency rather than quality. Also cost increments made to down-to-the-bone budgets will provide much higher returns in quality, while at lavish spending levels returns will be marginal. Value is quality in relation to cost. There are also issues of low initial cost and high running costs, and a premium for flexibility (loose-fit). It is also assumed that at each level of spending, we know how to allocate the total cost optimally among various demands. Such marginal valuations must be carried out to let the client determine the level of spending. This, in the context of overall quality issues raised above, is not an easy task.

(f) Quality is resource allocation. A building can either be designed to a cost (specifying a design to meet a budget limit) or designed to meet performance specifications (regardless of cost). In reality this is a recursive process. In this resource allocation the client’s priorities must be known.

(g) Quality must be optimised. Where alternative solutions—all meeting the same performance specs can be found, these must be pitted against each other, in terms of life-cycle costs, to test the sensitivity and robustness of solutions.

It is quality, *in relation to the total construction process and the expected benefits to all the stakeholders over the life of the building,* that should guide the design process. To measure this true quality would require a methodology that incorporates the various aspects of quality discussed above. Then appropriate decision support systems would be need to guide and terminate the design process using suitable measures of overall quality.

6 Knowledge-based decision support system

Design development is not the exclusive domain of any one discipline, though many architects may like to think otherwise. For the achievement of overall quality—be it at the highest level of satisficing spiritual needs or at the level of quality of individual parts—various disciplines must fuse their knowledge together interactively, recursively and iteratively (Mathur, et al, 1989). The professional ethics and attitudes towards this approach will not change unless we provide appropriate decision support systems. The decision support systems available today are for individual specialist areas and thus fail to assist the whole team. The implication of such multiple domain systems go well beyond the suggestion by Brandon and Newton (1986) for a centralised database to which all members of the design team would have at least partial access. Centralised databases keep professional consultants apart and thus each consultant would continue to work in one's own domain and communicate individually with the design proposal (McGeorge, et al, 1989). The multiple domain system's concept is to acquire knowledge as the design proposal develops through continuous interaction among the team members (professional consultants).

It should be clear from the discussion of the quality attributes that the kind of context dependent and time dependent knowledge that is generated, would need to be supported by a knowledge-based system (KBS). This system would also monitor design quality in order to:

(1) Control the design-process and terminate it;

(2) provide a portfolio on quality (which is not to be judged by the overt parameters such as finishes, etc); and

(3) control quality throughout the construction process (as defined; footnote 1).

Some of the items to be recorded in the *quality portfolio* would be:

(a) The intended quality of the product (building) and design intentions over *a time-frame* as perceived by the design team.

(b) The quality (performance) of each component or sub-system *in-place,* i e as it is in relation to other parts of the building. The optimum solution for the component, when designed in isolation, may not necessarily be the best choice. A sub-optimal solution may be chosen because it interacts synergistically with other parts and supports the quality of the integrated whole more than any other (optimal) solution for that part. Such records will help future maintenance and retrofitting processes when the part may need replacement.

(c) A clear statement of design constraints and autonomous (self-imposed) constraints. The latter should reveal the concern for quality and rationality in the design process. Such records would raise some ethical issues because they may also reflect poorly on the design team's lack of concern or rationality in dealing with the problem situations. Nonetheless if the clients demand such records, KBS will provide this log-book.

(d) All cases of compromise, coalescence and cost-performance tradeoffs. This would reflect team work, holistic approach and the overall quality. This would typically be a long historic record of ups and downs in favour of or against some requirements. The design team can trace its steps back anytime using such a route map during recursion.

(e) Statement of quality in relation to cost. The intended initial vs running costs will reflect performance mandates such as flexibility (loose fit) for future expansion or rehabilitation, and ease of maintenance or replacement.

(f) The client's priorities in the trade-offs in resource allocation. The (lower) quality of some parts must be reflected in constrained (limited) resources. The high cost for certain performance attributes (style, finishes, etc) would mean that the resources were unconstrained to achieve a desired performance. Indeed, arbitrary trade-offs which antagonise the synergy among parts would reflect a poor overall solution, and must form an important part of the quality portfolio.

7 Information Technology (IT)

The knowledge-based decision support systems will require voluminous amounts of information in a variety of forms. It will be possible in the 21st century to handle this kind of information not only on desktop computers but also via EDI (electronic data interchange). The sharing and exchange of information will be the key to the success of decision support systems, which would become possible through EDI networks. Some countries like Singapore have already started using such networks for the business community.

Construction professionals and organisations must recognise today that there will be no new techniques in the twenty-first century to provide a panacea for the control of cost or quality. It will be the process: a whole new process of conceiving and constructing built-forms in which information and participation of all key professionals will play the most significant role. Balancing cost and quality through trade-offs and conflict resolution using KBS as discussed above, requires a whole new way of thinking and interacting with the entire decision-making team. This will not only be true during design, but also construction and maintenance.

Construction teams are like cluster organisations, in which groups of people work together to solve business problems or define a process and which then is disbanded when the job is done. Team members may be geographically dispersed and unacquainted with each other, but information and communication systems will enable those with complimentary skills to work together. The (decision-support) systems will help teams to carry out their activities and track the results of their decisions.

While computers in the past primarily supported individual data processing work, computer systems of the future will be geared towards groups. Research on computer support for cooperative work has gained momentum and a number of vendors are working on software to support group activities. Researchers are now testing electronic brainstorming, group consensus, and negotiation software, and general meeting support systems (Applegate, et al, 1988).

It is the organisational structure of the construction team that has created the problems related to quality and management. The evolution of specialists in the last few decades has fragmented the decision-making process; thus the proliferation of individual tools and techniques to serve these isolated decisions. We now have to revert this process by putting the specialists together, not necessarily geographically, but in their thoughts and actions. This would indeed be possible in the next century though the use of IT and appropriate decision-support systems based on AI technology, neural networks, graphical simulation and hypermedia technologies.

The control of quality is a human and managerial problem, and not a data modelling or data processing problem. It is a lack of the availability of the right information when needed and/or of sharing of information that has created this problem. Computers and IT available to teams of tomorrow will assist in human learning and decision-making, and not just automate routine work. It would be possible, for example, to keep track of each member's 'knowledge' in the context of the project at hand and his decisions as at that point in time. Tomorrow's IT, based on associative information networks, will also assist each member of the team in keeping track of what information exists, where information resides and how to analyse it. In general, when IT becomes helpful with coordination, control, communication, and decision-making, there will be more time and incentive to explore new ideas, and design teams can be more creative and innovative in their approach to problems.

The rigid structure and hierarchy of construction teams must become more adaptive, responsive, and better suited to the next generation of technologies.

8 Conclusion

The quality of the built environment depends on so many people, processes, methods, techniques, and requirements, and yet the ultimate quality has traditionally been judged by the sum of money spent and by some visible physical parts of the built-form. This paper has attempted, first of all to draw attention to the lack of suitable vocabulary to address the performance (quality) implications of the many actions within the long and complex process of creating the built environment. Only when each action can be measured in relation to total solution, and not in isolation, that the true quality will begin to emerge.

It has also attempted to highlight the truism that, by definition, quality is performance in relation to cost. We thus need suitable measures for quality, *and not* the measurement of cost. Methods of optimisation, risk evaluation, and cost and time evaluation exist, but in the long process of balancing the performance of many different components through a complex process of negotiation requires a quality management system which can keep track of each action, each requirement and each component. This calls for *a whole new process of problem-solving that is multi-dimensional and multi-disciplinary*.

Every building project is unique. It is thus difficult to acquire domain-specific knowledge and built 'expert systems' which can be used to 'solve the problem'. The design process, a process of event exploration, requires broad general knowledge and wide ranging knowledge. Instead of developing brittle knowledge bases, which have a plateau of competence, but the edges are steep and descends into complete incompetence (Lenat, 1989), a knowledge-based decision support system is needed to be an assistant to provide a route map, a log book and a 'quality profile' that can be used throughout the construction process, i e its life-time. This paper has suggested some characteristics of such a Quality Profile.

The development of a Quality Profile will become possible with tomorrow's IT tools and other computer technologies. In highlighting these new developments, the need for a new process based on coordination, communication and consensus must be emphasised. This is not to suggest that the new technologies will povide a panacea for all our current problems. The initiative will have to come from the construction community. If we are at all concerned about the quality of the built environment that we create, then we will have to act now to identify the changes that are needed in the process of design and construction, and seek the new technologies to bring about these changes. The use of the new computer technologies merely to automate or support current processes will yield little except for minor gains in work efficiency and productivity.

9 References

Applegate, L.M., Cash, J.I. and Quinn Mills, D. (1988) Information Technology and tomorrow's manager. **Harvard Business Review,** 66, no 6, 128–136.

Armstrong, J.S. (1985) **Long Range Forecasting**. John Wiley.

Brandon, P.S. (1984) Cost versus quality: A zero sum game? **Construction Management and Economics,** 2, 111–126.

Brandon, P.S. and Newton, S. (1986) **The development of a knowledge based system for setting an economic strategy in building design**. Proceedings of X CIB Triennial Congress, Washington, DC.

Lenat, D.B. and Feigenbaum, E.A. (1989) On the thresholds of knowledge, in **Applications of Expert Systems Vol 2,** (Ed. J.R.Quinlan), Addison-Wesley.

Markus, T.A., et al (1972) **Building Performance**. Applied Science.

Mathur, K., McGeorge, D. and Lam, S.W. (1989) **Knowledge-based models for total cost performance control**. Proceedings of XI CIB Triennial Congress, Paris.

McGeorge, D. and Mathur, K. (1989) **Expert systems and artificial intelligence in quantity surveying**. Building Economist, December.

Powell, J.A. and Brandon, P.S. (1985) An editorial conjecture concerning building design, quality, cost and profit, in **Quality and Profit in Building Design** (Eds P.S.Brandon and J.A.Powell), E&FN Spon, 3–27.

79
Quality in EEC construction processes

C.MATHURIN

Abstract
The promotion of construction quality is a veritable challenge to Europe, and even a major target in terms of economics, because any lack of quality represents a loss of some tens of billions of ecus in the twelve countries of our Community

To reduce this loss, action must be taken at the same time on both legislation and technology.

This paper describes a few methods of integrating quality into EEC construction processes by new 'rules of the game' which could be included in a directive intended specifically for the industry.

Key Words: Capability, Motivation, Process, License, Employer, Project Planner, General contractor, Specific Liability, European Guarantee, European Construction Agency.

1 Introduction

Though true progress may have occurred, the construction industry is still low-tech with the parties not interested in true cooperation because their interests do not coincide; they are happy in their self-satisfaction.

The effectiveness of guarantee systems varies considerably when they exist, they are not just a doubtful form of "business". Defective housing has become a menace to the fundamental rights of citizens.

What can we do?

Just like a Mozart concerto, the quality of a construction is an objective and absolute value irrespective of personal opinions.

Quality, in the general meaning of the work, depends of course on the reliability and the technology of the production facilities including men and machines, on the performances imposed by the customer; on materials, elements, components and processes of construction, etc.

Some of these factors are technical and others are not.

This paper does not deal with technology but with liability, with the aim of being practical and concrete, rather than talking vaguely for the hundredth time of quality (this “Arlésienne” or absent member of the construction industry)

The number one target is to **‘integrate quality into the Community construction processes’.**

Assuming that, before the fateful date of january 1993, the Community authorities succeed in convincing the construction industry (if it merits the name) and its customers that this is the right target, should an agreement not be drawn up first on certain definitions without which there can be no communication, and on certain values dear to our advanced civilization.

Among these values, there is beauty (which must not be sacrificed to technology) and imagination (which must not be sacrificed to routine).

There is also sometimes the ambition of men which transcends them and, very often, the lure of profits which motivates them.

A European Directive should in the near future be drawn up on the basis of these definitions and of these underlying values, on the subject of construction, aiming at this number one target.

2. Building organization

2.1. Economics

In the area of definitions, it must be admitted that confusion reigns supreme in both the vocabulary and in the mind.

First, what is the construction industry?

Is it the whole world of building and civil engineering in which companies cooperate to construct new buildings, and to maintain old ones?

This represents a whole that is economically impressive, totalling 500 billions of ecus every year, that is, more than 10 % of total Community production.

Lack of quality would represent approximately 50 billion ecus every year, of which 25 are evitable (7 in Germany).

2.2 Construction processes

A construction is first defined by its economic and functional characteristics, it is then built in a second stage, and used until it becomes obsolescent.

An industrialist deserves the name when it markets a product—the construction—for which it has drawn up a construction program: this is rare!

In general, it is not the construction company that is responsible for the construction but the future owner—the employer—who has detailed the functional and economical specifications.

The employer at the design stage selects the construction process, and sets the distribution of jobs between the principal players who will then take charge of designing and building the construction

To ensure the quality of the future construction, a decision must be taken on who does what within the selected process. To standardize the 5 construction processes currently utilized in Europe could only contribute to improvement of quality, thus avoiding the obligation on the employer (capable? tyrannical?) of inventing a new form of "custom" organization for every project.

Table A: Construction process The employer is present in every construction process, signing contracts for design or construction.

Process n° 0	**B**	Only one contract, with a builder who designs and builds the construction based on the employer's program.
Process n° 1	**PP/GC**	Two contracts, one with a project planner who designs the construction, and another with a general contractor.
Process n° 2	**PP**	Only one design contract with a project planner, and several construction contracts.
Process n° 3	**GC**	Several design contracts, and only one construction contract with a general contractor.
Process n° 4		Several design contracts and several construction contracts.

2.3. Company capabilities

With regards to values, much remains to be done to give their true place to the concepts of capability and motivation.

Is it not possible to recognize capability at the start by allotting the players - developers, surveyors, designers, contractors, builders- a sort of European passport or, better like in Austria, a license allowing them to exercise their profession freely (liberal Europe!) throughout the Community?

Capability is acquired through training, apprenticeships and experience.

Bureaucracy should be avoided -either state or corporative-, but it would be better to quickly inform buyers on the failure of the licensees by warning devices.

2.4. The employer

The employer should not be allowed to exercise tyrannical and irresponsible power over the other players.

It should be said in particular that the employer must play his role and that it has rights and also obligations. The employer alone is responsible for the fundamental principles around which the construction is to be built, and is the first to be responsible for compliance with regulations.

The employer should direct and conduct the operation of building in accordance with the process selected (which should be clearly understood), and specify notably the levels of quality and of price of the future construction, etc.

The employer should appoint the designer or designers on the basis of the complete program, approving or imposing the specifications, contracting with the builders, paying the companies who provide services in good time, and accepting the construction.

The employer should be able to approve certain subcontractors or suppliers within the context of design and construction contracts.

And how this would contribute to clarifying the functions of all!

2.5. Other players

It should be affirmed that an occasional employer who believes it can start an operation of construction deserves no particular protection by the legislator. The occasional employer should make use of the services of a project manager.

In other words, the customers of the construction industry should be obliged to face their responsibilities:

. in agreement to recognize the incompetency of a buyer and to protect it at all times,
. or not in agreement to encourage the incompetency of an occasional employer.

Designers and builders work hand in hand with the employer. Would it be too much to ask that building design should be entrusted first to an architect, and civil engineering to an engineer, though not excluding a civil engineering contractor from the right of holding a license of designer?

On the other hand, to reserve work of construction to a contractor does not exclude the possibility of a building architect holding a license for building.

So much for capability.

We must not lose sight of the concept of motivation with which we shall deal below.

2.6. Control of construction

Even when capable, the players can make mistakes! But errors can have grave consequences in construction.

A major factor of quality is any system that allows verification, either beforehand of afterwards, that the construction at least meets the essential obligations of directive 89/106.

Another important factor would be the obligation on owners not occupying the consctruction built, of making sure periodically, such as every five years as in some German Länder, that the said obligations are being satisfied.

If nothing of this sort is done, can we still count on the conscientiousness of he who gains profit from the renting of a house or the exploitation of a commercial or industrial building? The reply is certainly negative.

2.7. The project planner

In order to increase the chances of producing a construction of good quality, it is essential to call on competent players.

But in order to make full use of the recognized capabilities of architects and engineers, the employer often finds an advantage in entrusting them with the complete building operation.

Is this not the case when it is clear that it is the contractor who possesses the know-how?

A definition should be given of a complete building operation: it is the operation that the employer entrusts by contract to one designer only and which covers architectural and also technological studies and the supervision of work during its performance.

In France, the party to which such an operation is entrusted is called the "maître d'oeuvre". Similar concepts exist in Belgium, Spain and Germany.

To ensure that the project planner is a motivated and responsible player, it is essential to entrust it with the preparation of the detailed specifications and the working drawings.

It should be given a right of veto over the list of contractors to be consulted, thus facing it with its obligation of producing results and its strict liability.

To ensure that the project planner achieves the target of price and quality set by the employer, its contrat may include financial incitation. This is how project planners are paid for public works in France.

If the employer does not call in a project planner, it is evidently free to sign a number of design contracts. The designers' work should be coordinated and one of them should, as in Germany, be appointed as the project coordinator to ensure consistency of the working drawings and to ensure that these drawings are handed over to the contractors in good time.

2.8. The General Contractor

If the owner wants to be faced with only one responsible builder, it signs a contract with a general contractor.

General contractors are bound to check the detailed specifications and the working drawings that they receive/ thus incurring an obligation vis a vis of results and their strict liability.

To ensure that the general contractor achieves the target of quality and time set by the employer, it's contract may include financial incitations and, why not, bonuses for quality.

2.9 Practical documents

The above covers motivation of the parties involved. But the employers, buyers and designers must be provided with practical documents in accordance with the targets set:

– certificate of conformance of the construction with basic requirements
– standards relating to commonly utilized processes
– standards relating to work of architecture and engineering
– guides, with appended general contractual clauses and models of commonly utilized contracts.

3. Liability

3.1. Acceptance

A quality factor would also be a standardized reception procedure involving the employer's responsibility and committing it.

If the employer occupies the construction itself, acceptance is its own business. But if it hands the construction over to an occupant or if it sells it to a buyer, it should be accountable for any consequences of badly performed acceptance tests.

The best way to do this is to apply the principle of liability after acceptance.

To the contestable notion of 'hidden defects' should be added the objective notion of 'accepted defects' with or without correction of price.

3.2. Gauging liability

It is plain that the liability of parties involved depends broadly on the scope of their obligations, whether contractual or not, when damage occurs after acceptance.

The temptation of making liability too heavy and too long, should be resisted.

Liability should be clear and objective and in relation with the scope of the work that the parties were responsible for carrying out.

It would for example be an error to make all the parties jointly liable, or even to generalize the notion of liability without combining it with that of making errors.

It must also be acknowledged that the principle of liability cannot be as strict when applied to work of maintenance or modernization, as to new building or even work renovation.

3.3. The basis of liability

Such are the reasons for which it appears opportune—in compliance with the resolution of the European Parliament dated 13 October 1988—to set up a standardized system for allotting liability of parties involved and of vendors, referring not to subjective or vague ideas but to compliance with the essential obligations of Directive 89/106, for a time of 10 years, increased to 20 years in cases of collapse or impossibility of utilization of the construction.

3.4. Strict liability

It might be wise to introduce the concept of the strict liability of the parties playing a particularly important function in construction, that is:

– the builder	(process n° 0)
– the project planner	(processes n° 1 and 2)
– the general contractor	(processes n° 1 and 3)
– the employer/vendor	(processes n° 0 through 4)

It should be sufficient, with a simple complaint of damage buttressed by proof, to allot liabilities as follows:

100% for a builder or employer/vendor

75% for a general contractor

25% for a project planner

There is no need to point out that considerable motivation would result.

The principle of joint liability should exist between a project planner and a general contractor (process n° 1).

3.5 Liability for mistakes

Should the employer have decided to distribute the work between several designers (processes n° 3 and 4) or several contractors (processes n° 2 and 4), proof of damage would not be sufficient to allot liabilities.

It would also be necessary to prove a link of causality between the damage and the work and also the party's mistake.

To perfect the system, the employer who neglects to correct defects for which reservations have been made should be strictly liable and any party holding no license should be considered as at fault.

Approved suppliers and subcontractors should also take liability.

Table B: Liability of parties involved

Process n° 0	**B**	The builder is strictly liable for damage up to 100 % of the total of the work of repair or of the compensation.
Process n° 1	**PP/GG**	The project planner is strictly liable for the damage up to 25 % and the general contractor up to 75 %.
Process n° 2	**PP**	The project planner is strictly liable for damage up to 25 %.
Process n° 3	**GC**	The general contractor is strictly liable for damage up to 75%.
Process n° 4		No party is strictly liable.

This said for liability/who gives the guarantee?

4. The guarantee

4.1. The guarantee and quality

The guarantee is also an important factor in quality because firstly/the defects guaranteed are ipso facto covered and because secondly, the guarantors do not give their guarantee if they are not themselves guaranteed (against the incapabilities of the players in particular).

The longer the guarantee/ the greater the chance of achieving good quality. To speak of a 20-year guarantee being offered or required is an indirect way of specifying a high quality or construction.

4.2. The European Guarantee

The very principle of a guarantee on every new of restored building should be generalized in our time.

More precisely/any offer for construction or sale of such a building should be covered by a European guarantee mandatorily included in the agreement; in its absence/the penal liability would fall on the builder or vendor.

The implementation of any such guarantee would be widely publicized and would be characterized notably by the category of the building covered and by the time of the guarantee expressed in years, for example:

– Guarantee ‘G10’ for a new house
– Guarantee ‘G15’ for a highway construction
– Guarantee ‘G 5’ for a restored apartment

The guarantee could never cover a time of less than 5 years after acceptance of the building.

It would mean that the building satisfies performances including at least the basic requirements of directive 89/106. It would be a guarantee of long life of the building.

4.3. Housing

In housing, particular attention should be paid to protection of the buyer.

In our advanced societies, all the economic agents should certainly take a share in the responsibility for their own decision.

They should however be provided with the correct information and should have at their service stable protection systems that are easy to understand and are reliable.

This is why a list should be drawn up at the european level, as in the Netherlands, of the types of damage that may occur that will be covered by the guarantee of long life of a new or restored housing unit, which list will be regularly updated and made available to the public.

The two other important characteristics of any official system of ‘housing guarantee’ should not be omitted.

Firstly, as in Great Britain or in Germany, repair should precede compensation.

The builder, if it can be found when the damage is discovered, or, failing it, the vendor, should repair the damage or to be repaired, and it is only when the builder or vendor cannot be found or refuse to pay that the owner whould receive compensation from the guarantor.

The other is the rapidity of repair or of compensation.

As in France, any system should limit to two months the time allowed to the guarantor either to obtain from the builder or vendor a commitment to make the repair, or to pay within an additional time of one month compensation to the owner amounting to a sum at least equal to that needed to return the building to its initial condition.

4.4. Housing to be built

In the case of housing to be built or to be restored, the European guarantee should allow the buyer to recover its funds immediately in case of failure of the vendor or to complete the work of building in the case of failure on the part of the builder. This system applies in Great Britain and in the Netherlands.

This would be a guarantee that the building is delivered in the condition that the buyer has the right to expect.

Every builder of a private house should be classed as a vendor even if the land does not belong to it.

5. A European construction agency

Even if the aforesaid principles were included in the 'European construction act', which would be a directive, much remains to be done to attain target n° 1.

This is the reason why it will be useful to set up a 'European construction agency' of which the duties could be listed as follows:

(a) gather informations on the pathology of buildings
(b) perform action to promote the security and quality of buildings or of civil engineering works
(c) define practical principles and conditions allowing specification followed by certification of the security and quality of a building or of a civil engineering work
(d) devise the conditions and facilities needed for better information of buyers
(e) draw up uniform standards on construction processes and on the duties of architects and of engineers
(f) write guides for employers, buyers and designers
(g) prepare standard contract clauses together with standard contracts of sales or leasing of housing
(h) promote utilization of architectural competitions
(i) detail the scope and the duration of the european guarantee for certain categories of buildings
(j) draw up and update standard lists of damage covered by guarantees of long life of buildings and notably of housing
(k) assist in the implementation in every country of uniform or recognized systems of conciliation and arbitration for the rapid settlement of disputes, or of litigation,

occuring either between an employer and a builder or between a buyer and a vendor, or between an owner and a guarantor

(l) promote innovation by providing guarantees of certain new construction processes or products

80
Quality assurance and its effect on liability, guarantee and insurance in the building sector

P.J.MEINDERS

Abstract
This article deals with the question how best to protect the private citizen who buys a new house. It begins by explaining the theory and practice of liabilities and guarantees as they operate in the building industry. It then describes success and failure of the practice of insured guarantees, and proposes Quality Assurance in the building industry as a remedy for failure. It then explains how the system of QA works and how enterprises big and small can adopt it. Finally it describes a pilot project with QA governing the relationship between the builder, the insurer and the protected buyer.

Introduction

In the eye of the casual beholder, the world of building somewhat resembles a carnival procession. Developers, architects, consultants, contractors, sub-contractors, inspectors, researchers, arbitrators…an endless variety of "parties involved" bemuses the eye. But for the innocent client who has in good faith engaged the services of this motley crew, the colourful pageant may soon lose its charm, and in the end take on the grimmer aspect of a funeral march.

The parties involved in the building process all work together in cooperative combinations that by sheer number and variety baffle the understanding of the outsider. The cooperative combinations ensue from contracts equal in number and variety.

And all these contracts are subject to General Conditions, or Standard Rules, governing liability between parties. The whole exercise mainly serves to tilt the balance of liabilities as far as possible towards the party that finally foots the bill: the client.

If professional clients have trouble inching their way through this minefield of contractual relationships the non-professional client must surely fear for his life, that is, if he recognizes the dangers. And once he recognizes them, what can he do? Swap the minefield for the traps and pitfalls of a new contractual relationship— that with a professional consultant? Like the owner of a four-man business who commissioned the construction of a new workshop because his architect had assured him that he could raise a 75% mortgage on it, and now struggles under the staggering burden of a 115% mortgage, while his “adviser” goes free!

By far the largest category of clients of the building industry are private people who buy a house from a developer or have one built by a contractor. For many of them buying their own house is a crucial step in their lives. Having taken it they face the daunting maze called “building sector” with its invisible web of responsibilities and liabilities that none but the expert’s eye can see. The private buyer recoils in fear, and well he may. Wailing from the maze come the voices of those whose faith in false guides left them stranded with defective properties on their hands. And very often their claims for help are met with too little, too late. Their last resort is the law of the land. But the road to court takes a heavy toll in money and time which many private buyers cannot afford. They had a dream which now turns out to be a nightmare.

Guarantees

To ease the risk of failure of some purchased property for their clients, sellers guarantee their wares for a certain period of time. For that period they pledge to compensate the buyer for any kind of damage caused by failure of the property. The Dutch building sector knows no such guarantees. Parts of buildings or installations in them may be guaranteed for certain periods, but there is no such thing as a full guarantee on a complete building.

Yet this is exactly what the inexpert client, that is, the average private buyer, needs. For even if the contractor has accepted liability for failure of his building for a certain period of time, the client may have a hard time persuading him to repair the failure or to compensate the damage it caused. All the private buyer wants is a good house and to be spared a tiresome battle to win what is his due.

To protect private buyers of anything, that is, “consumers”, the European Community has been taking steps, and the latest of these are aimed at the protection of consumers who buy a house. The Community’s Executive Commission has drafted a directive regarding liability for services, in which it includes the building industry. The need to protect private home-buyers seems to be troubling more governments than one, and the Dutch government is among those that are trying to do something about it. It has joined hands with the building industry to try to find out how the industry can improve its product. Apart from this it is studying the possibility of giving private house-buyers a full guarantee on their property, as well as ensuring the risk of such guarantees. And it does so with a keen eye for the remedy which Quality Assurance, according to Eurocode 29000, may prove to be.

For more important than full guarantees and safe insurance is the quality of the building, which itself must guarantee the buyer many happy years of *carefree use*.

Liability schemes, guarantees and insurances can never be more than the goal they serve, which is improvement of the product. The producer must use Quality Assurance as a permanent instrument to achieve this goal. Producers in other industries have found that

QA helps them to control their production cost and to ensure continuous demand for their product.

Insuring guarantees

In the Netherlands there is as yet no insurance covering the risk of a full guarantee on a complete house. Why? Any insurer asked to cover a risk must know in how far it is possible to control that risk. For the more controllable the risk, the more precise his assessment of its insurance cost can be. Insurers look for enforceable standards. Such standards exist for parts of houses, not for the process of producing a complete house. And in their absence no one knows how good or bad the complete house will be.

Insurers cannot live with such uncertainties. They make a living assessing risks and fixing their price for insuring them accordingly.

Some of them act out of character, incurring great losses by covering the risk of failure of whole buildings, as the law of their countries, say France and Belgium, requires them to do. That the poor quality of building is largely to blame for those losses is hardly a secret. Nor is it a secret that Dutch insurers are unwilling to cover full-guarantee risks for private buyers unless something is done to improve the quality of building. National and European legislators who want to protect the consumer must do so by encouraging builders to gear their entire production process to systematic quality control. Such a systematic control of quality will then enable insurers to cover the risk of full building guarantees at a price the builder can afford. And looking at the level of Quality Assurance in other industries, there seems little reason for the building industry not to try to adopt it.

Controlling Quality and risk

What the private buyer needs most is to be sure that all is well with his property during its building and after its completion. This means:

- they need to be safe from the risk of the contractor failing during or after building.
- They need a guarantee insuring them against the risk of failure of any part of their house for at least five years.
- Contractors must be able to insure themselves against the risk incurred by giving such guarantees.

As I argued before, few insurers are willing to cover guarantees of builders because they know that many of the builders' clients are discontented, which, in the modern jargon, puts builders in the category of producers with an "unfavourable risk profile". They seem to have trouble controlling the process of building. Even if all building materials and prefabricated sections were of assured quality, one still would have to wonder whether the house was soundly built. In building, not less than in other matters, the whole counts for more than its parts. But to make the insurer's risk acceptable the builder must be able to prove that he knows what he is doing. In other words, he must control the quality of what he is building. If he does, the builder's business will grow and prosper because by controlling his production he not only stimulates demand for his product but also cuts his expenses by saving on labour and materials. And the insurer, for his part, cannot do without fixed standards for his assessment of damage claims.

The solution is easy. It lies in observance of the Eurocode Series 29000, which was provided especially to deal with this problem. EC 29000 is about assuring quality. In our case we will look at

– EC 29002: model for quality assurance in production and installation;
– EC 29004: quality management and quality elements—guidelines.

For those who want to control the quality of the design phase as well, the EC has provided Eurocode 29001: model for quality assurance in design/development, production, installation and servicing.

Many industries use these norms. A striking example are the industry which builds petrochemical installations and the industry which does the civil engineering groundwork for them. Their activity activity closely resembles that of the industry which builds houses and public utilities. Yet in contrast to the petrochemical builders, the house-builders, at least in the Netherlands, still have to implement quality assurance as a regular practice. In the house and public utility building industry a few big firms are now learning to use it. But also among the medium-sized and small enterprises quality-awareness is taking root. Why are builders so reluctant to learn to control what they are doing? Many have asked the question, but no convincing answer has yet come forward. Leaving that question for the moment, let us consider the question how to introduce quality assurance in such a way that it becomes an instrument of management, assuring quality as the natural product of a well-managed business enterprise.

What is Quality Assurance (QA)?

Eurocode 29000 defines QA as “the aggregate of planned and systematic actions needed to assure to an adequate degree that a commodity or service meets certain standards of quality”.

For the definition to make sense we must define the term “quality”. Here, too, we refer to the standard: “the aggregate of properties and characteristics of a product that make it meet certain standards and self-evident requirements”.

The EC definition means that there is a system involved, as well as *planned actions*. In the building industry QA covers the whole of the building process and all the organizations that play a part in it. QA is an act of organization meant to ensure that a certain level of quality is maintained throughout the industry, in administration, in purchasing materials, in selling the product, in the product itself, in the training of staff and in service to the client. It covers everything from people to products, from means to ends. QA, in short, is the management instrument *par excellence* to ensure good and efficient work and a good product.

The system of Quality Assurance is, in spite of lingering beliefs to the contrary, essentially different from that of Quality Control (QC). QC means checking physically whether certain technical requirements are being met. It is by definition discreet and incidental in nature. QA, however, is a systematic reform of the process to make it run in such a way that it meets quality standards as a matter of course.

There are two ways of verifying this:

1. monitoring the production process
2. sampling the product.

(1) The QA system involves many procedures, some general, some more specific in scope. The general procedures cover the total operation of a company including its projects and products. The specific ones focus on the manufacture of a single product or the execution of a single project under a contract specifying the use of QA. Breach of contract in this matter may entail heavy sanctions, sometimes even suspension of production, and top-level discussions between producers and clients.

(2) Apart from monitoring the quality of the whole process, QA checks the incidental quality of products or parts of products. But the better (1) goes, the less checks on quality with their often damaging, at times even disruptive effect on production, will be necessary.

To monitor the operation of the QA system itself the “audit” instrument was developed. Audits are of two kinds: internal and external.

Internal audits are the work of the company’s QA manager and serve to ensure that the right procedures are followed and maintained. They involve questions like “does this procedure still work well in the current production process or should it be changed; is the current procedure being followed, are those following it informed of the latest changes, have they received the necessary training, where do they fail when they fail, what planning versions are used, and are materials purchased according to procedural specifications? Deviations are corrected and any problems reported to the highest authority.

External audits operate in a similar manner, but for a single production process, whose commissioner sends his own QA manager or a representative to keep an eye on the work. The commissioner’s QA manager tries to verify whether procedures are being followed as agreed, and as stated in the QA handbook and General Procedures that are part of the contract.

External auditors do much of their work on the shop floor where they check how the QA system works in practice. This is where management must look sharp! Auditors on the shop floor have often found fault with QA systems that were believed to be working well, but were operated by people who knew little of work procedures and directives, or who were not properly qualified for their jobs.

Introducing Quality Assurance

A traditional craft like building naturally has its doubts about introducing something modern like quality assurance. The building industry moreover is an amalgam of enterprises, big and small, with their various cultures that all need a different approach. Big building firms have more senior staff than smaller ones and more room for manoeuvre in their organization. The obvious approach for big enterprises would be to introduce QA from the top down whereas smaller firms would be wise to do it from the bottom up.

In building as in other industries the top-down approach is first to write the quality handbook, then to introduce general procedures and finally specific procedures that require a variety of registration forms. The quality handbook and general procedures affect the whole enterprise, regardless of the work currently in progress.

They describe the general operation and organization of the enterprise. Specific procedures "usually apply to specific projects, describing project-specific methods and organizations. The system is best introduced with the start of a suitable project. It should be borne in mind that the specific procedures must be developed from the very beginning of the project.

The handbook and general procedures must be ready before the project begins. An expert QA manager, reporting to the highest authority, should be in charge of the development and introduction of QA. It is not a job anyone can take in his stride, nor is it a job between jobs!

Smaller firms do best to begin by recording what happens in reality. Once this has become a permanent and organized practice, the recorded practice, corrected for the effect of organizational flaws, is taken as a basis for drafting a number of specific work procedures. Later on, the firm's whole organization can be involved in quality assurance and the general procedures and handbook written and introduced. This "bottom-up" approach does not spring surprises on workers, does not incur uncontrollable costs, and carries the quality assurance system up from the shop floor, where quality products are produced, to the top of the organization. On the other hand, the "bottom-up" approach takes longer, so the firm will longer be unable to meet traditional building contracts demanding QA. For the contractor this may raise problems of qualification.

QA and insured guarantees: an experiment

With my description of QA I want to show that QA can help contractors to guarantee their products without too serious a risk, and insurers to cover that risk. For QA provides the standard by which the insurer can measure the quality of the process whose risk of failure he is asked to insure. It will prompt the contractor to produce good quality as a matter of course.

To find out whether low-cost insurance of guarantees can be made a paying proposition, a pilot project is now in preparation. The form of the project is being debated between the government, a number of building firms and insurers active in the building world. The plan is to organize a number of medium-sized family-housing projects in such a way that builders will be able to operate a good quality assurance system and insurers to insure the builders' risk in giving his clients full guarantees. The project should bring to light what conditions exactly must be met to satisfy both builders and insurers. The housing market will be studied for its reaction. The way QA works for the builder and for the insurer will be studied for its mutual effect and actual reparation of claims for damages will be studied in relation to liabilities under contract.

The parties conducting this test are convinced that the system will work well for the building sector, improving its image through better quality and removing doubts as to its reliability as an industry.

If it does, the carnival procession that opened this article will find its way to the party in honour of delivery, setting a mood that befits a joyful birth.

81
Housing quality management for the nineties and beyond

R.J.MORTIBOYS

This paper describes how authorities, housebuilders and contractors in the United Kingdom and Hong Kong are taking the lead in the use of advanced quality management methods.

Keywords: Management, Quality, ISO 9000, Improvement, Business Success

1 Into the Nineties

1.1 Leading on quality

This paper describes the developments in construction industry quality management methods in two countries, the United Kingdom and Hong Kong. Both are leading the way. In the UK and Hong Kong the National Housebuilding Council (NHBC) and the Hong Kong Housing Authority are the two bodies with national responsibility for ensuring that dwellings meet the tenants or owners reasonable needs and expectations. In this paper you might not see the quality control and quality assurance terminology which you expect to see. This is because modern quality management principles and methods require full integration with the overall management of the business and becomes indistinguishable from it.

1.2 A Fight for Survival

As we go into the nineties, construction companies face a changing and challenging business situation. There are more competitors than ever; with fiercely competitive strategies, which will result in **the survival of the fittest**—those with the best strategies and methods and the most determination to succeed.

Tenants and owners' needs and expectations are increasing. They buy manufactured goods such as electronic equipment and cars, which are now of much better quality than a few years ago. They expect the construction industry to provide better quality too. Both the NHBC and the Hong Kong Housing Authority are responding to this inevitable demand for better quality. They cannot afford not to. On top of the outcry for better quality, **are insurance costs for the NHBC and maintenance and repair costs for the Hong Kong Housing Authority which cannot be tolerated**. In both countries contractors are either following the lead from the national authority or as the more enlightened ones are doing in both countries they are taking the lead themselves.

Employees' needs and expectations have risen too. There is a **shortage of good people** in the industry, **at all levels**. The successful contractors will be those who can attract and keep the best people.

1.3 Action by the NHBC

In 1983 the gentleman in the British Department of Trade and Industry responsible for the National Quality Campaign wanted to try out new quality management methods in an industry which would have great difficulty in implementing them—if they could work there they could work anywhere! He suggested housebuilding! The NHBC and eleven housebuilders took up the challenge. My company introduced advanced quality management methods based on BS 5750 (ISO 9000) and all companies reported back that not only had their quality improved but their business performance had improved too. Some which had previously only received letters of complaint were beginning to receive complimentary letters about their houses and the way they had dealt with their clients during the transaction. Sunley, a British housebuilder and one of the eleven companies in the Project became the first housebuilder worldwide to be registered to BS 5750 (ISO 9000).

1.4 Action by the Hong Kong Housing Authority and the Contractors' Association

The Housing Authority reacted by introducing a number of measures to improve quality—including the quality control of concrete; the standardisation of block designs; direct purchasing of components; the introduction of the contractor Performance Assessment Scoring System, and an internal quality assurance project, with the aim for the Construction Branch to achieve registration to ISO 9001 by March 1993. **With the Contractors' Association** they introduced an external quality management project to recommend **a strategy for managing quality throughout the industry** and the requirement for contractors on new works lists to be registered to ISO 9002 by the same date.

1.5 Housebuilders and Contractors' Options

Against this background housebuilders in the UK and contractors in Hong Kong have only three options:-

(a) Keep doing what you have always done,—but try harder!

In a rapidly changing business situation, to keep doing what they have always done is a recipe for disaster—even if it was successful in the past—profits today are the results of strategies developed years ago. In a changed business situation, trying harder with outdated management methods will simply hasten decline.

(b) Be aggressive

—usually to clients, employees, sub-contractors and suppliers. This usually has the effect of increasing profits in the short term, but it alienates clients, employees sub-contractors and suppliers and reduces profitability in the longer term. However, some large international companies which work this way are currently being very successful.

(c) Develop Total Business Management

—with time to manage; a clear vision of what your company is all about and where it is going; fully integrated management functions and department; employees empowered to improve the way things happen, and partnership relationships with clients, employees, sub-contractors and suppliers—so that everyone wins.

Registration to ISO 9002 can be achieved by housebuilders or contractors adopting any of these three options, **but only the third option is likely to be profitable** in the long term.

1.6 Time to Manage

There are basically two parts to managing a construction business—managing projects and managing the company. Managing projects is relatively easy, because the contract and the specifications spell out what has to be achieved and the timescales. Managing the company is much more difficult. There are no specifications. Not surprisingly, **most managers spend a lot of time on managing projects**. **Few managers spend enough time on managing the company.**

Another way of looking at it, is that managers must divide their time between:-

(a) Developing and implementing **winning business strategies**
(b) Planning and implementing **improvements**
(c) **The daily routine**

For most managers, **the daily routine takes far too much of their time,** because it includes **far too much firefighting**—doing any job which you are only doing because you, or someone else, didn’t do the job right first time. Managers get excited about their successes in solving problems which should not have been there in the first place! In most housebuilding and construction companies our experience has shown that **firefighting takes as much as 60% of total company time**. That leaves too little time for developing and implementing winning business strategies, or for planning and implementing improvements.

The successful contractors in the nineties will be those whose managers **can find the time to work on business strategies and on improvements** in the way things are done throughout the company—whose managers can find the time to work on Total Business Management. Managers must find time to **get out of Partial Business Management supplemented by firefighting, into Total Business Management**.

2 Total Business Management

—will be based on real benefits; driven by management commitment and leadership; focussed on clear objectives; dedicated to satisfying the **customers' needs and expectations (quality);** less time spent on routine; and will **achieve continuous improvement** through the active participation of clients, employees, sub-contractors and suppliers in the development of the company.

2.1 Gold in the mine

For most contractors, **firefighting and materials wastage account for up to 30% of sales revenue**. In some companies it is even higher. I don't ask you to believe this figure. I ask you to measure it in your company. You will need help to do it, but if you know where the money is going, you can find ways to do something about it. Regard it as Gold in the mine—there for you to transfer into profit. **How do your current profits compare with Gold in the mine?**

2.2 Beliefs

What people (clients, employees, sub-contractors and suppliers) believe about your company, puts a limit on what you can achieve. With negative beliefs you will be able to achieve very little. With positive beliefs you can achieve Total Business Management and be a winner in the nineties.

Some negative beliefs:-
Management don't care about quality!
Management don't care about us!
Management don't know what's going on!
We've always done it this way!
We haven't got time to do it right!
They won't notice it!
We can put it right later!
We can claim for it!
They won't know who did it!

Some positive beliefs:-
Management really do care about quality!
Management really do care about us!
Management really do know what is going on!
We can always improve!
It's quicker to do it right now, than to have to put it right later!
I can change the way things happen around here!
I can be proud of what I do!

2.3 The route to being a winner in the nineties

The starting point is **your beliefs, and the beliefs of your employees**. You should start by defining what you believe the business is all about and where it is going. Then define the sort of working relationships you want to have with your clients, your employees, and with your sub-contractors and suppliers.

Also, define **what you believe** to be the purpose of monitoring the performance of yourself, your employees, your sub-contractors and suppliers. The purpose must be **'To achieve continuous improvement'**. It must not be To criticise them for making mistakes'. This is a positive change which you can make to your beliefs. Then, it is possible to change some of your employees negative beliefs into positive ones.

When you are clear about what you really believe, **define your business and management objectives**—that you want to achieve in-line with your beliefs. Then you can **develop business and management strategies** to achieve them and **develop and implement plans** to put the strategies into effect. **Involve your employees, sub-contractors and suppliers** as soon as you can.

2.4 Making time to improve your quality and your business

One of the best ways to make time available for you and your managers to start on the improvement process is to improve your procedures. **Procedures are simply the way you do things**—in the boardroom, in the offices, and on site. **With good procedures, which everyone understands, firefighting is reduced** and managers and other employees can devote more time to strategies and improvement.

As in most industries, **owners and managers of housebuilding and construction companies dislike change**. The housing construction industry is fortunate in that their national authorities are insisting that they become registered to **ISO 9002**. This will force all of them to look at their procedures—**a golden opportunity to make time for business improvement**.

3 ISO 9000

3.1 What is it?

It is a standard for Quality Assurance systems. It helps you to develop and implement a system of management procedures which, if they are good procedures, will lead to an improvement in product quality and a reduction in firefighting. It is a tool, not the objective. It was originally designed for use by manufacturing companies, but can now be used by all industries—with the use of a document, which translates the standard into wording we can all understand. Such documents will normally be introduced by the controlling authorities or the trade associations for the industry.

3.2 The main requirements

(a) Scope

(b) Definitions

(c) Specifications

(d) Requirements

Quality system

Policy statement

Records

Organisation

Quality planning

Materials

Site quality

Sub-contractors

Information system

(e) Information system

(f) Training

(g) Complaints

3.3 Developing your procedures

In developing your procedures to achieve registration to ISO 9000, you must **ask yourself whether your procedures will eliminate firefighting** and make time for business and process improvement. It is all too easy to gain registration with procedures which won't reduce firefighting and which won't make time available for business and process improvement. It takes a little more time to prepare good procedures than to prepare indifferent ones. You will need help to do it, but it's well worth it. **Good procedures are crucial to your success in the nineties.**

3.4 The process of quality and business improvement

Stage 1—Laying the foundations

(a) Obtain REAL management commitment to improvement
(b) Define your beliefs and objectives
(c) Find out what your clients, your employees, your sub-contractors and your suppliers think of your company and your procedures
(d) Form a Business Improvement Team

Stage 2—Developing the procedures

(a) Identify the business processes you need
(b) Identify the organisational structure and related procedures you will need to operate the business processes
(c) Understand the requirements of ISO 9002
(d) Identify which people will be involved in each procedure and prepare a programme for preparing each one
(e) Prepare each procedure

Stage 3—Implementing the procedures

(a) Plan how you will implement each procedure and involve the people who will have to do it
(b) Implement the procedures as planned

Stage 4—Auditing the procedures

(a) Check that the procedures have been implemented as planned and that they are being operated as intended
(b) Ask yourself, your employees, sub-contractors and suppliers Can they be improved?' 'Do you have a process for improving your procedures?'

4 The Certification Process

4.1 Preliminary discussions with the registration authority

These discussions are to help you to understand the process and to deal with any questions you might raise.

4.2 Formal application for certification

This step is mandatory, and is done on the authority's documentation.

4.3 Review of quality manual

This step is to review your quality manual against the requirements of ISO 9002 and to tell you if there are any significant discrepancies.

4.4 Pre-audit visit

This is a voluntary step, to enable you to discuss how the audit will be conducted.

4.5 Audit visit

This is a mandatory step. A number of people from the registration authority will visit your head office and sites. They will see what is happening in each place and check that it conforms to your documented procedures. If they find discrepancies you will be expected to make good the discrepancies within an agreed time. They will then visit you again for a further audit.

4.6 Recommendation for certification

If your procedures conform to ISO 9002, the registration authority will register you and provide a certificate of registration.

4.7 First surveillance visit

This is mandatory and is planned to occur within three months of the successful audit visit.

4.8 Surveillance visits

Further visits will be made at about six-monthly intervals (mandatory).

5 Empowering employees

Having freed employees time by introducing more effective procedures that time can best be used for improving quality and the overall performance of the business by empowering all employees, sub-contractors and suppliers to improve the way your company operates. The empowerment process involves clearly defining what is needed and expected of each employee, sub-contractor or supplier, training them to be able to do what is needed and expected, delegating to them the authority to change the way that they work, trusting them to make the appropriate changes, supporting them even when things go wrong, and helping them to monitor their achievements against the needs and expectations.

6 Structure for improvement

Inter-disciplinary and local action teams should be formed and trained to tackle quality and business improvements at all stages from the initial brief through to successful handover, which won’t require that old euphemism for putting things right—maintenance!

7 Benefits

In the UK housebuilders have achieved dramatic improvements in as-built quality, build times, customer complaints and profits. For example, one international housebuilder has reduced the time spent firefighting from 64% of total company time to just over 10%. He reduced the cost of quality mismangement from 27% of revenue to 12%. Profits on sales improved from 11.3% to 33%. The value of the company increased from just over £1 million to just under £1 billion. Contractors in Hong Kong have only just started on this route but they are already beginning to see benefits.

GOOD LUCK

DONE PROPERLY, IT WILL BE WELL WORTH THE TIME AND TROUBLE.

82
An investigation into procedures leading to production of quality assurance in buildings of high quality

K.H.MURTA

1 Introduction

This paper is an account of research and development work carried out to indicate some answers to the principal problems which have been seen to be important in Quality Assurance system. It discusses some of the problems which have arisen in this work.

One question that has been posed when considering the application of Quality Assurance systems has been whether there should be different levels of Quality to be assured. Conceptually Quality Assurance cannot be seen in isolation. It is closely related to aspects of the building industry all over the world, notably in areas of litigation over defective building and Insurance. There is therefore a strong body of opinion which argues that the level at which quality is assured should be that of producing a building without any defective elements, i.e. 'zero defects'. There is no doubt that from the point of view of avoiding legal action and consequent reduction in overall insurance costs 'zero defects' is a reasonable concept. There is another aspect which may come into consideration in adopting a strategy which argues for definition of levels which would enable those who commission buildings to agree on appropriate levels of quality to be achieved. This would have implications for time taken in design and construction as well as fees. There are two points to be made in conjunction with this part of the argument. The first arose out of the preliminary work carried out by members of W.88. It became clear that building owners recognise the value of a prestigious building in terms of image and could in fact quantify the value added in monetary terms. The second point reflects the state of the art in architectural design. It is submitted that architecture is moving out of a pioneering phase into a period of refinement. There is no doubt that the aesthetic principles of the early modern period did not relate to the fundamental principles of physical laws of moisture and thermal environment. Design priorities lay in producing suitable aesthetically generated forms and which took precedence over considerations of constructional design. The defective buildings which arose was a factor in the resistance of developers and clients to modern design. The link with insurance and litigation has thus caused particular problems for innovative design. Yet any system of aesthetics must, by definition, progress, otherwise it becomes sterile and dies. Thus a major question is raised, how can the quality of innovative design be assured? One thing which is not usual in other industries, is the separation of design and implementation. This means that, different techniques are necessary to deal with design services and with building operations. A further complication, identified by members of W.88, is that motivation of building operatives on site was seen to be important in the attainment of appropriate quality levels.

2 Design Procedures for Buildings of Quality

The following section is a report of the research work indicating the methodology and conclusions that have been reached from the analysis of the findings of a study of design procedures for buildings of recognised excellence.

The selection of buildings was based upon a survey which was restricted to Britain. It was necessary to avoid the authors personal preference or make assumptions about architectural style which could distort results. The aim was to be as objective as possible. A starting point identified buildings that had won design awards at national level and where the status of the award could be recognised as ensuring that high design standards had been reached. The preliminary lists showed that several architects and practices consistently appeared. In addition a questionnaire was sent to architects asking for a ranking list of significant buildings of quality. Final selection was being made from a list drawn up after correlation of the two sets. Eventually a balance was struck reflecting both a variety of building types and a range of practice types. It was expected that the spread of offices would provide a variety of design methods which in some respects did not prove to be so. There was, in fact, a similarity of design methods both of the large practices and those of individual designers.

The investigating techniques included the following:-

a. Familiarisation with the work of the practice or architects but based on one of the award winning buildings to act as a vehicle for discussion on the design process.
b. Interviews in depth with the architect and other consultants.
c. Examination of drawings, documents, relating to the project.
d. Follow up with other members of building team where appropriate.
e. Analysis of material to determine major factors.

The practices which came out of this process were all in the private sector, which may be pertinent and requires explanation. It was felt that this was because the opportunities to exercise design skills were more readily seen in private practice and the rewards for building up a reputation for original and creative work could more easily be related to career prospects.

The list used eventually has been categorised as follows:

	Practice	Building used as exploratory vehicle
A	Large multi disciplinary international practice.	Head office for national institution on difficult site. RIB A national

		award.
B	Small practice headed by British architect with very high international reputation. Work in collaboration with small number of named associates.	U.K. Headquarters of international company,
C	Firm responsible for notable government and University developments.	University Building in Civic University,
D	Large firm described as commercial architects specialising in recreational, commercial and similar large scale developments in U.K.	Housing Scheme with awards from RIB A, Civic Trust etc. in re-development area,
E	Practice developed after division of former group headed by notable architect of National and International reputation. Responsible for educational, ecclesiastical, governmental and commercial work both in this country abroad.	Civic Building for District Council in in N. of England. RIB A Award, and
F	Small practice with one main designer.	House, award winning and widely published example typical of the work and expressing principles of an award winning building designer.

One question was intended to elucidate the attitude of practices towards adopting a deliberate policy of high quality design. All of the practices concerned were in the private sector and indicated the need to keep in business in the short term. All indicated that a high reputation led to further work, and that experience had shown that it was good policy to achieve high quality in creative work. All interviewees said that this usually meant employing a larger number of personnel than strictly necessary and more time spent in refinement which meant less profit. All practices questioned regarded themselves as being successful in both design and financial terms. One aspect of the study was to define the size of teams but preliminary studies indicated that close involvement of either the principal or named architects with the project was a factor in all cases which were studied. The specific case of Practice A which has a policy of not identifying any personal imput for publication purposes, on examination, showed that this personal involvement was present. An analysis of the information from the questionnaire revealed a major aspect which was worthy of putting forward for discussion. This is that there are two distinct phases in the design process. This does not include implementation or production processes. The latter may be regarded as a third phase but is different in character to the other two. This seems to be of considerable importance and is reported upon in the next section.

First Phase

This is when the main ideas which dominate the built form are conceived. The latter word is perhaps incorrect as there appeared to be a great deal of preconception in design. However, in the formal sense,—i.e. where ideas are matched to a particular problem this period tends to be very short and when analysed is usually the result of one person's endeavour. Of the firms studied, several are built around the design skill of one person, usually the named principal of the firm and this part of the process is only to be expected. But even when a practice (Case A) deliberately sets out to use team design in practise this amounted to ideas being put forward by individuals. Design then being criticised, rejected or accepted by the other members in peer reviews. At this stage there is necessarily little detail and ideas are in conceptual form. In those practices with a famous principal, there is submission to other people, closely connected with the project. This may take the form of a design cabinet (Firm E) or two partners working closely together (Firm D). There was confirmation of the necessity to test out ideas quickly and expose them to criticism. The objective part of the process seems to be checking against the major constraints of the programme as defined and construed by clients or peers.

This apparent divergence from the usually accepted sequential method caused investigation in each case to try to identify the source of basic ideas in each project. The first likely source was 'the brief' but clearly in several cases the brief itself had been formulated and modified during the formalizing of the design. It became clear that many designers have a pre-conception of what major components the design should incorporate. Part of the design process lies in adapting this to the brief.

In a sense, this is very close to the problem/solution couple suggested by Professor Bruce Archer in his work on design methodology but the findings indicate that the situation might be rather expressed as a solution/problem couple as being a closer description of this particular part of the process. This was surprising as initial thoughts, when formulating the questionnaires, were that there would be a more or less sequential process. We were alerted by the discovery of the surprisingly short time which was common for the basis of the design to be established. There was a search for pre-process activity. This became a surprisingly high factor in the projects which were examininged.

Since that time Mrs. Jane Darke, working independently on housing design, has perceived a similar phenomenon and uses the phase conjectural design to describe this phase of development. Creative work in other disciplines displays a similar phenomenon. This is an area which is complex and as yet ill defined. The work of writers, especially poets as well as musicians and visual artists all incorporate this preconceptual component and shows perhaps more clearly than that of architects that creative work can be seen as a continuing process not necessarily related to any particular task, project, or end product. There are bound to be differences given the unique nature of building production, but the conclusion is that architects continually devise and store material just as other artists do, to be used when appropriate. It is worth noting that part of beaux art training was to develop skills which led to this conjectural design process.

It was also clear that architects do analyse their own work. There is a great deal of feedback from buildings and both failures and successes are stored for either modification or reuse should the need arise. This is contrary to the popular view that architects are not interested in buildings once they have been completed. Without exception the practices gave evidence of detailed analysis of both their own and other significant buildings. There is a sort of hidden, often personal continuous criticism, rarely being formally recorded, more usually being stored as imagery in the designers memory file and perhaps needing the stimulation of a specific project to bring it into tangible form.

An assessment in relation to the designers questioned was made and had regard to the projects studied. The conclusion was that there was a spectrum ranging from subjective to objective values, and which one provisionally listed under these headings.

A. Imagery

The development and imprinting of idealised forms which please the designer; appears close to hedonistic and zen responses. May include fashion and cliche in less talented designers.

B. Relationships

The sorting and arrangement of forms, major elements and components, may include transformation and metamorphoses of analogous objects and concepts. Provisional hypotheses in built form.

C. Technical Innovation

Includes systems, ways of doing things, relationships for example of building to structure, service and energy concepts

D. Feedback

Recording of knowledge about buildings, operational use, visual elements, materials, structure, constructional details.

The very short period for crystallisation of the design raised the question of why this could be so condensed. To give examples; the time scale of this part of the work varies from 3/4 hours, (Case A), overnight (one evening and early morning (Case D), a few days (Case E). In all these projects a the brief was available. The answers to questions confirmed that architects drew wholly, or partly, upon previously accumulated material. Case E gave as the basic design idea the imposition of a previously formulated structure/service relationship which became the predominant factor in the building form.

Design formation consists of the combination of this personal hidden process with the more public one which draws objectively upon the brief. The two parts are not necessarily time related until the formation period. The brief in all cases was described by the architects as being a stimulation document; and in only one case included detailed schedules. The latter indicated the operational purpose of the building, and the type of response favoured by the client body. The one exception was the housing scheme (Case D) which had schedules of house types required relating to social structure, site density, cost yardsticks etc. In addition to this information, however, this document covered the planning and social policies decided by the local authority. The architects said that it had positive effects on their design. In this context the communication link between client and designer at brief making and during the second working up stage was considered to be very important. The brief was thus seen as an important part of the total process but more particularly as a complementary element allowing incorporation of material from the private process.

In this context the appointment by the client, of an individual with authority to make decisions about interpretation of client's needs and views was held to be essential. Again, there seems to be a demand for response time to be short and if there could be rapid checking out of ideas enabling progress to be maintained; this was held to be of great advantage. Designers consistently pointed out that continual work and development under deadlines was important not only in motivation of the design staff but in terms of successful design development. Possibly the two are related and Quality Assurance techniques should take account of this.

The first phase is summarised as follows:

a. Design objectives should deliberately include a demand for innovative and creative ideas. Originality is considered to be a criterion of high priority in acceptance of these ideas.
b. There is evidence of persistence of first thoughts or basic design function right through to the finished building.
c. Design time is short probably because of the existence of the continual, conjectural personal process. Personal and public processes are complementary during the briefing evaluation period.
d. Client considerations are important and must be so arranged to be of positive value in the period of brief evaluation.
e. The initial stage should be the responsibility of either individuals or small design groups with clear lines of responsibility.
f. The designers are usually experienced in terms of design but not necessarily specialists in the building type under consideration.

There are several points in this summary which could be incorporated in a Quality Plan.

The second stage

The investigation into this period of the work showed it was much nearer to the conventional sequential pattern. However there are points which are worth reporting on. The first is that this period is where development and refinement of the original scheme takes place. The design is open to the criticism of a larger team and this is where specialist consultants have a role to play. In Case A the practice argued that consultants were engaged at an earlier stage. Analysis showed that their contribution was advisory rather than as active participants. In theory this second period would allow the possibility of great change in the scheme. However, in all cases, the scheme in stage one was essentially that which entered the production stage at the end of stage two. There are two points to note in this respect. The first is that a particular type of skill, based upon personality and leadership, is required to pilot and defend the scheme through this critical period if its integrity is to be retained in the form the designer required. The ability to defend the earlier design decisions and convince the other members of the larger design team required a confidence in the initial decisions which points to the value of experience and maturity in terms of design and personal relationships. The second point has already been touched upon and concerns the critical appraisal of the work. This has particular relevance for peer review as part of Quality Assurance. This often leads to tension within the team which can either be disruptive or constructive. There is no doubt that constructive criticism is positive if well controlled during this second refining period but it should always be within the framework set out in the first stage. Techniques for dealing with this period were discussed. The possibility of deliberately asking a person to act as ‘devils advocate’ in the design team has been tried. This had not been done in any of the cases covered (as far as could be seen) Case A deliberately set up criticism sessions open not only to the team but other members of the firm, at which the scheme was presented. This aspect of the design process could be of importance and has been largely neglected in the literature of design methodology but of course is familiar to advocates of Q.A. in that it is essentially ‘peer review’.

It was found that the time given over to the second period was quite long and produced many studies. Some with much reworking of proposals. This aspect between schemes, but a common feature was the great number of detailed design studies, often in the form of models to a large scale. The scale of drawings was of interest. Many of the design studies were to a scale of 1:50 or 1:20 and obviously took a great deal of time. The use of colour was used to clarify and predict the spatial effects being considered. The evolution of the scheme into constructional form and selection of materials took place at this stage although, with one exception, designers argued that material choice and constructional feasibility had featured as part of the initial stage. The exception was that a Case B where it was said that form was the important characteristic and that truly original design could be inhibited by consideration of constructional matters and other constraints, and that these should be dealt with as secondary decisions.

To summarise this period we noted—

a. That a much larger team was involved than that which had included ancillary members of the design team.
b. A large number of large scale design studies were carried out thus extending the time required for design consideration.
c. A period of constructive criticism, particularly at the beginning, but also at other times during development is considered of great value. The independence of this criticism is vital and should be regarded as a ‘peer review.
d. There is an element of tension in the criticism sessions which can be either constructive or destructive to the initial ideas.
e. A particular skill is required to retain the integrity of the initial design through the working up period.

3 Implementation

This paper has concentrated on the design procedures before building commences but in the course of the study it became clear that just as a particular skill was required to pilot a scheme through the exposure to criticism from consultants and other designers that deliberate effort was needed to ensure that the building as erected was in accordance with the designers intentions. There was evidence of very careful specification writing in terms of quality and detailed description of those attributes required in the final result. The area of site supervision was included in the list of questions and it was found that use of architectural staff on site in the larger schemes was usual. These were not put on site in a purely supervisory role but were intended to interpret and carry the design decisions through implementation. Where there was not a permanent site representative of the architects the recruitment and standards of suitable supervisory staff was a factor but emphasis was laid on the frequency of site visits by the designers to ensure control.

4 Conclusions

Buildings of quality have a design procedure which differs from the conventional plan of work, particularly in the way in which basic creative work is applied to the design problems. In the light of the findings the value of formal design methodology in buildings of high quality is questionable. In terms of the categorisation of processes suggested by Christopher Jones in his book, Design Methods. It is felt that boundary searching is the nearest description to the position revealed by observation.

It is also clear that the success of the building depends very much upon the mastery and control of the designer through what is often a prolonged period of investigation and refinement. The depth, and length of this period seems to be quite different from that of other buildings. Indeed much genuinely innovatory work of high quality is lost by modification during this period. It might be argued that where a situation calls for high quality buildings, possibly in the historic centres of major cities or in areas of high landscape value, this should be recognised and extra fees to allow for the necessary manpower and time be allowed. There are many lessons for design education and it is hoped to continue this enquiry in more detail at a later stage. As a control a further study was developed which dealt with University Buildings in UK. This was carried out by Dr. W.Waterworth. The findings confirmed those of the earlier study.

I have taken the findings in these two studies and combined them with other material to produce a review of the state of the Art. I present this summary in terms of:

a. Conceptual arguments in relating to motivation for High Quality in Buildings.
b. Identification of principles arising out of the analysis of procedures used in producing buildings of high quality.
c. Some of the methodology and techniques which have led to high quality both in process and product.

5 Motivation for Quality in Buildings

Why should efforts be made to produce better buildings? The answer leads to the reasons for aiming at quality. There are two main themes. The first is philosophical in nature and points to the benefits to society of a stock of well constructed buildings of high quality. Then there are those economic arguments which indicate that features usually associated with buildings of quality, such as durability, reliability, high quality of materials and construction, prestige to owners, low maintenance costs and satisfaction in operation, meet usually accepted investment criteria. These qualities should be closely defined and pursued. Although both the philosophy and methodology are capitalistic in nature, there is an argument which suggests that this approach is both suitable and applicable to centralised economic systems. This is emphasised where there have been low levels of quality, which have been widely extended by application of national standards. By the same token, high standards and motivation can be fundamentally established if suitable national concepts can be developed and fed into the system. A Hungarian researcher Mdme. Gaspar has argued for the development of an attitude towards quality in a ‘culture of industry’.

I am reminded also, that Kovaks, in a presentation to W.88, had suggested that buildings were a large scale long term investment for most countries. Initial quality was vital if problems of maintenance and cost of repair and adaptation were not to become insurmountable in the future. One further aspect of this philosophical argument, is that the cost of 'getting it right first time' is less than that of remedial work or dealing with defects at a later stage. The economics can be left until later, but there is the need to create an attitude towards quality which pervades the procurement process, from initial study, through design to the erection and assembly on site and which continues after completion by arrangements for care for the building through its life cycle. I am reminded of one of our great conservation architects, Sir Bernard Fielden, who has suggested that our buildings are our real clients. To regard our buildings in this way will help towards the creation of a positive attitude towards quality, This is the major lesson for the building industry from other industries.

'Getting it right first time' is seen as the main motivation for better quality. There seems to be general agreement that taken over the life of a building, that initial quality pays. Rigorous research, by several respected workers, confirm this conclusion.

There are several other aspects in the economic sphere which may be of interest. A Canadian researcher Robinson made an assessment of Cost and Benefit over the life of a building using currency as the unit of measurement, relating this to performance in the rental market as a measure of quality. It is interesting to note that among objective parameters, which are of value to users, there is also recognition that many aspects are subjective including the prestige value of a quality building, its aesthetics and quality of planning and services. There is reference here to buildings without a market such as those on the social supply side of the industry. The concept of applying market economics to public sector buildings design has, direct relevance in terms of quality.

There are other topics which impinge on the reasons for motivation to produce buildings of quality. Ambition to produce such buildings seems general, and some efforts are made to enquire why this is not generally achieved. There is an opinion that this is because "architectural values cannot be achieved as systematically as technical and fundamental solutions".

There is need to establish standards at an early point in the process. Mathur and McGeorge point out that collective knowledge is important and the bringing in of existing knowledge at an early stage in the project can motivate all concerned with the project, to the possibilities and opportunities that exist in the production of a fine building. In the context of motivation, an essential ingredient is knowledge and understanding of what constitutes quality, and that pre-familiarisation with the inherent attributes of quality, should form part of the first stage in any methodology which is intended to produce fine buildings.

To summarise, it seems conclusive that buildings of quality are socially, and economically, necessary and therefore that the aim of providing high quality in the building industry has significant implications for national economies.

6 Definition of Quality in Buildings and Processes

As within many research areas, initial definition of the problem is a primary concern. Regarding definition of quality, there is debate. This is carried on in many papers, and the matter is not yet resolved. Several writers in the field, notably Ledbetter, and Cornick, argue that Quality can be defined as conformance to requirements. Varying quality, where required, can be thus obtained by simply redefining the requirements to cover high or low levels. In the same context, the principle of zero defects has been proposed as a base level, notably by Hosker and Taylor in papers set out in C.I.B. publication 109, which summarises work done in W.88. This started from a very practical viewpoint, arguing that although buildings are complex, it is objectively possible to provide a building with no design or constructional defects. Other aspects of quality, such as aesthetics, were subjective and impossible to define and, therefore, should be left out of any quality system. The difficulties of conformance of requirements as a concept has been well analysed by Cornick who gives a variety of reasons why the criteria of definition, agreement and conformability, are not being met. The most important of these being that those commissioning buildings are often not users, that innovation is continuous and that production requirements are not usually incorporated in design methodology. The importance of reaching even minimum quality in buildings can be illustrated by pointing out that remedying defects in buildings in the U.K. is estimated to cost 100 million pounds sterling per annum. There have been moves to propose building performance indicators as measures of Quality but there is an argument that “neither the definition nor the management of indicators can be perfect”. At best, the indicators only indicate where attention should be directed. There is also the time factor in design and fashionable attitudes regarding acceptance levels of Quality, so that good and bad are purely relative terms in respect of building.

The question of definition is quite critical to some of the proposals made. For example, Cornick in a paper to CIB Assembly in Paris 1989, has taken the categorisation of tasks rather further than most workers, and relies upon precise definition at various stages to ensure quality at each checkpoint. The total project process occurs over six interrelated but distinct phases.

a. briefing (including procurement)
b. designing
c. specifying
d. tendering
e. constructing
f. maintaining (including managing)

These phases are further sub-divided into tasks and the whole framework examined by a series of sub-process. Each section is examined for “correctness, completeness and adequacy”. Cornick is aware of the problems occurring in the industry. He suggests the ‘Conformance to requirements’ definition, but used ‘a chain of conformance’ which should remain unbroken. He also pinpoints where, in his opinion, the criteria against which conformity is to be measured are difficult to define. These include aesthetic considerations in the briefing phase, buildings where clients are not end users, and the problems of continuing innovation in technology and aesthetics.

Then there is the well known problem of production requirements not being considered at design stage or agreed before construction starts. There is an equally common problem of quality control in relation to site operations and sub-contract work, especially when it is claimed that lowest cost and budget targets bring down workmanship standards. There is the claim that in spite of the difficulties there is "nothing inherent in the nature of a building project to stop the ideal objectives in each of the model phases being realised" and that the chain of conformance can exist through and between every phase of a building project. Thus the question of definition is becoming critical in much of the ongoing work on Quality Assurance.

Probably, the way forward in the immediate future will be incremental. Some requirements can be defined quite closely and already demonstrate successful application of Quality Assurance systems. There are a number of points to be made here. Firstly, that individual or corporate responsibility might form the initial thrust of Quality Assurance systems and could be extended to cover the life of the project. This suggestion has merit in that it also involves designers, contractors and suppliers as well as users in the total process.

This is a pointer to the future, certainly W.88 in one of its formative meetings suggested that existing good practice, if properly applied, would solve most of the design and implementation problems of defective buildings. Attention to specific detail, including definition of performance and specification, at each stage is vital in the attainment of quality.

An alternative, is to accept the dichotomy which exists and differentiate quality systems between design and implementation. A pragmatic approach to this question might be to impose the 'conformance to requirements' system, but restrict it in the first place to those elements which can be objectively defined and suitably described. Materials, tolerances and other information which might be the subject of drawings or specifications could be made to comply with this method. It is of interest that the suppliers are well ahead in obtaining third party certification under BS570. This would reduce the area of uncertainty to those subjective components such as aesthetics. This would be a way forward from the present position. When the pluralism, endemic in architecture at present is considered, this pragmatic approach of using definition and conformance, where possible, has something to commend it. The goal should be to reduce the number of elements which are either not capable of definition, or can only be defined in terms which make conformance difficult to assess. It could expose the problem of that the price limits, possibly imposed as a mandatory requirement, are not always compatible with the performance required.

If there is to be any attempt to formalise a system, the legal insurance and contractual implications must be considered. My opinion is that an appropriate definition of Quality levels to be achieved must be determined.

7 Methodology and Techniques Leading to Higher Quality in Product and Process

The main thrust of work which has been carried out in the field is that of carrying through a positive attitude regarding quality onto the site. This is regarded as vital if high quality is to become the norm. The natural way to do this is to regard each project as a unified team effort. A phrase 'Total Quality Management' has been adopted by proponents of this concept. The theory is that from inceptance of a project to occupation the objective of high quality will be maintained. This could end the usual division between designers and constructors. There is an argument for one system. Some researchers argue that modelling systems used mainly by design teams could be used to form a project data base available to all involved. This is an alternative proposition and should be pursued.

W.88 at one of its early meetings expressed the view that motivation of site operatives is a major element in the achievement of high quality. A French sociologist Mm. Frazer has divided the whole problem into work site tasks. Her proposal is for a system of certification at the end of each sequence of work with a record document, signed by the person responsible for that task. This is a technique widely used in those manufacturing industries with high reputations for quality.

The identification of responsible parties and the concept of self or single certification in relation to quality levels has occupied those who have been involved in producing codes of practice relating to quality, such as the producers of BS.5750 and ISO.9000. Research into non-conformance has identified human failing as a primary reason for failure of quality systems at some point in the complex arrangements that pertain in the building industry. Communication at node points in the design process are particularly vulnerable to errors. The argument revolves around whether or not the principle of second opinion should operate. There does seem to be an acceptance that where absolute levels of public safety are concerned in construction elements such as Nuclear stations, dams and reservoirs, bridge design and other innovative structural systems, second opinion is necessary. It should be noted however that definition of requirements in this case is relatively simple, i.e. there should be no structural failure, even when there is possible exposure to maximum shock and environmental extremes. Should this concept of second independent opinion, be universally applied, then there are variations on the theme which might be dependent upon particular elements or, varying levels of quality. This is already an area for discussion. It was ventilated at a previous symposium where the legal definition of "fitness for purpose" was particularly relevant under British Law and had implications for indemnity insurance in the industry. This can be described as design validation or alternatively design review. This not only covers calculations but also can include checks upon buildability and reviews of specification. Several multi-disciplinary firms operate in-house procedures. The reviewers of a project are deliberately independent of the project staff. This technique is restricted to those organisations which have sufficient personnel to provide resources for review independent of the project team. It possibly provides a way forward for public sector design organisations. Those design reviews, which research has shown to be effective, have incorporated areas which obviously affect quality. These allow the economic framework to the design to bear upon quality and performance standards. This is important where project requirements may incorporate consideration of time and impose costs limits

The application of quality techniques to design work has been successfully tried by the American practice of Caudill Rowlett and Scott. They have formed a Quality panel of experts and have instituted a a system of grading buildings on a scale of 1:10. Ten being perfection and failure around four being a building with defects, including failure of the design to satisfy function. There are three factors. Function, Form and Economy. The relevant scores are set in vectors at 120°. The score on each factor is connected to give a triangle, the area of which becomes a quality quotient. This can be further simplified into a formula which is 0.433 of the sum of each pair of vectors. This analysis can be applied to existing buildings and narrows the subjective areas of assessment.

Design work is looked at by a jury within the practice but independent of the project and assessments made on those factors which lead to a quality quotient. The link between economy and the other two factors is particularly seen to be a useful tool, to designers and clients alike.

It has become commonplace to note that the cultural values of a civilisation are reflected in the form of its buildings. Architecture is a social art, and as George Steiner has recently pointed out, art sometimes sits uncomfortably in the scientific world, but it cannot be disregarded. Buildings do reflect the aspirations, virtues and values of those societies for which they are designed and constructed, and the creative process, if it is to be successful, must recognise and absorb sociological, as well as technological and economic influences into aesthetic concepts. One of the most optimistic feelings I have had in reviewing the state of the art has been the way in which professional and disciplinary boundaries are being dismantled and the demand, for co-ordinated efforts to be made to provide shelter for mankinds' activities. These will be of specific concern for the rest of the century and into the early decades of the next millenium. We all have the opportunity to contribute to the future by ensuring Quality in Building.

83
A quantitative model for the evaluation of construction quality

J.M.G.NERO

Abstract
The analysis of the theme **Construction Quality** has been ruled, in general, by the richness of concepts it introduces, but also by the difficulty of its quantification and unequal attention, exigence and appreciation criteria concerning the role of the multiple partners involved on the process that leads to it.

The reflection about these matters has led to a Quantitative Model for Construction Quality in which this quality depends on the participation and quality of the multiple intervenients which make possible the most different phases.

1 Introduction

The quality in construction is a difficult theme if one wants to go over the transmission of consensual ideas or formal theories, very often of difficult implementation. This difficulty is reinforced by the special concepts sustaining the quality in the construction industry. On it the quality can be understood as the adequation of the construction object, the work, to the purpose of its execution, the user, or as the value of the actions of the multiple partners taking part on it and the organizative structure established by them for the effect.

Whatever the perspective may be, the quality depends on space and time, and on technical, sociological, political and economical factors that articulated, naturaly or not between each other, several times lead to quality and sometimes keep it away.

Understood in this way quality, as a changeable concept, is not easily reachable, one shall look for it.

If on one hand quality in conceptual terms may thus be presented, on the other hand the great variety of intervening partners in construction, such as promoters, designers, undertakers, coordinators, financial institutinons, with distinct interests and roles, although to some extent ruled by the society by own legislation and by the action of the oficial organizations supervizing the sector, always renewals and turns into a unique one the organization responsible for each execution.

The work as a product of construction is the result of a complex industrial process, random and uncertain, with factory, construction site, movable and variable, caracterized by the specifity that makes difficult and sometimes prevents the repetition and uniformization always present on most of the other industries productive schemes.

The quantitative model for construction quality is here presented taking in account the characteristic versatility of the sector. This model conveniently applied and supported by expert systems available or to be created and by techniques of value analysis may lead, to forecasts and results about the efficiency of the organization and its performance on construction.

2 Presentation of the quantitative model

2.1 Formulation of the problem

Each execution in the construction sector may present distinct phases of development or actuation, such as- the definition of the program, the financing, the project, the execution, the coordination and surveillance.

Each of these phases groups different tasks requiring the intervention of one or more agents.

Naturaly the value reached on a certain phase depends on the quality and participation level of those working on its execution.

The phases and inside them the interventions may be developed sequencially or simultaneously, may influence the others or may be independent, may condition or be conditioned, all depending on the organizative structure and the specified plan.

The application of the proposed formulation relies therefore on the knowledge and analysis, as deep as possible, of the organizative structure which is assumed for achieving the execution.

The model here established, within the described framework, tries to answer the following question:

> For a given work, of known structure, what is the global quality, expected or achieved, η, represented by a real number in [0, 1], as a function of the quality, η_i, evaluated for each of the n phases forming it, and of the influence, α_i, of the individual phase on the whole, taking in account that on each, phase, i, there are k_i intervenients with distinct contributions, β_{ij}, and qualities, δ_{ij}.

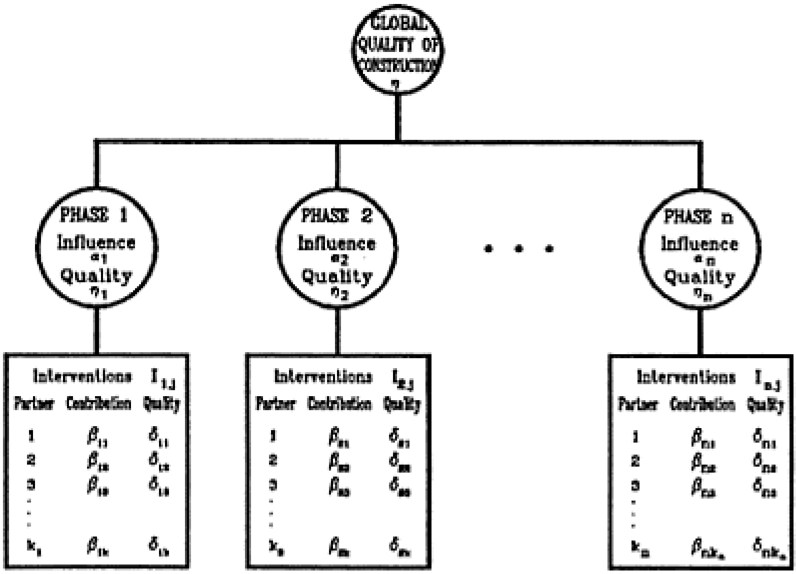


Figure 1: A diagram representing the model for constuction quality

The configuration of the proposed formulation is shown in figure 1.

2.2 Assumed hypotheses and their analitical translation

To make possible an analitical treatment taking in account the different possibilities of articulation between the different actions to be performed during the construction it is necessary to translate into the same basis the basic principles or hypotheses supporting it.

In this section the most important hypotheses and its analitical formulation are presented using the symbols introduced previously. A distinction is made between the hypotheses concerning the phases and those assumed for the activities inside the phases.

Phase level

HI –Each phase may be or not be indispensable to the work and may also influenciate in a different or in the same way as the others the execution of the work.

$$1 \le \sum_{i=1}^{n} \alpha_i \le n \quad (0 \le \alpha_i \le 1) \qquad (1)$$

HII –The contribution from a given phase on the global quality is a function not only of the quality reached on that phase but also of its level of influence on the whole.

$$\eta=\eta(\eta_i, \alpha_i) \qquad (2)$$

This functional relationship can be expressed in different forms depending on whether the phases are developed in a sequential or in a paralel way.

On the first case, **H II–1,** the function will be:

$$\eta = \prod_{i=1}^{n} \eta_i^{\alpha_i} \tag{3}$$

which is grafically represented on figure 2.

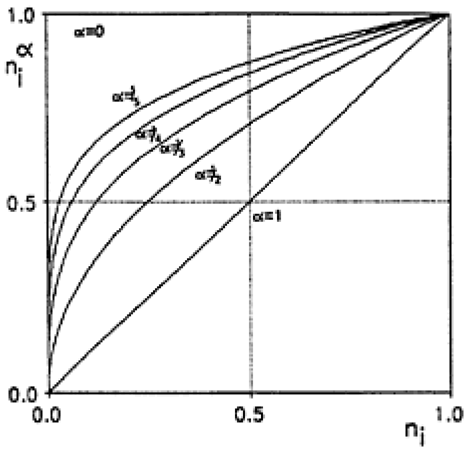


Figure 2: Contribution from one phase on the final quality in the case of a sequential development.

On the second case, **H II–2,** it will be:

$$\eta = \sum_{i=1}^{n} \alpha_i^{*} \eta_i \tag{4}$$

where

$$\alpha_i^{*} = \frac{\alpha_i}{\sum_{i=1}^{n} \alpha_i}$$

The graphical representation of this relation is shown on figure 3.

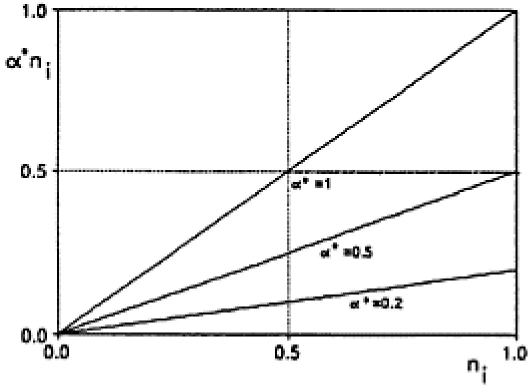


Figure 3: Contribution from one phase on the final quality in the case of a paralel development.

H III –Whenever the phases are developed in a sequential form a subsequent phase may contribute, if its quality is higher than that of a previous one, to improve the quality of the product obtained from this previous phase.

$$\eta_i = \dot{\eta}_i^{\alpha_i c_i} \tag{5}$$

where

$$c_i = \prod_{k=i+1}^{n} (1 + \dot{\eta}_i - \eta_k)\Delta_{ik} \tag{6}$$

and η_i would the quality of phase i if it could not be influenced by other phases and

$$\Delta_{ik} = \begin{cases} 0 & \text{if } \eta_i \geq \eta_k \quad \text{or if k has no influence on i} \\ 1 & \text{if } \eta_i < \eta_k \quad \text{and if k has influence on i} \end{cases} \tag{7}$$

Intervention level (inside each phase)

H IV –The contributions of the various agents who assure the concretization of a given phase are complementary.

$$\sum_{i=1}^{k_i} \beta_{ij} = 1 \tag{8}$$

H V –These contributions are usually produced independently

$$\eta_i = \sum_{j=1}^{k_i} \beta_{ij}\delta_{ij} \tag{9}$$

H VI –In case the contributions are produced sequentially a formulation similar to the one proposed for the phases in hypotheses **II–1** and **III** can be adopted and in special cases it will also be advisable to considere the hypothesis I.

2.3 Some comments about the data necessary to feed the model

The aplication of the model presented above imposes that some parameters and factors are defined at an initial stage. These are:

– Definition of the phases

These phases which may range from the definition of the program to the coordination may eventually include the steps of appreciation that the society, by the central or local governments, traditionally imposes to the process.

– Articulation of the phases

It must be established clearly how the different phases are articulated, refering those who are completly independent and those that can, to some extent, influenciate previous phases.

– Influence of the phases

Traditionally the influence of the different phases on the process is evaluated via the responsability for the non-quality in construction. It is considered that in Europe this non-quality has the following main causes:

Design –	42%
Execution –	24%
Material defects –	17%
Usage defects –	10%
Other –	7%

In this model it is considered that that the influence must be estimated or result from a comparative analysis with similar cases. If a given phase is indispensable and the tasks performed in it can not be done in other phases than it is legitimate to considerer its influence α_i=1. If a given phase is not at all necessary than α_i=0.

– Definition of the partners and its contribution to the execution of each phase.

It is necessary to define who are the executers of each phase. For instance at the design level all the speciality studies, from the stability to the fire detection, can be considered.

The final design version is usually the result of the sum of the various studies developed, although they can be differently valuated from case to case. The inluence of the architeture in the construction of a retaining wall is not the same if it is located on an highway area or on a Botanical Garden.

Also the financial support of a given work may be subdivided by different partners. It is usual that the promoter, the constructor and the financial institutions share, in each moment, the required effort. Each ones contribution will be quantified by a real number between 0 and 1.

– Interventions quality

There are methods which allow to evaluate the interventions quality at the project level and at the execution, such as the Qualitel Method. However for the other interventions these kind of methods are not available. We believe that the clearness of objectives, the viability studies, the organization of the process, the payment terms, the accomplishment of the execution terms are, among others, aspects that could lead to quality criteria easily applicable. As it is not the aim of this paper to define this criteria the qualities of the partners will be assumed as given.

3 Sensitivity of the proposed model. Application

In order to evaluate the sensitivity of the proposed model consider the following application.

The objective is to know the expected quality for the construction of a road bridge, for which six main phases are considered. The phases and the partners carring out each phase are shown in the next table.

Table 1: Bridge development scheme.

Phase			Partner			
(1) i	(2) Name	(3) α_i	(4) I_{ij}	(5) Name	(6) β_{ij}	(7) δ_{ij}
1	Program	0.8	I_{11}	State	1.00	0.95
2	Environment and viability studies	0.8	I_{21}	Consultancy Office	1.00;	1.00
3	Financing	1.0	I_{31}	State	0.50	0.85
			I_{32}	Financing Companies	0.50	0.95

4	Project	1.0	I_{41}	Structural Calculation Office	0.80	0.90
			I_{42}	Geotechnical Office	0.15	0.95
			I_{43}	Infrastructural Office	0.05	1.00
5	Execution	1.0	I_{51}	Constructor	1.00	0.85
6	Surveillance and Coordination	0.6	I_{61}	Consultancy Office	1.00	0.95

The values of α_i, β_{ij} and δ_{ij} are given in columns (3), (6) and (7) of the table.

To obtain the solution it will be considered that all the phases are developed sequentially and can not influence the others with the exception of the Surveillance and Coordination which may act in benefict of the Execution. In what concerns the activities in each phase, it is assumed, for simplicity, that they are all independent.

It is now easy to evaluate the qualities, according to the hypotheses formulated in 2.2:

Phase 1 $\eta_1=1\times0.95=0.95$
Phase 2 $\eta_2=1\times1.00=1.00$
Phase 3 $\eta_3=0.5\times0.85+0.5\times0.95–0.90$
Phase 4 $\eta_4=0.8\times0.90+0.15\times0.95+0.05\times1.00=0.91$
Phase 5 $\eta_5=0.85^{1.0(1+0.85-0.95)}=0.86$
Phase 6 $\eta_6=1\times0.95=0.95$

The final quality is given by

$$\eta=0.95^{0.8}\times1.0^{0.8}\times0.9^{1.0}\times0.91^{1.0}\times0.86^{1.0}\times0.95^{0.6}=0.66$$

From the above example it is possible to make the following remarks about the model proposed:

– The events that are developed in a sequential form influenciate in a more sensitive way the final quality.
– The great importance attributed to each phase has a strong contribution fot the decreasing of the quality.
– The existence of phases that can influenciate, with improvement, the results of previous phases may constitute a correcting factor to the evolution in the quality of a given work.

4 Conclusions

The Quantitative Model for Construction Quality here presented, which may be developed as completly as required, allows to highlight the most important influences and the factors where to act in order to improve the final result.

Acknowledgments

I wish to thank Mrs. Ana Pires, Teaching Assistant at the Department of Mathematics, I.S.T., for her colaboration.

84
Information technology and quality in hospital buildings

R.del NORD, A.ANDREUCCI and P.FELLI

Abstract
The design of hospital buildings is becoming more and more complex due to the increasing use by the building sector of technologies originating in other productive areas, such as informatics and automation. Not always, however, is this change of site achieved by means of an "integrated approach" which closely correlates technological evolution with changing needs.

Very often the building, which is still conceived in "traditional" terms, is enriched with new sophisticated technological devices figuring as "added parts" rather than as elements which substantially modify the solutions underlying the project.

The result is a forced adaptation of the constructional elements to those of the engineering plant, thereby penalizing the functionality and efficiency which the building as a whole could express if conceived and developed with a multidisciplinary approach.

It is seldom realized that "innovations" are radical to the point of completely revolutionizing typological patterns established in the course of time: Space requirements change together with functional relationships and, fundamentally, so does the logic underlying functional aggregations and dislocations.

Designing a building implicitly becomes an opportunity not to be missed for proposing new organizational and functional patterns for hospital services and for implementing new forms of management which give due consideration to the potentialities underlying the new technologies.

1 Introduction

The specific purpose of the present report is to illustrate some “concrete” reflections on “organizational and typological changes” which the New Technologies of informatics, automation and telematics may bring about in buildings as a result of their introduction in structures with a high level of functional and technological complexity in those earmarked for hospital services. The fundamental requirement for ensuring that these “technologies” produce real benefits in terms of efficiency and well-being with respect to the patients is that the “innovation” generated by typologies is not regarded as an automatic reflection of the technical sophistication which it incorporates, but as an aptitude and a capacity for reacting in service terms to the new and complex requirements of users who utilize and/or manage such buildings.

In other words, the intelligence of new buildings must depend on the way in which the incorporation and integration of the New Technologies is planned and on the manner in which the management of systems designed to ensure increased productivity and added facilities is “conditioned” by the project.

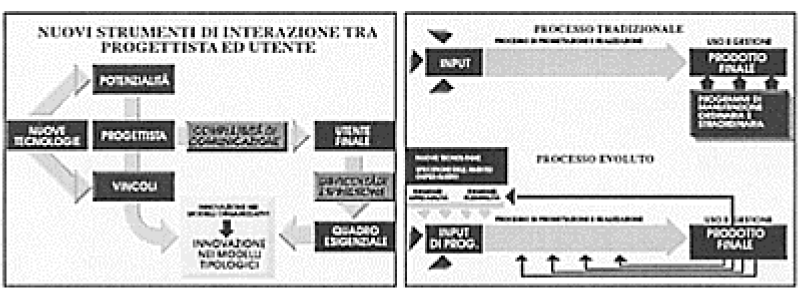
This implies a correct approach to “technological integration” problems typical of an “intelligently” managed project as well as the total revision of typological patterns which have characterized hospital structures in the past with their more or less traditional technologies.

In other words, the marked changes which have taken place in informatic techniques, automation systems and plant technologies must have as their counterpart similar changes in functional patterns, distribution schemes and building typologies in order to maximize the benefits which their use may entail.

Unfortunately, the most advanced proposals for modifying current solutions are not backed up by a systematic and comprehensive evaluation of the real potentialities of typological renewal which the new techniques are capable of generating.

The results of recent surveys aimed at analyzing the nature of the duties performed in hospitals and that of the corresponding changes produced by the use of New Technologies show that the technological and typological solutions now being adopted are becoming inadequate for providing answers compatible with the behavioural and evolutionary patterns determined by the man/machine interface.

The new design approach is based on a logic of experimentation and must, for this very reason, bear well in



mind the risks inherent in the indiscriminate use of advanced materials and technologies in the building sector operating for the health services. In other words, the introduction of High-Tech cannot ignore the analyses relating to the evolution of social habits and current patterns of life, as well as the customary motivations relating to the reliability of the systems and their economic advantages. Failure to give this problem adequate consideration would mean encouraging an unbalanced relationship between users and new technologies, leading in some cases to grotesque results. Some of the solutions adopted for buildings reaching a more advanced level of technical sophistication should therefore be judged with the detachment and irony of a person who is aware of the limits beyond which it is unwise to venture.

This is said with the specific aim of avoiding understandable reactions of disbelief and rejection of innovation on the part of customers to whom solutions are submitted which are not always backed up by detailed analyses with regard to financial and management benefits and by an analytical verification of feasibility.

2 The peculiarity of hospital structures

The functional features of hospital structures are undoubtedly very peculiar, but what strikes the observer more forcibly is the strong “internal contradiction” which they express day by day. Opposed to the increasingly high level of sophistication of medical technologies used for diagnostic and patient treatment purposes is the stationery level (to avoid using the expression backwardness) of technical and informational solutions used in the construction of the containers housing these devices.

The clash between the High Tech of medicine and the Low Tech of the building industry is warming up!!

But the evolution in the other sectors (advanced services) is a lesson which confirms that it is no longer possible to attack the container project and the project relating to the contents with a differentiated methodology and logic, since it is precisely the advanced and integrated container which is helping to improve facilities, productivity and the efficiency of the services it provides.

The integration levels required are becoming more and more exacting while the skills needed for the proper management of decision-making in a project context are still limited or lacking.

The risk to which we are exposed to an increasing extent is that of producing an uncontrolled impact (monopolized by a sellers’ market) whose effect could be economically disastrous.

In other words, guarantees of success presuppose a capacity for managing the predictive assessments which confer a value of fundamental importance on feasibility studies for individual solutions, on the systematica evaluation of cost/ benefit ratios and on initiatives which are collateral to the planning needed for ensuring a continuing process of familiarisation with the New Technologies.

A clarification is nevertheless required.

The decision to use technologies typical of Intelligent Buildings for hospital structures is fundamentally a “strategic” decision which can, in part, be motivated by assessments expressible in monetary terms and which, in part, must be backed by an “analyses of value" using parameters which are not always commensurable with current "items of cost".

It can nevertheless be said that nowadays motivations favouring the use of these technologies are becoming more and more numerous:

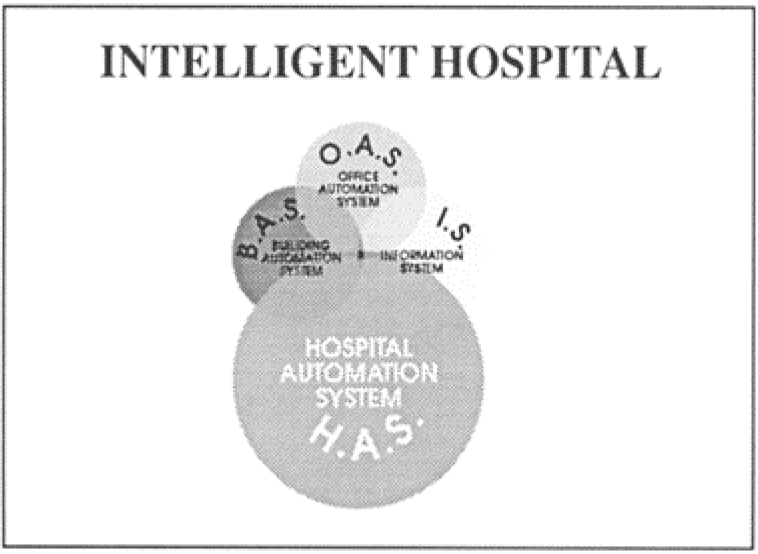
–The slogan used for urging a recourse to "Intelligent Buildings" is that which enables **people oriented** structures to be built.

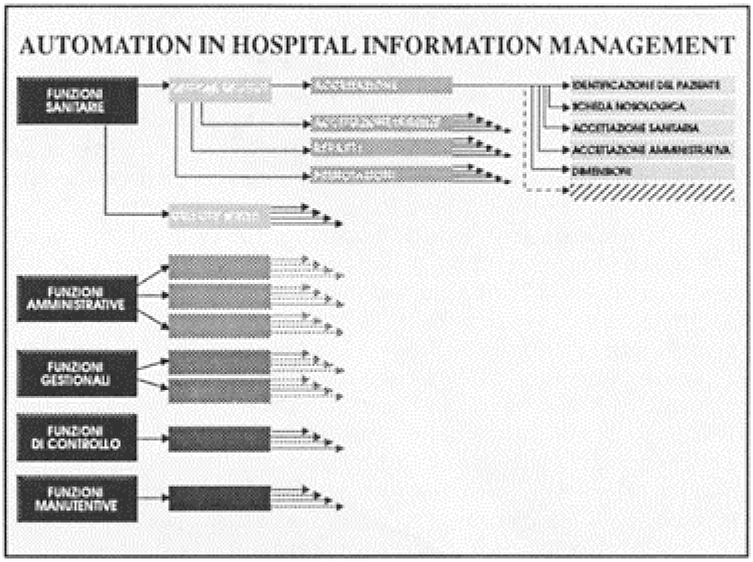
What other typology is more justified than a hospital to demand the construction of people oriented premises and structures?

–The problem of curtailing energy consumption in structures, which can be likened to machines in perpetual motion since their functionality is never interrupted, has become a matter of public knowledge, and it is perhaps that more than anything else which has rendered so widespread the recourse to intelligent systems.

–The problems of managing security, from the level of controlling pharmacies to that of controlling protected areas, accesses and the micro-climatic conditions in hospital areas, require the use of increasingly sophisticated systems;

–The need to reduce management costs, even by systematically





acquiring data on "cost centres" and rationalizing the use of personnel, is fundamental in structures slanted towards administratives bodies of the managerial type.

–The need to manage in real time the supply of medicines and goods etc. for the store and that of reducing the obstruction of premises by accumulating data in advanced media (optical discs) has led to the adoption of new operational patterns and boosted the professionalism of health workers.

All this makes it essential for the E.I., which was successful in the services sector with its DA services, to appropriate the hospital sector with the most complex system of Hospital Automation services.

However, the important thing is to avoid and forestall the risk of failure.

And it is precisely to this point that we must devote greater attention.

3 The renewal exigency of the planning methodologies.

Introducing, very swiftly, the different solutions that the production market is nowadays able to offer, rather than describe the working and the potentialities, I would like to point out the implication, the bonds and the expedientes to be adopted in plan sitting.

Generally speaking we can say with the introduction of N.T. comprehensible forms of failure can rise if we do not consider, as already mentioned, the necessary modifications of the organizing models derivable from the introduction of the flows. In such a prospect the plan of the building becomes first of all the "information and management plan" and it involves the whole second thought of the outlines and of the functional interdepences historically consolidated.

The informatics application has to be therefore, first of all, specific replanning of the procedures, of the roles of the operators, of the procedures, of the functions and i. e of the whole organization. That means, indirectly, to invent again the hospital standard for a renewed modality of reply to the requirements of the patients and of the operators. Necessary condition in order that that occurs is the one able to reach a planning more and more “attended”.

The execution modalities of the briefings are therefore to be established again as well as common languages are to be found out and unified as they allow an effective interaction among everyone who is involved by the planning decision-making choise, the organization of the planning teams and their relative provinces are to be revised and, above all it is necessary to invent the instruments, the logics and the methodologies for the settlement of the user requirements (user=patients, doctors, staff, etc.)

But to plan the Organization means to know and to orientate the degree of “permeability” of the staff and the users in general, towards the innovation.

The need to reach for certain a relationship “user friendly” with the N.T. and the planning of initiatives able to promote it, (like the formation, the incentives etc…) become fundamental moments of the decision-taking choise to be taken on in programming and planning sitting of the interventions. But they likewise become a cost factor and time engagements.

Therefore forming, revision, involvement and responsability become the fundamental ingredients to create a new operating “culture”, and, nevertheless, to do correct estimates of all-in cost of the programmes.

Besides, it has not to be disregarded to consider that, often, the planning and learning times for the use of the N.T. are higher than the ones of the progressive decrease of the efficiency possibilities of the sames, and then the retroactions on the plan have to be suitably programmed.

The use of N.T. conditions the functional interactions suppressing some bonds of spatial proximity, introducing the machine as “medium”, requesting new sorts of spaces for the machines and new requirements for the surroundings putting them up.

The recourse to the N.T. in a high risk structure like the Hospital imposes the attribution of fundamental importance to the requisite of “Certainty of correct operation” of the technological devices. And that reveals itself in new induced not negligible.

The same flexibility concepts combined by tradition with the mobility of the components of spatial delimitation, assume a completely unlike meaning being able to be managed with procedures made automatic through systems of facilities management.

4 The new information and automation technologies in the hospital buildings.

If now we try to come into the specific sense of the solutions already avaible on the market and widely tried in numerous European and extraeuropean contexts, we notice the application fields of the new technologies in hospital ambit concern:

–“internal systems”, operating in the ambit of the same structures;

–“external systems”, operating in connection with the extrahospital context.

The internal systems, that more condition the organization and the form of the building organism, are in their turn classifiable into three main categories:

–mechanization and automation systems of the flows;

–transmission and management system of the sanitary information,

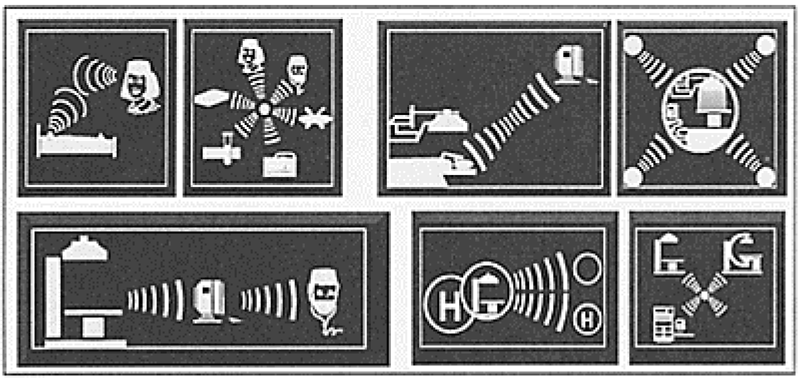
–management system of the buildings.

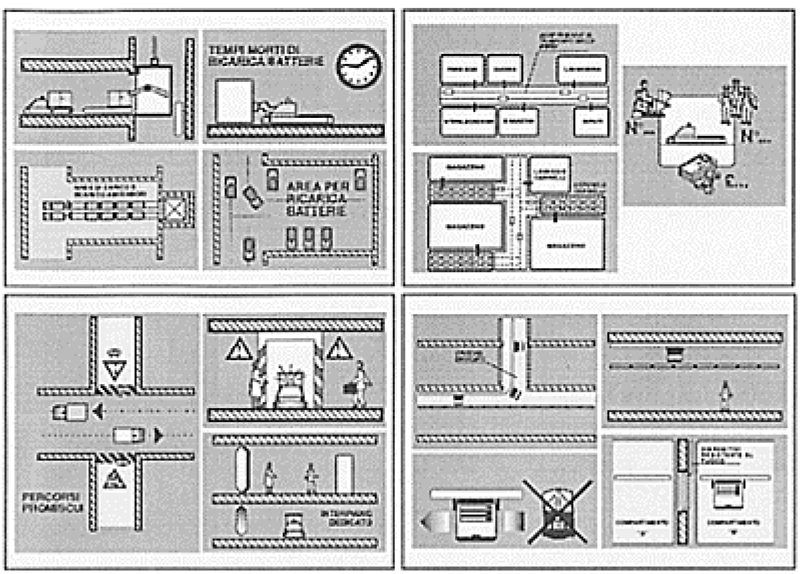
These one are substantially interested by New Technologies coming from the area of the informatics, of the automation, of the telecommunications and of the telematics.

In particular:

–The new informatics technologies are employed for the processing and filing of data and images, for the resource management, for the check and the control of medical equipment, for the management and the organization of operating units, for the management and the administration of warehouses, and as decision-making support for the diagnoses.

–The new automation technologies are employed for the management of climatisation plants, of the waterworks, of the electrical and continuity installations of the elevation systems, of the light and heavy goods transport systems, of





the fire prevention and extinguishing systems, as well as of management of the electromedical equipments.

–The new telecommunications technologies are employed for the data and the diagnostic images spreading, for the research and the information transmission to the staff, for the medical emergencies, for the presence note, for the data interchange among work stations and for the spreading of internal and external audiovisual programmes.

–The new technologies of telematics are employed for the direct access to data banks palced "at distance" for the teleradiology, for the teleaid, for the telebookings, for the plant telecontrol and for the contemporaneous utilization of the transmissive supports.

In the light of the potentiality offered by such "innovations" the typological requisites of the single spaces and of their reciprocal interdependeces suffer radical variations: the bonds of spatial nearness motivated by the necessity of mutual information exchange among operators disappear, the layouts that arose from the principal exigency to control, visually, a zone from a point, are modified; it is imposed the creation of specific spaces to be destined to the "receiver trasmitter stations" (for automatic trolleys or materials and operating information), of acousticly protected spaces for the dislocation of the motor-compressors for the light transport, of gap spaces or of devoted small courtyards where to put the light and heavy trolleys up, and to let them run, of stop stations for the delivery and the withdrawal of the trollleys, of elevators devoted for the transfer of the goods, etc.

But what maybe mainly conditions the traditional organizing schemes is the need to see concentrated, in barycentric position or along privileged axes, the totality of spaces acting as starting and arrival points of the materials and of the goods, that in one way, feed the hospital, and that they are made up of the dispensary, of the kitchen, of the laundry of the sterilization station, of the warehaouses, of the rubbish storages, of the trolley washings, of the trolley storages, of the bed washing station and so on. The plan of this complicated made automatic system becomes, at the same time, producer of planning bonds and instrumental support for the set-up of an organizing "logistics" that finds its principal reference terms in a new conception of the space-temporal bonds of delivery of the services.

If, to simplify the comprehension of the problem, we limit our remarks to the only spaces which the department of patient hospitalization is made up of, we note that the more substantial effects in terms of typological renewal regard:

–the different configuration and size of the additional spaces designed to the consultation of the spread information;

–the reduction of the bonds of the possibility to control directly for effect of the employment of closed circuit TV systems and access control systems;

–the release of the medical studies from the hospitalization zones for the employment of telematics systems;

–the disappearance of the nearness bond among general service zones and hospitalization zones, thanks to the systems of transport automation;

–the redefinition of the supply of bed and consequently of its spatial appearance, in connection with the possibility to send by wire the medical information to the hospitalization bedroom;

–the introduction of new spaces to be devoted to terminal stations of the different flows (transport of goods, receiver transmitter of information, etc.).

From this point of view the capabilities of the single spaces become highly integrated capabilities and the building, as a whole, can really become innovating.

85
Danish quality management—the ten steps

I.S.OLSEN

Abstract
This paper provides an overview of the efforts in Denmark to strengthen quality assurance within the building industry. The efforts form part of a total reform aimed at a number of elements in the building process, i.a. the liability period and the operation of the finished building. The paper gives the state-of-the-art of quality assurance and the experience hitherto gained. The description is formulated as the ten most essential rules or steps in Danish quality management and, thus, constitutes a checklist. In addition, the paper pinpoints the main trends for the coming years.
Keywords: Denmark, Quality Assurance, Ten Steps.

1. Introduction

For the last five years and in collaboration with the parties in the building sector, the Danish Ministry of Housing has worked on an improvement of quality assurance within the building sector and the operation of the finished building.

The reform builds upon a number of elements which focus on various problems in the building process. Only a small part of the reform involves legislation, the main part of it being implemented by administrative means through regulations and directions issued by the Ministry's National Building and Housing Agency as well as agreements with the organisations in the building sector.

The efforts made by the actors in the building sector are of great importance, as improved working routines, organisation, training and motivation are urgently needed. It is the opinion of the Ministry that these areas are illsuited for detailed regulation by means of statutory requirements.

The new system took effect in 1986 and aims at assuring the quality of new building works during planning, execution and operation.

The main points of the system are:

–quality assurance of those individual services under building contracts which are performed during planning and execution,

–effective supervision of the quality of the work in its entirety, both during execution and at the handing-over,

–preparation of detailed plans for building operation, including maintenance, heating supply, etc.,

–introduction of a standard 5-year liability period for defective work and materials, to be applied to design professionals, contractors and suppliers,

–building inspections to be made shortly before the expiry of the 5-year period (which begins on the day of the handing over), and

–establishment of a Building Defects Fund for government-subsidised building projects (residential housing).

The reform elements constitute a coherent system in which the individual parts are mutually supportive.

2. Quality assurance

The reform is based upon the principle that it is better to prevent the occurrence of building damage than to focus on repair and to quarrel about the assignment of liability. Defective work and materials can, in fact, be avoided if all parties in the building sector—architects, civil engineers and contractors—are willing to make an extra effort with regard to improving the quality of the services provided by them.

The main principle of the directions issued by the National Building and Housing Agency is to express in a systematised and intensive form what is already common practice in sound and well-managed undertakings in which quality assurance forms an integral part of planning as well as other activities.

The parties are free to choose their own means of effecting quality assurance. The National Building and Housing Agency has issued a circular which briefly outlines the framework for quality assurance and gives a set of directions with more detailed guidelines. The actual methods to be applied are, however, chosen by the parties themselves.

In the circular and the directions, the terms ‘sound quality assurance practice’ and ‘aids and facilities available to all members of the profession’ are employed. These terms express legal standards which, today, are frequently used in similar directions, e.g. ‘sound competition practice’.

Design professionals and contractors work according to sound practice if, in the performance of their services, the contractual and assumed quality of such services is assured by means of a careful and professional application of the knowledge of quality assurance available to all members of the profession at the time of performance.

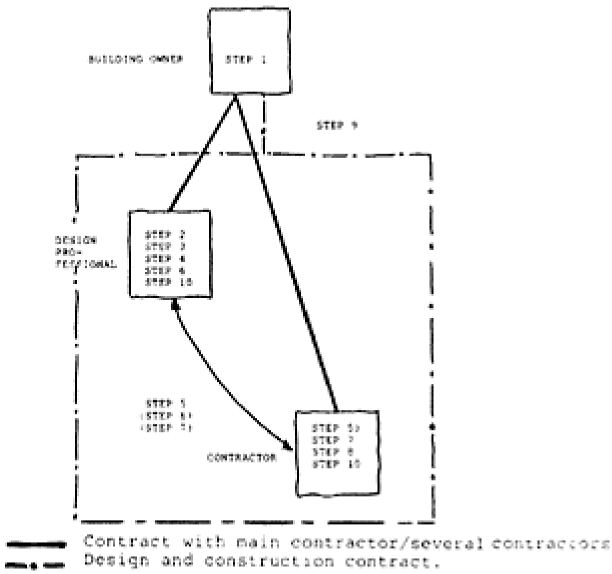
The directions include a list of tools which have been developed over the last few years with the aim of helping actors in the building sector perform quality assurance in practice, e.g. directions on design review, designer/ contractor dialogue, supervision plan and control plan.

3. The ten steps

For the last couple of years, a number of training courses have been arranged on the subject of quality assurance. Through these courses it has been possible to reach a clarification of the concept of building quality assurance and, thus, a simplification and systematisation of its elements into 10 rules or steps.

Out of these 10 steps, some are regulatory in nature, whereas others are purely advisory. However, their joint characteristic is that they give coherence to quality assurance. The initiative and the liability depend upon the nature of the individual steps.

There are no restrictions as to the method applied in relation to quality assurance. But there is good sense—and good method—in following the 10 steps.



The ten most important steps within Danish quality assurance are performed by building owners, design professionals and contractors. For d/c contracts/responsibility ity for QA in both design work and execution lies with the contractor in accordance with directions from the building owner.

The ten most important steps within Danish quality assurance were developed in a joint effort by the organisations in the building industry, the companies and the public sector, i.a. in connection with pilot building projects.

3.1 The first step—the building owner is responsible

The building owner is responsible for ensuring that design professionals and contractors involved in the building project provide quality assurance for the work and services provided by them.

The building owner is responsible for the overall planning of the building project. Consequently, responsibility for ensuring quality assurance of the project lies with him.

To fulfil this obligation, the building owner must require quality assurance of services and work provided by consultants and contractors involved in the building project. This is done by inserting provisions in the contracts which require observation of the framework given in the government circular.

Thus, by delegating the responsibility for quality assurance to design professionals and contractors, the building owner ensures himself against claims for defective quality assurance. In case defects occur, such defects will be considered a breach of contract in relation to the contracts entered into with design professionals and/or contractors.

3.2 The second step—the quality assurance manual ensures order

Through the drafting of a quality assurance manual and, for the individual building project, a quality plan, design professionals are able to ensure order and systematisation in their quality assurance activities.

A useful approach for consultants would be to systematise and describe their quality assurance activities in a quality assurance manual—the QA-manual. This manual, which describes the company's quality assurance and quality control systems, will be of great help to its staff in their daily work.

For the purpose of large building projects, the company can prepare a quality plan based upon the nature, size, complexity, etc., of the project.

In other words: the quality plan shows the company's chosen strategy for quality assurance, quality control and the necessary documentation in relation thereto, for a specific building project. The plan could include information relating to e.g. the assignment within the company of responsibility for quality assurance activities, the carrying out of the design review and the cooperation between design professionals and contractor in connection with the designer/contractor dialogue.

The ten most important steps within Danish quality assurance—from conceiving the idea to operating the building:

- the building owner is responsible,
- quality assurance manuals prepared by design professionals ensure order,
- designer documents can be systematised,
- design reviews prevent problems,
- designer/contractor dialogues involving both designing and executing companies may prevent problems,
- supervision plans allow building owners to monitor the construction process,
- contractors provide the material for building owner control plans,
- contractors, too, need quality assurance manuals,
- all quality assurance work performed must be documented at the handing over (at

the latest),
– operating manuals form the basis of building operations.

3.3 The third step—planning of the design work can be systematised

Design professionals can prevent misunderstandings and mistakes by appropriate planning of the design work.

A systematisation of the work in the planning stage is achieved by applying identical principles to the drafting of drawings and tender documents from one building project to the next, e.g. as shown by BPS (Byggeriets Planlægnings System—the coordinating body for practices within the Danish building sector).

Furthermore, in a number of areas (e.g. concrete, brickwork) it is possible to use BPS's standard specifications.

In government and government-subsidised building there is an obligation upon the building owner to commit his design professionals and contractors to use the Danish basic concrete specification (the BBB) for the planning and execution of concrete structures.

Preference should be given to products for which precise and exhaustive information is available. Also, whenever possible, products should be used which are subjected to some kind of public control or approval procedure.

3.4 The fourth step—the design review prevents problems

Design professionals should carry out one or more design reviews during the design stage.

The design review is a coherent and systematic study of the designer documents with the purpose of identifying problems and assessing the project's ability to fulfil specified and stipulated requirements.

It is necessary to fix the time in the design stage when the design review is to be held. Usually, reviews are effected upon completion of the different steps of the design stage.

In addition to the design review, it is important to effect the usual control of measurements and calculations in the project.

3.5 The fifth step—the designer/contractor dialogue improves cooperation

The designer/contractor dialogue allows companies involved in design and execution to go over the designer documents and the execution methods chosen.

The purpose of this dialogue is to draw upon the contractor's expertise in construction and execution matters, with a view to identifying any aspects that may lead to defects, or which are particularly hazardous or difficult to execute. Operational matters, too, may be discussed, and the dialogue also provides an opportunity to take into account the production equipment of the contractors.

The designer/contractor dialogue is not intended to lead to a revision of the intentions behind the designer documents.

The participants in the dialogue should include the resident engineer or the clerk of works from the companies involved in the execution stage.

3.6 The sixth step—with the supervision plan, the building owner is able to gain an insight in the construction process

The building owner must prepare a plan for his supervision of the building during the execution stage.

For each individual building project, the building owner must prepare a plan for his supervision of the execution of the construction work by the contractors. The main parts of this plan—the supervision plan—should be drafted during the design stage.

The supervision plan should contain a thorough examination of the individual supervision jobs, including their staffing. Supervision should be effected wherever defects are most likely to occur and where they will do the greatest damage.

3.7 The seventh step—the control plan ensures that the work and services provided are up to contract

In the tender documents, the building owner must stipulate the requirements to those parts of the contractor's quality assurance work for which documentation is required.

In addition to the supervision plan, the building owner needs to be able to control performance of and compliance with the contract. This is done by requiring the contractor to furnish documentation for the work completed in the form of a control plan.

The building owner's requirements to the control plan, i.e. what has to be controlled as well as the scope of such control, must be contained in the tender documents in the form of a main framework. This framework is binding.

The contractor who wins the contract provides details and supplements to this framework, all of which, upon approval by the building owner, becomes the control plan.

Control plan and supervision plan constitute a whole, the content of which must be given an overall assessment by the building owner.

The contractor must keep all control documentation until the five-year inspection has been effected and any questions raised in relation thereto have been settled and their solutions approved.

3.8 The eighth step—contractors, too, need quality assurance manuals

Through the drafting of a quality assurance manual and a quality plan, contractors are able to ensure order and systematisation in their quality assurance activities.

Each company is responsible for the quality assurance of the work and services provided by it. Like design professionals, contractors, too, could benefit from the preparation of QA-manuals. Not only does the manual systematise the company's quality assurance activities; it is also of great help to the staff in their daily work.

In addition, the contractor may prepare a quality plan for the individual building projects, containing i.a. an outline of quality assurance activities during the execution stage.

The quality plan comprises the control plan as well as the contractor's internal quality assurance work. In the quality plan are definitions of which documents to use and which control methods to apply.

The quality plan should be drafted in cooperation with those people who will be using it later. It should be simple and concise.

The building owner may stipulate in the tender documents that his supervisors/clerk of works are to see the plan.

3.9. The ninth step—quality assurance must be documented and the documentation available in a complete set upon the handing over of the building

The handing over of the completed building is the formalised confirmation of its completion and delivery unto the building owner.

Each contractor is to hand over the work or service provided by him to the building owner upon its completion, including documentation for execution control as stipulated in the control plan.

At the handing over of the building, registration is made of any defects, i.e. work or services that are not up to contract. In case such defects occur, the building owner should arrange for the preparation of records thereof prior to the handing over. The lists should be drafted in a joint effort by supervisors/the owner's clerk of works and contractors involved in the execution stage.

In case of serious defects, the handing over of the building will have to be postponed.

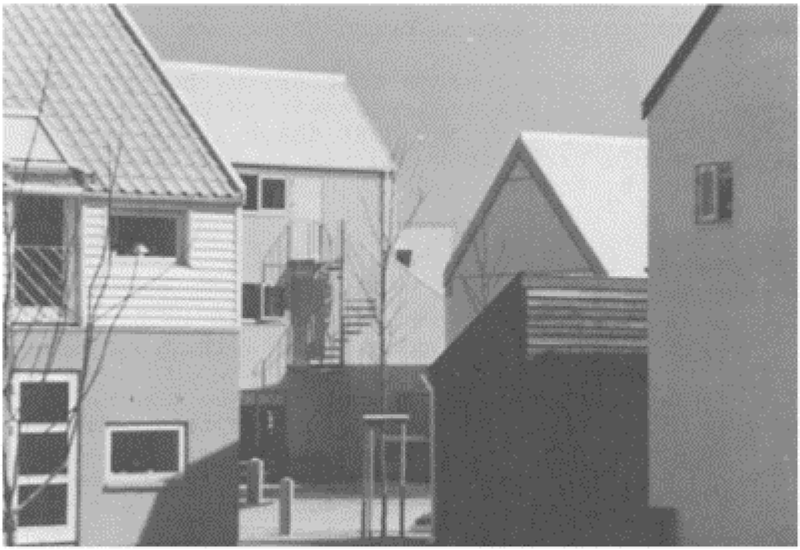
3.10 The tenth step—the operating manual forms the basis of the operation of the building

Concurrently with design and execution stages data are collected for the operating manual which must be available when the building is put to use.

Once completed, the building must be operated systematically in accordance with a plan—the operating manual. This manual must ensure that the operation of the building is planned, budgeted, controlled and implemented in an appropriate manner.

The basis for the manual is the building owner's directions with regard to the building's external appearance, indoor climate and other operational functions, energy consumption and state of repair.

The manual must cover three groups of main operational activities: (1) heating supply, ventilation, etc., (2) cleaning and (3) maintenance and superintendance of the building and its installations.



4. Experience gained in relation to the ten steps

As mentioned above, a large part of the technical quality assurance work done today is not new.

Apparently the steps relating to systematic design work, design reviews and handing over procedures are followed in full in approx. half of the building projects currently under construction. Nobody omits these steps, which could, therefore, also be termed 'old acquaintances'.

However, 30% of today's building projects lacks a supervision plan, a control plan or a designer/contractor dialogue. It looks as if this practice is less well-established.

The worst situation is found in connection with the steps relating to the preparation of QA-manuals and building operation plans. In approx. half of today's building projects, they simply don't exist. Clearly this is an area where the companies need to bring their own houses in order.

The experience gained seems to confirm the general impression that quality assurance within Danish building got off to a good start, but that there is still some way to go before old traditions and new systematic approaches come together to form a whole.

5. Development trends

The two most important development trends in Denmark in the coming years will be implementation and internationalisation.

As mentioned above, 'the ten steps' were the result of a joint effort by the organisations in the building industry, the companies and the public sector. The exercise involved a number of courses where viewpoints, experience gained and wishes were discussed. Thus, the courses were not devoted to teaching alone, but included the building up of an inter-professional approach to quality assurance shared by all actors in the sector, irrespective of the stage in the building process in which they are involved.

The next step has already been taken. It involves a broadening of the teaching activities in the direction of information and training proper. The target group consists of architects, engineers and contractors, down to the last man on the building site. In this way, the coming years will see an increasing demand for teaching and information activities at a number of levels, from the general to the more practical level.

In charge of this educational effort will be institutions in the educational sector, ranging from those offering professional training to the technical universities. In addition, a large effort will be required within the field of vocational training, and here the organisations will have important parts to play.

The second most important main trend in the coming years will be the internationalisation of building quality assurance. The efforts made in Denmark over the last couple of years to improve and develop quality assurance will have to be supplemented through international cooperation.

In Denmark, emphasis has been on the overall building process. The governing idea has been to create coherence and documentation within the quality assurance performed in relation to the individual building projects. Lately, this work has been supplemented with proposals for the certification of systems, products and individuals, motivated mainly by the harmonisation efforts within the EC in relation to legislation, regulations and practice.

This raises questions such as: how do we apply ISO 9000, the international standard for requirements to quality assurance systems, in the building sector? Will we have to have certification of the quality assurance work done by building companies? What does the future look like for the existing Danish control schemes?

It is the general opinion that the Danish approach, as it manifests itself in 'the ten steps', will be of fundamental importance, also in the future. Consequently, an increased use of certification will not render the developed practice superfluous.

Further conclusions are:

> –that building owners must not give preferential treatment to certified companies, and
>
> –that certification of contractors may reduce the need for building owner control of the efforts done by them in relation to quality assurance.

The general impression is that the use of certification will escalate because of international developments. However, there is no doubt that, also in the future, the quality assurance work done by the Danish building industry will be based upon the Circular issued by the National Building and Housing Agency—and, thus, upon 'the ten steps'.

86
Educating for quality in construction and design

J.A.POWELL and P.M.NEWLAND

Abstract
The time of traditional professional training is past. The technology now available enables so much more; the value of experiential education—where learners know the moment, the responsibility and how to act—is the future. In this paper we discuss and demonstrate learning approaches, supported by advanced interactive media, which aim to give emotive and involving experience rather than imitative training. Using such systems construction professionals can learn the deep and broad meaning of quality so that they know how to achieve it for the good of society, the paying client, the using client and themselves.

Keywords: Experiential Education, Advanced Interactive Multi-Media, Construction Professionals, Management, Quality.

1 Acquisition of invisible knowledge

While we often tend to ignore it, in most professional design situations the real problem is usually to know what the real problem is, Rittel and Webber (1973). Our underlying aim in the research reported here was to understand how the quality of British (Construction Engineering) Design competitiveness could be enhanced by the new training technologies. Our use of the verb 'train' in this text may be misleading, since we have in mind neither the one way teacher-to-learner 'chalk and talk' pedagogy, nor the 'imitation' which so often occurs in traditional design training. Rather, we have been investigating the role of interactive media in the creation of appropriate experiential learning environments for use in the area of continuing professional design education. We have found such self motivating interactive learning technologies promote confidence in the acquisition of useful skills and decision making knowledge. Indeed, we intend to demonstrate that the quality of professional decision-making and competitiveness can be enhanced by such technologies.

2 Flaws with imitation—an analogy for understanding

A good demonstration makes explicit the decisions made in the course of any activity. Thus a good demonstration shows students what not to do as well as what to do. Unfortunately, for those trying to learn skilled performance, skilled decision making is usually invisible to observation, Olson and Bruner (1974). This insight from Olson and Bruner hints at two crucial factors we have found to be missing when inappropriate decision-making understanding results from traditional pedagogic training and 'rote' learning, as opposed to emotive experiential learning.

We believe much skilled professional performance, especially decision-making in the face of complexity and uncertainty, has components of actor, stage and script; it often appears to be essentially a set piece. As with acting, introducing any form of training to naive professional learners, which simply instigates mere imitation of set pieces, has two fatal flaws with respect to the knowledge learned:

i. no account can be taken of either change on the stage (context) or in the script (content)

ii. no account can be taken of learners (actors) cultural/psychological nature (timing).

In order to aid understanding let us maintain the theatrical analogy of learning contexts just a little longer. Imagine a naive actor (learner), who has simply 'rote' learned a script, being faced with one of those magical revolving stages whose sets s/he had not seen before. A ninety degree rotation of the stage would produce a totally new set, a novel situation with which our naive (learner) actor would at least feel uneasy. If the script no longer matched the setting what would learners do, since their 'rote' learning would have left them without, either the confidence to create a new script for the novel set, or the experience to ad lib around this anomaly until the previous set returns. Imitation of the skilled performance leaves (learner) actors bereft of truly **useful** tacit knowledge of how to act in the 'wicked real world' contexts which, as Rittel and Webber (1973) point out, both designers and actors so often frequent.

We suggest that, as with our naive actor, without proper timing, the professional will be unable to assimilate skilled competent performance. For, learning through imitation negates the **development of adaptive design ability so essential for real world professional decision-making**. It also spurns the possibility for creative self-discovered knowledge and the requisite variety in design so necessary to enrich our lives in a positive manner.

Looking for a means to overcome these two flaws has served as the generator for the investigations reported here—we believe this is the real training problem for professionals. In particular we seek approaches for creating educational environments which will motivate useful and emotive experiential learning for busy building professionals.

3 Approaches to learning

Accepting the above, our first goal was to tackle the problem of individual preference for the assimilation of knowledge. Various studies including our own (Newland, Powell and Creed 1987), Powell (1987), Newland (1990), Pepper (1942) and Thompson (1981), have looked at the approaches different individuals, including architects, engineers and surveyors, take in order to acquire knowledge (about design and construction) in order to act viably in their practice worlds. Our original research strategy was guided by the seminal theoretical work of Pepper (1942) who argued with adroitness that there can exist only four approaches or strategies for individuals attempting to understand the world they inhabit—only four strategies that permit them to operate in some viable way, thereby allowing a continuous flow of useful sensory input about the world to be structured in their minds, preparing them for necessary and parsimonious action. Pepper believed these world views were generated by a process of structural corroboration, where individuals attain a refined knowledge of reality by continuously testing any new notion against their existing model of the world. Further, *to keep their professional sanity,* he indicated that individuals had to have a strong predisposition to reduce uncertainty and doubt by strictly adhering to those beliefs which support their **one world view,** rather than the views of others. He suggested new understanding only seemed to replace the inappropriate old when a diversity of **personal observations and experience** truly provided a consistent alternative for them.

The particular *strategic action pattern* taken onboard by different individuals has been found to closely relate to the way they approach learning. The field of learning has been extensively investigated by Kolb (1976) who summarised the various approaches open to an individual by a learning cycle, shown in Fig. 1. Kolb's model portrays an ideal situation where the learner has immediate experience of the world, steps back to reflect on this feeling in context, thinks up an abstract model to explain the phenomenon, which is then tested by further active exploration. These doing actions cause the learner to re-sense the world and so begins a new learning cycle.

It might be thought that well balanced individuals would be those who follow this idealised learning circle. For this might reasonably be thought to give them a well balanced view of the world. However, Thompson's (1981) studies indicate that such a fully rounded view may be impossible and even counter productive to real world living, learning and especially complex problem decision-making. His view is based on the observation that in the real world people are not simply individuals learning by themselves, rather they are social animals in continual negotiation with each other—as they learn, act and interact. He, and we, have found that learning is clearly as much a socialisation process as a means of acquiring factual knowledge. Socialisation imposes severe constraints on learning, leading different people to learn in different or **preferred** ways. This itself eventually drives particularly professionals to adopt one of the four different and often incommensurable world views which we portray in summary below and in detail elsewhere, Newland, Powell and Creed (1987).

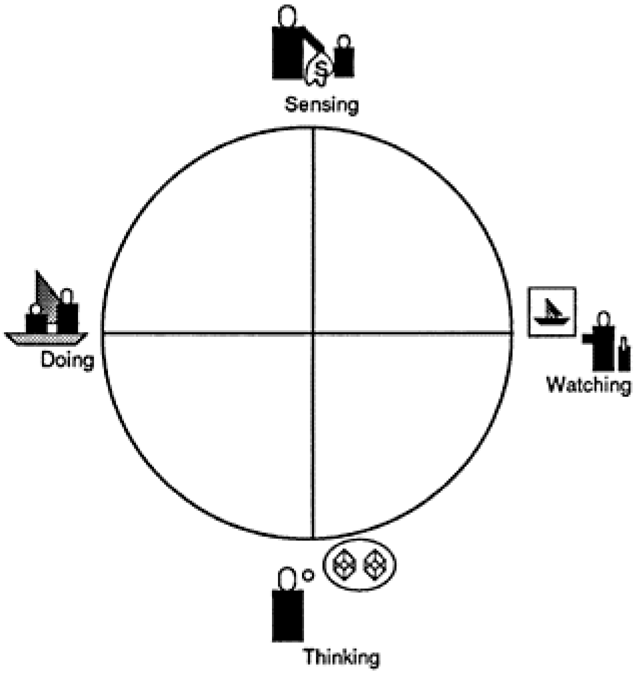


Fig. 1 The Learning Cycle (after Kolb)

In order to cope with pressures of lack of time and resources, decision-makers will tend to *stick* to their preferred learning approach and corresponding action style while practising their professional decision-making. This gives them a secure basis from which to make decisions and we have found they rarely change their approach to learning new ideas—it is not only too much effort, it also drains their confidence. In summary, it appears that all individuals have a predisposition to learn, then think about the world as they see it and finally act in it, using one of four *strategic action patterns,* each is different, independent and recognisable. Powell (1987) has called the four types of learner who portray these underlying traits Dynamics, Focussed, Rigorous and Contemplatives. Let us briefly discuss each of these in turn.

i. Dynamics have an approach to learning which is centred on *doing and sensing*. They are entrepreneurial and innovative, acting for the moment, sensing its potential and doing something about it immediately. It is the dramatic active events in the world which give them motivation and allow them to register understanding. To learn they must be personally involved and if this necessity is satisfied then they are eager for challenges and novelty. By being assertive and individual in their actions they can swiftly switch tack, being entrepreneurial and initiating centres of profit at one moment and, at the next, rapidly creating innovative designs. They seek acclaim for their work. Their risk-taking attitude makes them good copy for glossies and the professional, financial and management pages of national newspapers.

ii. The Focussed concentrate their attention on decisive action. They operate in the world with a down-to-earth approach which is above all practical. Their need to do can often lead them into being campaigners and expounders of alternative technologies and conservation policies. Their *small is beautiful* philosophy may make them reticent to try untested approaches. Instead these people stay with the *safe*, known approach.

iii. The Rigorous understand the world by creating abstract models of it. These models give the rigorous predictive power over the environment. Through assumed knowledge of the underlying patterns from nature these professionals have secured rules that guide them in all their decision making. They stand as the guardians of professional standards and aim to produce regularly competent solutions.

iv. Contemplatives with their emphasis on reflection, may feel no great urgency in real world decision making. Their reluctance emanates from a desire to create the all encompassing solution. To this end they will thoroughly analyse all the data which is at hand and then try to retrieve more in an effort to ensure every angle has been covered.

4 Appropriate tone and interaction

The preceding fourfold of *strategic action patterns* have guided our design and production of information or learning systems which enable the acquisition of useful professional knowledge about different aspects of building design. The important means by which our systems are different from others, but thus become acceptable to busy building professionals, relates primarily to the special ways in which they handle the *interaction* with the learner and especially through the *tone* of the information portrayed to the learner. We place particular emphasis on getting the *tone* of knowledge in the system right as a means of achieving cognitive resonance between any individual and the imagery, learning, interpersonal interaction preference, philosophical basis and social assumptions they naturally seek. Of equal importance is the development of an acceptable acquisition mechanism for the information in the system. For example we believe the visual portrayal of a topic can be either: by a set of still photographs with text annotation; or via a film with an audio commentary; or through self-paced questions and answers; or as audio/visual sequences etc. The mix and style of media presentations provided by any system like film, audio and text will facilitate different self-informing strategies, Jonassen, (1985) and Salomon (1986). The following descriptions indicate the general characteristics of media presentation, tone and interaction relevant for each strategic action patterns.

4.1 Dynamic

The tone of information needed for a Dynamic individual centres around the notion of ‘information transfusion’. In terms of portraying a particular topic, a sense of transfusion is only invoked when a topic is made tangible. Therefore, for these individuals, any topic of information transfer should draw heavily on personal experiences or shared experience events leaving them to weave a description of the topic into their own viewpoint. Dynamics portray their knowledge through their actions, and to be of a matching tone, an information source needs to be similarly active. It appears to us that retelling anecdotes to others is one such active expression used by Dynamics and helps them personalise, retain and find meaning in information. Another acceptable alternative for Dynamics is listening to autobiographical experience from other similar individuals. Taking a topic and describing it by having individuals talk of their personal experience within the topic would encourage the Dynamics to give this information source attention. However, such communications need to be short, for if their interest is not caught then such Dynamic individuals will soon want to pursue their own personal experience of the topic in question instead of taking on board alternative views. Appropriate interactions with information sources would be ones that attempts to facilitate such self-discovery and allow these professional learners to engage in a series of raw and challenging experiences. Interaction, for Dynamics, needs to be novel with respect to both style and access. We have found one useful mode of interaction for Dynamics is setting up a framework of challenges. Such challenges can give a near *real life* quality to involvement with an information source thereby demanding spur-of-the-moment acquisition of knowledge.

4.2 The Focussed

Those who choose to inform themselves by a Focussed strategy seek information that has a ‘tone of transposition’. For this individual there should be provision for practical knowledge both at a general and specific level. For knowledge to be acceptable to these individuals it should be capable of grabbing their attention and being naturally incorporated or transposed into their own normal professional processes. The Focussed engage with the environment in order to understand why processes are as they are. Their philosophy is essentially *small is beautiful* which demands information to be clear cut and have a down-to-earth quality. Focussed individuals are encouraged by, and take an interest in, information which is voicing beliefs of adaption and equilibrium of man with nature. The necessary tone of information required to support such beliefs is only possible with directness and presentation by similar believers. In essence Focussed individuals want to be assured there are others of like mind who support their views. We suggest the best presentation for this learner is an audio/visual documentary style, where a presenter, who comes across as both friend and supporter, gives faithful, step-by-step and coherent guidance on any topic. The main emphasis in such documentary productions would be parsimonious case studies of relevant problems and their sound solutions. These individuals would appreciate an interaction which makes it possible to readily interrupt the documentary style case studies when detailed questions are raised. Such interrupts would give the Focussed opportunity to: review the material presented; enquire about the general usefulness of the topics covered for their present concerns; select particular points in the material for which greater detail could be requested. In essence the aim of such an interaction is to allow these individuals to navigate their own path through a tone of information which is in *good faith* with their beliefs and seeks to provide well-founded guidance on practical issues which is endorsed by respected others.

4.3 The Rigorous

These attain viability through the principle of 'transcribing' codes into practise. Individuals who find this strategy appropriate are those who seek information which reinforces the validity of the rules they already use to guide their action. Such rules are recognised as emanating from authorities. In a similar fashion information which is seen to have been generated by these authorities will also be given credence as well. Therefore, they would be assured by information whose tone implies it is a code or standard practice. Procedural information would also be welcomed for its strength in providing straightforward, economical solutions. An appropriate interaction for the Rigorous is with a stable, historically accumulated knowledge base, on a given topic of precedents which would emphasise the training algorithm of pretest—teach—post-test. In our view Rigorous individuals appreciate being stage managed through an introduction which gives a topic authoritative approval, then delivers a logical set of procedures and finally gives an opportunity to quantify their expertise. In essence Rigorous individuals require formalised knowledge which can be retrieved from a well structured hierarchy of authoritative findings.

4.4 Contemplatives

Our Research shows that those who choose to adopt a Contemplative strategy are interested in a broad spectrum of information. For them a comprehensive montage is necessary to adequately support their desire to accumulate a mass of knowledge which is sufficient to allow them to transcend a unifying principle. These individuals are given confidence through having access to a wide range of primary information sources. Though they are willing to listen to others' opinions, and summaries of primary sources, they much prefer delving into the unedited data and drawing their own conclusions. Unlike the Focussed approach, commentaries which in anyway preempt the Contemplative arriving at their own conclusions would be a low priority option. Contemplatives would prefer to self-pace themselves through annotated high quality visual stills and be given access to comprehensive references and global views of a topic's causes and effects. In essence these individuals are seeking the means to undertake an integrative analysis of a topic and a welcomed information source would need to divulge uncensored data and incorporate guidelines to unify the known facts.

5 Technological facilitators

Embracing the above scenarios has lead us to investigate information technology which facilitate educational environments allowing responses on a bespoke basis to at least four different types of user. We have already completed the development of one such information system which presents information on energy conscious design from four perspectives and aims at engaging individuals of any strategic action pattern preference Newland, Powell and Creed, (1987). This is accomplished by use of interactive videodisc a medium which allows a pictorial base of film and stills to be instantly sequenced and re-sequenced by the learner. The context from which such visual imagery is presented can be easily manipulated, extended by multi-track audio, integrated with text and combined with an overlay of computer generated graphics. The effectiveness of this information system for busy building professionals is currently being comprehensively tested under an SERC grant.

Recently we have been able to refine our learning/information system using Apple Macintosh series II computers extended by the addition of transputers and real-time video digitising boards. These hardware improvements have enabled us to make more responsive educational environments to support specific strategic action patterns.

The following detailed description concerns one educational environments we are currently developing using this refined system. This system along with the energy package mentioned above will be demonstrated at the conference for those interested.

6 Demonstrable environments

The experiential environment described now is not aimed at construction professional alone, however, it does relate to an area of considerable importance in finished structures, namely general quality in design; topic should clearly be of much interest to those at the present conference. The demonstration will also portray the possibilities of state of the art interactive technology. As such the techniques involved in their creation are easily adaptable to any profession which requires attainment of adaptive competency in its members.

7 Case Study—QUALITY; My definition

7.1 The need

At present their exist in Britain well over five thousand small to medium architectural design practices who need to quality assure their design work if they are to remain viable against large scale firms as we enter Europe in 1992. There are also similar numbers of Building Services Engineers, Structural Engineers, Builders etc. who are also realising they need to know how to present their services as being assured quality service. In future we believe their professional status, face validity and continuing practice depends on projecting an image of quality and competency. Many have begun to think of adopting the “Quality Assurance” British Standard B.S. 5750; this in turn is causing them to ask questions about the nature of the **quality** they should strive to achieve in their building design work.

It is clear that different parts of the construction industry have very different views of what quality is needed and indeed what is achievable. They have such different views because they come from very different cultures, each with its own definition of quality, how it is perceived, when it is required and what factors are involved in its attainment.

We believed an interactive videodisc, improving cross-disciplinary understanding of quality, would also be a benefit to the industry in general because it would initiate a collective appreciation of the need to know how quality should be defined.

7.2 The problem in greater depth

In order to gain an understanding of different peoples strategies for attaining quality design, it is important for those managing design projects to have a clear, reciprocal awareness of what each active participant involved in the design process means by quality. At present quality is a noun looking for appropriate adjectives. In the round table design discussions normally associated with most early phases of designing, each participant of a design team, and even the client, can bring their own particular and idiosyncratic view of quality to bear. In many cases they will not be sure themselves what they mean by quality. The project manager should somehow experience that *quality* before it all too easily becomes a catch all noun to represent many facets and contradictions that can be left undefined.

7.3 The solution

Through the use of a MacIIx equipped with a video digitising board and CD-ROM/ videodisc storage sources a one screen mouse controlled environment is being created giving learners access to a montage of information on designed artefacts portraying very different aspects of quality of nine well-known artefacts to the British consumer. A changing array of menus gives access to the views, thoughts and expressions on quality, from architects, engineers, and product and fashion designers, about these artefacts, which are shown diagrammatically in Fig. 2 below.

Fig. 2—Designed Artefacts presented on the Quality Videodiscs

The Lloyds Building; A Z88 Portable Word-processor; A Jaguar Car; The

Thames Barrier; The Tate Gallery Extension; A Kneeling Chair A JCB Digger; A Heinz Tomato Ketchup Bottle; A Walter Segal House

Filmic vignettes of impressions of quality and a database of Design Council award products are also open to interaction using a unique hypermedia interface. Designers using this package can explore their personal definitions of Quality without recourse to manuals of Quality Assurance, or to the design of a completed artefact. The highly interactive nature of the package enables a wide range of impressions to be gathered in just one session, and for detailed feedback and reinforcement to be given through the use of Agree/Disagree choices and the "my words" window. A wide range of design precedents have been gathered into one system so that designers can establish common themes arising in the material and identify differences in approach.

Hypermedia systems are still in early stages of development, particularly in the context of the flow of information to suit individual requirements, and the underlying communication protocols. The package we are developing is one of the few systems to be built within a multi-windows Hypertext style environment, and as such it breaks new ground in the field of information delivery which will be of benefit to all researchers working on interactive information retrieval systems.

The agreements or otherwise, of those interacting with our information system, are constantly stored and participants find themselves negotiating their own perception of quality which is summarised for them when they leave the package. The environment can also act as database of raw information appropriate for a more Contemplative individual.

7.4 The effectiveness

Students within our own Faculty, industrialists, managers and designers have found their use of the package illuminating and rewarding. All find they are familiar with at least one of the key artefacts and the range of comments accessible for each artefact is often surprising and an inducement to constructive discussion with colleagues when they have finished using the system. They leave with a clearer understanding of their own perception of quality and many comment that the experience encourages them to seek out the opinions of others on this concept. We have also seen that participants become more aware of the nature of language and the creation of definitions as a social construct. The design process itself then benefits from this heightened understanding that negotiation of as many viewpoints as possible to achieve an agreed design objective(s) is a fundamental basis for quality design.

8 Conclusion

We believe better quality in building design, as well as an edge in competitiveness, is achievable if individuals can forge their understanding in experience rather than having it formatted as training. Use of our systems seems to aid deep design understanding and thus decision making skills in building professionals: their capacity for immediately knowing the right actions to take when faced with novel situations is undoubtedly improved. The demonstration at the conference will show that interactive videodisc technology is approaching a quality where support for experiential processes is possible.

9 References

Rittel, H.W.J. and Webber, M.M. (1973) Dilemmas in a general theory of planning. **Policy Sciences,** vol. 4, 155–169.

Olson, D.R. and Bruner, J.S. (1974) Learning through experience and learning through media, in Media and Symbols: the forms of expression, communication, and education. The 73rd year book of the National Society for the Study of Education (ed) Olson D.R. The University of Chicago Press, Chicago.

Pepper, S.C (1942) World hypotheses. University of California Press, Berkeley, California.

Thompson, M. (1981) Beyond self interest, a cultural analysis of risk, WP-81–17 IIASA.

Newland, P.M., Powell, J.A. and Creed, C. (1987) Understanding architectural designers' selective information handling, **Design Studies,** vol. 8, no. 1, 1–17.

Newland, P.M. (1990) Understanding the Knowledge Acquisition Processes of Architects, Unpublished C.N.A.A. Ph.D Thesis, Portsmouth Polytechnic

Kolb, D.A. (1976) The learning style inventory technical manual. MacBer, Boston, USA.

Powell, J.A. (1987) Is design a trivial pursuit, **Design Studies,** vol. 8, no. 4.

Jonassen, D.H. (1985) Learning strategies:- a new education technology. **Programmed Learning and Educational Technology,** vol. 22, no. 1, 26–34.

Salomon, G. (1986) The use of visual media in the service of enriching mental thought processes. **Instructional Science,** vol. 9 327–339.

87
LNEC mark of quality—a global approach for building quality management

A.RAVARA

Abstract

The basic concepts of the LNEC Mark of Quality, put in force through a Decree-Law issued in October 1990, are presented. The mark creates a global certification process for construction works that includes all their relevant phases, namely the quality of design, materials, components and of the construction itself.

Three entities are involved in the certification process:

LNEC as the technical and legal authority for issuing the Mark;

The Owners of the Works as entities benefiting from the Mark;

The General Quality Managers, who are qualified by LNEC to perform for the owners of the works the technical actions required to obtain the Mark.

The role of those three entities and the procedures implied for the granting of the Mark are summarized.

Keywords: Building Quality Management, Mark of Quality, General Quality Manager, Owner of the Works.

1 Introduction

To support the development of the construction sector, as needed by the pressing demands of evolution and adaptation within the framework of Portugal's full integration in the EEC, has been a strong national priority.

Accordingly, raising the quality in the various domains of activity of the sector and, in particular, at the various levels of the overall process of carrying out building projects and public works, appears as one of utmost importance.

It has therefore been considered opportune to extend the effort that has been made to create the conditions required for generalized adoption of procedures as regards certification, namely in the area of construction products, including the granting of quality mark—this matter has, in fact, been the object of the Community Council Directive No 89/106/CEE—as well as the certification of the actual construction works considered, in an integrated manner, as final products of the whole construction process, taking into account the respective social, economic and technical enhancement.

Within the framework of the national system for guarantee of quality in construction, which it is necessary to improve and develop, the Laboratório Nacional de Engenharia Civil (LNEC) is specially suited for carrying out measures of this kind.

Therefore a Decree-Law (1) has been issued laying down the procedures to give the owners of works access to the complete certification of their projects, by the Laboratório Nacional de Engenharia Civil of the LNEC Quality Mark. The Decree also creates a system of qualification, for which LNEC is responsible, for the entities able to act as General Quality Managers.

The following paragraphs summarize the main features of the Decree.

2 Aims and benefits of LNEC Mark of Quality

The Mark objectives are:

a) Full implementation of a general pre-established quality assurance plan that will be conductive to effective compliance with the applicable contractual and legal conditions and regulations and technical specifications which envisage compliance with the essential requirements, and to following the correct rules of the art, in executing projects;
b) Higher standards of execution as regards the requirements laid down, particularly in respect of functionality, durability and safety;
c) Reduction of the risk of damage associated with the project and, especially, of the risk inherent in potential anomalies that may occur in the construc-tion process;
d) Conditions tending to reduce any professional indemnity and/or construction insurance that may be concerned.

3 Type of projects eligible for the award of the Mark

All the works carried out by public bodies as well as all those that are subjected for municipal approval can be awarded the Mark.

According to the Portuguese Law (2) construction works are classified in four main categories:

Buildings and monuments;
Transport and urbanization works;
Hydraulic works;
Special installations

each category being divided in classes according to the cost of the work.

4 General requirements for granting of the Mark

As aforementioned the three entities concerned in the certification process through LNEC Mark of Quality are:

LNEC as the technical and legal authority for issuing the Mark;

The Owners of the Works as entities benefiting from the Mark;

The General Quality Managers, who are qualified by LNEC.

The basic requirements for granting the Mark are thus the following:

Appointment, in due time, by the owner of the work of a competent entity within the framework of guarantee of the quality of construction, with contractual functions of overall control of the quality of the project, already registered at LNEC and qualified by that institution as a General Controller of the quality of works and whose classification is adequate to the project concerned;

Preparation by the General Controller of the quality of works of a general plan of assurance quality, including all the aspects involved in execution of the project, such as promotion, design, execution, materials and components, subsystems and equipment, and its approval by LNEC;

Statement of conformity, testifying to compliance with the contractual and legal provisions and regulations and technical specifications that are recognised to ensure compliance with the essential requirements, as well as the correct rules of the art, in executing to work, issued by the General Controller of the quality of projects on completion of the work and duly ratified by LNEC.

5 Special duties of General Quality Managers

The General Quality Managers are responsible, apart from the duties refered in the previous paragraphs, for compliance with the following:

Provisions of the law and regulations that are applicable and forming part, namely, of the list published by the Ministry of Public Works, Transports and Communications, in aggreement with Articles 6 and 25 of Decree-Law No 166/70 of 15/4/70.

Contractual obligations to the owner of the work by the parties participating in the project.

Standards and other technical specifications which are envisaged by contract.

Observance of the correct rules of the art in execution of the work.

Obtaining approval of LNEC as regards the use of any technical control entities to whom he may delegate specific tasks of control of quality, such approval being given case by case until there is functioning a system for registration and classification extended to technical control entities with specific scope.

Adoption of those orientations that may in due course be envisaged by LNEC for development of the control process and defined on the basis of available information or suggested by visits to the work by members of LNEC technical staff.

Preparation in due time, of interim and final reports concerning his activity, containing the respective conclusions, namely reports on quality control at the levels of promotion and design of the work, reports on control during the execution stage of the work, at monthly intervals, and a final report on the overall control activity carried out.

6 Qualifying of General Quality Managers by LNEC

Eligible for registration and classification as General Quality Managers are all technical control entities that make application to LNEC, indicating the categories and classes that they wish to obtain, and show that they meet the requirements as regards suitability and technical capacity.

The technical capacity of the entities is assessed according to their present and past activity, the curricula of their permanent technical staff, their organizational structure and dimension of their means of action, including specialized personnel and equipment. The impartiality and professional deontology of their administrative and technical staff is also appreciated.

The prerequisites referred to in the preceding numbers are evaluated by a committee, set up at LNEC, on the basis of documentation submited by the applicant entity and any other information that may be required.

The committee specifies the categories and classes of works the General Quality Managers are entitled to act.

The qualifications are periodicaly revised on the basis of professional services on behalf of the Mark as well as on possible changes of legal and technical capacities. Subsequently the categories and classes are up-dated

7 Charges and costs related to the Mark

General Quality Managers are subject to a registration charge proporcional to the value of the works for which they are entitled to act.

The owners of the works must freely contract with General Quality Managers their services. Besides they must support a cost, payable to LNEC, for the granting of the Mark, propotional to the design fees established in the Portuguese Legislation for Public Works (5).

8 Final considerations

The LNEC Quality Mark for Construction Works, starting at 1991, intends to fill an important gap in global quality management. The reaction of the technical comunity to this initiative has been so far very positive and it is hoped that the Mark can be extended to other countries, with the necessary adjustments.

8 References

1) Decree-Law no 310/90, Oct. 1st, on LNEC Mark of Quality

2) Decree-Law no 100/88, March 23rd, on Public Works and Civil Construction
3) 1st National Meeting on Quality Construction, LNEC, Lisbon, June 1986
4) 2nd National Meeting on Quality Construction, LNEC, Lisbon, June 1990
5) Instructions for Design fees in Public Works, Minister of Public Works, 1973.

88
Flexible industrialization in the individual private housing sector

O.ROLAND

Abstract
The purpose of this paper is to analyze the evolutionary trend in offers proposed by builders of individually-built private homes. The issue of the conceptional design of houses is consequently raised, and an analysis of how this demand is being expressed is provided. At a time when the Public Housing sector is experimenting with sequential and performance-oriented processes, and there is a growing development in the use of diverse components, the individually-built private housing sector reflects an original approach regarding innovation policies.
Keywords: Innovation, Products, Processes, Housing, Supply Strategies, Industrialization.

1 Introduction

In the individual private housing sector, the 1980s reflected in France an abandonment of heavy prefabrication (the structure), a homogenization of technical choices (products, materials), and a diversification in architectural design and engineering.

From this confrontation between homogenization and diversification emerged a flexible industrialization driving force which, if it did not foreshadow, at least challenged the innovation perspectives of the technical and quality management policies affecting the entire housing sector in France and probably in Europe.

2 From boom to crisis

In the 1960s, the boom that shook the individual private housing market permitted the emergence and development of catalog-listed houses and the establishment of a concentration of national contractors intervening on the market as true builders.

From a limited series of typical models these builders developed their own specific prefabricated processes for the housing structure in a closed industrialization logic rationale.

And, on account of the development, distribution, and growing momentum of industrial products available on the market in an open industrialization logic rationale, there emerged in the early 1970s a growing trend which fostered the belief that the prefabrication approach for a home product typified to the extreme and reproducible in large industrial series could in the long run be reduced to three man-years for the installation on the site and no longer for production.

The combination of technical, economic, and social changes encountered during the 1980s counteracted this ambitious technical/industrial venture.

3 Abandonment of prefabrication

High credit costs, rising land prices, and restrained purchasing power have caused during this last decade a drop in the overall activity in the building field.

Although a stabilization and then rebound in activity closed the 1980s, this effort benefited public housing to the detriment of individual private housing.

The unfavorable world economic situation provoked tough competition between builders, on the one hand, and between builders and small local contractors, on the other.

To stimulate recovery by turning to the least fortunate financially, Government provided financial assistance in the development of the expandable home by offering a package deal of “buy now pay later” loans payable in successive installments.

A gradual swing in the market toward the medium priced home segment was also recorded: that segment where the demand is strong but more demanding in terms of quality and personalization for a home product.

The convergence of these two phenomena rendered obsolete the prefabricated processes used by builders for the housing structure because they prevented the implementation of the expandable home approach, as well as the personalization of the architectural design.

As a result, the “technical channel” (centralizing the distribution of fluids) that had been thought integratable in the structural elements prefabricated in the factory also fell under attack.

4 Homogenization of technical choices

In this global evolutionary context, a growing homogenization of technical choices (materials and products) began emerging in 1985 involving all categories of home builders, in particular, national, regional, and local builders alike.

This was reflected through the practically systematic and uniform use of:

– traditional brickwork (bricks and cement)
– industrial framework (trusses)
– woodwork

– plaster sheets and plaques for walls
– branched electrical installations
– electric heating

This homogenization resulted in: (1) the abandonment of prefabricated construction processes; (2) the gradual distribution of industrial components and products from builders and multiregional contractors; and (3) the pressure imposed by the demand for certain materials (traditional woodwork and wood products), symbolizing in the eyes of the home buyer the strength and durability of his or her home.

5 Diversification of offers

The homogenization of technical choices faced with a growing demand for better home quality and personalization was concretized by a search for greater flexibility in offers and intervention modes on behalf of builders.

Although builders (regardless of their size) could operate a few years ago with a limited number of models (five to 15), today they are proposing 50 or more. But these 50 models represent the bases upon which multiple variants will be incorporated, furnishing 400, 500, or even 600 components of products with their own specific technical features.

With the development of computer-aided design and documentation (CAD) initially implemented by big builders, but now within the reach of a growing number of regional and even local builders, a full complement of components (1,500 on the average) can not only be easily combined, but also allow getting work done faster on a structure. In less than 15 minutes a builder equipped with this capability can propose to a customer an extremely accurate cost estimate, millimeter-precise blueprints and floor plan, integrating all the builder’s possible services and the different price ranges.

Home building options, like appropriate sizing and personalization, are important not just at the architectural level and the design of models: frontage clearance, high- or low-pitched roof (1), combination of interior spaces, size and surface of the home (see above).

In fact, home usage linked to life styles and the habitat (2) also implicates a personalization of the home product at the installation level: electrical installations, heating, plumbing.

Actually, most builders offering a catalog of housing products tend to direct the customer as close as possible to the models typified by the customer’s income segment during commercial talks.

It is this “give-and-take” relationship arising between the confrontation and negotiation of offers and customers that one can focus on the point where the challenges of home product personalization crystallize.

Although builders still propose in their typical models (at any rate in the low and medium price ranges) grouping together “damp” rooms (bathroom, kitchen, toilet) in order to save money on the linear length cost of pipes for plumbing and to simplify the electrical installation, the home buyer with the financial backing will “explode” this damp room block into a different type of zoning arrangement. Zone 1 will accommodate the “private life” space, comprising the bedroom(s), the bathroom, and storage space. Zone 2 will incorporate the “common living”, “visitor”, and “friendly exchange” space, comprising the living room, the kitchen, and the entrance. The toilet(s) are most often located between these two zones (see Figures 2, 3, and 4).

In addition to these architectural requirements, customers for catalog-listed, individual private homes highlight the more and more complex and diverse requirements regarding, in particular, sanitary and electrical installations: power outlets, number of outlets, number of water taps, etc.

As these two phenomena overlap, it renders the use of a centralized and standardized technical channel for connections dissuasive. Some builders find it advantageous to entrust to their subcontracted electricians or plumbers the responsibility of mounting the connections in the shop. This amounts to personalizing the number of connections in the shop, as well as the number of wires and their lengths as a function of desired power ratings.

This might also prove to be a good opportunity to foster new relationships with the subcontractor and eliminate resistance to industrial components, often not attractive to those who tend to favor the know-how of a traditional profession.

Moreover, the personalization of connections can impose such a breakdown of product series, thereby inciting some builders to exploit the capability of CAD as rapidly and as closely as possible with the connections to be actually realized.

Some small builders have hurtled an additional obstacle by making appropriate investments in tooling so they can design and manufacture their own branched electrical installations on an individual home unit basis.

6 Toward flexible industrialization

From the confrontation between the offer (model policies, and product and component homogenization) and the demand (personalization requirements) has emerged a new equilibrium in concert with permanent negotiation, permitting a renewed evaluation of customer requirements.

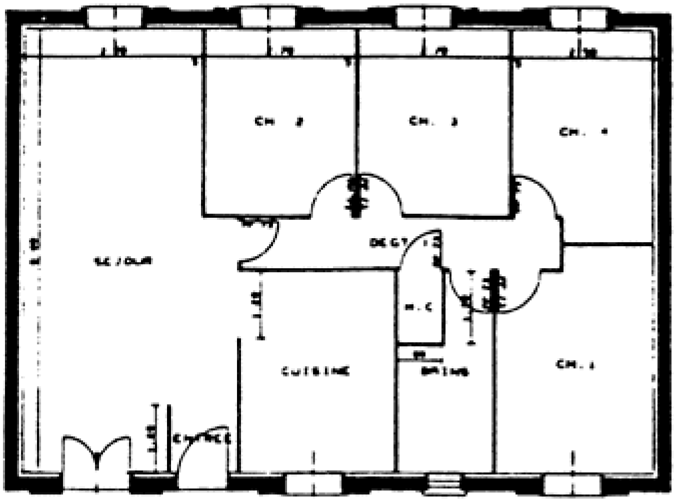
It underscores the end (today) of prior hopes for the development of large-series prefabricated processes specific to enterprises or available on the industrial market.

10 years ago one could imagine that the end of the 1980s would hallmark the development of a technical channel that would distribute electricity and plumbing manufactured in large series, that is, workarea tasks would be totally transferred to the factory.

Since neither closed industrialization (integrated prefabrication and construction systems) nor open industrialization (industrial components produced in large series) have proved tenable, the individual private home sector seems to be championing a flexible industrialization driving force: the development and use of industrial components and kits realized in small series.

This driving force, which is specific to the cataloglisted individual private home, foreshadows perhaps what might became a housing offer designed and produced “à la carte” (like in a restaurant), plunging the building sector straight into the era of industrial service offers.

FIGURE N° 2 : PLAN TYPE 102 m²



between these two typical models extract from one builder's catalogue, the difference consists in similar extending of plan: the bedroom 1 of the first plan has been made into a garage

FIGURE N° 3 : PLAN TYPE 117 m²

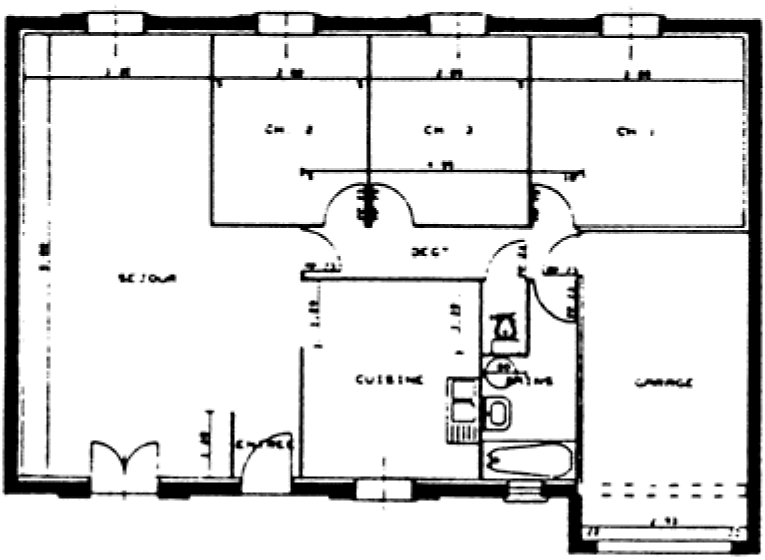
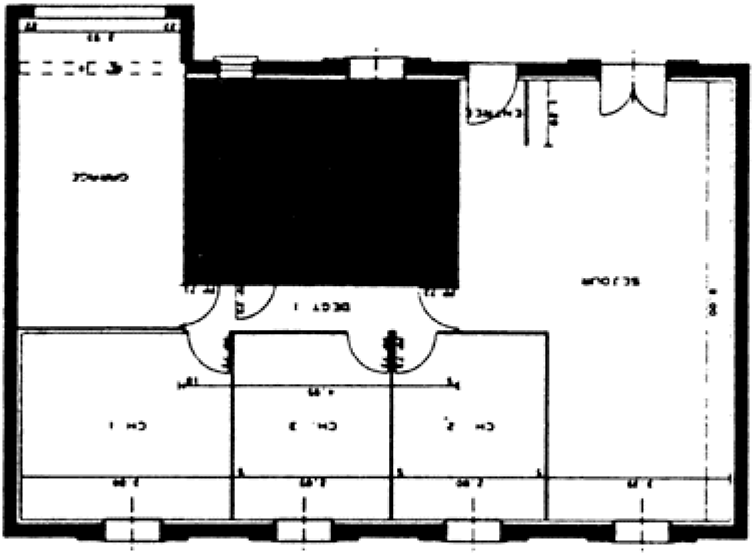
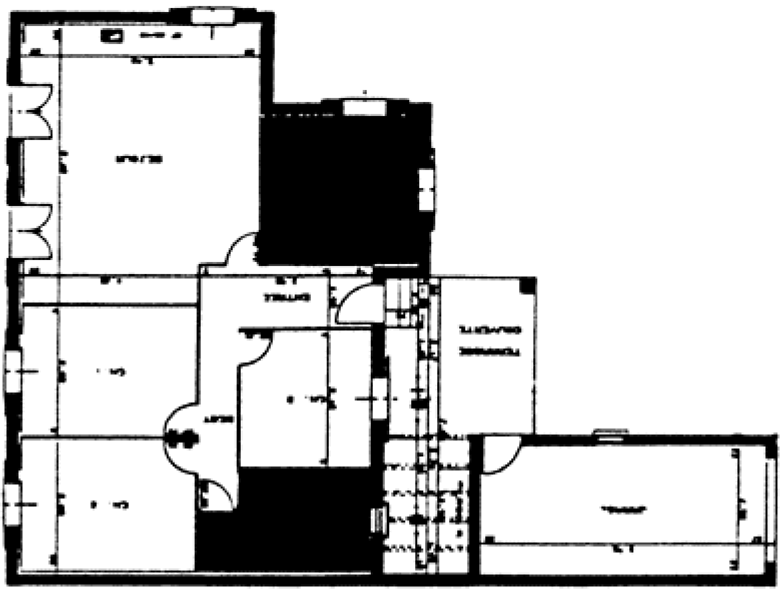


FIGURE N° 3 : PLAN TYPE 117 m²



the personalization has caused the separation of the bathroom and the kitchen

FIGURE N° 4 : MODELE PERSONNALISE



89
Problems encountered in plan evaluation

R.ROSCELLI and F.ZORZI

Abstract
This paper compares three evaluation techniques applied to a plan of urban regeneration in a district in the outskirts of Turin. The Analytic Hierarchical Process, concordance/discordance and regime analyses were compared to test the reliability of procedures, highlighting how they can be applied and how they differ.
Keywords: Plan Evaluation, Analytic Hierarchy Process, Concordance/Discordance Analysis, Regime Analysis.

1 Introduction

The aim of this paper is to compare the three methods of evaluation by applying them to the same case with the same data input. The result of each procedure was evaluated by testing the requirement for the case and result comparability.

In fact by extending the use of these techniques to the qualitative assessment of plans and area action or intervention plans one has to select the technique best suited for the case.

Due to the increasing number of multicriteria techniques and their degree of sophistication analysts have to choose a technique among many available to them (Voogd, 1983).

The procedure dealing with the strictly quantitative, economic aspects are more established so that choices can be more informed and straightforward. Furthermore they are not as complex, while the results of qualitative analysis may not be as satisfactory (Misham, 1974; Graziani, 1987).

The results we obtained with the three techniques were in agreement which per se is not so surprising since the initial weights attributed to the criteria were the same. However, what is more important is that if these analyses had to be carried out separately by different analysts, the results might have differed on the basis of the initial hypothesis.

This proves the extreme importance of the initial phase when the analysis is set up, especially in the case when value judgements are required because of the wide margins of discretion in this case.

The following techniques were compared: Analytic Hierarchical Process (AHP) (Saaty, 1980; Saaty and Vargas, 1982), concordance/discordance analysis (Roy, 1985), and regime analysis (Hinloopen, Nijkamp and Rietveld, 1983; Fusco Girard, 1989).

These three methods were selected because of their ease in application, especially for interventions or area action plans where criteria are prevalently qualitative (Roscelli, 1990).

The vector for weights for the first method (AHP) was also used with the other two methods since AHP offers a more accurate and detailed weighing of an issue.

2 Case description

Effective regeneration in integrated projects requires multiple sources of finance and investment, coupled to a good level of coordination between private and public funding.

The case in question takes the above requirements as a starting point in so far as its avails itself of funds from several sources. The aim is to indentify a hierarchy based on a series of predeterminated criteria.

The district belongs to public agencies and is located in the Northern outskirts of Turin. The initial plan was part of a more comprehensive plan for Council or Public Housing covering 16.70 hectares. The area shares the features of so many other districts in the outskirts: separate from the rest of the city, with visible remains of its previous agricultural economy; its road lay-out differs from Turin's characteristic right-angled chequered pattern that starts just a few blocks away.

Currently the district has 2 seven-storey buildings in a row, and 16 eleven-storey tower blocks built in the early 70s, totalling 875 units and roughly 4,500 residents.

The area has schools and places of worship but lacks shopping, business and service centres. Regeneration is called for both to refurbish and renovate existing properties as well as to deal with a declining environment and social habitat caused by isolation.

The plan has identified several steps leading to a functional regeneration while developing the area's "identity". The process has to be related to the needs of the residents (participation and information); to the needs of the body that owned it (IACP=Istituto Autonomo Case Popolari, the self-governed body that manages Council or Public Housing), that also happened to be our client, and to the needs of all concerned parties and agencies such as Local or Municipal Governments. Furthermore both the legal framework and the availability of funds were considered.

A multi-faceted approach was deemed necessary to upgrade living standards and favour the integration of the district with the rest of the city. The project included: a new road lay-out, improving road connections with other districts, creating areas for crafts, small enterprises shops and businesses, as well as cultural and leisure services. Further projects for green areas and car parks in the district were also considered, as was the expected increase of residence in neighbouring districts.

The plan has all the ingredients of an integrated approach to urban regeneration requiring both public and private action with a view to making it a more liveable district (Zorzi, 1989).

Simulation were aimed at testing the plan's feasibility, the object being that of identifying an optimal "balance" among sources to regenerate the district effectively (Roscelli and Zorzi, 1989).

3 Procedures

As stated, three distinct evaluation procedures were used (Roscelli, 1991). Because of its lenght, this paper will only be outlining the procedures.

AHP is an analytic hierarchical process which classifies elements according to a given order and does so by comparing variables two by two, according to criteria, subcriteria—if any—and alternatives; the solution is obtained using a rather small matrix (made of a value judgements expressed as real positive numbers from a nine point series). The method is also known as the eigenvalue since the end result is a vector of priorities among the available alternatives.

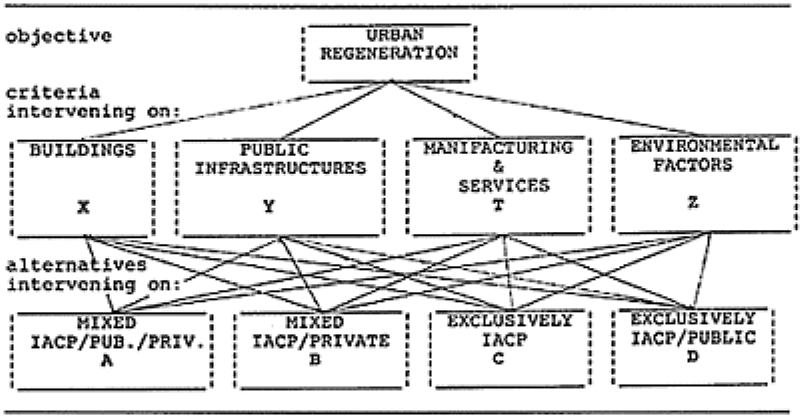
The concordance/discordance analysis is a method used with non comparable criteria and which bear a different importance in terms of the decision or result. Alternatives can be ranked according to their response to a series of point of view, and the best fit can be identified. The procedure is based on the calculation of a concordance index (=the prevalence of one alternative over the other in relation to all or most criteria), and of a discordance index (prevailing of the second alternative over the first one in relation to a given number of criteria). Procedures are then followed to compare indices and interpret results correctly.

The regime method proceeds by comparing alternatives two by two within an impact matrix (J*I) to create vectors indicating preference for an alternative. These vectors are then used to produce a "regime matrix" containing + and − signs only, of a J*I(I−1) order. A subsequent calculation of probabilities focuses on the dominance of each alternative in relation to all others produces the final order of alternatives.

4 AHP application

In the course of our first AHP application a hierarchical system was developed. An initial set of criteria can be obtained by analysing the said system in relation to the general objective—that is the fulfilment of the plan's objectives. A second level can be developed by analysing possible alternatives, as shown in Table 1.

Table 1. Plan feasibility: conditions Steps: objecive—criteria—alternatives



Four variables were taken as criteria for a "comprehensive and global urban regeneration": buildings **(X),** public infrastructures **(Y),** manufacturing and tertiary **(T)** and environmental **(Z)**. The various interventions required by the plan can now be listed under homogeneous categories.

Specifically, refurbishing and renovation of existing residential housing stock as well as building new houses come under the heading "building interventions"; "public infrastructures" stands for both facilities, roads, etc. (urbanisations) and the creation of services missing in the district. The third variable (i.e. manufacturing and tertiary) was introduced because of the great importance these factors play in the plan in question. The last of the four variables, "environment" accounts for urban furnishing, green areas and empty spaces in the context.

Criteria and the subsequent alternatives were consistent with the initial objectives of the plan. However, at the time costs had been allocated indifferently to one or the other of the parties involved (IACP, Local Authority, private sector) leaving the actual sharing out of responsibilities and spending to be determined subsequently.

Specific projects within the plan may be developed by one or the other of the parties without it making any substantial difference. The combined presence of public and private investors and the resulting mixed finance channels, leads us to consider the funding combinations as four alternatives in the initial phase. Since the district is publicly owned, it has been suggested the owner, the IACP could act jointly with other public bodies and with private sources (first alternative **A**), or solely with private capital (second alternative **B**), on its own or jointly with other public bodies (alternatives **C** and **D**).

The content of the project is not affected by the possible connections between objectives and alternatives and remains in its initial form. Optimal conditions for implementation are sought with regards to the various combinations of sources available.

AHP is applied by creating a matrix and then weighting the first level variables two by two, with reference to the main general objective, that is urban regeneration. Four new matrices are then defined with variables contained in the lower level alternatives, each time taking a variable from the upper level as a criterion.

The score for each criterion and/or alternative are based on the information and data accurately obtained from the project.

Maximum eigenvalues were then calculated for each matrix with their relative eigenvectors, and then normalised. Mathematical operations then led to preference vectors.

Furthermore, the consistency ratio (CR) was calculated for each matrix; CR acts as a reliability indicator for the matrix itself.

Matrix 1. Objective: Urban regeneration Assigned weights CR: 0.0169

	X	**Y**	**T**	**Z**
X	1	1/3	1/4	1/4
Y	3	1	1	1/2
T	4	1	1	1/2
Z	4	2	2	1

The weights used for the matrix range from 1 to 9 and their reciprocal values. The environment factor it has been given a slightly greater weight than both infrastructures and manufacturing & services since it was considered the single most important non-residential variable in relation to the attainment of the objective, although the difference with the others is not so great.

Here is the vector for the weight of the criteria; it is subsequently also used for the application of the concordance/discordance, and the regime methods:

X	–	Intervention on buildings	8.20%
Y	–	Intervention on public infrastructures	23.40%
T	–	Intervention on manufacturing & services	25.50%
Z	–	Intervention on the environment	42.90%

Matrices 2, 3, 4 and 5 refer to the identified alternatives which are weighed using each one of the second level variables as a criterion. Weight determination also took into consideration hypothesised expenses defined in the project phase which make it possible to evaluate the relative importance the presence of each economic actor (IACP, local authority, public or private) had in determining the success of the intervention.

Matrix 2. Criterion: Intervention on Buildings. Assigned weights CR: 0.046

	A	**B**	**C**	**D**
A	1	1	4	3
B	1	1	3	3
C	1/4	1/3	1	1/3
D	1/3	1/3	3	1

Matrix 3. Criterion: Intervention on Public Infrastructures Assigned weights CR: 0.069

	A	B	C	D
A	1	7	9	1
B	1/7	1	4	1/6
C	1/9	1/4	1	1/7
D	1	6	7	1

Matrix 4. Criterion Intervention on Manufacturing & Services Assigned weights CR: 0.084

	A	B	C	D
A	1	2	8	7
B	1/2	1	8	6
C	1/8	1/8	1	1/4
D	1/7	1/6	4	1

Matrix 5. Criterion: Intervention on The Environment. Assigned weights CR: 0.055

	A	B	C	D
A	1	5	6	2
B	1/5	1	3	1/4
C	1/6	1/3	1	1/4
D	1/2	4	4	1

According to the assigned weights, the preference vector obtained for the four alternatives will define the following ranking order in relation to the overall objective, that is urban regeneration.

A	–	Mixed intervention	48.68%
B	–	IACP/private intervention	19.20%
C	–	IACP intervention	5.47%
D	–	IACP/public intervention	26.65%

The significance scale of the alternatives clearly places the mixed intervention first (IACP, private and public economic actors), followed by IACP and other public funds and then by IACP with private actors. The IACP only solution appears not to bear much weight.

The hierarchical order of the results comes as no surprise and is altogether consistent with the premises: what is important is to notice the percent weight the funding/expence channels bear.

5 Application of the concordance/discordance analysis

The analysis of the concordance/discordance indices obtained from the application of criterion weihts inferred from the AHP, highlights the “absolute” preference for alternative **A**. In fact alternative **A** does not display any discordance, since its results is always preferred, and the sum of the total concordance index is greater than any other (3.00 points).

The worst alternative (alternative **C**) is also very clear cut: as well as displaying the highest discordance value, it does not obtain any concordance and the index is equal to 0, that is to say, when comparing pairs it always fares worse.

The position of the two other alternatives, **B** and **D,** appear to be less clearly defined. Alternative **D** can be identified as better than **B** since its level of concordance is higher (1.66>1.34) and that discordance is lower (68.5 <70.6). However, the highest value of **D**’s discordance index (compared to alternative **A**) is higher than **B**’s (compared to the same alternative), that is 42.6>38.9.

In choosing between the two one might have to give it some thought, especially in view of this last element.

Table 2. Alternatives compared with criteria

Cr. Alt.	**X**	**Y**	**T**	**Z**
A	1	1	1	1
B	2	3	2	3
C	4	4	4	4
D	3	2	3	2

Table 3. Weights of criteria

	X	**Y**	**T**	**Z**
w	0.8	2.3	2.6	4.3
wn	0.08	0.23	0.26	0.43

Table 4. Alternatives scores

	X	Y	T	Z
A	39	45	52	51
B	36	9	35	12
C	9	4	4	6
D	16	41	9	31

Table 5. Concordance indices

	A	B	C	D	SUM	MAX	MIN
A		1.00	1.00	1.00	3.00	1.00	0.00
B	0.00		1.00	0.34	1.34	1.00	0.00
C	0.00	0.00		0.00	0.00	0.00	0.00
D	0.00	0.66	1.00		1.66	1.00	0.00

Table 6. Normalised discordance indices

	A	B	C	D	SUM	MAX	MIN
A		0.0	0.0	0.0	0.0	0.0	0.0
B	7.7		0.0	3.8	11.5	7.7	0.0
C	8.7	3.6		4.9	17.3	8.7	0.0
D	5.0	3.0	0.0		8.0	5.0	0.0

Table 7. Discordance indices

	A	B	C	D	SUM	MAX	MIN
A		0.0	0.0	0.0	0.0	0.0	0.0
B	38.9		0.0	31.7	70.6	38.9	0.0
C	47.6	31.0		36.9	115.6	47.6	0.0
D	42.5	26.0	0.0		68.5	42.5	0.0

6 Application of regime analysis

The implementation of this type of analysis requires an impact matrix made up of eij elements (see Table 8). These elements correspond to value 1, 2, 3 and 4 (up to four since there are 4 alternatives) where 4 corresponds to the highest value in the ranking of the alternatives and 1 to the lowest.

Table 8. Impact matrix

	X	**Y**	**T**	**Z**
A	4	4	4	4
B	3	2	3	3
C	1	1	1	1
D	2	3	2	2

The impact matrix gives the following regime matrix:

r**AB**	r**AC**	r**AD**	r**BA**	r**BC**	r**BD**	r**CA**	r**CB**	r**CD**	r**DA**	r**DB**	r**DC**
+	+	+	–	+	+	–	–	–	–	–	+
+	+	+	–	+	–	–	–	–	–	+	+
+	+	+	–	+	+	–	–	–	–	–	+
+	+	+	–	+	+	–	–	–	–	–	+

making the vector of the criteria weights:

w=(w1, w2, w3, w4)=(1, 2, 3, 4, 5)

which implies the following condition for w*:

w4* > w3* > w2* > w1*

The probability indicator pii' associated to the dominance of i (i=1, 2, 3, 4) over i′ (i′=1, 2, 3, 4) gives the following result:

pii′=(1; 1; 1; 0; 1; 1; 0; 0; 0; 0; 0; 1)

where the aggregated probabilities are:

p1	=	1
p2	=	2/3
p3	=	0
p4	=	1/3

that calculated automatically gives:

A	–	Mixed intervention	1.000
B	–	IACP/privates	0.667
C	–	Only IACP	0.000
D	–	IACP/public intervention	0.333

The number of drawings (100 or 1,000) did not affect the outcome, and the final result did not change even when the order of criterion preference was changed.

7 Conclusive remarks

We would like to conclude this brief comparative overview of evaluation techniques by drawing your attention to the fact that both AHP and concordance/discordance analysis gave the same end result, while the second and third position were the other way round when considered alternatives were evaluated with the regime analysis.

One can explain this with the fact that regime analysis does not allow one to grade value judgements when comparing criteria two by two as happens in other cases.

One can therefore conclude that regime analysis tends to over-simplify the parameters used in evaluating the possible options in relation to a given problem.

8 References

Fusco Girard, L. (1989) **Conservazione e sviluppo: la valutazione nella pianificazione fisica,** F.Angeli, Milano.

Graziani, A. (1987) **Lezioni di analisi costi-benefici,** FORMEZ, Napoli.

Hinloopen, E., Nijkamp, P. and Rietveld, P. (1983) Quantitative discrete multiple criteria choice models in regional planning. **Regional Science and Urban Economics,** 13, 77–102.

Misham, E.J. (1974) **Analisi costi-benefici,** Etas libri, Milano.

Roscelli, R. and Zorzi, F. (1989) La valutazione di progetti di riqualificazione urbana. **QUASCO,** 11.

Roscelli, R. ed. (1990) **Misurare nell'incertezza,** Celid, Torino.

Roscelli, R. (1991) La valutazione dei progetti e dei piani. **Genio rurale,** 1.

Roy, B. (1985) **Methodologie multicritere d'aide à la decision,** Economica, Paris.

Saaty, T.L. (1980) **The Analytic Hierarchy Process,** New York.

Saaty, T.L. and Vargas, L.G. (1982) **The Logic of Priorities,** Kluwer, Kijhoff Publishing, Hingham.

Voogd, H. (1983) **Multicriteria Evaluation for Urban and Regional Planning,** Pion, London.

Zorzi, F. (1989) **Lavori e opere pubbliche,** Celid, Torino.

90
The quality of design of housing in the United Kingdom

R.S.W.SHAW

Abstract
The most common form of dwellings in the United Kingdom tends to be three-bedroom two-storey houses. This form of house provides accommodation in the public sector for renting by the less well-off sector of society and, in the private sector, for purchase by those people who aspire to house ownership. The provision of houses for 'the working classes' became an important issue in 1918 after the Great War and an official report was commissioned to recommend design requirements for such houses which were to be provided by the public sector for renting: the same requirements were intended to apply to private sector houses. Subsequent official reports in 1944 and 1961 updated design requirements. Reference to these reports, and other publications, should provide comprehensive house design criteria. In addition, consideration of design should include orientation and aspect and should be appropriate aesthetically. This paper examines the influence of the official reports on the establishment of house design criteria features and how the importance of each feature may be weighted to reflect the relative importance to the overall design. The paper examines also, the economics of complying with the established weighted house design criteria.

Keywords: Housing, House Design, Design Appraisal, Weighting, Housing Economics.

1 Introduction

The design of three-bedroom two-storey houses tends to be specialised and is a challenge to the expertise of the architect. Segal (1948) refers to what he calls the old truth 'nothing is so difficult to design as a good house'.

The Department of the Environment (1974) published a check list to provide 'an aid' for the designer when appraising alternative plan arrangements. Leopold and Bishop (1983) relied on this check list to appraise various designs; affirmative answers correlating with high quality 'as a rough yardstick of quality'. However, they refer to 'the lack of any meaningful quality index'.

The establishment of weighted criteria for the design of houses in a temperate climate environment is limited to the internal planning. This, therefore, excludes site layout and orientation of the houses and specification level. The list of design features was compiled from an analysis of the recommendations of government and other reports which had, and still have, a considerable influence on the standards of design, together with other sources and the results of a home user survey. Only the relevant design elements of the reports will be highlighted.

2 Government and other reports

2.1 Tudor Walters Report (1918)

The majority of the working classes in the 19th century lived in speculative accommodation for rent. Lack of regulation of standards for dwellings led to the situation where many dwellings were sub-standard in terms of construction. By 1917 there was a shortage of houses due, mainly, to the increase in the population and the replacement of unfit houses. Bowley (1945) expressed the view that at the time of the Armistice in November 1918, the deficit of houses was 'probably about 600000'. The government set up a committee to report on the problem of future production of houses, the 'Homes fit for heroes' to paraphrase the pledge of Prime Minister Lloyd George at that time. (Swenarton, 1981)

The committee, under the chairmanship of Sir John Tudor Walters, was appointed 'to consider the questions of building construction in connection with the provision of dwellings for the working classes…and report upon methods of securing economy and despatch in the provision of such dwellings'.

Concerning the design of houses, it was recommended that every housing scheme submitted for approval should be prepared by a competent architect, the aim being to obtain the best value for building cost. It was considered most desirable that plans for dwellings should indicate furniture and the swing of doors. The committee proposed a number of economical house types and guidelines were laid down for desirable minimum sizes of rooms. The total available area for a house was 957 sq. ft. (88.9 sq. m) for accommodation comprising living room, scullery, larder, WC and coal store on the ground floor and three bedrooms and bathroom on the first floor and 1 079 sq. ft. (100.3 sq. m) for accommodation comprising living room, parlour, scullery, bathroom, WC and coal store on the ground floor and three bedrooms on the first floor.

Specific requirements suggested included the sink being under the window which should overlook the garden to allow a view of children playing, the bathroom should include a lavatory basin with the water closet (WC) in a separate compartment for the convenience of a large family and the coal store being accessible under cover.

Criteria in respect of economy in planning and design included a simple rectangular form and simplified roof design to avoid expense of detailing around dormers and avoidance of painted woodwork externally to reduce maintenance.

2.2 Dudley Report (1944) Design of Dwellings

The cessation of house building during the Second World War, enemy destruction and damage and a population growth of a million resulted in a house shortage of ‘enormous proportions’ (Cullingwith 1966). The problems of providing houses of types and in locations acceptable to the occupiers led to the government setting up a committee under the chairmanship of the Earl of Dudley. In the words of Burnett (1986) ‘It was intended to do for postwar housing what the Tudor Walters Report of 1918 had done for inter-war housing, but to upgrade former standards in line with new needs, social trends and expectations’. The committee emphasized that the standards recommended were equally applicable to all types of housing whether built by local authorities or private enterprise.

It was recommended that all local authorities were to employ trained architects for their housing schemes, their plans indicating the position of furniture. Floor space standards required two good rooms on the ground floor. Laundry should be done in a separate compartment they proposed to call the ‘utility room’. The bathroom and water closet (WC) should be upstairs with a separate WC for dwellings with three bedrooms, larger houses should have two WCs, one downstairs with a lavatory basin and one upstairs combined with a bathroom. The minimum average floor area of 900 sq. ft. (83.6 sq. m) was recommended. Thermal insulation should be considered under roof tiles and for protection of water tanks and pipes from frost. Sound insulation was recommended with cavity wall construction. The utility room should be located between the kitchen and the back door with an outside shed and fuel store accessible under cover.

Recommended equipment and fittings included an open fireplace in the living room and kitchen fittings arranged in a sequence convenient for working. Clothes cupboards should be placed on internal walls and rails with hat and coat hooks should be provided in a convenient place in the hall and in the utility room. Meters should be placed so that they were readily accessible and easily read, together with a small delivery hatch near the back door.

2.3 Parker Morris Report (1961) Homes for Today and Tomorrow

Starting in 1951, there were successive reductions in the sizes of houses. By 1960 ‘it became clear that the whole question of standards for public and private sector alike would have to be rethought’. (Berry, 1974)

The government set up a committee, under the chairmanship of Sir Parker Morris, ‘to consider design and equipment applicable to family dwellings and other forms of residential accommodation, whether provided by public authorities or private enterprise, and to make recommendations’. The primary task was ‘to consider standards of internal design’.

The key findings of the report were that major changes were required involving space and heating. The first priority was space for activities demanding privacy and quiet, better planned equipped kitchens with space for some meals and more satisfactory circulation and storage. The second priority was for better heating. Minimum sizes were set for the whole of the dwelling so that the designer would be free to arrange the space and equipment to meet the requirements of particular sizes of family. The conditions necessary for family pursuits would be in terms of space, atmosphere, efficiency, comfort, furniture and equipment.

The committee provided guiding considerations for the internal design of houses. They stated that architects must be employed in the design of houses and that main furniture should be shown on all plans. The adaptable house, the house which could easily be altered as circumstances changed, was becoming ‘a national necessity’. The hall provided a neutral space and a place to store outdoor clothes. An enclosed porch or lobby ‘might be satisfactory’. At least one room should be provided in the living area to cater for activities needing privacy and freedom from disturbance. There should be space in the kitchen for occasional meals. Adequately heated children’s bedrooms could be used for leisure or study. The minimum satisfactory provision for water closets (WC) was, for a five person family in a two-storey house, one WC combined with bathroom and one WC separate with a wash basin, normally on the ground floor. The committee observed that a home without good heating was a house built to standards of a bygone age. Minimum standards of heating were proposed for the ground floor: a system capable of heating the bedrooms as well represented greater value for money. Ideally heating systems should be clean requiring little or no attention. Double glazing was relatively expensive in relation to the amount of heat saved. Roof and wall insulation and weather stripping of doors and windows were likely to give better value for money. The kitchen work-sequence should comprise: work surface/cooker/work surface/sink/work surface or in reverse order, unbroken by a door or obstruction. The utility room should meet the aim of separating household washing from kitchen functions. Designers should provide a space in the kitchen to accommodate household machines that may come into general use in the future. Storage space, in or adjacent to the kitchen, was required for food, household utensils, cleaning materials and portable equipment. General storage was required for items such as seasonal clothing, luggage and gardening equipment, at least half of which should be on the ground floor. Built-in wardrobes were suggested. Space for hats, coats and outdoor footware should be provided near the main entrance with suitable facilities for leaving working clothes, preferably in conjunction with a lobby. A minimum provision of 15 electric socket points was required: the desirable provision being 20 points.

Houses for occupation by 5 people should be designed with a net floor area of at least 930 sq. ft. (86.4 sq. m) In two-storey houses for 5 people two WCs were required, one of which could be in the bathroom. Where a separate WC did not adjoin a bathroom, it must contain a washbasin.

2.4 Homes for the Future (1983)

This report, not government sponsored, was published jointly by the Institute of Housing and the Royal Institute of British Architects. This was a comprehensive report, updating Parker Morris and introducing new standards where required to meet future housing needs.

The adoption of flexible housing designs, capable of extension to provide accommodation for single or elderly relatives, was suggested. The report continued ‘it is essential that all ground floor…accommodation is designed to mobility standards…but it is also desirable that all dwellings and their surroundings should be accessible and convenient to visitors who may be disabled.' Whole house heating was considered important. The adoption of 'whole-life costing' was strongly urged to provide value for money. Parker Morris internal space standards were still considered relevant and should remain the minimum for public sector housing. There was a need for greater flexibility in design of housing for the future to accommodate increases in aids to living and leisure. The three principal areas, where a review of standards was required, were general storage arrangements, kitchen accommodation and heating systems.

An area for enclosed storage space could be used to enlarge a living room or bedroom on ground floor. Built-in cupboards should be located in circulation areas where they were more easily accessible with long narrow stores being avoided. General storage requirements could be in the form of a small room which could be used as a study or utility room.

The Parker Morris sequence for kitchens was still relevant. Refrigerator space should be at the end of a run of units as few would fit below a worktop. The provision of a utility room was 'strongly recommended' to isolate water vapour-producing activities likely to cause condensation, and to provide space for a freezer and central heating boiler. Storage space and a WC could be combined with the utility room which could also serve as a draught lobby if located between the kitchen and the external door.

All floor plans for the design of new houses should indicate suggested furniture layouts, radiators, electrical points and kitchen equipment. The main entrance hall should open into an enclosed lobby or hall. The entrance door should be recessed or protected by a canopy and the inclusion of a draught lobby door is an advantage both against heat loss and for privacy. An enclosed store should be provided accessible under cover. External meter reading facilities should be convenient to the entrance. Where patio doors are provided in a living room they should be located with the possibility of adding a conservatory later. The minimum corridor width should be 900 mm with door sets of the same width for wheelchair access. Two separate living areas should be available where possible. Dining space may be combined with the kitchen, the living room or the entrance hall. Staircases should not pitch directly down to the entrance door and single steps and winders should be avoided but, if required, are better at the bottom of a flight. The provision of a second WC was considered 'essential'. Access to bathrooms by the elderly and disabled should be considered and baths should not be placed under windows. Linen cupboards, with at least 0.5 cubic metres of storage space, should open into circulation areas. Single bedrooms should be capable of accommodating a bed in more than one position and two double bedrooms should be planned to allow for future sub-division into two rooms. Built-in wardrobes should be on internal walls and ventilated. Roof spaces should be considered for storage. All windows should be capable of being cleaned and glazed from inside the dwelling and openings should facilitate emergency escape. Entrance doors should have a small glazed panel or peephole to enable occupiers to see callers. Letter plates should have internal flaps and hoods to prevent access to locks. Non-slip finish should be specified for kitchens and bathrooms. Window frames and internal doors should be self-finished to minimise maintenance.

Heating and other services: Extract systems in kitchens were considered 'essential'. The use of draught lobbies on external doors was an important contribution to energy conservation. Weather stripping of door frames was essential. It was strongly recommended that all future housing be provided with central heating which would enable bedrooms to double up as studies or workspaces. Heating levels were recommended; living areas 21° C, kitchen and circulation area 16° C, bathroom 21° C degrees and bedrooms 18° C. Living areas should be fitted with a radiant heat source in addition to central heating. The provision of a chimney ensures that the dwelling is suitable for all types of fuel. Individual thermostatic valves add greatly to flexibility. It may be neccessary to install a full mechanical extract ventilation system coupled with heat recovery. Window design should include ‘trickle ventilation’ features and small top hung opening sashes. Extract fans in kitchen and bathroom were considered desirable. An alternative was a ‘natural’ stack from the kitchen ceiling to a ridge terminal. Combustion air intakes through underfloor ducts should be considered.

The original Parker Morris desirable standard of 19 electric sockets should be regarded as the minimum: a new desirable minimum of 30 sockets was recommended. Double sockets should be used in preference to singles. Sockets positioned about 600 mm above floor level were convenient for everybody to use. TV aerial sockets should be provided.

3 Establishment of design features/weighting factors

3.1 Design Features

The mechanisms used in the establishment of design criteria were:

(a) content analysis of relevant literature viz government reports, official publications, articles in journals and books

(b) analysis of perceptions of occupiers concerning their requirements, expectations and attitudes towards specific aspects of design

Concerning the latter, the population of interest consisted of occupiers of three-bedroom two-storey houses designed since 1983 and built in 1987 or 1988.

An analysis of the results of the Home User Survey and the 140 questionnaires received, confirmed or, in some cases, augmented the list of features. The initial list of 201 features was organised under these headings: generally, entrances and circulation, stairs, living areas, kitchen, bedrooms, sanitary accommodation, general storage, utility room, windows, electrical installation, heating installation, energy conservation, external features.

3.2 Weighting factors

A House Feature Survey was undertaken as a means of establishing a weighting factor for each of the 201 features of design. Discrimination in the importance of the various design features was by means of a ten-point Likert scale for each feature. An analysis of the results of the questionnaires received from 33 architects raised some anomalies regarding the architects’ perceptions of the importance of some features. Median scores were used but they required adjustment for them to be meaningful in their application to various designs of houses. The 33 architects were approached with a questionnaire on which the design features were arranged into six categories of importance related to the overall design of a house. A median was assessed for these responses. As quantity surveyors are specialists in costs of construction, they were sent the same questionnaire; 33 were received and medians assessed for the responses.

The multiplier of the median of the house feature survey and the median of the categories of importance provided a maximum score of 54 (9×6) for the perceived most important features and 2 for the least important feature. The scores obtained were divided by ten to provide manageable factors.

Table 1. Range of design features and factors

Feature	**Factor**
Maximise sunlight and natural lighting	5.4
Kitchen: cupboards not directly over cooker	5.4
Kitchen: cooker not below a window	5.4
Main bedroom (BR) to take a double or twin beds	5.4
Weather stripping windows and external doors	5.4
Space for child’s pram/buggy	3.2
Letter plates with draught flaps and hoods	3.2
Hand rails grippable by child’s hand	3.2
TV aerial socket; Living room	3.2
Baths not placed under windows	3.2
Non-slip floor finish; bathroom	3.2
Roof space storage, sealed trap, ladder, light.	3.2
Adequate number of shelves in storage cupboards	3.2
Double electric sockets instead of single	3.2
Sockets on opposite walls	3.2
Paving at GF windows to facilitate cleaning	3.2
Plain rectangular form	0.2
Dining space combined with hall	0.2
Two single BRs divided by folding doors	0.2

in order to provide an indication of the range of 180 features, the five features with the highest factor (5.4), the three features with the lowest factor (0.2) and the eleven features with the median factor (3.2) are indicated on Table 1.

4 Economics of house design

The recommended Parker Morris standard relating to the floor space of a 5 person 2-storey semi or end terrace house, is a minimum of 930 sq. ft. (86.4 sq. m) An increase or reduction in the floor area of (say) 10% would not result in a proportional increase or reduction in cost compared with a 930 sq. ft. (86.4 sq. m) house. This is because some of the building elements will tend to remain constant, assuming that the number of rooms remains the same. In particular, the constant elements are stairs, windows and external doors, internal doors, fittings and services. The building elements which will increase or reduce in cost in proportion to the floor area are substructure, upper floors, roof, external walls, internal walls and partitions and internal finishes.

Costs expressed in financial terms apply at a specific time and are subject to adjustment for inflation. The increase in cost of building a basic house to comply with the main established design criteria, expressed as an approximate percentage, are set out in Table 2.

Table 2. Increased costs of main design features

Feature	**Increase(%)**
Designed to mobility standards (GF)	1.0
Canopy protection against weather	1.5
Enclosed entrance porch/draught lobby	2.0
Extract fans to kitchen and bathroom	1.5
Roof space prepared for storage	1.5
Utility room	5.0
Additional WC and basin in compartment	3.5
High performance windows	1.5
Additional 11 electric sockets (19 standard)	1.5
Whole house heating	2.0
Thermostatic radiator valves	0.5
Increased insulation to floor, walls and roof	2.0
Double glazing	2.5

The costs of each of the features are in isolation, for example, selection of increased insulation and/or double glazing would affect the cost of heating, both capital and running costs. A comparison with appropriate cost implications of recommended standards in ‘Homes for the Future’ (1983) reveals a close correlation.

5 Conclusion

The weighted criteria for the design of houses could be used at the design stage of a house or used to appraise the completed design of a house or used to appraise the design of a completed house. This criteria can apply to public sector and private sector houses alike and should enable those involved with housing to evaluate the quality of design of houses. The established criteria may be applied to large private houses also.

6 References

Berry, F. (1974) **Housing: The Great British Failure.** Charles Knight, London.
Bowley, M. (1945) **Housing and the State 1918–1944.** George Allen & Unwin Ltd. London
Burnett, J. (1986) **A Social History of Housing.** Methuen, London
Cullingworth, J.B. (1966) **Housing and Local Government in England and Wales.** George Allen & Unwin Ltd. London
Department of the Environment (1974) **Housing the Family: Design Bulletins.** MTP Construction, Lancaster, England.
Institute of Housing and The Royal Institute of British Architects (1983) **Homes for the Future.** IOH/RIBA London
Leopold, E. and Bishop, D. (1983) Design philosphy and practice in speculative housebuilding; part 2 in **Construction Management and Economics,** 1, 233–268
Local Government Boards for England and Wales (1918) **The Tudor Walters Report.** HMSO, London
Ministry of Health (1944) **Design of Dwellings. (The Dudley Report)** HMSO, London
Ministry of Housing and Local Government (1961) **Homes for Today and Tomorrow. (The Parker Morris Report)** HMSO, London
Segal, W. (1948) **Home and the Environment.** Leonard Hill Ltd. London
Swenarton, M. (1981) **Homes Fit for Heroes.** Heinemann Educational Books, London

91
Accoustic conditioning of buildings

P.M.da SILVA

Abstract
Some aspects about acoustic conditioning of buildings are presented in a legal perspective established according to the General Regulation on Noise whose expected updating is commented.

This conditioning is considered integrated in the general design of complex buildings, special reference being made to those called “intelligent buildings”.

Keywords: Acoustic Conditioning, Noise Regulation, Intelligent Buildings.

1 —Acoustic conditioning as a part of general design of buildings

1.1—Technological development in different areas related to the construction of buildings, evolution of functional requisites related to the different occupations, conditions established by limitations to the space available to be occupied and other kind of conditions necessary to the functioning of buildings have forced the abandon of the image of the “building—conglomerate”, replaced by the idea of “building—system”. The total is no more a simple union of the parts, because the interactions of those parts play an important role.

The Design, with its characteristics of ideal structure, modellising the building must represent duly this systemic perspective: the design team must know how to create truly an interdisciplinarity without barriers, which will allow an adequate circulation of information, in spite of the different codes as a consequence of the specialization of its components.

In this perspective it is obvious that the acoustic conditioning may not be considered as the definition of “corrective measures” to be taken a posteriori; it must be developed harmoniously integrated among the several other specializations. In addition to the reasons of general kind that have been pointed out, those that follow emphasize that necessity:

–Acoustic conditioning must be considered from the initial phases of design, as this is the time for choosing the place for the construction, because if this does hot happen the final result may be definitively wrong.

–The joint consideration of acoustic conditioning with other specializations (architecture, structure, technical installations, energy balance) allows the optimization of joint solutions, with the consequent reduction of costs and increase of the standards of the final results.

–The acoustic conditioning a posteriori (correction…) permits that situations of annoyance may occur with the inherent consequences.

1.2—There are several problems to solve in order that the acoustic functional exigencies are satisfied in the spaces inside a building. Obviously the nature of these problems depends on the specificity of the situations, although it is possible to indicate the following in general:

–Sound insulation (aerial and impact sounds between spaces) in order that sound transmission that may affect the fulfilment of tasks, the security or even their private character may be avoided.

–The characteristics of sound fields in different spaces, specially in those where there are sound messages to be transmitted, have to be cared of specially in what is related with reverberation time, sound reflections (their distributions in time and space) and diffusion.

–Noise and vibrations created by several equipments integrated in the building and that may propagate through the structural elements or be guided through any kind of pipes.

Besides what happens in the interior of buildings owing to noise sources that are integrated in them, acoustic conditioning must take into account noise stimuli that may propagate, from the outside, affecting the activities inside the building. It is also necessary to consider that a building, essentially the technical installations that it integrates, may affect the acoustical component of the environment, creating an impact that has to be properly mitigated.

Obviously it is necessary to arrive at an adequate concatenation of those different aspects in order to have a global result that means an acceptable acoustical environment to people inside and outside the building.

1.3—The fundamental legal basis of acoustical conditioning is the General Regulation on Noise, which became effective in the beginning of 1988. This Regulation, supported by a corpus of National Standards—following in general the ISO standards—specified what was considered essential in the field and fixed limits according to data collected about the reaction of the Portuguese population to noise in general; of course these limits were fixed in a forecasting perspective, that is according to what was considered appropriate as acceptable standards.

2.1—The General Regulation on Noise specifies that it should be revised three years after its publication, which is being done now, in order to integrate data collected from application, procedures established by European standards and adaptation to now a days needs of population in terms of fighting noise pollution.

One of the changes that will certainly be included is the exigency of noise conditioning design not only for buildings with special acoustical requirements (such as schools and hospitals for example) but also for housing buildings.

This important change that meets the practice already existent in several municipal councils intends to attain several targets, namely:

–Avoiding the interference of unqualifield people that could (and it really happened, enriching the anedoctory on the subject…) propose solutions unfit for really solving the noise problems or that could interfere with other aspects of the building functioning even with its security, as it is, for example, the use of combustible materials as sound absorbers…

–Allowing the possibility of integrating the noise conditioning solutions with construction proposed in other fields as it happens, for example, with thermal conditioning, fire security, natural illumination, technical installations; it must be however emphazised that this integration can (and must) cover other fields as the choice of structural solutions, setting up of installations for water, gas electricity and comunications and industrialization of construction. And, last but not least, the economic aspects, as a whole.

–Other change is directed towards giving a deeper importance to the European standards, fully adopting their procedures and parameter designations. Also, the fact should be recognized that, nowadays, the use of mechanical equipments in residencial buildings is becoming more usual—lifting people and goods, pumping water and waste water, generating electrical energy—, a limit is specified to noise intensity (expressed by means of continuous equivalent noise level) produced by those equipments in rooms of residencial buildings.

It was also definitively accepted that the general character of the regulation implies that everytime it is possible it must send to other specific regulations, which reduces the volume of the General Regulation and so makes its use easier; this is, for instance, what has been made with questions related to noise in working places.

2.2—If the preparation of noise conditioning design is mandatory, of course, then must be created a structure able to appreciate these projects in the licencing phase. This structure does not exist in the majority of small municipalities but its creation specially for groups of associated small municipalities will prove profitable because it is, of course, much easier to observe and analyse a project than to investigate the behaviour of a construction; moreover considering the financial and social implications of the process, the creation of that structure appears as a very good investment.

In order to make it easier to design and survey a noise conditioning design, the Regulation, in its revised version, will present, as an annex, prepared sheets that will establish the general lines to be considered in the organization of that design.

3 —Acoustic conditioning of complex buildings

3.1—Above it was emphasized the multiple links and mutual influences that occur between acoustical conditioning design and other fields of design that must be considered. And what has been considered is only what we may call “passive” acoustical conditioning. In more complex buildings we may have to face some questions of “active” conditioning, meaning by that the sound emitting systems used as message transmitting means or to create an artificial acoustical environment that will “condition” the behaviour of people according to the objectives defined for their activities.

The situation is, of course, not specific of acoustical design; the same occurs in other fields of the global design of the building and shows that nowadays the design of buildings is becoming more and more complex, in such a way that it must be considered following a systemic approach which obliges to a real integration of the several disciplines involved. Thus, from a multidisciplinary group it should evolve to a true interdisciplinary group with really permeable interfaces between the several specializations.

The extreme complexity that some buildings attain—and it is necessary to consider that this happens not only with service buildings but also with residencial ones makes it necessary to integrate a computer system in the building which will receive the monitoring information collected by several transducers that give the situation in what concerns lighting, thermal balance, integrated safety, sound, transportation systems etc. and, according with the data received, orders the functioning of the several systems involved, in normal situation and in disaster ones as it is, for example, the case of a fire situation.

At that state, we have to consider the building as a complex organism, able to respond logically to the conditions present in the outer and inner environment. That is the reason why those buildings have been called "intelligent buildings", a neologism perhaps a little exagerate when we consider the exact meaning of the word, though it gives a vivid idea of the constitution and behaviour of those buildings. And, of course, the control exerted by the computer system may go further in the "life" of the building and of those who live or work inside it, for instance controlling their presences, actuating in accordance lighting and thermal conditioning of the spaces they occupy, controlling stocks of goods they consume, etc.

3.2—Nowadays, with the acceleration of the technical progress the duration of the structure of a building is much longer than the functional duration of several equipments installed therein. So it will be necessary to change several times the electronic equipment of a building during its functional life as a structure. Of course it is not possible to forecast all changes that will involve that equipment but the building must be prepared to undergo those changes without deep transformations—which, sometimes could just be impossible—, what means that, for instance, it must be equipped, from the start, with cables fit for these changes.

This is one of the most acute problems that may arise with complex buildings and has to be done in order that they may deserve the classification of intelligent ones, because, in a certain way it indicates their ability to adapt to changes, responding to them without very deep troubles, that is what really characterizes an "intelligent" system…

92
Objective body of legislation and technological success, the case of Veneto region

N.SINOPOLI and V.MANFRON

Abstract
In residential building, and not only in that one, we face new building procedures that modify the role of the various subjects of the building process; moroever we are in front of new ways of using it and of substantial, even if not very showy, technological innovations. Also in building programmes of small dimentions, wich are the more widespread in our country, building systems are hardly comparable with those in current use even few years ago.

The innovation have surprisingly involved a remarkable decrease of quality and reliability. The reasons of the above mentioned failures are to be found in the insufficient comunication among the operators because of the greater complexity of the building process. For this pourpose the objective body of legislations, which are relatively widespread in Italy, seem to be inadequate while a body of legislation wich can provide for requirements and services could guarantee more adequate levels of quality and reliability.

Keywords: Public housing, New construction, Quality, Reliability, Italy, Veneto Region.

1 Introduction

In Italy the public housing financement has been carried out in the last decade on the inside of one national law called “Ten year plan for building”, as well as through extraordinary measures, or emergency laws, aiming at the solution at contingent problems such as the requirements in cities with a strong dwelling tension.

The above-mentioned financings, all aiming at the same objective, which is the realization of flats with settled dimensional characteristics to rent at a low price or to sell at a fixed price, are distributes to different public and private bodies, operators, organizations and institutions, with different procedures and with different incidences on the total cost of the flat.

The larger financial participation of the state is in the so-called subsidized building, in this case the public financing covers in fact the total value of the flat. Usually it is about flats to rent, forming a pubblic estate, realized by public organizations, called Autonomous institutes low class-houses, or with less incidence, by communes of medium and big dimensions.

There is only one partial participation of the public financing for arranged or facilitated building formed by flats to sell. In this case the financing, formed by soft loans, is directly distributed to the users, who the majority of time are assembled in cooperatives, or to the building enterprises, sometimes associated in syndicates, that then transfer them, with the flat, to the user.

2 Subjects of quality

It is usual to distinguish the planning stage of the interventions of this kind in four phases that correspond to different levels of choice:

– environmental project, it is that one relative to the choices of urbanistic and dimensional valence of the intervention;
– spaciofunctional project, it is that one relative to the typological-distributive and architectonic aspects;
– technological project, which determines the building system to adopt;
– procedural project, which concerns with the operations that are necessary to the realization of the intervention.

Relatively to this there are many ways of organizing the building process that depend from the procedures of distribution of the financing. Besides there are many proceedings of contracts that are distinguishable in the so-called traditional contracts, contracts competition or contracts in concession.

With the words “traditional contract” we mean a proceeding of choice of the executory enterprise through the right price from this tender for the realization of a project carried out by the customer and constituted, beside the architectonic plans, by objective specifications that describe the materials to use as well as the procedures of the installation. Therefore in this case the contracting station draws up all the four above mentioned planning stages, and to the executive enterprise is only referred the function of executor, a sort of “nudus minister” of the will of the contracting station with technical abilities that are restricted only to the operations of building.

The decisional role of the builiding enterprise in the case of contract competitions seems to be greater. In fact in this case the contracting station, through specifications of performances, sets only the elements that considers the strategic ones for the realization of its own objectives that are the ones relative to the environmemtal and procedural projects; therefore the building enterprise has the task of supplying with spaciofunctional and technological projects. A change in this procedure is constituted by the contract on schematic project in which the contracting station arranges the spaciofunctional project.

Finally with the contract in concession the contracting station gives the enterprise even the procedural project arranging only the environmental plan formed, beside the framework of the objectives, by specifications of performances and requirements. The last one is substantially the role of the executive enterprise if the financing is directly distributed to the same.

These different directions, generally introduced in order to lighten the building procedures imply a different role of the various subjects of the building process, whatever the public agencies, the builders or finally the owners are; the same diversifications involve, and this is the objective of the present work, different levels of quality and reliability.

3 The role of the various subjects.

In a report during the Congress in Paris CIB 1989 (1) we had explored these themes from the point of view of some aspects of the housing quality meant (2) as the capacity of the building product to respond to the exigencies of the user. We consider there, with reference to the public residential building realized in the Veneto Region with the procedures of financing here formulated, as the different decisional role of the owners, public agencies and builders involved different results in relation to some choices such as those relative to building and structural typologies and building systems.

The different directions of which we have talked about a short while ago can in fact be classified according to the subject to which the prevailing decisional role is up to. This subject can be individualized in substance with the usufructuary of the loan, who is the owner, for the building that is managed by the cooperatives of dwelling-place, the public agency for the building with total public financing, and the builder when the financing is distributed to the last one. Besides, as we have said, with the introduction of the contracts-competition and the contracts in concession a non-negligible part of the decisional power can be delegated form the first two subjects to the builder.

The sample of the enquir of which we have talked about, complessively 6002 flats realized in the Veneto Region in the last decade, was substantially homogeneous because both the dimensions of the flats and the building and selling prices were fixed by law and where substantially the same on the three above-mentioned cases; moreover it was always a question of medium and small dimensioning interventions, it must be considered that the greater dimensioning interventention counted 88 flats and the medium 27 flats while the lower limit was constituted by interventention of 12 flats. Even the different cultural approach and the different strategies of the various subjects implied different results according to the planning choices.

As far as the building typologies are concerned, referable therefore to the spaciofunctional project, the owner preferred terraced houses in the 50% of the cases followed by lined up houses (29.5%) and by block (11.7%) and by gallery houses (8.8%); the choice of the public agency is different: lined up houses in the 36.6% of the cases, terraced houses in the 25.6% of the same, block (24.8%) and gallery houses (13%); in the end the builder almost exclusively chose the lined up houses (77.6%) followed at a long distance by block (17.4%), gallery (2.2%) and terraced houses (2, 8%)

Moving on to the structural typologies, referable to the technological project, the owner in preference adopted masonry bearing walls (41.2%) followed by reinforced concrete septa (38.2%) or columns (20.6%), the public agency chose the masonry bearing walls (58.7%) too, followed by reiforced concrete columns (21.6%) or septa (19.7%), instead as far as the builders are concerned, the choice was for the reinforced concrete septa (73.2%), followed at a long distance (as for the building typologies by masonry bearing walls (13.9%) and by reiforced concrete columns (12.9%). It is to be noticed, in conformity to the national tendency, the lack of steel structures.

In the end, as regards building systems, that are referable to the technological project as well, the owner chose (67.7%) the rationalized systems, that are up-to-date traditional systems, secondarily (32.3%), the industrialized ones, here there is a reference to the reinforced concrete castings and rejected the prefabricated ones, thast is panel building. In his turn the public agency adopted almost homogeneously the rationalized systems (92.1%) and only in a minority way the industrialized (5.1%) and the prefabricated ones (2.8%). The options that have been done by the builders were different; in fact they chose the industrialized systems (49.4%), followed by rationalized (31.1%) and prefabricated ones (19.5%).

Therefore different subjects, substantially choosing to do the same thing on the inside of a normative and financial homogeneous framework, make different choices. In short the owner’s reasons are different from the pubblic agency’s reasons and from those one of the builder. This point deserves some reflections.

4 The reasons of the diversity.

We examine first of all the owner’s reasons that in our case is a subject that realizes, with the state contribution his own house with the above mentioned bonds. It seems to be the less favourable subject to the typological innovation because he chooses the terraced houses and besides a refusal of the prefabricating techniques, he does not demonstrate relevant choices as regards the structural typologies and the building systems. Therefore his strategy is that one of the traditional hause according both to the building typologies and to the building system; by the way we remind you that in our country a traditional house is realized with brickwork and reinforced concrete hollow tyle floors. In the end, relatively to the structural typologies the subject shows a substantial lack of interest.

As for the public agency, that realizes inside the same framework of bonds flats to manage within the span of their life, does not seem to have substantial preferences on the building typologies, in fact it is the only subject that uses them all, while it favours masonry bearing walls and traditional building systems. Even in this case then it is verifiable a substancial diffidence as regards the innovation.

In the end the builder who realizes flats to sell, he preferably works, according to the building typologies, with the lined up houses that are relatively economic, but still appreciated by the buyers and with terraced houses, mostly valued by the users, but of more difficult marketing; consequently the preference is for the septa structural typologies. In the end as regards the building systems the builder prefers the industralized ones. Therefore there is a more complex strategy that is dictated from one side by the market wich imposes the housing building with typologies easy to sell, and to the other side by the necessities to reduce the times of building reducing at the minimum the incidence of the masonry and adopting reinforced concrete septa.

Now we remember that the first two subjects usually work, as we have seen, with regulations formed by objective specifications that describe the physical and mechanical characteristics of the various components of the building, while the third works with regulations of requirements and of performances that does not describe the characteristics but the requirements to which the components have to respond and the performances that the same have to supply. It is this particular system of rules that in fact allow the builder to make innovations while searching for different solutions.

5 General reliability and building reliabilty

The second aspect to be considered is that one relative to how the different directions thanks which it is possible to obtain the realization of the flats can influence the reliability of the product. The different strategies with which, as we have seen, the various subjects work imply, even if it is difficult to conceive, different results with regard to reliability.

The reliability, in the case of the building organism, is different from that one we are used to talk in the case of the industrial production. In fact for this last one we can assume with S.Ragusa (3) the definition of reliability as the probability that the component, subjected to well-defined stresses, performs his function for the expected period of time.

The difference depends on the fact that in the industrial production the laying in market of any object, for exemple you can think of the phases that precede the marketing of a computer but even of a shaver, is proceeded among other things by the experimentation in use of a adequate number of prototypes. This experimentation is difficulty conceivable in building, in experimental building also, when this one is financed. In this last sector as soon as the house is ready is put in use, in other words the experimentation is carried out, for obvious reasons of economic character, “in corpore vivo”, setting directly in use the prototype: every new intervention is in substance a new prototype, this is encouraged by the european building tradition in which the mass-production of flats is very reduced.

The above-mentioned reasoning is valid also when we are in front of productive processes of flats with strong industrial connotations, that are formed by components of industrial production that have undergone the adeguate experimentation on the prototype. In fact in these cases, the thing that escapes to the experimentation is the systematic effect that is generally different from the sum of the behaviours of the individual parts that form it, and it can be verified only on the building organism in its whole, consequently relapsing in the previous case.

For this reason, speaking of building reliability it is more appropriate to assume the definition by G.Ciribini (4) that talks of the capacity of maintaining its own quality invariable in time; the reliability of which we talk coincides, in substance, with the behaviour in use and with the duration. Now we examine, with reference to the same sample previously used, how the choices made by the various subjects influence the last one.

6 The falls of reliability

The enquiry on the field of which we talk about has allowed to draw up a list of the crisis of reliability, of the rivals of the duration, as G.Blachère in (5) defined them, that reduce the levels of behaviour in use of the immovable properties.

We refer, in conformity to what has been previously said, to the failures and the pathologies of the building systems, meaning that, relatively to failures and pathologies of the building components that also present levels of unreliability, the problem has to be brought back to the inside of a sufficient experimentation that, for these, it is easier that it is put into practice on prototype. Substantially the rules of the general reliability are valid for those components, and on the reliability of the same, at least theorically, the choices of the operators of whom we talk about, should be negligible.

The pointed out crisis states are classifiable as follows:

STATIC LACKS

SL1 – incompatible deformability of the floors

SL2 – insufficient ductility of vertical enclosures

SL3 – discontinuity of vertical elevations

CRACKING

CR1 – incompatible deformability of the floors

CR2 – incompatible rotation of the upper enclosures

CR3 – erraneous execution of executive details

CR4 – cracking with infiltrations of rain

CR5 – lack of dimensional coordination

ATMOSPHERIC DEPOSITS

AD1 – heterogeneity of surface temperatures

AD2 – solubility of external surfaces

AD3 – inefficiency of external materials

CAPILLARY RISES

CP1 – lack or inefficacy of waterproofing coats

CP2 – excessive washing away or stagnation of rain

CONDENSATIONS

CD1 – inefficacy of insulation in vertical structures

CD2 – inefficacy of insulation in horizontal structures

CD3 – lack of ventilation

The pointed out crisis states has been besides distinguished in three levels as follow:

1. First level, light crisis state: the crisis states that decrease the perfomance of look are classified inside this category,
2. Second level, medium crisis state: the crisis states that decrease the performance of comfort are classified inside this category,

3. Third level, serious crisis state: the crisis states asking for immediate measures of maintenance are classified inside this category.

7 The results of the enquiry on reliability

In the following pictures we bring back, in diagrams, the results of the enquiry. The interventions that have had as director the owner are catalogued in the first column, those ones carried out rispectively under the directions of the builder and of the public agency in the second and in the third column. The diagram in semicircle presents all the analized cases, the three sectors L, M and S represent rispectively the percentage of light, medium and serious crisis states, the R sector represents the case af total reliability. We examine first the static lacks and the cracking.

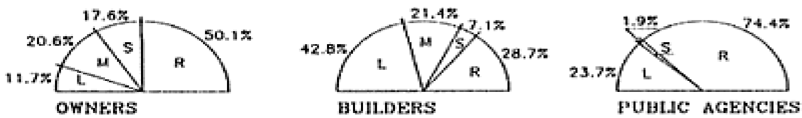


Fig. 1. SL1—Incompatible deformability of the floors.

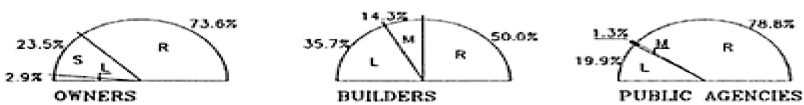


Fig. 2. SL2—Insufficient ductility of vertical enclosures.

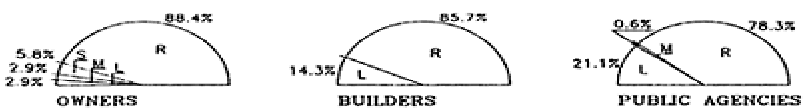


Fig. 3. SL3—Discontinuity of vertical elevations.

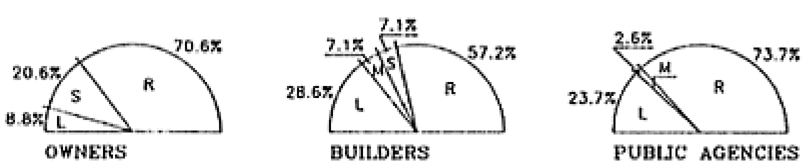


Fig. 4. CR1—Incompatible deformability of the floors.

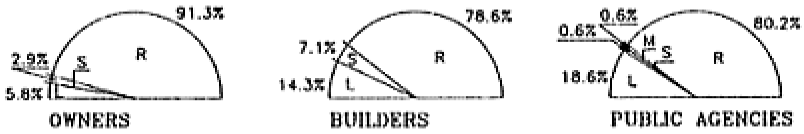


Fig. 5. CR2—Incompatible rotation of the upper enclosures.

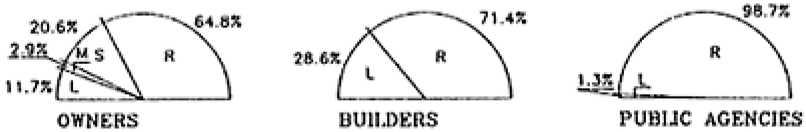


Fig. 6. CR3—Erroneous execution of executive details

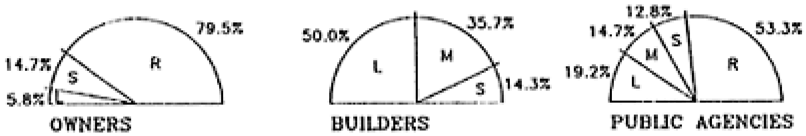


Fig. 7. CR4—Cracking with infiltration of rain.

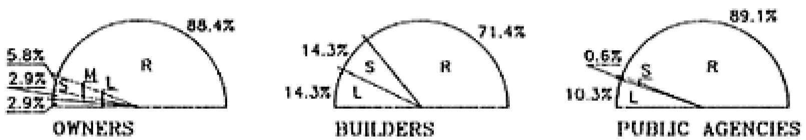


Fig. 8. CR5—Lack of dimensional coordination.

The principal problem seems to be that one of an excessive slenderness of interior and upper floors, in our country generally made of monodirectional reinforced concrete hollow tyle floors, not prestressed. As we can see from the diagrams the excessive elastic strain of the floors can generate some crackings of the same (Fig. 1), of the walls (Fig. 4) or of the upper enclosures (Fig. 5). It is convenient to specify that, even in the case of serious crisis, it is not about ultimate limit states but about service limit states, generally the limit states of deformability that do not absolutely compromise the stability of the building.

As far as the above-mentioned phenomena are concerned it is useful to specify that only in 1985 the National building codes have imposed relations of slenderness that are more prudential for the floors of the above-mentioned type (that is ratio of one to twentyfive between tickness and length instead of the old ratio of one to thirty) and that the analized sample has been realized for about 50% with the old regulation.

The diagrams of which we talk about reveal us that the builder is the most exposed to this type of failure, with worryng incidences, but fortunately with the prevalence of light crisis. In fact the incidence in the case of the owner and of the public agency results smaller. We remember that the builder is the same person who has preferably adopted, see above, lined up houses with septa of reinforced concrete. Here there is a thight relation between the choice of the typologies and of the building systems and the failure. We will be back to this point in the conclusions.

As regards the frequency order there are the failures due to behaviour of the masonry walls that reveal (Fig. 2) an insufficient ductility, (Fig. 3) discontinuity of vertical elevations and (fig. 7) crakings with infiltration of rain.

In the first and third case it is still the builder the most exposed to failure, while in the second he is overcome, but not much, by the public agencies. The reasons of this failure this time are due principally to the introduction of new materials. We will be back also to this point in the conclusions.

In order to finish with static lacks and crackings we find (Fig. 6) erroneous realizations of executive details and (Fig. 8) lacks of dimensional coordination. These are phenomena that are above all connected with the negligence in the execution stage in the first case and in that one of planning in the second. As regards the erroneous executions it is the owner, followed by the builder, who pays for the main frequency of failures, instead the greater incidence as regards the lack of dimensional coordinations is due to the builder. With reference to this third group of failures we have to say that in any case it is about, as for the following cases, less worryng inconveniences as far as the whole quality of the intervention is concerned.

We can now analyze the failures that are relative to the atmospheric deposits, capillary rises and condensations.

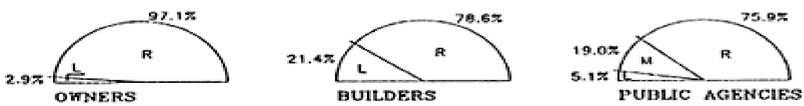


Fig. 9. AD1—Heterogeneity of surface temperatures.

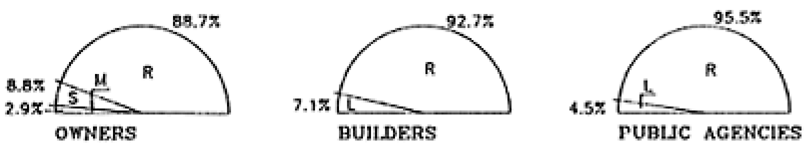


Fig. 10. AD2—Solubility of external surfaces.

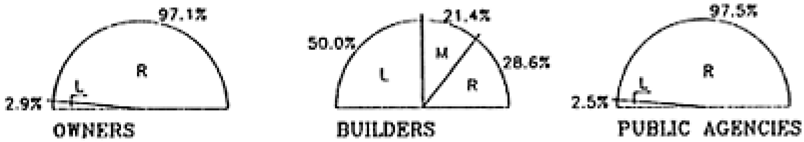


Fig. 11. AD3—Inefficiency of external materials.

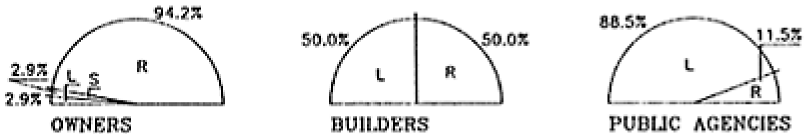


Fig. 12. CP1—Lack or inefficacy of waterproofing coats.

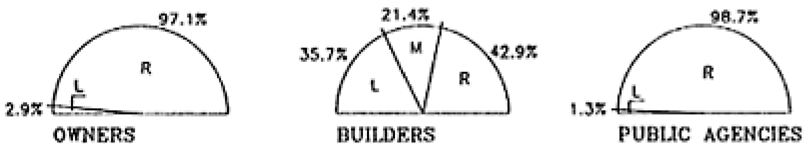


Fig. 13. CP2—Excessive washing away or stagnation of rain.

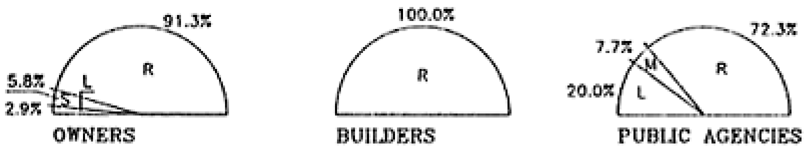


Fig. 14. CD1—Inefficacy of insulation in vertical structures.

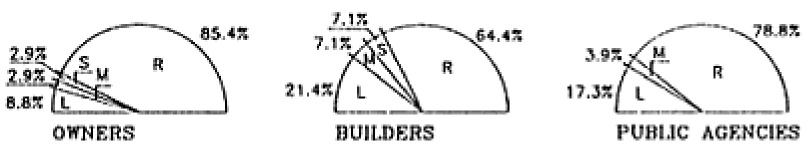


Fig. 15. CD2—Inefficacy of insulation in horizontal structures.

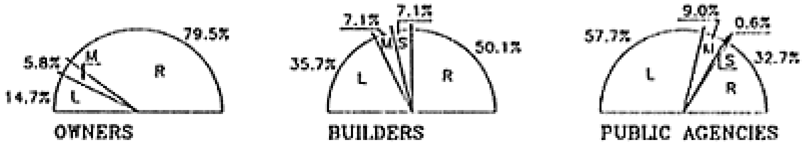


Fig. 16. CD3—Lack of ventilation.

We begin with the atmospheric deposits caused by the eterogeneity of the surface temperatures (Fig. 9), solubility of external surfaces (Fig. 10) and inefficiency of external materials (Fig. 11), in these cases it is about phenomena that are connected with inadequacy of materials and of techniques with which the layer of wall plasters are made.

With an exception in the first case it is still the builder the most exposed subject to failures which, as far as the inefficiencies of materials are concerned, reach sistematic frequencies. The causes of these phenomena, as we will see in the conclusions, have to be above all sought again in an insufficient direction of the building process as for the builder. This question as well deserves to be taken up again in the conclusions. Meanwhile it is useful to observe that in diagrams the areas of the sector repre-senting the reliabilty enlarge, in short the frequencies of the failures start to assume numerically less worryng values.

As regards the capillary rises, the palm of the failure is up to the public agency for the case of lack or ineffi-cacy of waterproofing cots (Fig. 12) and gets back to the builder for the excessive washing away on stagnation of rain (Fig. 13).

We conclude the list of "what do you expect in your new house built with modern technologies" with the phenomena of condesation. We have represented the percentage of crisis due to inefficacy of insulation in vertical (Fig. 14) or in horizontal (Fig. 15) structures and to lack of ventilation (Fig. 16). We are most interested in the first two failures, as regards the lack of ventilation it is a matter of a phenomenon linked to the procedures of management of the flats and not to those ones of building.

The termic insulations of horizontal structures, in short of the floors, generate the majority of problems with a main frequency for the builder, followed close behind by the public agency and by the owner, while for the vertical structures, in short almost ever reinforced concrete columns, which besides, as we have seen dealing with structural typologies, had a modest incidence, it is the owner the mostly hit subject by failures.

8 Conclusions

There are two types of conclusions to draw, the first relative to the causes af the above-mentioned crisis states and the second to the role of subjects and of the normative apparata relatively to the pointed out levels of quality in use, which is reliability. We consider first of all the crisis states of wich we will deal, for reasons of space, only the mostly significative.

Previously we have talked about the relation between some static lacks and crackings with the building and the structural typologies, we have seen it is mainly a matter of lined up houses with bearing septa: generally it is about a "national" version of the European building systems with industrialized reinforced concrete casting usually called tunnel, semitunnel or banc et table.

The arrangement that is made in our country, considering the building typologies, consists of either a sostitution of the reinforced concrete floors with reinforced concrete hollow tyle floors, or a sostitution af the reinforced concrete septa with masonry bearing walls. It is useful to remember about this matter that is generally about buildings with a small number of stories. With the above-mentioned substitutions, which sometimes are both effected, the behaviour of frame of the structure and the stifness of floors to septa connections are compromised, in other words the whole efficacy of the structure is diminuished. This means a bigger deformability of both the floors and the walls and this causes the failure of which we talk about.

Now as regards the static lacks and crackings that are connected with the behaviour of masonry, it is to be pointed out the national tendency to the substitution of the traditional brick (cm. 5.5×12×25) and of the most recent double brick (cm. 12×12×25) with bigger dimensioning blocks (cm. 24×25×30) which can also be realized, but this is not a problem, with other mixing. To this we have to add the tendency to reduce the operations of immersion into water before the laying in use. A wall realized with the above-mentioned technologies, has quantity of mortar much inferior to the traditional walls, besides with dry bricks the setting of mortar is gone worse, this signifies levels of ductility much inferior and this is the cause of the failures.

Still in this first part of the conclusions, we consider the athmospheric deposits. Here the motivations are different. The Italian builder has remarkably changed his own organization in the last few years, tendentially transforming himself in a general contractor who bids to skilled subcontractors the various workings. In the current builder’s yard several contractors or subcontractors meet togheter, whose objectives are different from the one of the whole success of the intervention. The failures of which we talk about are due mainly to the plasters and they are generated by a non-correct communication, in short by an insufficient regulation about the relations between the operations of plastering and the others, those one of bricking up above all.

In the end we move on to the conclusions about the role of the various subjects. We have just seen that there is a thight relation between innovation and failure. Now then, and we are back to the main aim of the present paper, it is the builder who, inside the contracting proceedings of which we have talked, when he becomes the subject of the choice as regards the building typologies, the structural typologies and the building systems, he works the main innovative attempts and he mostly exposes himself to the failure.

It is not a problem of inability, it is to be consi-dered that, inside this particular building sector, the operators are more or less always the same and therefore the builders who pays for the big percentages of failure when he is the principal decision maker, he is the same subject who realizes the buildings with the greater levels of reliability when he acts with traditional contracts.

In this sense the obiective body of regulations are insufficient to guarantee the teghnological success in presence of innovation. On the other hand a block of the last one can not be realistically proposed, as well irrational. The double aim to obtain high levels of quality and reliability, leaving free room to innovation, it is then to be pursued changing the normative apparata and moving on to building codes that do not produce the physical-mechanical performances of materials and components any more, but with requirements and services to which materials and components have to answer.

9 References

(1) Sinopoli, N. and Manfron, V. (1989) Owners, Pubblic aggencies, Builders: their influence on quality and reliability, PROCEEDINGS OF XIth INTERNATIONAL CONGRESS CIB 89, Paris, France.
(2) Turchini, G. (1985) Qualità edilizia e qualità architettonica, ARCHI E COLONNE, n. 3–4, Bologna, Italia.
(3) Ragusa, S. (1986) INTRODUZIONE ALL 'ANALISI DEL RISCHIO NELL' INDUSTRIA, ed. Safety Improvements, Milano, 1986.
(4) Ciribini, G. (1984) TECNOLOGIA E PROGETTO, ed. Celid, Milano.
(5) Blachére, G. (1966) SAVOIR BATIR, Ed. Eyrolles, Paris.

93
Norwegian quality management system ready for use in EEC

O.SIØHOLT

Abstract
This paper is an extract from the results of the Norwegian Building Research Institute's (Byggforsk) work on quality management from five years of research and consultancy in Norway and other countries. One general conclusion is that methods and results on a national level are dependent on the driving forces behind them (demands, subsidies and research funding). It seems important to stimulate the concept of Total Quality Management as an overall management approach. A process of continuous improvement within a firm/project is a necessary basis for any implementation of quality systems. The Norwegian Quality Management System is created as a reference model appropriate in the building industry to all kinds of firms and projects, and applicable also in other countries. The international quality standards are taken into account, to be integrated in a firms management system step by step. Third party certification of quality systems in firms or projects as the primary target is seen as a disservice. The paper ends with some comments on national and european strategies on Quality' Management.

Key words:
Total quality management, Changing method, Implementation, Quality system model, Certification.

1 Quality assurance results are dependent on national driving forces

The quality assurance within individual organisations does not develope along the same path. The measure of encouragement and enforcement, the 'pull and push' forces, often vary from country to country.

Governmental demands on documented quality systems for their suppliers may be a strong force (Denmark). Such demands can refer to quality standards, and give preference to companies with a third party system certification. Linked or independent we also find subsidies to promote development in small firms, export, campaigns, education etc. (Great Britain). Other funding can be available for research and development work (Norway). The national stimuli greatly affect the methods for implementation of quality systems. They also affect the market conditions and methods chosen by consultants on quality systems and the establishment of certifying bodies as a new business area. The question is: Which forces are most efficient?

2 Total Quality Management as a step-by-step improvement process

Since 1985 Byggforsk has been collecting experience with the intro-duction of quality management from about 50 Norwegian companies. The most important single factor to emerge was that the development of a quality attitude in an organisation is a process that takes time, and it must be carefully supervised by the management. Therefore a 'fivestep development program' was worked out, based on small increments of improvements. The steps are overlapping, fig. 1.

The main task for the management is to work-out and monitor such a quality program for the execution of quality improvement work in the company. It must state concrete objectives, which tasks are included, who is responsible and who is involved in each task, time limits, and if applicable, budget (step 1).

The development (step 2) starts with small improvement programmes where the main objective is to get rapid and measurable results, fig. 2. The easier these results are to measure, the more successful the whole process will be, and the more widely accepted in the firm.

Then the company collects in its 'state-of-the art'-procedures, using these to develop a consistent quality system (step 3).

The paper system is finally defined and 'new' quality management and assurance elements are integrated in the procedures, both for management activities and for operations (step 4). Discussions arising during this phase lead to rationalisation, and the resulting written material is of great value for training new staff and sub-stitutes. It must be worked out at the various levels of organisa-tion, not by a quality manager. A quality manager can be a pulling force, or a consultant for managers at all levels. He can also be a secretary, coordinating, maintaining and supervising the system.

The last step is to ensure that the system is distributed and implemented at every level of the company. Step 5 should also make sure that any practical experience gained from the use of the system is fed back into the system again.

3 Supervising improvement processes in groups of companies

Byggforsk organises company co-operating groups for implementing quality management. At the present time we have 12 different company groups representing five trades within the building industry. Two new groups for architects and professional clients are prepared (fig. 3).

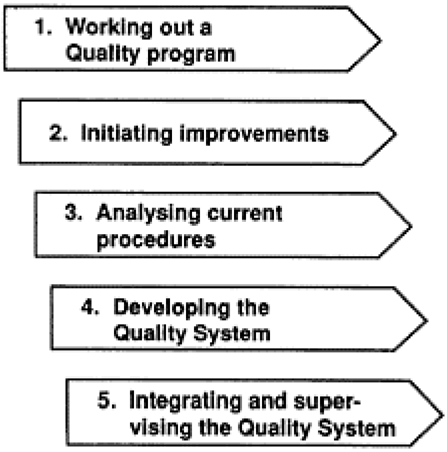


Fig. 1. Five step quality development program.

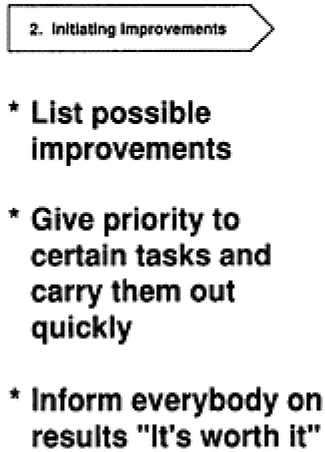


Fig. 2. Step 2 involves people and gives enthusiasm.

Groups consisting of 6–8 companies are, during a 30 month period, guided through the five-step program. Managers meetings and company meetings for the key personnel are closely co-ordinated with the steps. Between meetings each company is visited by Byggforsk representatives and given individual guidance. All the time each company works individually with its quality program, including a tailor-made quality system (fig. 4).

In the group they discuss experience, problems and good solutions—and Byggforsk gives a step wise introduction and instruction. This learning from each other's experience is extremely inspiring and mutually educational. The 'company group' approach has proved to be a cost-efficient method of implementing a quality system, providing the companies involved with cost-saving systems. The most important result is a sustained change in management behaviour and employees' attitudes to continuous quality improvements.

It seems important to be patient, but on the other side to keep the process moving on continuously. A company may spend two to three years going through the five steps the first time—but the process of improvement should never end. Some of the groups have prolonged their co-operation and the supervision from Byggforsk for another two years.

A new service has been developed by Byggforsk to achieve a speedier and wider propagation of the system. Byggforsk is now guiding and supporting consultants from specific trades or from local districts in their management of groups of firms, using the same methods as Byggforsk. By now such groups are working in Norway as well as in Finland and Holland.

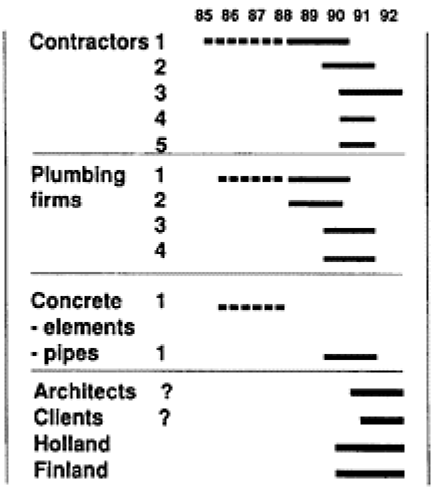


Fig. 3. Quality management co-operative groups.

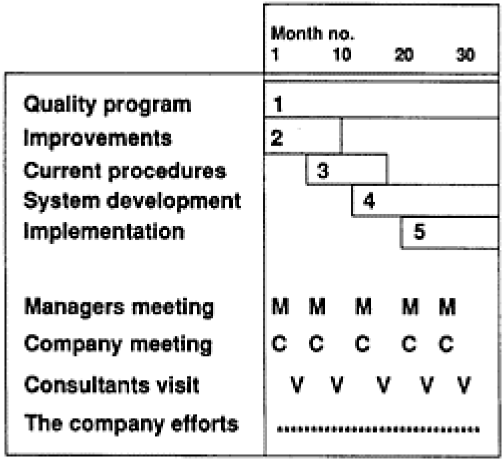


Fig. 4. Group program under supervision of consultants.

4 Quality Management System—QMS—a universal reference model

As an integrated support to this process of implementation Byggforsk has developed the Quality Management System. The system is based on the 'best practice' within a number of co-operating firms—sup-plementing the company and site management procedures with the 'new' specific quality assurance elements. Both the structure and the contents can be used as ideas for a company developing its own qua-lity system—with separate versions of about 400 pages each for contractors, plumbing firms and precast concrete factories. An important conclusion is that the basic activities in the different trades are so much alike, that the trades' versions of the system have nearly 80% of their structure and contents in common.

The design of the trade model was chosen to mirror a company system and to form a rational base for a quality plan for each individual building project. The system is built upon three main levels, fig. 5.

The top level is a general survey of the system for customers and employees. It includes a description of objectives, main principles and contents.

The middle level contains procedures including all sorts of routines and instructions.

The ground level consists of all kinds of forms, check lists and memo lists. They are directly referred to in the procedures. These are the day to day tools used in a company or in a project, providing documentation where necessary.

The universal Model book was designed to act as a reference work, with procedures and forms for the most frequent administrative activities—including information on quality techniques. Though Byggforsk has published this common model, we are warning companies against 'copying' the system. A quality system must be based on the company's existing, and working, routines and procedures, documented as well as not documented, fig. 6. The company may however occasion-ally pick out some 'supplementary' procedures from the model.

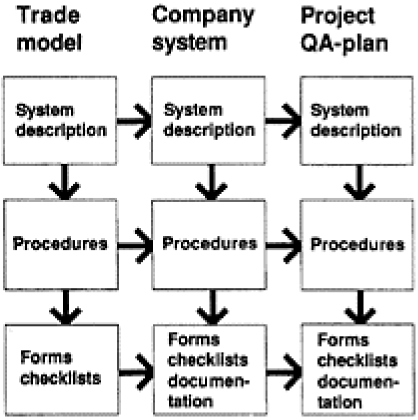


Fig. 5. The trade model on three levels.

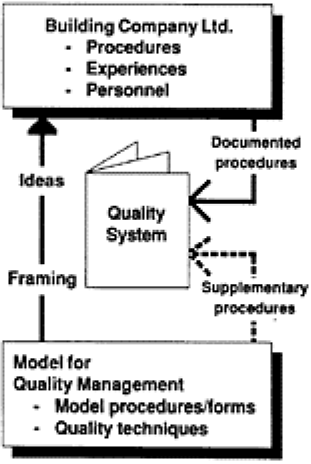


Fig. 6. A company's use of the model.

The paper system also needs a filing—or a numbering—system. The division of a quality system into chapters ought to follow the phases or main tasks a company usually covers, fig. 7. It then becomes easier for the individual to place and retrieve material. The first chapter—Universal—is reserved for general matters concerning the whole company, including staff functions which are not described in other separate chapters.

Further on the system design is based on a consistent subdivision of 0–9 for each chapter. The numbers refer to different aspects, a system which allows the user to find documents about any one particular aspect at the same place in different chapters, fig. 8.

While developing the models we realised the importance of a company's writing all its procedures according to a set model. This simplifies both the drawing up and the use. A standard form with fixed guiding words was designed, including a number, name of the procedure, objective, responsibility, timing, corresponding forms, reporting and the execution step by step. A procedure should be well-limited, well-defined and described on one page—exceptions should not exceed a very few pages.

Most of the procedures are supplemented by practical means, such as forms, check lists and memo lists, and the Model book includes several standard patterns.

A numerical code for easy storage and retrieval is designed to identify each of the documents in the system. The numbering system can effectively be used as file-names in word-processing systems. With a comprehensive company system based on word processed routines it is easy for project leaders to develope practical quality plans for new projects.

The principles of the QMS are proved to be universal both in relation to trades and to different countries. The use of the system is currently extended to new trades in Norway as well as internationally.

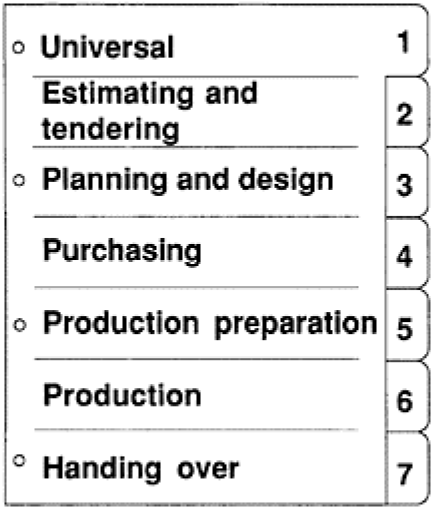


Fig. 7. Chapters within the quality system.

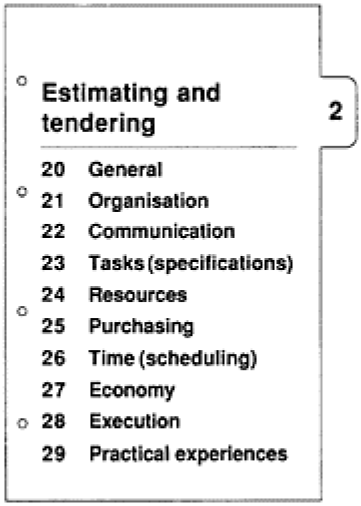


Fig. 8. The common sub-division of chapters.

5 The step wise integration of elements from quality standards

Byggforsk's experience with the implementation of step 4 'Developing the quality system' very much emphasised the necessity of a step wise progress.

The general aim has been to integrate the system elements of ISO 9004 'Quality management and quality system elements—guidelines' into a company's existing management system. Other elements might also be chosen as defined in the rest of the ISO 9000-series, fig. 9.

For contractual purposes it seems sufficient to give cross ref-erences to ISO 9001 'Quality systems—Model for quality assurance in design/development, production, installation and servicing', fig. 10.

The standards define what a quality system should contain, not how to implement it. Each company has to decide for itself the progress in development and implementation. Priority decisions should be re-lated to the risks—the probability and the consequences of failure.

The basic goal is: 'Right First Time'. Many principles are designed to aim at this goal. All these principles must be incor-porated in the company's culture during the process of quality development: the quality policy, the role of the management, responsibilities, project specification review, working methods, control plan etc.

Some of the elements have to be introduced in a sequential and logical order, aiming at preventing errors and mistakes, not at detecting them. This means building up the process management before launching the checklists and nonconformity elements, which again must occur before corrective actions and quality audits.

In larger firms it seems appropriate to concentrate on the company system and the total management from the beginning, while in some small firms it might be necessary to start with work on quality plans for a specific project. The advantage here is a parallel development of both management and the practical work.

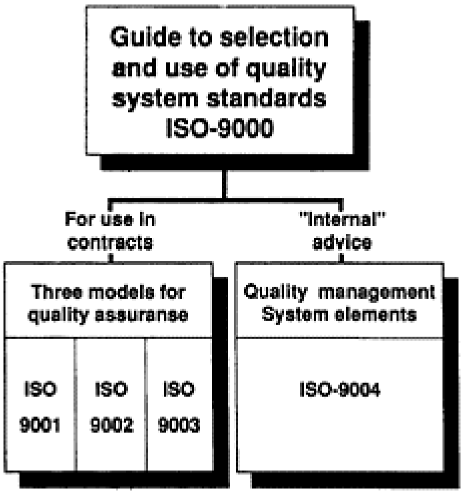


Fig. 9. Quality standards, ISO series.

A company's Quality System							
1 Universal	1						
2 Estimating and tendering		2					
3 Planning and design			3				
4 Purchasing				4			
5 Production preparations					5		
6 Production						6	
7 Handing over							7
ISO-9001 Requirements							
1 Mfmt. responsibility	*	*	*	*	*		
2 The Quality System	*		*			*	
3 Contract review		*	*		*		
4 Design control			*				
5 Document control	*	*	*	*	*	*	
6 Purchasing		*		*	*	*	

7	Cust. suppl. product							
8	Prod. traceability							
9	Process mgmt.	*		*		*	*	
10	Inspection and testing			*	*	*	*	*
11	Insp. and testing equip.							
12	Insp. and test status							*
13	Nonconformity	*				*	*	
14	Corrective action	*						
15	Handling, storage, deliev.							
16	Quality records	*		*	*	*	*	
17	Internal quality andits	*						
18	Traning	*						
19	Servicing							*
20	Statistical techn.							

Fig. 10. References from a company system to ISO.

6 Third party certification should come—if ever—at the end

Five years experience of the implementation of quality management shows that success clearly depends on the methods for changing the attitudes rather than the content of the system developed.

Where improvement in a company’s efficiency is the main objective the development process tends to proceed in an evolutional way—primarily based on changes that get people involved. In fig. 11 this is indicated on the horizontal axis: the left showing the basic quality improvement activities concerning people, proceeding to more formal activities involving paperwork on the right.

Where external formalised demands to fulfill quality standards dominate, the process will primarily be ‘paper work revolution’—yielding no sustained improvements in quality.

On the vertical axis the illustration indicates the main participants in the building process at the bottom, proceeding to the peripheral actors at the top. Experience shows that there should be a balanced development between the partners, but that the initiative should come from the core partners rather than the outsiders.

Even though the parameters are not easy to measure in practice, it can be postulated that an ‘evolutionary approach will give the most positive improvement on quality. This means a diagonally upwards direction in the diagram, as opposed to a ‘revolutionary’ downward approach.

This implies that a long period of development and implementation should elapse before one introduces third-party certification of quality management systems for architects, consultants and contractors. Obviously the circumstances for these groups vary greatly from those within the factories for building products. The danger is that an acquisition of a certificate becomes an aim and not a result, and this aim can damage a positive effort to achieve real quality.

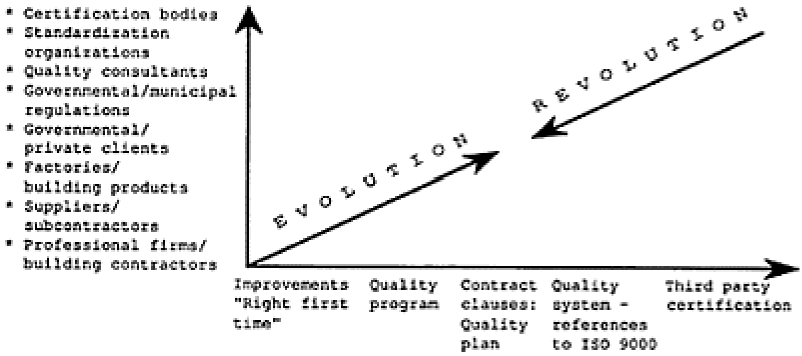


Fig. 11. An evolutionary implementation progress is recommended

7 National and European strategies on Quality Management

The Norwegian Quality Management System and methods of implementation are translated into English, Dutch and Finnish. There are company groups licencing the system in Holland and Finland. The approach has gained international respect—and is ready for further use in EEC.

The work Byggforsk has done so far affirms that the economical driving force is the main key to successful quality work. Companies primarily aiming at measurable improvements can, in the later stages, use external demands as motivation for continuous improvement. Companies that start with quality assurance as a condition of the contract very often ‘write books’ and experience greater difficulties both in getting people involved and in getting the system to work.

The following national strategies for promoting improved quality are recommended, based on the experience gained by Byggforsk:

> Accept the quality movement as a way of increasing efficiency of both management and physical work.
>
> Focus on the principles of total quality management based on existing cultures—instead of purely on quality assurance.

Favour improvement processes before system development. Support (subsidise) pilot companies in their development—preferably in joint groups.

Start with contractors, architects and consultants, proceed to the other core partners and then to more peripheral parties to achieve a parallel and balanced development (fig. 11 upwards).

Coordinate trades on their systems, framing and contents.

Encourage the trade organisations, if capable, to broadcast the system amongst their members, based on the trades cultures.

Ensure that the clients develop their internal quality systems before they claim documentation from their suppliers. In contractual demands, primary concentrate on the potential risks and problems, secondary check against the ISO-9000 standards.

Avoid certification of quality systems as a driving force.

Stimulate research and education connected to the preceding recommendations, and take advantage of international experience.

Hopefully the nations voting in the EEC will delay formal demands on the supplier's quality assurance. Such bureaucracy will be enormously demanding to supervise, and there is no evidence that a company using the ISO-9000 standards, or being certified according to these, is any better quality-wise than other companies.

8 References

Hansen, R. and Sjøholt, O. (1989) **Quality Management: A challenge for the Building Industry.** Project report 50, Norwegian Building Research Institute, Oslo, Norway, 43 p.

Sjøholt, O. (1991) Certification: A disservice to quality assurance, in **Practice Management: New perspectives for the construction professional** (eds P.Barrett and R.Males), Chapman and Hall, London.

94
Methodology of the development of an inspection and testing plan for the placement of precast concrete panels

E.T.de SOUSA, A.A.BEZELGA and A.J.O.BRAZ

Abstract
This paper presents an Inspection and Testing Plan (IPT) model for the placement of precast concrete panels. The requirements of the various sections of the ITP are indicated, a production flow chart has been drawn up, inspection and testing points have been located and a procedural “check-list” has been defined. The experimental application of the model is also described during the placement of the precast panel at the work, with only the variable time for placement being evaluated. Finally, mention is made of the advantages in applying a model of this type.

1 Introduction

This paper presents a methodology for the drawing up of an Inspection and Testing Plan for the placement of precast concrete panels.

This methodology can serve as a guide in drawing up an ITP for any product in being asssembled on site and, generally, for any building activity.

An Inspection and Testing Plan is one of the essential requirements of the Quality System necessary to guarantee conformity, both in production and in the finished product.

The ITP has the objective of localizing and describing, within the production cycle, the inspection and testing to be carried out by the company.

This should be carried out in a planned and systematic way and fall on all the phases of the production cycle.

It is from a careful analysis of the results that conclusions can be reached about the level of quality, the eventual need for corrective actions and the efficiency of the Quality System introduced. One can also then decide on what coordinating actions should be taken, and on the economic and organizational measures underway.

An Inspection and Testing Plan should be divided into various sections, and each one of them can be treated exhaustively or only with reference to the applicable documents in force, according to the applicable quality system model.

In a complete model the requirements put forward in the various sections of an ITP are generally the following:

a) the identification of the place for inspection and testing:

the place will be indicated in a plan—a flow chart of the work—where the inspection and testing will take place; at each work position there should be a description of the activity to be carried out, the means of control, and all the information required for the inspection and testing.

b) the identification of the activities covered:

referring to the principal characteristics of the activities to which the Inspection and Testing Plan is applicable.

c) the identification of the standards and specifications of the tests:

the criteria for carrying out the tests, the standards, the specifications or other documents to be applied at each inspection and testing will be identified.

d) the identification of the size of the sample:

the size of the sample and the respective criteria for acceptance and/or the standards applicable will be identified for each inspection and testing.

e) the identification of those responsible for the carrying out of the plan:

the manpower involved in the various inspection and testing operations should be referred to, defining their respective qualifications, competence and responsibilities for each action or group of actions.

f) the identification of the equipment necessary, as well as its calibre: a list will be drawn up identifying and referring to the principal characteristics of the equipment and other methods of control used, showing its calibre and establishing the times between verification of the respective measuring and testing instruments.

g) dealing with non-conformities:

actions resulting from the detection of nonconformities will be dealt with, particularly the register and the analysis of the causes and the identification of the decision paths for the respective corrective actions.

2 Model of the Inspection and Testing Plan for the placement of precast concrete panels

The study presented is a "Sub-plan" for Inspection and Testing, which is part of the General ITP, relative to a producing company and applicable to precast concrete panels.

In this sub-plan only the placement phase of the panels on site will be exemplified, assuming that the other phases—conception, manufacture and transport—have already been dealt with in the General ITP referred to.

Various activities are included in the placement stage, involving different tasks and operations, which can be grouped together into three main areas:

a) pre-placement activities: project, planning and coordination of the different operations, ways of access, storing, unloading, movement and binding of the panels on site;
b) activities during placement: elevation, colocation, regulation and fixing of the panels among themselves and to the structure of the building;
c) post-placement activities: preparation of the joints, collocation of the insulating material, repairs, cleaning and final finishing touches.

In the model drawn up “who”, “how”, “when”, “where” and “what” are described in the placement cycle, they have to show the conformity of the different operations to the requirements applicable and they are also to establish the methods of analysis and the inspection and testing activities in the whole cycle.

The model is accompanied by two basic documents:

> Document 1—A flow chart of the placement cycle giving an idea of the whole course of the panel with the various tasks and operations involved, including the localization of the inspection and testing points as well as the logical circuit of the decisions to be taken in the process (Figures 1 and 2).
>
> Document 2—A check list of the inspection and testing procedures, systematized in diagrams, where the characteristics to be inspected, the objective of conformity, the reference documents supporting the inspection, the manner and the frequency of the inspection and the respective corrective actions are indicated. (Diagrams 1, 2, 3)

Figure 1—Flow chart of the production cycle of precast panels (continuation) (Inspection and Testing Plan)

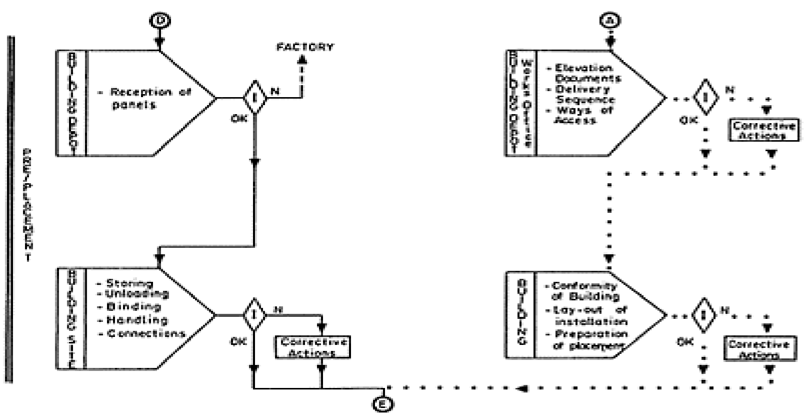
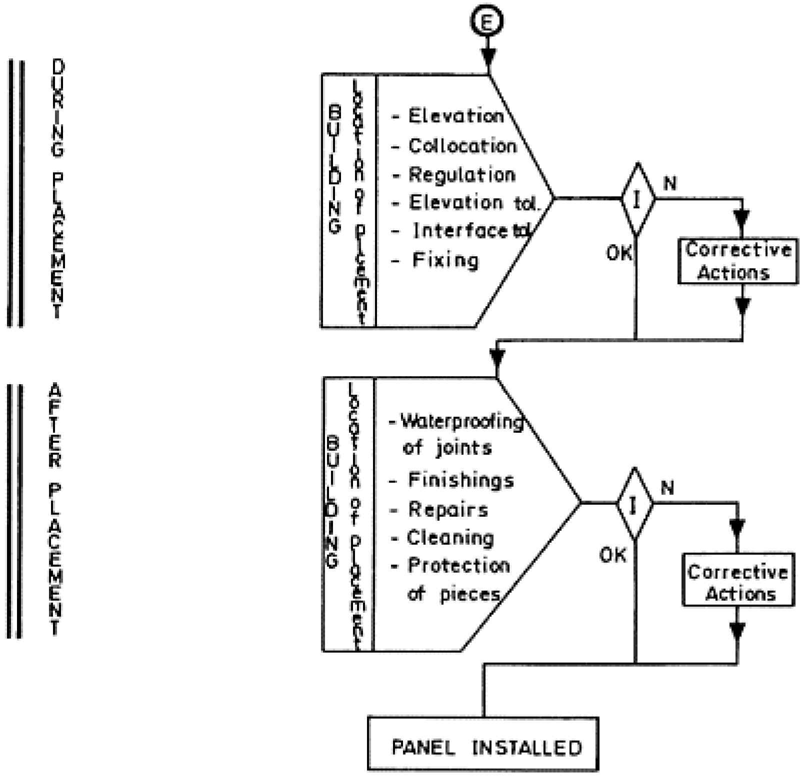


Figure 2—Flow chart of production cycle of precast panels (conclusion) (Inspection and Testing Plan)



Inspection and Testing Procedures

Tasks and placement operation (location and type)	Objective of conformity	Reference Documents (aiding inspection)	Method of Inspection	Corrective Action	Frequency of Inspection
Building under construction					
1.11—Layout of installation	Before placement verify if all the marks for placing of the panels were established and if all the devices for	Plan of placement of panels. Design of space (details)	Detailed inspection (person responsible for placement)	Correct all differences found between the actual and planned structure	All spaces

	fixing, grooves, bolts, etc. are ready				
1.12—Preparation of placement	Before carrying out the placement verify if all the material and equipment necessary for collocation is in order: connection mortar, supports, soldering equipment, etc, and are placed next to the location for placement	Checklist of materials necessary	Self-control (placement team)	Take precautions in case of nonconformity	Each space

Diagram 1—Inspection and testing procedures for the elevation of panels

Inspection and Testing Procedures

Tasks and placement operation (location and type)	Objective of conformity	Reference Documents (aiding inspection)	Method of Inspection	Corrective Action	Frequency of Inspection
II During placement. Building.					
11.1 Elevation	Elevation in accordance with placement plan	Placement plan	Self-control (crane-operator)	Elevate in the exact position. Avoid damage to the piece. Warr of the possibility of accidents.	Each panel
11.2. Collocation	Inspect: Collocation of wedges Support of panels Way of protecting staff against risks of falling Mortar	Internal operational procedures	Self-control (placement team)	Correct deficiencies. take precautions, warr of the possibility of accidents.	Each panel
11.3. Regulation	Respect all agreed tolerances	CSTB Standards (tolerances) Panel plant (details of	Self-control (placement team)	Place in the agreed positions by transversal, longitudinal, height and	Each panel

placement)		vertical adjustment.	

Diagram 2—Inspection and testing procedures for the elevation of panels

Inspection and Testing Procedures

Tasks and placement operation (location and type)	Objective of conformity	Reference Documents (aiding inspection)	Method of Inspection	Corrective Action	Frequency of Inspection
11.3.1 Tolerances of elevation	Verify the diference between the maximum and minimum toelerances admissable	Plan of the panel (details of placement) Tolerances: overall evenness width of vertical joints width of horizontal joints verticality disalignment	Self-control (placement team)	Regulate the differences	Each panel
11.3.2 Tolerances of interface	Verify the gaps between adjacent materials	Plan of panel (details of placement with tolerances)	Self-control (placement team)	Regulate the differences	Each panel
11.4. Fixing: Connections of the panels among themselves and the structure	Verify the operation is in accordance with the respective procedures	Procedures: Technical specifications soldered connections screw connections and concrete connections	Self-control (placement team)	Correct non-conformities	Each panel

Diagram 3—Inspection and testing procedures for the elevation of panels

3 Application of the model

The model has been tested on site, with the analysis falling only on one of the phases of the cycle—the second—corresponding to the activities during the placement: the handling and binding of the panel, the elevation, colocation, regulation and fixing of the panels among themselves and to the structure.

The time for the placement of the panel was inspected within a given sequence of placement, using a sample of .pa panels representing the total number.

For this, the “elevation time” was noted for each panel, or rather, the time during which the crane is occupied from the first handling and binding operation up to the last, the fixing of the panel to the structure of the building.

A curve was obtained, for the “time of elevation” function, with a rising tendency, as the number of placements increased.

It is normally accepted that, in repetitive activities, curves of this type should have a falling tendency, with a given rate of fall increasing with experience and practice.

In view of the reporting of this fact, the Pareto Diagram analyses the relative importance of the delays in the various operations in the placement of the panel (Figure 3).

The following was verified:

operations	percentage of delay
collocation	74.3%
handling and binding	14%
fixing	9.6%
regulation	1.1%
elevation	0.6%

Thus the two most important operations causing the delays were i) the collocation, ii) the handling and binding of the panels.

There followed a qualitative analysis of the causes of the delays for the two operations referred to (Cause-Effect Analysis—Figure 4) with the following conclusions:

> For the collocation operation—the most important cause was the non-conformity in size of the actual structure with the plans; the problems which caused the greatest delays, were those concerning corrections to non-conformities detected in the spaces where panels were being placed, namely: differences in texture, evenness, horizontality, verticality, length, width, height and thickness of the structural features surrounding the

Figure 3—Pareto Diagram Of the causes of non-conformities in the elevation sequence

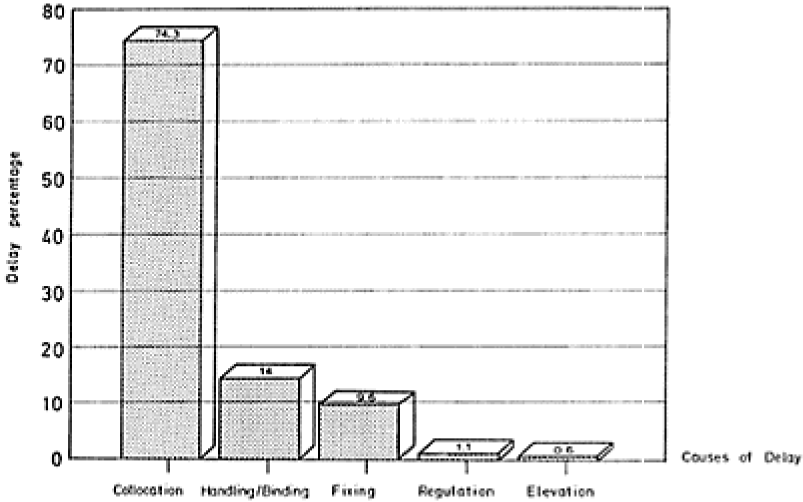
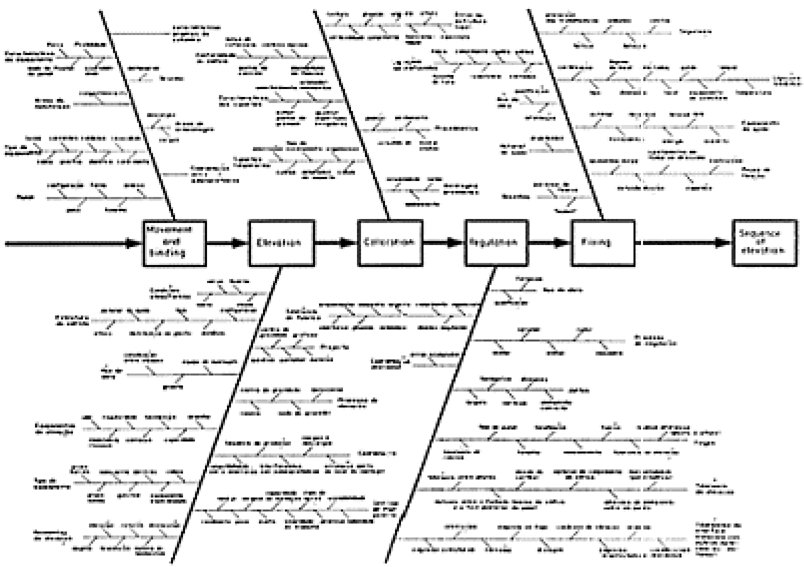


Figure 4—Cause/effect diagram by the sucessive stage method—Sequence of elevation.



spaces.

For the handling and binding operation—the most important cause of delay was the lack of coordination between the various sub-contracted firms in the management of the building site; this lack of coordination meant there was a deficient storing of panels on site which made it at times difficult to identify the panels to be elevated.

Faced with this analysis the following corrective actions were proposed:

So far as the non-conformities in the collocation operation are concerned: these were duly corrected before the start of the panel placement operations.

So far as the non-conformities in the handling and binding operation are concerned: the coordination between the various sub-contractors improved, and individual operating areas within the site were defined. An attempt was made to separate, handle and store correctly all the panels on site, so as to avoid incorrect use, deterioration damage and loss, as well as to assure that all the panels were duly identified, so that they could be located.

4 Analysis of cost-benefit in implementing an ITP

This analysis is taken from the work presented but it should be said that the planning of an Inspection and Testing Plan should be carried out after evaluating the cost-benefit relationship inherent in it.

Thus the economic analysis of the application of an ITP should always be equated following the cost-benefit binomial.

The formalization of the plan has its costs for the company, as there will normally be investments, be they in means, be they in staffing, as well as expenses inherent in its structure.

The benefits for the producer are various: a) it allows productivity to increase by improving the competitive power in the panels market which is expected to be even more demanding in 1993; b) it means there is less risk of pieces reaching the user which do not conform to specifications; c) it promotes the rapid correction of the non-conformities detected; d) it qualifies the work force through incentives for self-control in their activities; e) it shortens the deadlines for delivery and reinforces commercial promotion, through quality marks.

In an overall economic balance of the whole process one can say that the greatest advantage results from the decrease in costs due to the lack of quality (failures), despite the increase in costs for quality (prevention and evaluation).

The final benefit will surely be positive, be it in the short term, or be it in the medium term so long as the IPT is correctly introduced, and linked to a cost control structure. It will contribute to an increase in profitability and to the modernization of the company.

5 Conclusion

The quality of the placement of the precast panels on site depends, as was verified, on various factors.

Analysing only the sequence of elevation, there was observed the necessity for strict coordination between the owner of the work, the general contractor, the company responsible for the placement, the planners, the controller, the various sub-contractors, in fact all those who, directly or indirectly, intervene in the operation of the installation of the precast panels.

It was also observed that it is necessary to coordinate the tolerances between the structure and the various building components which form the facade and especially the precast items. This is a more general problem, deserving future institutional investigation so as to try to form a doctrine for the coordination of tolerances between traditional construction—with fewer demands on the practice of construction—and the placement on site of precast items, carried out with more open tolerances.

It would be without doubt useful if, besides the other procedures which research can provide, measures are adopted to guarantee quality.

For this, the drawing up and application of Inspection and Testing Plans (ITP) at three levels would be useful:

By the promoting bodies—to guarantee the quality of the enterprises they promote.

By the construction companies—to guarantee quality in the execution of the construcions which are carried out, be it through self-control, be it through quality control of work supplied by the sub-contractors, diminishing the costs of lack of quality, increasing productivity and the confidence of the work owner clients;

By the companies producing materials and components (and eventually responsible for the respective placement) to guarantee the quality of the respective products and/or services, increasing the profitability of its production and confidence in the client construction companies.

References

Ashford, J.L. **The Management of Quality in Construction** E. & F.N.SPON, London.

Chauvel, A.M. and Poivreau, M. (1987) **Gestion de la Qualité dans la Construction.** Editions Eyrolles, Paris.

Implementation of Quality in Construction. Proceedings of the 6th Seminar of the European Organization of Quality Control, 1989. EOQC, Construction Section, Vol. I and II, Copenhagen.

Murs Exterieurs en Panneaux Prefabriqués de Grands Dimensions, in Cahier du C.S.T.B., no. 210, D.T.U 221, Paris.

Prestressed Concrete Institute (1988, 2nd edition) **Manual for Quality Control for Plants and Production of Architectural Precast Concrete.** PCI, Chicago.

Teixeira de Sousa, E. (1990) **Garantia de Qualidade na Prefabricação e Montagem de Painéis Prefabricados de Betão.** Instituto Superior Técnico, Lisbon.

95
Qualitel method and label

C.TREHIN

General Introduction

For the last twenty years, quality of new dwellings has been improving regularly. This significant progression is linked to the evolution of technical knowledge, the development of new materials and construction processes as well as to a much more qualitative demand from the consumers.

Today, the user’s insistence on quality is much stronger than it was ten years ago. “We can’t sell the way we used to” is a familiar estate agent’s lament. Nowadays both buyers and tenants make their desire for quality quite clear—and the typical sales approach has adjusted accordingly.

The qualitative approach is necessarily global. It concerns the professionals in the industry whose job it is to make estimates, plan, manage and bring to a successful conclusion all the diverse elements and functions necessary to achieve a given level of quality as economically as possible.

It concerns the users—the occupants of the dwellings-who have insufficient technical knowledge to judge quality and have to resort to a kind of mediation: expert opinions, certificates of quality, labels and so on…

This mediation, after consultation between the professionals and the users, makes it possible to certify the level of quality of a given equipment or dwelling. The problem is objectivity: how to arrive at objective investigative procedures to evaluate quality?

Qualitel Label deals precisely with the objective evaluation of technical quality. It is awarded if agreed-upon standards are met. These standards are set after consultation between the French Ministry of Housing and the Board of Directors of Qualitel, a non-profit making organization.

The Qualitel Method and Label

The Qualitel Label is based on a very precise methodology: the Qualitel Method.

This method involves two types of research: finding out the users’ needs and priorities, and predicting the performance levels of projects for new dwelling on the basis of their technical characteristics.

Very briefly, the Method determines basic needs, spots products and techniques which satisfy these needs and communicates this information to the interested parties.

Quality levels are always formulated in terms of requirements. In other words, the Qualitel Method does not set up norms and does not not act as a brake on innovation, particularly where new materials and new building are concerned.

The Qualitel Method was created in 1974 and is periodically updated to take into account the progress achieved in building processes, materials and equipement. The sixth update was effected at the beginning of 1989.

In practice, every new housing project can be evaluated, dwelling by dwelling, and a rating table drawn up which expresses the level of quality on a scale from 1 (“poor”) to 5 (“excellent”). To receive the Qualitel Label it is necessary to obtain a minimum rating of 3 for each dwelling and under each of the following headings established by the Qualitel Method.

- **Protection against noise emitted outside the building**

  For facades where insulation is required by French Regulaion, the rating is established by examining the insulation of the solid walls, woodwork and accesories and the insulation of the roofing.
- **Protection against noise emitted inside the building**

  The rating for a given dwelling is established by examining insulation against airborne noise coming from other premises in the same building, airborne noise inside the dwelling itself, impact noise through walls, floors and ceilings and noise from both individual and collective installations.
- **Maintenance costs for facades and roofing**

  These are evaluated with respect to the durability of materials and building procedures used as well as the frequency and extent of maintenance they require. The rating is expressed globally by successively examining the solid sections of the facades, outside woodwork, blinds and shutters, solid doors, watertightness in general and particularly of underground, garages and roofing.
- **Thermal comfort in summer**

  The rating is established by examining the summer climate zone, the inertia class of the building, the presence and type of solar protection and the type of ventilation.
- **Estimated costs for heating and hot water**

  These are estimated for each dwelling with reference to standard consumption. The purpose of this rating based on estimates is to permit comparison between dwellings.
- **Plumbing**

  In this category, hot water production, the presence of stopcocks, the range of sanitary appliances, the quality of the taps, provision of supply and drainage of washing machines and the facings in kitchens and bathrooms are considered.
- **Electrical installation**

  Power supply, the number and distribution of outlets and fixtures throughout the dwelling and provision for household appliances in the kitchen are evaluated.

In order to help and advise the architects, engineers and builders involved in a given project, a preliminary estimate of quality is provided before attribution of a Qualitel rating, so thaty they can alter plans and improve quality if necessary.

The procedure followed in attributing the Qualitel Label is very open and guarantees a diversity of conception and design. A desired level of quality can most often be attainded thanks to a wide range of technical solutions and designs.

Favour improvement processes before system development. Support (subsidise) pilot companies in their development—preferably in joint groups.

Start with contractors, architects and consultants, proceed to the other core partners and then to more peripheral parties to achieve a parallel and balanced development (fig. 11 upwards).

Coordinate trades on their systems, framing and contents.

Encourage the trade organisations, if capable, to broadcast the system amongst their members, based on the trades cultures.

Ensure that the clients develop their internal quality systems before they claim documentation from their suppliers. In contractual demands, primary concentrate on the potential risks and problems, secondary check against the ISO-9000 standards.

Avoid certification of quality systems as a driving force.

Stimulate research and education connected to the preceding recommendations, and take advantage of international experience.

Hopefully the nations voting in the EEC will delay formal demands on the supplier's quality assurance. Such bureaucracy will be enormously demanding to supervise, and there is no evidence that a company using the ISO-9000 standards, or being certified according to these, is any better quality-wise than other companies.

8 References

Hansen, R. and Sjøholt, O. (1989) **Quality Management: A challenge for the Building Industry.** Project report 50, Norwegian Building Research Institute, Oslo, Norway, 43 p.

Sjøholt, O. (1991) Certification: A disservice to quality assurance, in **Practice Management: New perspectives for the construction professional** (eds P.Barrett and R.Males), Chapman and Hall, London.

a.q 06.04.91

Qualitel Label: a base for 3 new quality labels

Cotation scale 7 criteria examined	1	2	3	4	5
Protection against noise emitted outside the building					LABEL QUALITEL COMFORT ACOUST.
Protection against noise emitted inside the buiding			L A B E L		
Estimated costs for heating and hot water				LABEL QUALITEL HPE ***	LABEL QUALITEL HPE ****
Maintenance costs for facades and roofing Plumbing Electrical installation Thermal comfort in summer			Q U A L I T E L		
			+a 8th		
Access for disabled people			LABEL QUALITEL ACCESSIBILITE		

96
Introducing a quality assurance system into a medium sized contracting organisation

A.H.TYLER

Abstract
This paper describes an applied research and development project at present being undertaken by the Department of Civil Engineering at Loughborough University to produce and implement a Quality Assurance System in a medium sized contracting organisation. Details are given of the methodology used, the actual work undertaken, the documentation produced, the implementation into the company and the initial effect on the company. The scheme has operated for three years and has one more year to run.

Keywords: Quality Assurance, Contractors Organisation, Management Systems.

1 Introduction

Quality Assurance is a subject which has only been taken seriously in the construction industry in Great Britain in the last six years. The large contracting companies have introduced Quality Assurance Systems into their organisations but a Loughborough University survey (D P Bhattari, 1990) showed that none of the medium sized construction companies surveyed had introduced such a system.

This case study describes the development and implementation of a Quality Assurance system in a medium sized contracting organisation. The work is being executed under a Teaching Company Scheme and jointly funded by the company and the Science and Engineering Research Council. Two Teaching Company Associates have been employed to carry out the work under the direction and supervision of a management committee comprising of three academics from the University, three representatives of the Company and one representative of the Teaching Company.

The aim of the project is to improve the productivity, efficiency and cost effectiveness of the company through the introduction of a Quality Assurance system. The management committee set the following objectives to achieve the aim:

To review the existing company systems covering the use of materials, plant, labour and sub-contractors.

To develop revised systems for use in the four agreed management areas.

To produce a total Quality Assurance system with appropriate documentation, based on the company review, to satisfy BS5750.

To develop an in-house training programme to train staff in the efficient use of the system.

One Associate was employed for the first two years of the project and a second Associate for a subsequent two years with only a two month overlap in their employment. The research has been carried out under three broad headings, materials, including sub-contract procurement, plant and labour. The first Associate also undertook a detailed study of Quality Assurance as part of his familiarisation programme and this initial work also greatly assisted the academics and company staff too fully understand the subject.

2 Materials

2.1 Scope

Materials was the first area to be investigated as part of the research. Every time materials were "influenced" by anyone in the company their involvement was studied, documented and reviewed. In this way we built up a complete picture of materials control and management to enable the relevant Quality Assurance documentation to be produced. The investigation covered Estimating; Buying; Materials control; Accounts Procedure; Supplier Evaluation and Company Documentation.

2.2 Review of existing systems

A thorough review of all the existing company systems in which materials featured was undertaken. Much of the information was not formally recorded within the company and so had to be documented by means of in-depth interviews with all the companies site and head office managerial staff. The interviews concentrated on the various managerial functions, e.g. Estimating; Site Control and Accounts.

Details of the actual tasks undertaken by the various personnel were recorded together with details of where they obtained information and where they passed on their completed work. The interaction between head office staff and site staff was also clarified and recorded.

All the data obtained was analysed and a review of existing systems was produced in report format. In many instances more than one system was recorded within the company for achieving the same task. All inconsistencies within the systems, as recorded, were checked with the personnel involved to authenticate the document.

2.3 Report to Company Directors

The Material Systems review document was then studied by the team to identify areas of weakness in the system, areas of duplication, areas of inconsistency between departments and any other problems connected with the existing practices. Based on the areas of possible failure in the system, identified in the study, a list of recommendations were prepared with the aim of producing fully co-ordinated procedures for all materials functions within the company.

These recommendations were added to the Materials Systems report and then passed to the Company's Directors for their consideration and comment.

After serious consideration the Directors responded to the report and its recommendations. The Directors welcomed the report and in a written response they answered all points raised, wherever possible instructing that the recommendations should be implemented immediately

2.4 Preparation of new company materials management system.

Implementation of the recommendations accepted by the Directors required further work to be undertaken by the Associate. A quantitative analysis quesionnaire was produced and circulated to all staff to establish the time spent each week on materials functions. The form used to collect the information, was similar to a standard time sheet with a box for each hour of the working day. When working on materials functions only the staff recorded the process undertaken, the material involved and whether own or sub-contract material. Other management functions were not recorded.

The results of the survey were not conclusive and only proved that except for the buyers, staff had no recognisable pattern to their work involvement with materials. This basically told us that there was no predetermined order for the new documentation.

2.5 Supplier Evaluation

One of the main recommendations of the report concerned Supplier Evaluation. Such a system is a pre-requisite of a Quality Assurance system and the company did not practice any formal evaluation of its suppliers. An evaluation system was, therefore, designed based on a simple monthly return form from the sites. The site manager records data covering such items as quality, delivery and service, for each main material supplier who delivers to site, using a simple points system to indicate the level of achievement under each heading.

The returns from each site are analysed by computer and a league table prepared of the good and not so good suppliers. This league table is then circulated to all staff involved in procurring materials as a guide to good and bad suppliers. The back-up data is held at head office should any staff member require details of a suppliers performance. These Evaluation Reports have already proved their worth as improved performance has been recorded from suppliers who were informed of their poor rating with regard to the company.

2.6 Site guidance notes for materials

A major piece of documentation was then produced by the team. This was a set of site guidance notes for materials control, basically for use by site staff. The process of producing the document took a total of four months as the team could not obtain details of any similar document and had to produce their own "notes" completely from first principles.

Firstly, a number of the team members attempted to produce a set of notes on a particular material. These drafts were then scrutinized and a preferred format agreed for each section which consisted of a series of points under seven headings. The seven headings were:

British Standard References
Delivery
Handling
Storage
Health and Safety
Protection and Waste Avoidance
Testing

Using this format meant that the final document was kept to a manageable size that staff would refer to.

The first two sections were produced by the Associate as examples for the site managers who were then used to produce the remaining sections. This strategy meant that the document was produced by the best qualified staff for the task who, in turn, would be more likely to use a document drafted by themselves and their colleagues.

The completed draft was then circulated to all requisite staff and the resulting comments incorporated into the final document. When issued the document contained three sections, Material Certification Schemes; Material Guidance Notes and Health and Safety References. The Material Guidance Notes covered twenty eight materials and the document has sixty seven pages.

2.7 Procedures Manual

A section of the Company Procedures manual covering the management procedures for materials was also produced and this document is described in section 6.2 of this paper.

3 Sub-Contractors

British Standard 5750 "Quality Systems" contains a recommendation that the selection of Sub-Contractors should also be based on records maintained by the company listing the previous capabilities and performance of firms.

An evaluation system for sub-contractors was, therefore, developed based on a similar form to the materials evaluation record sheet. The site manager, again, rates the sub-contractors performance against a number of criteria using a points system. The completed returns are then analysed and a league table produced which is circulated to all staff involved with sub-contractors. To date, the use of the evaluation sheet has only had limited effect on the company but there is evidence of improved performance from some sub-contractors.

4 Plant

4.1 General

The second main area of the project was an investigation into the existing Plant management procedures to enable a review of the procedures to take place and formal documentation to be produced.

4.2 Review of existing plant procedures

A review of all compnay systems involving Construction Plant was undertaken using a similar methodology to that used to review materials. Fifty-six members of staff were interviewed and any work undertaken in connection with Plant was recorded. Particular attention was paid to the plant department at head office, plant selection, plant hire arrangements, conditions of hire, hire charges, operatives, maintenance, damage to plant and safety requirements.

4.3 Report on assessment of systems affecting plant

All the data collected was, again, analysed and a report produced on the systems operating within the company. The report covered Administration Systems, Site Control, Plant Suppliers and Financial Control. At this stage in the project the team felt confident to add a "discussion" section to the report straight away, pointing out good and bad practices and highlighting the weaknesses in the systems. A list of recommendations was also added to the report and the complete document was submitted to the Directors for consdieration.

For this section of the project the Directors dismissed some of the recommendations as not suitable for the company and produced a directive to implement all the other points in the report.

4.4 Implementation of Directors decisions

The Directors decided to re-organise the company's plant administration provision but dealt with the matter themselves.

The majority of recommendations to be implemented were concerned with plant management procedures. This entailed a revision to the plant section of the company procedures manual which had been prepared by one of the companies staff following the production of the materials section earlier in the scheme. Details of the complete manual are given in section 6.2.

The last part of the plant procedure requiring revision was the plant procedure form, which had been in use for some years. This form was revised in conjunction with selected site staff and the accounts department.

5 Labour

5.1 Scope

The third main area of research is the management systems concerned with the employment of labour. Work on this section of the project has only just begun and preliminary work has been carried out to prepare for the collection of the required data.

Construction labour will be studied under three headings, directly employed labour, daywork sub-contract labour and package subcontract labour. As with the previous sections of the project the existing systems will be recorded and analysed, revisions to the system will be proposed and accepted recommendations will be implemented.

5.2 Human resource assessment

In order for any Quality Assurance system to operate efficiently, all the company staff must be well trained for their job and their well being must be maintained by the company. A further section of the project will, therefore, address these issues with a view to completing the Quality Assurance system by the inclusion of a human resource management section in the documentation.

This phase of the project will involve research in three areas.

Employment administration
Training and eduction
Welfare and employee relations

The research methodology will, again, be to define current procedures, Employees will then be interviewed to establish the effectiveness of the current procedures and current “best” practice in personnel management will be established. Using this data the relevant company procedures will be recommended to the Directors and their directives implemented.

Quality Assurance Documentation

6.1 General

One of the objectives of the project was to produce appropriate Quality Assurance documentation. Towards the end of the first year of the project when the materials management documentation was to be produced the Associate conducted some research into the documentation requirement for a Quality Assurance system and the required format of the documents. This entailed checking all available references on Quality Assurance and visits to other contracting organisations who were kind enough to offer advice on the subject. The research showed that Quality Assurance documentation operates in a hierarch-cal format as illustrated in Figure 1.

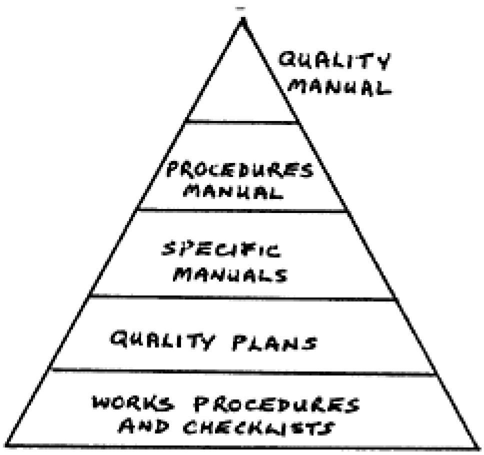


Figure 1. Levels of Documentation for a Quality System

The investigation into documentation requirements also confirmed the teams detailed view of the long term implications of implementing a Quality Assurance system within the company. This led to the production of a report setting out in detail both the short and long term implications for the company. The report was submitted to the Directors who confirmed their commitment to the aims of introducing a Quality Assurance system in the company.

6.2 Procedures manual

A complete procedures manual has been produced under the scheme covering the management procedures for all departments of the company. The manual incorporates the following sections, Estimating and Planning, Purchasing, Purchased Supplied Material, Document Control, Inspection and testing, Finance and Cost Control, Valuation and Credit Control, Sub Contract Control, Plant Management, Site Control.

6.3 Quality Plans

Quality plans are produced for each individual contract. The plan collects together the basic data relating to the contract and formalises its presentation. One of the essential functions of the Quality Plan is to enhance the site managers knowledge of the project and it is important to compile the plans at the commencement of a project. The use of Quality Plans has also been found to be a useful tool at pre-enquiry and pre-contract stages of a project as part of the marketing strategy to demonstrate commitment to Quality Assurance principles.

7 Current Position

The introduction of a Quality Assurance scheme into the company is now well advanced. The first Associate on the scheme has now been appointed Quality Assurance Manager for the company in order to develop and maintain the scheme within the company when the present project ceases.

The Procedures Manual has been produced covering all aspects of company management and has been distributed to all staff.

Material suppliers and sub-contractors evaluation forms are now in regular use to monitor the performance of suppliers and sub-contractors. The "league" tables are produced and distributed to all site staff.

Quality Plans are now prepared for all new contracts and issued to the site manager prior to contract commencement.

Fifteen staff training sessions have been organised to introduce the system to the staff and keep them informed of further developments to the scheme.

The overall research and development project is on programme and the company should be in a position to apply for third party accreditation at the end of the scheme if it so wishes.

8 Conclusions

Whilst this is a research and development scheme and not a pure research project it is possible to draw conclusions on the development and implementation of the scheme.

Take the introduction of Quality Assurance step by step.

Obtain the complete understanding and backing of the Directors and top management.

Ensure the company understands the long term implications of such a shceme.

Keep all employees informed of developments.

Document the existing systems thoroughly.

Revise existing systems only where necessary.

Keep documentation simple.

Use seminars to “present” documents and systems to the staff, do not just issue documentation.

Have a plan and personnel for future development and maintainance of the system.

97
Quality aspects of wet area construction in residential buildings

T.E.UHER and B.V.WOLLASTON

Abstract
This paper addresses issues of quality control with regard to wet area construction (bathrooms and shower compartments) in residential buildings. The main causes of waterproofing failures were found to be related to poor design and detailing and poor on site quality control. Research has found that most waterproofing problems can be overcome through an effective on-site quality control policy.

Keywords: Waterproofing, Quality Management, Housing.

1 Introduction

Despite the conservatism which prevails in the construction industry, some changes in technological processes and management practices have been evident in the last 20 years. Designs have become more innovative and more aesthetically pleasing, more effective project management practices have been employed by contractors, and new and challenging non-traditional procurement approaches have been tested. The underlying objectives of the changes were not only to create a better and more pleasing built environment, but also to make the construction process more cost effective and productive, thereby achieving better returns on the invested funds. These objectives were generally met through more efficient designs, better control of costs and faster construction.

The desire to build faster and cheaper often obscured the importance of quality control. However, there were other factors which eroded quality control:

The change in the role of design consultants under the non-traditional contractual process with the resulting loss of control over quality issues.

The abolition of the clerk of works.

Much greater reliance on subcontractors to do the work.

The shortage of skilled labour.

The high level of competitiveness among contractors and subcontractors.

Designers have in the past been required to ensure that building projects were built to the “required quality standards”. However, these quality standards were generally expressed subjectively and thus were likely to be interpreted differently by different parties. The true quality of buildings is judged by their owners and occupiers over a length of time after the buildings have been commissioned. But when quality related problems occur, it is generally too late for clients to recover under the building contract for damages. The cost of repairs and maintenance becomes their problem.

Clients have realised that quality control issues must be resolved and paid for “up front” during the design and construction stages of building projects. Every effort is now being made in Australia to set in motion a new approach to quality control. Quality control has become the theme and the topic of many conferences and research studies which aimed at the development of a new quality standard. The standard was released in 1987 as Australian Quality Standard 2990—1987 “Quality Systems for Engineering and Construction Projects”. It has since become a contractual document for many building projects in Australia.

Quality related problems have plagued all types of building projects from houses to multistory commercial buildings. This paper will focus on quality control problems associated with the construction of wet areas, particularly bathrooms in residential buildings. It will report on the findings of two research studies conducted by the Building Research Centre in the School of Building at the University of New South Wales directed to issues of quality in domestic construction (Uher and Wollaston, 1988 and Forsythe and Marosszeky, 1988).

These research studies were carried out by the Building Research Centre in the last four years to examine “quality” in residential building. The first study, undertaken by Forsythe and Marosszeky (1988), set out to identify the main causes of poor quality in domestic construction and to recommend inspection regimes that would help to improve the effectiveness of quality control.

The second study, carried out by Uher and Wollaston (1988), attempted to find reasons for waterproofing problems in bathroom and shower installations in residential buildings, and to develop an efficient and effective system of waterproofing such installations.

2 Research by Forsythe and Marosszeky, 1988

The structure of this research project was based on three different surveys, each examining different controls of quality in the building process.

The first survey of 33 projects, including new homes, alterations and additions, focused on builders’ on-site quality control.

The second survey involved the assessment of inspection reports compiled by building inspectors (surveyors) in 10 different municipal councils (these councils are responsible for local planning and development and for building approvals) within the Sydney metropolitan area. Records from a total of 1223 inspections were analysed.

The third survey analysed 1571 consumer complaints about defective work which were lodged with the Building Services Corporation. The Corporation is a statutory body responsible for the licensing of contractors and subcontractors operating in the residential sector of the building industry in NSW and for the administration of a compulsory insurance scheme.

In summary, the causes of defects in house construction identified by Forsythe and Marosszeky were:

> The lack of a quality control policy.
> The lack of management skills on the part of builders, particularly with regard to the co-ordination and control of subcontractors.
> The lack of understanding and observance of building regulations by builders and subcontractors.
> Inadequate training of tradesmen and supervisors, and The high degree of subcontracting.

In order to improve the quality of work, the research team called for better and more effective systems of trade training by the Colleges of Technical and Further Education. It further called for the establishment of a formal technical training course for supervisors. There is no doubt that such courses would not only improve the competence of trade contractors and supervisors but also improve their knowledge of sound quality management practices.

3 Issues affecting quality in house construction

Until the introduction of the Australian quality standard AS 2990–1987, there was no objective quality control policy in force in the Australian building industry. Quality standards had been formulated by designers in various clauses of the specification and had to be contractually complied with by builders. They have commonly been described subjectively as, for example, “first quality finish” or, “to be performed in a tradesman like manner” or, “to be built to the satisfaction of the designer”. However, problems arose as to the interpretation of such quality standards which often resulted in numerous contractual disputes. What the designer perceived as “first quality finish” did not necessarily correspond with the builder’s understanding or the client’s expectations. Clearly, this approach to quality control was doomed to fail.

The housing sector of the building industry has generally operated without an effective quality control policy. While this does not come as a surprise in reference to housing projects developed and built by builders/developers, it has been surprising to find the lack of adequate quality control on government projects (Uher and Wollaston, 1988). Traditionally, the role of the quality controller has been performed by a clerk of works: however, this position has generally been abolished over the last decade as a cost cutting measure. Thus, without an effective quality control policy and without the presence on site of a quality controller, quality of work has declined.

It has become a common practice to sublet most if not all of the building work to subcontractors. The role of the builder then changes to that of a co-ordinator of all the activities. It is claimed by some that subcontracting improves productivity by virtue of specialization of individual trades (Twyford, 1977, Rocher, 1980 and Peacocke, 1979). However, others, notably Ferrett (1985) and Uher (1990) argue that subcontracting not only increases the project cost but also the client's risk. Because subcontractors are often exposed to harsh subcontractor conditions and unethical bidding practices (Uher, 1988), they may, in adverse situations, compromise on quality in order to meet the subcontract cost and time.

The high level of subcontracting requires the builder to concentrate on the co-ordination of activities and effective contract administration in order to minimize the incidence of contractual disputes. It has been reported by Uher (1990) that subcontractors are often required to co-ordinate the work of preceding and following trades. Where the builder attempts to transfer the responsibility for the co-ordination of the work to subcontractors, he is not in full control of the project and he is therefore not in full control of quality

Those who are concerned with human behaviour generally believe that a strong association with the final product is an important motivator of the work force (Fulmer, 1983). However, subcontractors come and go as required and move to another project when their work has been completed. It is unlikely that a single subcontractor would have been on a building project from start to finish. It may well be that their relatively short association with the project and the lack of appreciation of the final product may actually be detrimental to the quality of work.

Training of subcontractors and builders' supervisors in effective quality control procedures will undoubtedly improve their knowledge and awareness of quality issues. However, it may not necessary lead to the improvement in quality standards, particularly if builders are responsible for setting such standards. An objective quality standard or code with an input from builders, designers, subcontractors and also clients has a better chance of success.

4 Wet area construction research (Uher and Wollaston, 1987)

4.1 Objectives of the research

Objectives of the research team were to find the causes of and remedies for waterproofing failures in bathrooms and shower compartments in residential buildings.

4.2 Surveys

Investigations unearthed a wealth of information relating to the causes of waterproofing failures in shower installations. The main causes can be summarised as:

Omission of horizontal angle flashing.
Incorrect installation of horizontal angle flashing.
Poor detailing of floor waste connections.
Unsupported and poorly fitted shower trays and bases.
Inadequate support for plumbing.

Inadequate hob detailing.
Abrasive action on fibreglass.
Inappropriate tray materials.
Poor workmanship.
Non-compliance with specifications of manufacturers of building materials.
Ignorance of waterproofing principles.

The investigation found that the majority of waterproofing failures occurred in timber framed construction and were caused by poor design and detailing, and poor quality control.

A similar result was obt obtained from an examination of new and defective shower installations. In total 34 houses under construction and 32 defective installations were inspected.

4.3 Experimentation

The survey results did not provide any guide as to whether or not good Quality control minimizes the extent of waterproofing failures. It was therefore decided to test the hypothesis that good quality control of building work will reduce the incidence of waterproofing failures.

To verify or reject the hypothesis, a number of experimental shower cubicles was tested under laboratory conditions. While strict quality control standards were imposed in construction of all the test cubicles, each cubicle was designed and detailed differently. Performances of individual cubicles were monitored throughout the test period.

In total, 11 different designs of full scale shower cubicles were constructed. All the test cubicles were timber framed. Each cubicle was designed to contain an impervious tray or base waterproofing system. Such tray and base systems can be classified as (refer to Figures 1, 2 and 3):

An external tray system, where wall lining passes inside the tray.
An internal tray system, where wall lining passes outside the tray.
A shower base system.

External tray systems fall into three categories; prefabricated, in-situ and sheet trays. In the experiment two types of prefabricated trays, one made from copper and the other from PVC, one type of in-situ tray made from fibreglass, and one type of sheet tray made from vulcanised synthetic sheet rubber were used.

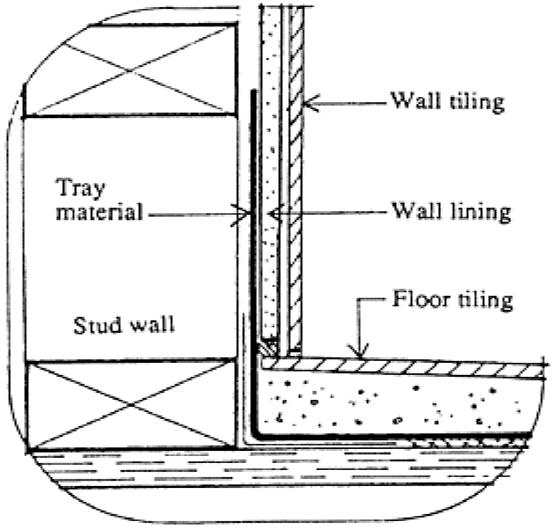


Fig. 1. An external tray system. Wall lining passes inside the tray.

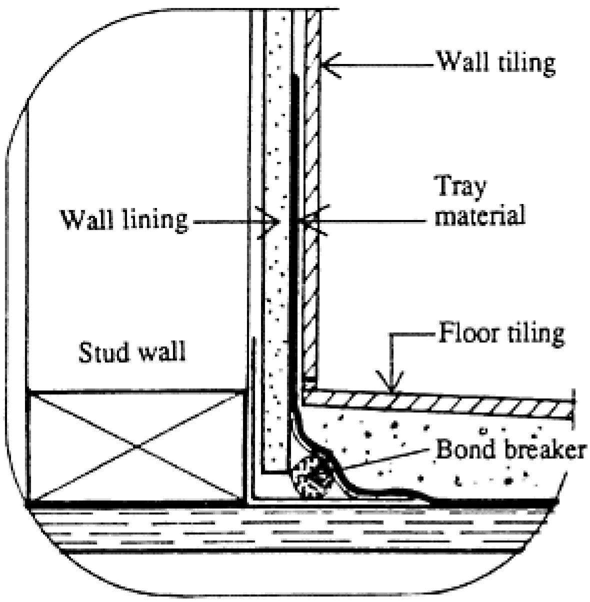


Fig. 2. An internal tray system. Wall lining passes outside the tray.

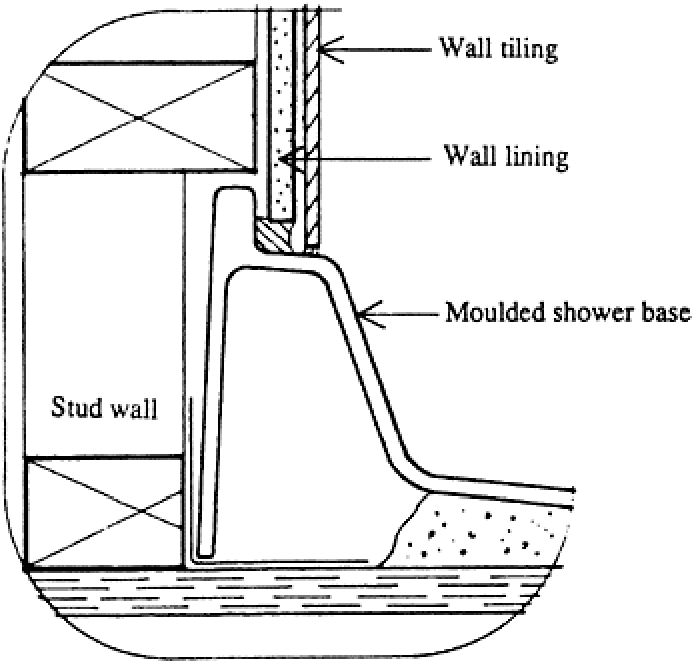


Fig. 3. A shower base system.

Internal tray systems are built in-situ. In the experiment three different types of materials were used to build such trays: acrylic, fibreglass and epoxy.

Shower bases are always prefabricated and in the experiment a cast resin shower base was used.

The cubicles were built and tested at the University of New South Wales Architecture and Building Research Laboratory between June 24,1986 and December 5, 1987. The research team adopted a method of accelerated testing to simulate the shower use in a typical household corresponding to 2.5 and 3.5 years.

Fully automatic control equipment capable of heating and pumping water to each cubicle on a predetermined cycle as well as blowing warm air into the cubicles to simulate drying between showers, was employed. It operated 24 hours a day, five days a week to the specification given in Table 1.

At the end of each testing stage, the shower cubicles were carefully demolished and examined in detail.

4.4 Results

All of the experimental shower cubicles performed satisfactorily irrespective of the type of the waterproofing system installed. Minor waterproofing problems which were brought to light during the testing arose mainly from the properties of building materials and purposely introduced design flaws. The lack of failures confirms the validity of the research hypothesis that good quality control of the building work reduces the risk of failures. It is also interesting to note that good quality control may partially offset inadequacies of the design.

Table 1. Technical specification of the test equipment

Activity	Technical data
cycle time shower	5–8 minutes
cycle time drying	10–30 minutes
water temperature	35–40 °C
quantity or water	7.51/minute
duration of test	56 weeks
total no. of showers per cubicle	2,725–3,680

5 How to ensure quality in bathroom construction

Quality assurance in bathroom construction begins with the design and detailing of the waterproofing system. The designer needs to have a knowledge and understanding of the construction materials and methods which are commonly used, the relevant regulations and standards as well as waterproofing techniques in order to develop a reliable waterproofing system. The problem is that designers have not always been able to develop such reliable waterproofing systems in the past. This has been particularly noticeable in designs carried out by builders or developers themselves. Problems with inadequate designs were further compounded by a poor knowledge of building construction and the properties of building materials by subcontractors who performed the work with a minimum of or no supervision, and with only limited and often inaccurate information provided by manufacturers of building and waterproofing materials.

5.1 Knowledge of building construction

Because the quality of bathroom construction depends on all aspects of construction working together to create a reliable functioning system, the most commonly used construction methods have to be understood, particularly with regard to the behaviour of materials and to detailing.

5.2 Accuracy in setting out

Accuracy in setting out a bathroom will help ensure the performance of the three tray and the base systems. However, inaccuracies in setting out will severely affect athe performance of prefabricated tray and base systems as they would not fit accurately within the designed space. This was verified through inspections of defective and new bathroom installations. A general disregard for dimensional tolerances has led one manufacturer of a rigid plastic tray to develop a flexible transparent plastic tray which can be distorted to accommodate the inaccuracies in the set out.

5.3 Choice of building materials

Most building materials will perform satisfactorily in wet area construction under ideal conditions. However, their performance may be severely affected when installed incorrectly, when manufacturers' specifications are ignored, when connected to incompatible materials or when exposed to environmental conditions for which they have not been designed.

The test results showed that the shrinkage of green hardwood timber framing at wall-to-wall and at wall-to-floor junctions produces stresses which are capable of tearing joints in rigid tray systems.

Wet area plaster board lining is satisfactory for bathroom and wet area construction if used correctly. However, because its ability to resist the effect of prolonged contact with water is limited, its performance will depend on the method of installation, compliance with the manufacturer's specification and the industry standard, and the degree of exposure to moisture. Poor design, lack of supervision or less than adequate training of the trade contractor involved would increase the risk of a waterproofing failure. If the level of such a risk is likely to be high, fibrecement sheets should be used as a wall lining instead. Although they absorb moisture, unlike plasterboard sheets they retain their structural integrity even when subject to prolonged contact with water.

Water based wall tiling adhesives, for example acrylic, latex or rubber latex display excellent adhesion characteristics when properly cured. Under normal conditions such adhesives would fully cure within 24 hours and once cured would remain unaffected by exposure to moisture. However, when applied over non-absorbent surfaces, such as waterproofed wall lining sheets, or liquid or sheet membranes, their curing time increases to a number of days or even weeks depending on the porosity of the wall tiles. When a tiled shower compartment is put to use before the wall tiling adhesive has fully cured, a tiling failure is likely. To minimise the risk of such a tiling failure when early commissioning of a shower installation is required and when wall surfaces have a low or no porosity, an epoxy wall tiling adhesive should be used.

5.4 Choice of waterproofing tray systems

When quality control over both design and construction is not effectively applied, the risk of a waterproofing failure will increase. From the defined shower tray and base systems, the prefabricated shower base system is likely to be more effective and safer in such situations than the other tray systems. Because the base is pre-fabricated, there are no joints in its surface and the wall lining sheets are kept above the shower floor. In comparison, the risk of a waterproofing failure is higher for the other two tray systems because:

They contain grouted joints in floor tiling through which water will penetrate.

They commonly require wall lining sheets to pass bellow the tiled floor surface, thus increasing the risk of their exposure to possible contact with water which will penetrate the floor surface through the grouted joints in the floor tiling.

Prefabricated trays may need to have their joints welded or soldered.

Such welded or soldered joints are known to have failed in the past.

Prefabricated trays may have been fixed to timber walls with non-compatible metallic fasteners causing galvanic corrosion.

Liquid monolithic membranes do not readily adhere to some materials, for example to PVC waste pipes.

Liquid monolithic membranes may have been incorrectly mixed on site or applied in either too hot or too cold weather, or applied too thickly in corners without adequate reinforcement which may cause shrinkage cracking.

The wrong type of fibreglass resin and/or glass fibre may have been used.

6 Conclusions

The wet area construction research study has shown that most waterproofing problems in bathrooms and shower compartments can be prevented through on site quality control. However, the housing sector of the building industry has been slow in developing clearly defined quality control procedures and even slower in adopting the AS 2990—1987. The adoption or the industry wide quality standard should be considered as the first step in developing a quality management policy for an effective approach to quality control.

Such a policy will not by itself improve the situation. There is a need to provide adequate training in equality management to building professionals so that they can competently implement such a policy.

Much greater appreciation of risks involved in wet area construction, particularly with regard to the choice of materials and systems, detailing of work, inconsistent level of competence among operatives and the likely low level of supervision provided by the builder should be taken into account by designers in designing and detailing the work. When such risks appear to be high, the design should incorporate the use of low risk materials and systems.

The thrust of modern quality management lies in the involvement of workers in the assessment of the quality of their own work and in the subsequent correction of any faults at source within the shortest possible time span. This would necessitate workers (mostly subcontractors) receiving further trade training and also specialist training in quality control techniques. Training to bring about attitudinal changes would also be necessary.

7 References

Ferrett, T. (1985) **A study of subcontract conditions of contract within the construction industry.** M.Sc Thesis, Loughborough University of Technology.

Forsythe, P. and Marpsszeky, M. (1988) **Improving quality in domestic construction.** Building Research Centre Report R2.88, School of Building, The University of NSW.

Fulmer, R.M. (1983) **The new management.** 3rd Edition, MacMillan Publishing Co, NY, 526p.

Peacocke, D. (1979) Better methods of contractor selection, the subcontractor’s views. **BSFA Semin.**, June, pp. 1–5.

Rocher, R. (1980) The future of subcontracting. **Builder NSW,** March, pp. 85–89.

Twyford, J.W. (1977) Contracts and the builder. **The Chartered Builder,** Vol 19, pp. 73–75.

Uher, T.E. (1988) Bidding practice in the Australian building industry. **Australian Project Manager,** Vol 11, No 3, pp. 27–30.

Uher, T.E. (1990) **The effect of risks and uncertainties on the subcontract bid prices.** PH.D. Thesis, The University of NSW.

Uher, T.E. and Wollaston, B.V. (1988) **Wet area construction in dwellings.** Building Research Centre Report R1.88, School of Building, The University of NSW.

98
Quality control of precast concrete facade walls industry

M.VALLES

ABSTRACT :
The communication presents the French organization for third party certification of concrete facade wall elements precast in-plant. It indicates the impact of an organization like this upon the quality of production both with respect to the delivered product and the cost resulting from non quality.

It analyzes the conditions of success for quality development. Finally, it goes in to relations with the EN 29000 standard relative to quality assurance.

KEYWORDS:
Precast concrete—facade walls—quality—third party certification—quality assurance.

The industrial production of concrete facade walls contributes to an improvement of construction quality.

Indeed, industrial production is particularly suitable for certification by an approved body (Construction Products Directive 89/106/EEC—Annex III—§ 2i) and to the application of standards concerning quality assurance.

The trench qualification certificate “Qualif—IB” approved by the public authorities has applied since 1985 to productions such as these. After presenting its organization we will examine the effects upon production, the conditions of success and the possible developments.

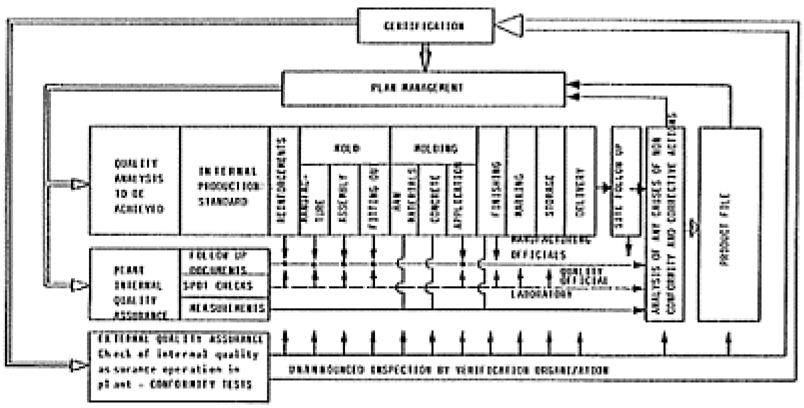
1 —FACADE ELEMENTS THRID PARTY CERTIFICATION

Industrial manufacture is a favorable context for the development of quality: repetitive processes, permanent teams, indoor production halls, etc… Therefore, sophisticated quality assurance arrangements can be brought in gradually.

Precast concrete wall elements are parts which are often complex and expensive. Detecting a defect when the product is finished is therefore too late and leads to considerable expenses. That is why the organization set up at the manufacturer's (described in diagram 1) is aimed at obtaining "zero defect" at each stage of product manufacture. More particularly it is based on:

• detailed analysis of the order,
• precise definition of the tasks to be performed,
• constant monitoring of process control (in particular, maximum development of operator control),
• checking by testing and sounding of this control,
• methodological application of a system of proof,
• analysis of anomalies and wavers with a view to progress.

All this is verified by the verification organization appointed by the certifying body. The certification arrangement is in conformity with standard EN 45.011.



QUALITY ASSURANCE OF IN PLANT FABRICATED WALL ELEMENTS

2 —EXAMPLES OF THE EFFECTS OF QUALITY ORGANIZATION

At the present time, seven plants hold a qualification certificate following a voluntary approach (in the same was as for the other certifications, the contract reference is optional). Each plant has its own personality but some significant examples are worth presentation

2.1 —Evolution of after sales costs:

Plant A	1987:	4% of turnover
Plant A	1990:	1% of turnover
Plant B	1987:	5% of turnover
Plant B	1990:	1.8% of turnover

(Certification obtained in 1990)

2.2 —Evolution of lost time:

Plant B	1987:	5,5% of turnover
Plant B	1989:	28% of turnover

(Certification obtained in 1990)

2.3 —Evolution of product quality

Plant C

Elements in architectonic concrete

Semester	1st 89	2nd 89	1st 90	2nd 90
Manufactured elements	520	1161	849	939
Elements with minor faults	224	451	850	150
repaired before delivery	(42%)	(39%)	(29%)	(16%)
Discarded elements	2	1	0	1
Client grievances	65	39	27	20

But not all the examples are so positive:

Plant D

Elements in architectonic concrete

Semester	2nd 88	1st 89	2nd 89	1st 90	2nd 90
Manufactured elements	324	2214	644	715	1609
Elements with minor faults	215	1536	381	597	1066
repaired before delivery	(66%)	(70%)	(60%)	(87%)	(66%)
Discarded elements	3	9	4	7	31

In this plant, quality organization has been oriented more toward inspection at the end of production rather than to a prevention effort. The elements received by the client are therefore good overall at what a cost for the producer!

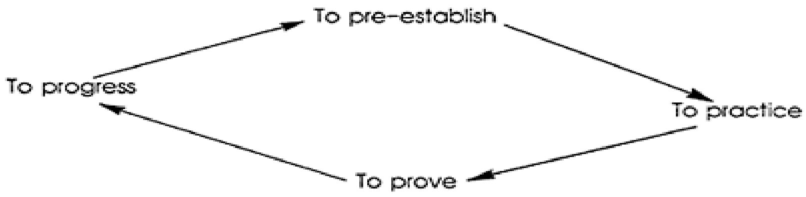
This clearly highlights that the success of quality action depends upon many different factors.

3 —CONDITIONS FOR SUCCESS

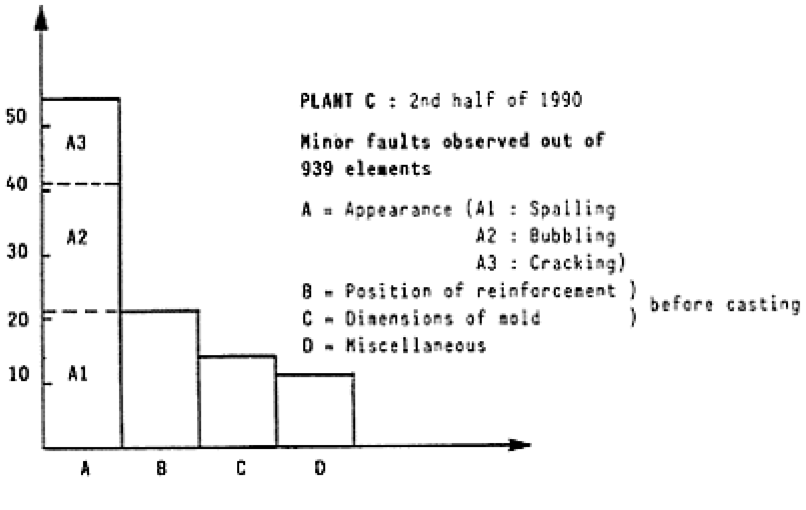
For any company, secure quality assurance requires a change in thinking which can only be obtained with time.

This evolution will be all the faster in that management will be participative and that collaborators will feel that they are associated with this approach.

The quality assurance system set up cannot be perfect the first time. Therefore it has to be organized so as to generate, with everybody's collaboration, its own progress.

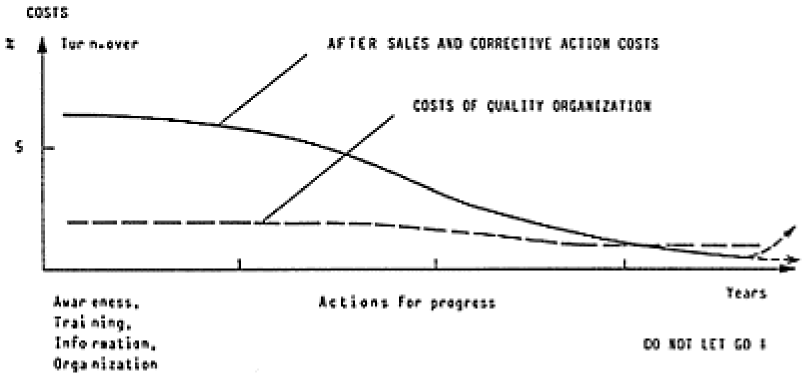


This is done with methodology by systematic analysis organized to deal with the faults observed and while defining common priorities.



PARETO ANAYSIS BEFORE CORRECTIVE ACTION

Only if these conditions are complied with, can a manufacturer obtain any considerable drop in costs resulting from non quality; the diagram below attempts to represent some of the times needed.



4. —APPLICATION OF STANDARDS EN 29000 (ISO 9000)

The EN 29000 series standards are an indisputable reference basis for defining the basic principles of quality assurance.

Standard EN29002 more than covers the plant production of concrete facade elements. From experience gathered on its application, it appears however that it is necessary to:

– allow for the specific aspects of the construction sector,
– insure that all the applicable standardizing texts are considered systematically as forming part of the document (4.3 EN 29002).

If these two conditions are satisfied, certification according to standard EN 29002 can be a terminating point when its logic confirms the overall aspect of the quality assurance process initiated by the third party certification of products.

99
Innovative housing design in Europe—new forms of housing in response to new social relations and expectations

T.WOOLLEY

Abstract

In this paper I describe the contribution made to housing construction in Europe by user controlled groups such as housing cooperatives and other organisations, where the eventual occupants have played a significant role in the design and development process. I suggest that, while the practice of involving lay people in architectural design is still full of problems, the occupants are generally more satisfied with their housing than people who were “anonymous clients”. I also argue that when looked at as a whole, participatory designed housing displays a more imaginative and innovative approach to housing design, catering in a more responsive way to new social groups and aspirations than more conventional housing. I conclude by admitting that participatory housing may seem organisationally more complex and time consuming but it may, in the long run, prove to be more successful in terms of quality, fitness of purpose and user satisfaction. This may have benefits in terms of capital and management costs. Plans for housing development to solve homelessness on a mass scale that do not involve future occupants run a higher risk of failure and subsequent demolition as happened in the 70’s and 80’s. Housing agencies should be willing to experiment, not through imposed technological solutions to mass housing, but by supporting self help and user groups and financing less conventional forms of housing rather than rigidly adhering to nuclear family units. In order to assist in this, professionals in the design and development team, need to become more familiar with design participation practice and more willing to encourage user involvement than is presently the case.

Introduction

Talk of self help housing (Turner, JFC & Fichter, R 1972), community architecture (Wates, N and Knevitt, C 1987), and design participation (Lawrence, R J 1982) was very fashionable in the 1970's and early 1980's in the UK, USA and Europe. Various conservative commentators have more recently announced its demise as an architectural fashion (Scott Brown, D 1990, Jenks, C 1990, Farrelly, E M 1987) and it currently appears to be of less interest to many architects and architecture students. The mistake that was made by most commentators, however, was to assume that architects were responsible for introducing this new approach. Some, most notably, Rod Hackney (Hackney, R 1990) built a career on the publicity attracted by one or two relatively insignificant self help housing projects and one professional institute in the UK, the RIBA, continues to promote "community architecture" despite a scathing attack on it by its own president, Max Hutchinson (Hutchinson, M 1989). But the real reason for this new way of working was the growth of community pressure groups, user groups like cooperatives and the willingness of housing agencies to consult with their customers.

Ordinary people were sick of architects and planners knowing what was best for them and wanted to exert more control over their environment. They demanded a different approach from professionals such as architects (MacDonald, A 1986). In the UK there were two social movements, working class community groups in cities like Glasgow, Liverpool and London, who formed housing cooperatives (Ospina, J 1987). Also in London there was a massive squatting movement, protesting at the wastage of empty property when thousands were homeless (Wates, N & Wolmar, C 1980) many of these people formed self help housing groups and cooperatives and went on to form long term housing groups managing their own permanent housing. In more prosperous countries like Denmark and Germany, groups of middle class intellectuals or young professionals who wanted to develop alternative life styles, formed collective housing groups and experimented with new forms of housing and participatory design (Hatch, C R 1984, Franck, K A & Ahrentzen S 1991, Fromm, D 1985).

The attractiveness of these approaches soon became recognised by housing administrators and experiments began with social housing for low income groups, particularly in France ('H' Revue 1984) and also Denmark. It is also possible to recognise similar developments in Germany and Austria where groups of people wanting to develop more 'alternative' ways of living came together to finance housing schemes which always involved some degree of design participation (Johaentges, K 1986, Hannay, P 1986). Many of these groups also have adopted 'Green' or ecological principals and have therefore experimented with forms of building that are highly energy efficient, use healthy materials and reduce pollution (Woolley, T 1989 (1)).

The Scope of Design Participation

I have identified 25 UK new build design participation projects in the UK housing over 5000 people and a similar number of published projects throughout Europe in a recent study (Woolley, T 1989 (2)). Since completing this study in 1989, I have come across a further 10 UK projects and there are many more throughout Europe. It has been estimated that over 30,000 people in Denmark live in innovative housing co-operative projects where there has been some degree of user participation (Gudmond-Hoyer J 1986).

As the success of these projects has become recognised, the concept of participation has become more widely adopted. Establishment professional bodies such as the Institute of Housing and the RIBA have published a report on the ideas (Institute of Housing, 1988) and Central Government now finance organisations like the Tenants' Participation Advisory Service and makes tenants' consultation a condition of funding development schemes (Mills, R 1991). Much of this official support for participation tends to be tokenistic however and is limited by wider policy constraints that limit genuine participation. I have, for instance, advised the UK Housing Trust Partnership in Sheffield where some 2000 new houses for rent are being built. Here, the pre-allocation of houses is opposed by the City Council and the Tenants' Federation, so consultation has to take place at a more general level and focuses on community development issues.

Problems of Participation

There are many problems associated with participation in design and development. It is frequently argued that it is time consuming and at the end of the day makes little difference to the end product (Hannay, P 1988). There is little doubt that participatory projects take a great deal of time of both architects, future occupants and others, but in my investigations of actual projects, the delays and time wasting are always found to be a result of external bodies causing the usual delays in capital projects, or where they are deliberately obstructive because of the innovative nature of projects. Participation can in many cases, speed things up due to the higher level of consultation and involvement of all parties (Woolley, T 1985).

The other big problem associated with design participation is that the constraints and influence of external and official bodies tends to be very powerful. Planning departments, traffic and road engineers, funding agencies and politicians all exert substantial influence on the form of schemes so that the room left to participation by the occupants is very limited. Often this influence is benevolent but misguided. In a recent interview with tenants on a project in England I was told that the participants wanted to lower standards in certain aspects of the design so that money would be available for other facilities. The Chairman of the local authority housing committee refused to agree to this. As the scheme was to be a show piece participation project, only the 'best' would do.

The Role of Architects

Despite the growth of design participation schemes, there is little evidence that architects have developed much expertise in the field of design participation. Most are unaware of the literature on the subject, it is rarely taught in schools of architecture and specific techniques such as full scale modelling (Woolley, T 1987) and computer aided design (Sharp, T 1989) are relatively undeveloped. I have recently been asked by a large housing association to run a training session for consultant architects because they "don't know how to talk with tenants." These consultants include firms who market themselves as "community architects."

On a European scale certain famous names such as Lucien Kroll or Gian Carlo di Carlo have become "famous" as advocates of participation (Blundell Jones, P 1987, Kroll, L 1986) but while these "noted" architects seem acceptable to the fashionable avant-garde, more modest architects who genuinely respond to users are "ignored" (Prak, N L 1984).

Users change the product

What I do believe is of great interest is that the accumulated experience of participatory projects shows that, user involvement leads to a wider variety of housing layouts and designs than has been the case with housing development previously. Layouts, internal arrangements, construction method and the use of materials is strongly influenced by clients. While one project in isolation may seem to be quite simple and apparently conventional one can identify over a larger number of projects a willingness to experiment with form. Often this form specifically reflects social and communal objectives in a way that would be impossible in anonymous housing. In the Liverpool Cooperatives, for instance, (Fig 1) one can see a wide variety of layouts responding to both site conditions and the views of the future tenants. Tenants were preoccupied in some cases with creating a sense of community either with a social focus or a sense of enclosure. At the Weller Streets Scheme (Fig 2) the layout was generated by a decision of each courtyard of tenants to look after frail elderly residents in the corner of each L shaped block.

In Denmark, designs were influenced by the decision in many cases to fund a "common house" where residents could share facilities and even lead a partially communal life style (Fig 3). Layouts reflect a desire to enhance contact between households rather than reinforcing separation and isolation. These forms have been developed with covered circulation areas, usually enhancing energy efficiency requirements as well. (Fig 4)

Many participatory schemes are also architecturally imaginative and exciting. The involvement of lay people does not inevitably lead to conservative, boring or compromise solutions. Decisions are frequently taken to reduce costs and opportunities for residents to finish off, alter, extend and personalise their houses. Arrangements for this kind of variety and flexibility would be hard to create without the participation of user clients.

Attempts to reinforce a sense of community and to tackle social problems of isolation, security, safety for children and so on are the subject of much discussion at design participation meetings. Solutions arise from this process that have occupant support and commitment. Such a process is very different from that of 'architectural determinism' where designers try to produce built solutions that will result in predictable social behaviour (Coleman, A 1985, Hillier, B 1988, Newman O 1972).

Figure 1 Site plans of 17 Liverpool Housing Cooperatives showing the diversity of layouts. Reproduced by permission of Rob MacDonald Liverpool Polytechnic.

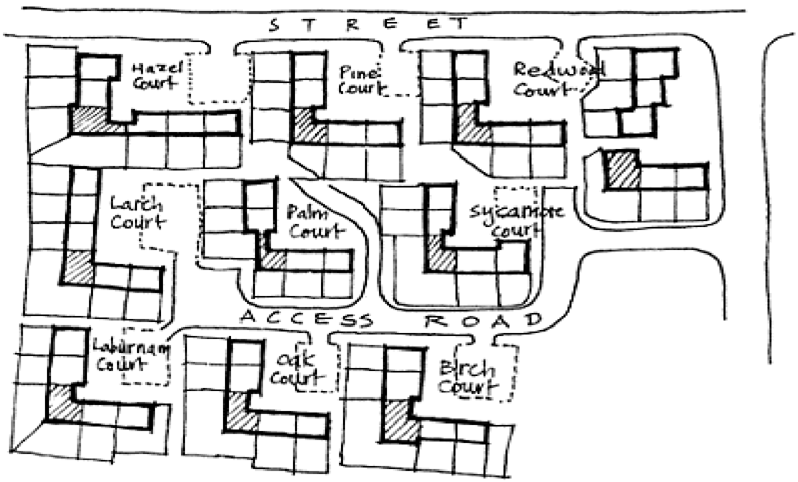


Figure 2 Weller Streets Housing Cooperative Liverpool Architects Wilkinson, Kindle, Halsall.

The hatched units in the corner of each L-shaped block are the flats of old people, looked after by their neighbours—a clear design feature reflecting social objectives.

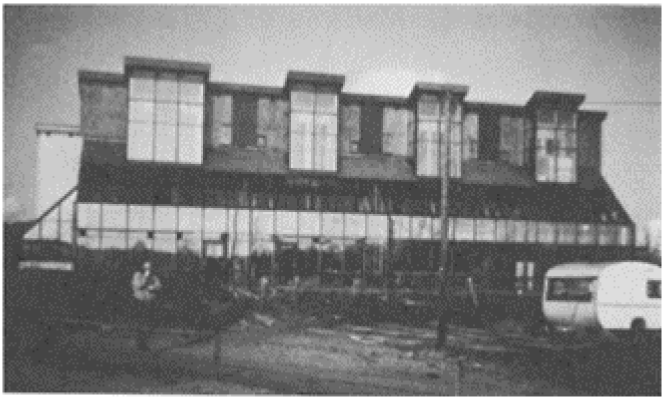


Figure 3 A partially self built collective housing scheme in Hamburg Germany. This development includes a number of shared facilities including a

self contained, ecological waste disposal system.

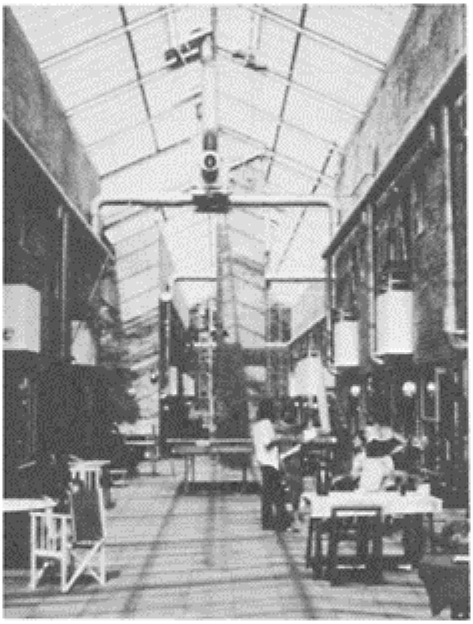


Figure 4 A Danish housing cooperative where the houses are linked by a glazed atria, permitting social contact between residents without losing privacy.

User Satisfaction

It can also be argued that there is some evidence that housing projects resulting from design participation result in higher occupant satisfaction than conventional housing (Woolley, T 1985). Often the satisfaction is a mixture of objective factors, but also subjective feelings of commitment which are a result of active involvement. Clients who have participated are likely to be more loyal to both the product and process as they are more aware of the problems involved in housing development.

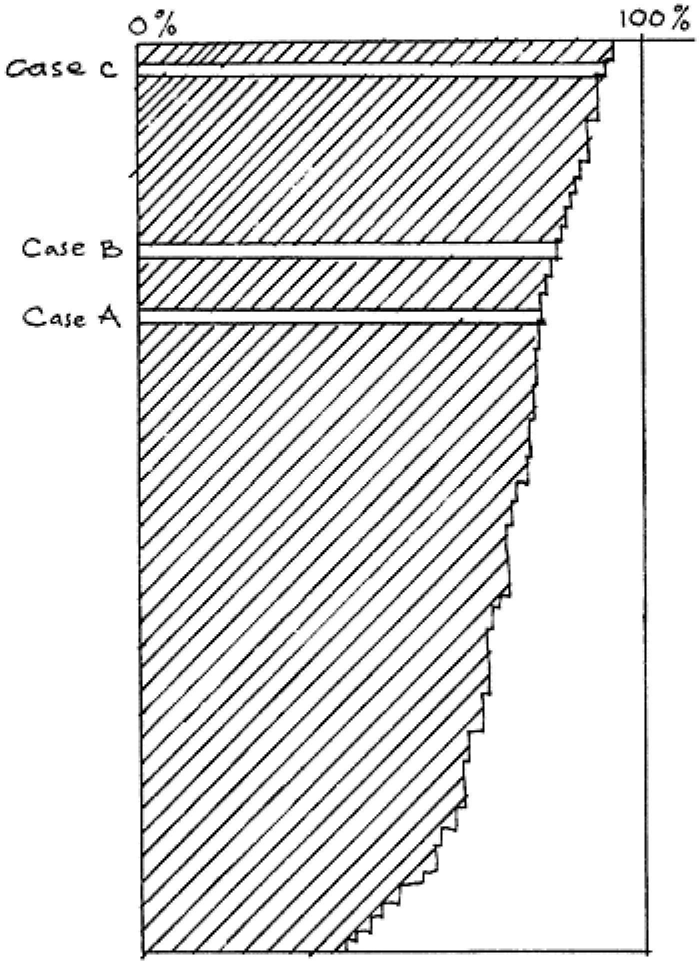


Figure 5 3 user participation projects compared with 42 conventional housing projects. Percentage of satisfied tenants. Measure of satisfaction drawn from the Housing Appraisal kit. From WOOLLEY T (1985).

Further research is required however, to evaluate the success of participatory projects on a European wide basis, particularly after a longer period of occupation, so that the emergence of management problems can be identified.

One interesting facet of occupant participation is that it is a concept relatively independent of tenure. Design participation has been found in a wide variety of different kinds of projects including council run social housing, cooperatives and owner occupation. Different aspects of different forms of tenure may facilitate or hinder participation, but no particular form of tenure is a prerequisite.

There is also a big overlap between the area of self building and design participation though in the UK most traditional self building is of conventional house types where the self builders buy an off-the-peg design and have little say in the housing layout. Only in UK schemes initiated by Walter Segal have self builders been able to participate in design (Architects Journal 1988). However in many German schemes there is only a fine line between self build and user participation schemes. Often tenants or owners have the opportunity to finish off, adapt or personalise shell or minimalist buildings. There is an interesting debate between those who advocate participation on design and those who advocate participation in building (Day, C 1990), but both share the same objective of facilitating peoples' control over their evironment.

Conclusion

To conclude it is necessary to admit that much of the information about user participation in housing development is anecdotal. There has been very little rigorous and objective evaluation of it as a phenomenon. My own experience of speaking about the idea to groups of professional and lay people is a general recognition that it is 'common sense' to involve the future inhabitants of housing in the production of their environment. To some commentators like Colin Ward this has been an obvious 'truth' about housing for some 25 years (Ward, C 1990) but more recently other experts have shown how these ideas have universal applicability (Hamdi, N 1991).

Participatory housing will, I believe, in the long term prove to be cost effective. It is the antidote to anonymous mass housing that is ruthlessly imposed on society, and eventually rejected. However, the only way the ideas can be developed and the processes improved is for more housing authorities and funding agencies to encourage, support and finance innovative housing projects. At present the cut backs in public expenditure in the UK, the red tape and prescriptive policies adopted by bodies like the Housing Corporation and Department of the Environment makes it extremely difficult to develop user responsive housing.

Architects and allied professionals, also, in my view, are not adequately equipped to work on participatory projects. Their approach is too defensive and egotistical. Greater interdisciplinary education of building professionals will help to change this as the elitism of architectural education is challenged, but the importance of design, design innovation and participatory design must not be neglected.

References

Architects Journal (1988) Special Issue on Walter Segal **Architects Journal** 4.6.88

Blundell Jones, P (1987) Housing: Mazzorbo near Venice by Gian Carlo di Carlo **Architectural Review** July 1987

Coleman, A (1985) **Utopia on Trial** London Hilary Shipman

Day, C (1990) Places of the Soul Wellingborough Aquarian Press

Farrelly, E M (1987) Community Architecture—Contradiction in Terms? **Architectural Review** March 1987 pp 27–31

Franck, K A and Ahrentzen, S (Eds 1991) **New Households, New Housing** New York Van Norstrand Reinhold

Fromm, D (1985) "Living Together Housing" Architectural Review April 1985

Gudmond-Hoyer, J (1986) Consumer **Friendly Housing Design in Denmark** unpublished mimeo

'H' Revue de L'habitat social editee par l'union Nationale des HLM (1984) "Histoire de participater" 'H' No. 93 February 1984

Hackney, R (1990) **The Good, the Bad and the Ugly: Cities in Crisis** London Frederick Muller

Hamdi, N (1991) **Housing without Houses** New York Van Nostrand Reinhold

Hannay, P (1986) "Participation in Austria" **Architects Journal** 3.12.86

Hannay, P (1988) "Love at First Sight" Housing at Eisbach-Rein **Architects Journal** 9.11.88

Hatch, C R (Ed) (1984) **The Scope of Social Architecture** New York Van Nostrand Reinhold

Hillier, B (1988) "Against enclosure", in Teymur, Markus and Woolley **Rehumanising Housing** London Butterworths

Hutchinson, M (1989) **The Prince of Wales: Right or Wrong?—An architect replies** London Faber and Faber

Institute of Housing (1988) **Tenant participation in Housing Design:** A guide for Action RIBA Publications Jenks, C (1990) The New Moderns: from late to Neo Modernism

Johaentges, K (1986) "shared adventure—Laher Wiesen-Hannover" **Architects Journal** 10.9.86

Kroll, L (1986) **The Architecture of Complexity** London—Batsford

Lawrence, R J (1982) Designers Dilemma : Participatory Design Methods **EDRA Conference Proceedings** pp 261–271

Mills, R (1991) Head of Estate Action Department of the Environment in speech to conference "Reclaiming Estates" London 4.3.91

Newman, O (1972) **Defensible Space** London Architectural Press

Ospina, J (1987) **Housing Ourselves** London Hilary Shipman

Prak, N L (1984) Architects: **'The Noted and the Ignored'** London: John Wiley

Scott Brown, D (1990) Urban Concepts: The Rise and Fall of Community Architecture A D Profile No. 83

Sharp, T (1989) "CAD and User Participation" British Sociological Association Study Group paper 18.11.89 (unpublished)

Turner, J F C and Fichter, R (Eds) (1972) **Freedom to Build** New York MacMillan

Ward, C (1990) Talking Houses London Freedom Press

Wates, N and Knevitt, C (1987) **Community Architecture** London Penguin Books

Wates, N and Wolmar, C (1980) **Squatting The Real Story** London Bay Leaf Books

Woolley, T (1989) "Kassel—German Architects and Ecological Settlements" **Architecture Today No. 5**

Woolley, T (1989) op cit

Woolley, T (1989) **Design Participation Today** September 1989 Architects Registration Council Research Report unpublished
Woolley, T A (1985) Community Architecture: An Evaluation of the Case for User Participation in Architectural Design Oxford Polytechnic PhD Thesis
Woolley T (1987) “1:1 and Face to Face” **Architects Journal** 29.4.87

100
Quality control systems for wooden buildings in Japan

T.YASHIRO

Abstract
This paper is a case study on quality control systems on wooden buildings in Japan now. It describes how explicit and tacit, regulatory and circumstantial, formal and informal codes are combined in quality control systems. First Japanese regulatory quality control system including Building Standard Law and building professional system and significance of code by carpenters are described. Next case study of moisture content control and structural safety control are illustrated from the aspect of combination of two kind of codes above.

Keywords: Quality Control, Code, Japanese Building Standard law, Japanese building profession, moisture content, structural safety Timber structural, Wooden Buildings

1 Introduction

Japan has a tradition of timber construction. Before 19th century, all buildings in Japan together with large temples and shrines was erected by timber construction. And even now most of detached houses are constructed by timber frame structure.

Structural safety, durability and other required performances of Japanese timber construction have been tested and refined by carpenters through plenty of years' experiences. It is remarkable that in this refinement process excellent modular coordination rule were formed which is even now applied not only in conventional timber structural but also in modernized structural type. Carpenters established a sort of private/informal/regional/implicit code based on the modular coordination rule in which technical guideline such as required dimension of structural members and specification for wooden materials and so on are included. Private code have been transferred from master carpenter—older generation—to pupils—younger—through practical work, and have been modified over generation to generation. Before establishment of regulatory building control system, quality of Japanese wooden buildings had been controlled mainly by circumstantial and tacit know-how of carpenters.

Basic framework of Japanese regulatory building permit system was enacted in early 50's of this century. Building Standard Law legislated in 1951 prescribes technical condition of all kinds of buildings including wooden structural. GHLC (Governmental Housing Loan Corporation) published standard specification for timber structural detached houses also in early 50's. These regulatory explicit codes for wooden buildings was formed mainly in the aspect of fire prevention, safety and durability. These formal explicit codes do not have serious contradiction with informal tacit codes kept by carpenters, but formal codes contains additional technical conditions.

Additional conditions had considerable impact on carpenters' technics and introduced several technical changes in site, and some of them have been worried how they can harmonize formal and informal codes.

In the side of government, officers considered how they can evaluate informal carpenter's code. Some officers believed all of detailed technical conditions should be prescribed in technical guideline published by public bodies, based on building engineering. The others thought role of implicit code by carpenters should be admitted, be combined with explicit one and be involved in total quality control systems for timber structural detached houses, partially based on practical knowledge. It seems that even now in Japanese government, there exist these two kinds of opinions.

Anyway until early 80's, latter opinion have been accorded with practical situation, and a sort of delicate combination between formal and informal code seems to performed enough role in quality control for wooden buildings in Japan.

But recently, situation seems to be completely changed; First of all, new type of wooden structural building & new wooden materials are introduced from north American and European countries, and Japanese innovative attempts tried before in this field are also re-evaluated. Secondly production system of wooden structural detached houses are changed. In 50's master carpenters can control directly all of construction process from selection of materials & components in market until completion of building. But nowadays carpenters can control directly only part of construction process by dissemination of prefabrication of components and by change of delivery system of materials and components. Furthermore, carpenters lost relatively their technical potential. It is said that "average" carpenter is not skillful as before.

So in Japan now, quality control system for wooden buildings are reconsidered and many proposals are offered and argued on the building control system including revision of formal codes.

This paper is a case study on several phases of quality control systems on wooden buildings in Japan now. It describes how explicit and tacit, regulatory and circumstantial codes are combined in every phase.

2 Outline of Japanese Regulatory Building Control System

2.1 Building Standard Law

In the field of building regulation, Japan has a centralized government. Nationwide standards and codes are established by central government, related technical informations and guidances are published by public authorities entrusted by the central government, otherwise local building regulations by regional government have the role in the limited field.

Building Standard Law is the national wide basic regulation. There are several kinds of related public codes based on Building Standard Law such as cabinet orders, MOC (Ministry of Construction) notifications, circulations.

In the framework of Building Standard Law, wooden structural building is classified into 3 types. First type (Type A) is a small size wooden structural building which has less than 2 stories and 500 m2 total floor area. This type only have to meet specific prescription in Building Standard Law and related codes such as size of columns and beams, detail of joints, construction of anti-earthquake walls, and do not have to be checked by structural engineer. It seems that tacit code of carpenters supplement in the field that the law does not prescribe.

Second Type (Type B) is building which have more than 3 stories or which have more than 500 m2 total floor area. This type must meet more severe specification than type A, and structural safety of this type should be examined by structural analysis calculation.

Third type (Type C) is particular construction type which can be accepted in building permit based on 38th article of Building Standard Law, if it is approved by authorized body that the building has more superior performances than specification in the Law. Now BCJ (Building Center of Japan) is the implementing authorized body of the approval procedure based on the 38th article. The purpose of the article is to ensure flexibility to accept new technology because the law is made based on existing technology and contains many specific criteria.

2.2 Building Profession

In Japan, there exists licensed profession of "building designer" based on Building Designer Law. It is a peculiar profession combining architect and building engineer because students in department of architecture are trained both as architect and as building engineer in Japanese educational system.

MOC deliver license to the person who pass the license examination, where basic knowledge and ability for building technology, building regulations and capability of architectural design are tested.

The profession of building designer is classified into 3 categories.

– first rank
– second rank
– mokuzo (Japanese word which means wooden construction)

first rank "building designer" is for university or college graduates and experienced second rank, second rank is for high-school graduates, mokuzo is for educated carpenters.

Originally the government wanted to provide first/second rank professional license to master carpenters. In another word the government wanted to involve informal ability of carpenters in formal professional system. Actually many carpenters took license but not all of them took license. So in 80's the government made additional rank of "mokuzo" mainly for carpenters.

In building permit building designers represent all interests of clients and they have the obligation to offer required drawings and papers to inspector in the local government, in order to prove building meet with Building Standard Law and to get certification of building permit. This building permit is officially called as “confirmation procedure” with the law, which is only public service to citizen to investigate accordance to the law to protect property and keep safety of living, but it practically acts as a sort of permission for construction of building by local government based on Building Standard Law.

In case of construction of timber structural detached houses, carpenters who do not have building designer license or even who have license hire agents who have license to go through building permit procedure because carpenters appear to be not fond of desk work for application of building permit. But they are practically architect builder. Based on their own tacit informal code, they negotiate with clients on planning as designer and conduct total construction as contractor without consultation by architects and engineers. In the field of timber structural detached houses, there seems to exist so called double system of informal/formal profession and code.

3 Items of Quality Control for Wooden Buildings

Generally speaking, there seems to be several important items in quality control for wooden buildings as bellow.

1 Materials
- 1–1 Control of moisture content (dryness)
- 1–2 Strength
- 1–3 Dimensional stability

2 Performances
- 2–1 Structural Safety
- 2–2 Fire Proof Safety
- 2–3 Durability
- 2–4 Insulations

Among items above, in this paper, 1–1 Control of moisture content (dryness) and 2–1 Structural Safety is picked up as the target of case study. As for each item, situation on quality control is described following stage of building project below.

(1) Fabrication of wooden building materials and components
(2) Delivery of materials and components
(3) Design
(4) Construction work

4 Case study 1: Control of moisture content of wooden Materials

4–1 Existing formal codes for wooden materials and dissemination

Japanese Agricultural Standard (JAS) is based on AFF (Ministry of Agriculture, Forestry & Fisheries) notification related JAS-act. Timbers, plywoods, and laminated woods which satisfy JAS criteria are stamped by “JAS-mark”. Authorized grading organization can carry out the examination and stamp “JAS-mark”. Factories which satisfy conditions prescribed in JAS-act and related governmental orders, ordinances and notifications, can also provide JAS-mark to the products periodically.

Concerning timbers, All Japan Federation of Lumber Association (AJFLA) is authorized grading organization and provide classified “JAS-mark”. Sawmilling factory approved as authorized factory can also stamp “JAS-mark” by self examinations. AJFLA voluntarily provide training course for inspector in authorized sawmilling factories to maintain their technical level of self examination. Timbers are classified by looking appearances based on JAS. Only about 40% of timbers sold in the market get “JAS-mark”

Concerning plywoods, authorized grading organization is Plywood Inspection Association (PIA). Furthermore many factories are approved as authorized factory. Approximately 50% of plywoods sold in the market get “JAS-mark” stamps.

As for laminated timbers, Laminated Wood Industry Union (LWIU) is authorized grading organization. Also there are factories approved as authorized factory, carrying out examinations and provision of “JAS-mark” stamps. About 30% of laminated woods get “JAS-mark” stamps.

4–2 Fabrication of wooden building materials and components

In this stage of building project, authorized grading organization such as AJFLA, PIA, LWIU and authorized factory are in charge of control of dryness of wooden materials. JAS for timbers (AFF notification no.406 3/Mar/1981) prescribe that dryness should be under 15% in case of coniferous woods or 13% in case of dicotyledonous woods. JAS for plywoods (AFF notification no.383 11th/APR/1964) prescribe dryness should be under 14%. JAS for lumbered woods (AFF notification no.778 30th/MAY/1980) prescribe dryness should be under 15%.

Items to be checked is moisture content, but as for timbers practical method of inspection is not included in JAS except for artificial drying timbers. As for plywoods and laminated woods, measurement of moisture content in factory is obligated to fabricator by JAS.

Concerning timbers, it is almost impossible to confirm actual moisture content ratio except artificial drying timbers even if the timber get “JAS—Mark” stamps. Moreover, there is no way to confirm dryness for timbers which does not get “JAS—mark”. Recently “pre-cut” columns and beams whose complicated joint shapes are cut by automatic machine in factory instead of hand crafting by carpenters, are applied for timber frame structural detached houses. As for these kind of “pre-cut” timbers, moisture content are measured voluntarily by fabricator to prevent dimensional instability of their products.

Plywoods and laminated timbers got “JAS-mark” are expected to meet criteria of moisture content of JAS, otherwise the other products without “JAS-mark” can not be expected to keep dryness.

In the stage of manufacturing of wooden material, moisture content of most of timbers supplied to market are not examined whether “JAS-mark” are stamped or not, and more than half of plywoods and laminated woods are not checked on moisture content because they are without “JAS-mark”.

4–3 Delivery of materials and components

In this stage, wholesale dealers and retailers are expected to be entity to check dryness of wooden products. But there is not formal or informal code for them. They seems to have little concern about dryness of products they deal except confirming the existence of “JAS-mark” stamps. Only perfunctory check seems be expected in this stage to related entities.

4–4 design

In this stage Model Specification published by GHLC (Government Housing Loan Corporations) is explicit code which has major influence on moisture content control of wooden materials. Model Specifications is officially an information to debtor to show concrete technical method to meet GHLC construction code which must be observed by all applicants for GHLC loan. Other kind of specifications not included in Standard Specification can be accepted if it meet GHLC construction code. But most of applicants copy Standard Specification, so the specification has considerable influence on design of timber structural detached houses. It seems to be mentioned that even in the case of building without GHLC loan, the specification is traced by designer.

GHLC Model Specifications prescribes that applied timbers, plywoods, and lumbered woods should meet JAS and JIS (the Japanese Industrial Standard). In the pamphlet for explanation of the specification published by GHLC, it is recommended that moisture content should be kept under 19% as for all timbers applied. Besides Model Specification, AIJ (Architectural Institute of Japan) publishes JASS 11 (Japanese Architectural Standard Specifications for wood construction), which has not so much influence as GHLC Model Specifications.

In JASS 11 (Japanese Architectural Standard Specifications for wood construction) recommends that moisture content of furnishing timbers should be under 18% (category a), 20% (category b), 24% (category c).

Entity expected to check moisture contain in design stage is architects or carpenters who is in charge of practical design of building. But all they can do is to order contractors to keep moisture content under required percentage. But as it is described in next paragraph, contractors do not have effective way to obtain reliable dried wooden material in open market. Generally speaking, in the stage of design it seems to be difficult to implement effective control of moisture content of wooden materials.

Concerning building type A (under 2 storied and 500 m2 wooden buildings), there is a little number of cases now that the designer set up severe moisture content by forming private delivery route from reliable fabricator, or that they order contractors to offer proof of dryness of applied materials.

Concerning building type B and C, checks of moisture content are obliged to be also perfunctory because designers have to believe dealers in purchase of wooden materials. But most of cases now, engineers participate in the design and insist the importance of moisture content control. So there might be a sort of improvement on this matter.

4–5 Construction work

There is not explicit code for contractors on moisture content control in construction work stage.

Generally, contractors including carpenters are obliged to believe dealers of wooden material in case they obtain materials in open market now.

Formerly carpenters were expected to have ability to select good quality material among others in his intimate dealer's shops. There were many cases that master carpenter walk along mountains and forest to find most appropriate tree for his future project, to register more than 3 years before starting construction to maintain enough period for timbers to be dried naturally.

Tacit codes of carpenters involves know-how for selection of dried wooden material though they do not contain quantitative evaluation of dryness such as moisture content. This tacit code seems to perform important role if carpenters can join in fabrication process of timbers and other wooden materials. Actually it was, but situation seems to be completely changed.

In delivery system of wooden materials now, carpenters is only end-user or consumer and have little opportunity to participate in fabrication process of materials.

4–6 Effect of explicit/implicit code on moisture content control

Premise condition that implicit codes by carpenters be effective for moisture content control was changed, so potential of implicit code is not so effective as before on this matter.

As for explicit codes like JAS do not have reliable share in open market of wooden materials. So they also do not provide effective influence on moisture control.

Situation on this matter appear to be pessimistic because both explicit and implicit code are not effective in practice. Creation of appropriate and more practical combination of explicit and implicit code is expected on moisture content control.

5 Case study 2: Structural Safety

5–1 Fabrication of wooden building materials and components

Criteria and method of examinations of strength of timbers are prescribed in JAS for timbers; there is no numeral prescript for strength in JAS, instead, there exist the criteria of classification of timbers into 3 groups by checking appearance of timbers with checking several items below.

> Number of infault chamfer, number of knot, unsound knot, crack and defects of cut surface, wane, end split, ring shake, sapwood, bending, warping & twisting, cross grain, insect hole, discoloration and so on.

It is expected that this grading by appearance have correlation with grading of strength of timbers. But it had not been measured in order to confirm the correlation between appearance classification and real strength grading.

In case of plywoods, items to be examined and measuring method for them relating strength of materials are prescribed in JAS for plywoods. Items to be checked is as follows;

> bending strength & Young’s modulous
> compression strength
> adhensive bond strength

methods of measurement of bending strength & Young’s modulous and compression strength are defined in JAS. As for adhensive bond strength, method of tension test of adhesive bond and immersion test of adhensive bond are defined in JAS.

In case of laminated woods for structural usage, items bellow should be checked based on JAS for laminated woods;

> bending strength & Young’s modulous
> adhensive bond strength
> strength against surface cracks (in case of beams)

Method of measurement of bending strength & Young’s modulous are defined by appendix of JAS. Adhensive bond strength is examined by both immersion test of adhensive bond and block shear test. Strength against surface cracks of beams are checked by test against surface cracks defined by JAS.

Entities in charge of checking strength of wooden materials base on JAS is AJFLA, PIA, LWIU and authorized factory as well as moisture content control.

As it is mentioned above no explicit code on strength of timbers exist in Japan except classification by appearance.

Plywoods and laminated timbers got “JAS-mark” are expected to meet criteria of required strength. But as it is mentioned in 4–2, only about 50% of plywoods and approximately 30% of laminated timbers got “JAS-mark”. Plywoods and laminated timbers without “JAS-mark” have no evidence that they meet required strength.

5–2 Delivery of materials and components

Situation is similar with in case of moisture content control. Please see 4–3.

5–3 Design

In the stage designers including architects and carpenters are in charge of structural safety. Furthermore through building permit process inspectors in local government take part in checking structural safety.

In case of design of building type A, Model Specification by GHLC is a explicit code applied in practice for structural safety control. In the specification there is no prescription of strength of wooden materials. The specification only contains recommendations of minimum size of structural members. This recommendation is almost a copy of informal code by carpenters. In another word, partial content of tacit code is traced and is converted into explicit code by public body as for type A.

In building permit for type A, structural analysis calculations are not required so that strength of wooden materials or allowable unit stress of wooden structural members are not examined by inspector based on formal code. It suggests that even in building permit process, content of informal code is traced. Here also informal code is practically involved in formal building permit system.

Actually it seems to be very difficult to make it obligation to implement structural design based on unit allowance strength for type A made by timber frame structure, because as it is mentioned in 5–1, strength of timbers sold in open market are not measured by fabricator.

In design of building type B and C, it is generally desired that structure of these building type are designed based on unit allowance strength.

Furthermore, in building permit process, designer of building type B and C must offer required drawings and reports on structural analysis calculations so that allowable unit stress of wooden structural members can be examined by inspector. Inspector and his/her staffs examine accordance with cabinet order attached to the 89th & 94th article of Building Standard Law and MOC (Ministry of Construction) notification no.1799 related to the cabinet order. But strength of sold timbers in open market is not measured as it is described in 5–1.

So it is a very serious and urgent task in Japan now to establish explicit and formal criteria of strength of timbers in order to make it possible to implement structural design in case of building type B and C as well as in case of steel structural.

Allowable unit stress of wooden structural members seems to be out of control by designers and inspectors in practice. There is no way to confirm that applied wooden materials really have allowable unit stress required in structural design and in building permit procedure.

Several explicit codes concerning design of type B and C, is not integrated on structural safety control. Situation seems to be better concerning type A which depend on implicit code on this matter.

5–4 Construction Work

There is no way in construction site to check the strength of applied wooden materials. In case of building type B and C, it is seriously desired that there exist simplified method to confirm strength of materials in site but actually not. So contractors are obliged to expect voluntary check by fabricators of wooden materials.

5–5 Effect of explicit/implicit code on moisture content control

As for structural safety, public explicit codes seems to be made on the supposition of existence of two category by building type.

In case of type A, role of tacit code by carpenters seems to be admitted to some extent by public bodies, so it is traced and involved practically in formal structural safety control system.

In case of type B and C, these types have little concern with informal code, so all of detailed technical specification relating to structural safety should be defined by explicit formal codes. But present situation and system is not reliable because explicit code including JAS, Building Standard Law and so on seems to be not integrated and harmonized. JAS qualification do not have enough potential in fabrication and delivery of wooden materials in open market.

Integration and harmonization of explicit codes is expected to establish synthetic system to ensure structural safety of type B and C in Japan.

6 Conclusion

As it is shown in above case studies, in the field of quality control for wooden buildings in Japan, even now both formal and informal, or explicit and implicit code have significant role. But situations which make codes effective in practice is changing, it seems to be significant to observe what is premise conditions that make code effective. And also it seems to be essential to continue intensive survey on the transition of these premise conditions and to establish more flexible and integrated combination of regulatory/formal/explicit and circumstantial/informal/tacit code in this field.

7 References

Groak, S. (1990) The deadline of robust technologies in the building industry, Building Research and Practice, vol.18 no3 162–168

PART THREE
ECONOMICS

101
Reduction of energy consumption in building materials

V.AGOPYAN

Abstract
The reduction of energy consumption is proposed by the reduction of building wastes and by the use of alternative materials, usually containing agro-industrial by-products. Some achievements in using residues as building materials are presented in this paper. The following residues are mentioned: blast furnace slag, rice husk ash and carbitelime.
Keywords: Building Materials, Energy Conservation, Alternative Materials, Residues, By-products.

1 Introduction

Energy consumption in construction is considerably large but not sufficiently analyzed by researchers. For this reason the major achievements of the reduction of this energy consuption very often happens by accident when some other property of the materials are being studied.

The Civil Construction Industry consumes large amount of manufactured building materials, which cannot be reduced with the technology development. This happens because the dimensions and volume of the buildings are not affected directly with the improvement of the building materials and techniques. Moreover, due to thermal comfort and habitability requirementes, the thickness of the buildings can not be reduced significantly. The only possible changes in construction is the mass reduction using lightweight materials which are also high energy consuming products. In fact, the mass reduction does not imply economy of energy.

The amount of energy expended for the production of the traditional building materials are quite high. For instance: steel (30 MJ/Kg), portland cement (4 to 5 MJ/Kg), and ceramic bricks (8.5 MJ/Kg). Certainly the load of energy in a building is not high because of the use of low energy content materials such as timber which needs only 300 KJ/Kg for its production.

A composite material sometimes demands less energy, for instance, a concrete with consuption higher than 300 Kg of Portland cement per cubic meter has an energy content of about 1 MJ/Kg due to low energy expended for the preparation of aggregates (sand and crushed stone). For this reason some authors even present concrete as energy-conserving material for structures in comparison with steel (Mehta, 1986).

However the problem of energy rises due to large amount of material necessary for a building. This conducts to a energy demand of about 0.5 GJ per square metre in a Brazilian traditional building system. This high demand of energy has been worrying some researchers for the last two decades, mainly after the energy crisis in the beginning of the seventies. The reduction of the energy consuption can be achieved with two joined actions: the reduction of the wastes and the use of alternative materials, usually containing agro-industrial by-products. In this paper these two actions are discussed with emphasis on the use of by-products as building materials, showing the results of main developments in Brazil.

2 Reduction of Building Wastes

The construction rationalization is one of the most efficient tools to reduce building costs. Therefore it is pursued by the industry even in developing countries such as Brazil. One of the results of the rationalization is the reduction of the wastage during the actual building of the constructions.

In the Brazilian building industry the waste of materials is a very crucial problem. The available data from the Contractors Union of the State of Sóo Paulo shows that 25% of the materials (by weight) are wasted in the conventional building system. This waste is extremely high and it means that about 400 Kg of building materials are lost per square meter in a traditional construction process without enough control measures.

Analyzing 4×10^3 Kg of building wastes, Paula Pinto (1987) found that 64% were mortar (rich of cement and lime) and 29% consisted of ceramics, mainly bricks (both high energy consuming materials). This amount of waste must be reduced at least to European standards which are less than 7% of the materials put on site.

Rationalization does not mean only the reduction of the wastage of materials, but rationalized building system implies the optimization of the production therefore it also means reduction of energy expenditure as a whole.

For housing production in Brazil, the contractors using the rationalization process try to increase the productivity and reduce the costs and duration of the work without changing the typical production basis of this industrial sector (IPT, 1988). Their main aims are the reduction of wasted of materials and time spent. This is pursued by solving the main drawbacks of the conventional building procedure such as: integration among the projects, and between the consultant and the contractor, better working conditions to improve the productivity, improvement of the site organization, etc.

The same approach is valid for the production of the materials themselves. The rationalization of the process can reduce the energy consuption signicantly. This aim can be achieved by the development of new processes, improvement of the existing ones and mainly by the direction of the managers concerning the importance of energy conservation. Two examples show the importance of this approach in the material industry:

a) the change of the wet to dry way of clinker production has reduced its energy content from 5 MJ/Kg to 3.7 MJ/Kg;

b) the re-use of hot air from the furnace for heavy-clay components has resulted in a 20% of economy of firewood expenditure and at same time the improvement of the uniformity of the products (Messias, 1988) .

3 Alternative Materials

Alternatives are always necessary for the existing building materials, components, systems and processes.

The development of a new product comprises the following steps:

(a) design,
(b) experimental production,
(c) evaluation,
(d) preparation of prototypes,
(e) reevaluation and production.

Specificaly for new building materials development the use of locally available products is encouraged to reduce transportation costs. Moreover, the use of non toxic or non radioactive residues must be pursued to achieve further cost reduction.

It is necessary to point out that the term ‘alternative’ does not imply low performance but only new options to the designer when selecting materials, eventhough some alternative materials are prepared with appropriate technology (Agopyan, 1985).

4 Solid Residues In Construction

Civil Construction can be considered as the only industry able to absorb these residues produced today because it consumes large amount of materials. The reduction of residues becomes a major task to the community as it prevents several problems such as: high cost for storage; ocupation of useful sites; air-soil-water pollution and its cumulative effect (their volumes always increase). For these reasons the use of residues is in fact an important step, not only for cost reduction but also to help solve the complex problem of residue storage. Other advantages are also achieved with the expenditure of these materials such as: reduction of the use of scarce or non-renovated raw materials in buildings, creation of new suppliers besides the cartels which control the main raw materials and also improvement of the enviroment with the reduction of pollution.

In fact **residues** are only a temporary designation for cumulated materials without any use, as Cincotto (1988) mentiones, but untill a qualified application is found these materials continue to become **by-products**.

4.1 Blast Furnace Slag (BFS)

Certainly BFS is the most known by-product in construction due to large consuption of slag cement. Moreover, in Brazil, the BFS is also added to the ordinary portland cement (up to 10%).

The Brazilian Steel Industry produces about $22\times l0^6$ metric tonnes of steel per year. Therefore about 4×10^6 metric tonnes of BFS are produced, mostly granulated. The surplus of this by-product is very high and the disposal of this residue around the steel plants is a crucial problem. Only one of the producer has more than 3×10^6 metric tonnes of BFS around its plant.

The use of BFS activated with products with lower energy content than portland cement was studied. Besides of the use of granulated BFS as an addition to the Portland clinker for slag cement and ordinary cement production, and also the use of air-cooled BFS as aggregate.

The best results were obtained with BFS activated with lime and gypsum. A binder with the proportion of 0.88:0.02:0.10 (BFS: lime: gypsum) was selected for precast building components. The cost reduction for the final component was significant and the binder has shown good performance concerning strength and durability (John et alli, 1990).

4.2 Rice Husk Ash (RHA)

Rice husk is largely available in Brazil, more than 2 million metric tonnes are anually produced. The main uses of the rice husk are: mixture with soil (agriculture use), production of plywood and burned as a fuel. In Brazil, most of the rice processing industries give the husk free of charge because the equipment used in processing are electrical.

When rice husk is burned the resulting ash (RHA) is the most promising agricultural residue to be mixed with ordinary portland cement. In a controlled burning system the ash can have a good pozzolanic activity. In order to improve the pozzolanic activities of RHA and also to maximize the energy output a study was carried out with fluidized bed boiler (FBB) where the residence temperature and time can be controlled (Cincotto et alli, 1988). The resulting ash has a better pozzolanic activity (Chapelle Method) and mechanical strength than the ordinary ash. Ordinary ash is burnt in static furnace, starting with a fuel and smouldering during 24 h at temperature below 800°C. For non ground ashes, mixtures of up to 50% of FBB ash have higher compressive and bending strengths than those of 30% of ordinary ash.

4.3 Carbite-Lime

Calcium carbite reacts with water for acetilene production, the resulting by-product has the same chemical composition as hydrated lime. However it has a large water content which makes it difficult to get a powder binder. Nevertheless a suitable use has been developed as a soil stabilizer where the water is necessary for optimum compaction of the soil. Solid stabilized soil bricks have been developed with commercially available equipments. These bricks have similar performance of those produced with ordinary lime.

4.4 Others

Several other residues have been studied for building in Brazil, the most promising are:

– Paper: consists mainly of cellulose fibres wich are suitable for reinforcement of materials as cement and gypsum; panels reinforced with desintegrated newsprint were produced sucessfully (Agopyan and Derolle, 1987).
– Construction wastes: as mentioned in section 2 they consist mainly of mortars and ceramics, materials with some chemical activities. Ground wastes are 8 times more active than the natural sand (Paula Pinto, 1987). Therefore it is possible to reduce the cement and lime content of mortars when the wastes replace the sand in these mixtures.
– Phosphogypsum: although it is very well known this residue (from phosphoric acid production) is not much used in Brazil, only the cement industry add it to the clinker for setting control. Attempts were made to produce blocks and today plasterboards are being developed with this residue.
– Sludge: lightweight coarse aggregates were produced by sludge calcination in a pilot plant, their properties are quite similar to those made with expanded clay and are suitable for structural concrete production.

5 Comments

The construction rationalization process is already in course in the Brazilian industry. It is essential to optimize the use of resources for the industry to maintain survival in the present critical economical situation.

However, the use of residues are still incipient, only BFS today can be considered an ordinary material in construction industry. The lack of knowledge of the properties of the available residues and the prejudice against these materials in the building from consumers are the main preventions of the increase of consuption. This paper demonstrates how convenient and important the application of agro-industrial wastes in the Building Industry can be.

6 References

Agopyan, V. (1985) O estudo dos materials de construção civil—materials alternatives. **A Construção.,** 1935, 13–16.

Agopyan, V. and Derolle, A. (1987) Materials de construção reforçados com fibras: uso de papel-imprensa. **A Construção.,** 2080, 43–46.

Cincotto, M.A. (1988) Utilização de sub-produtos e resíduos na indústria da Construção Civil, in **Tecnologia de Edificações.** Pini, São Paulo, pp. 75–78.

Cincotto, M.A. Agopyan, V. and John, V.M. (1990) Optimization of rice husk ash production, in **Vegetable Plants and their Fibres as Building Materials** (ed. H.S.Sobral), Chapman and Hall, pp. 334–342.

Instituto de Pesquisas Tecnológicas do Estado de São Paulo—IPT (1988) **Programa de Atualização Tecnológica Industrial—Construção Habitacional.** IPT, São Paulo.

John, V.M. Agopyan, V. and Derolle, A. (1990) Durability of blast furnace slag based cement mortar reinforced with coir fibres, in **Vegetable Plants and their Fibres as Building Materials** (ed. H.S.Sobral), Chapman and Hall, pp. 87–97.

Mehta, P.K. (1986) **Concrete—Structure, Properties and Materials**. Prantice Hall, New Jersey.

Messias, L.S. (1988) Recuperação de gases quentes em fornos intermitentes—aplicaçóo na Indústria Cerâmica Estrutural, in **Uso Racional de Energia na Indústria,** 12, CNP-IPT-FINEP, São Paulo.

Paula Pinto, T. (1987) Utilização de resíduos de construção—possibilidades de uso em argamassas, in **Produção e Transferência de Tecnologia em Habitação,** IPT-CIB, São Paulo, pp. 189–193.

102
A review of the use of appraisal techniques in housing development

R.BARHAM

Abstract
Techniques of appraisal for housing development have, naturally, concentrated on the assessment of financial viability. This paper reviews the wider issue of appraisal and briefly considers other aspects affecting the feasibility of projects in addition to considering the various techniques available for use in viability studies. The paper concludes with a precis of a recent pilot study on the extent of use of such techniques in practice.
Keywords: Appraisal, Housing, Feasibility, Viability.

1 Introduction

The property world in general, and the housing developer in particular, have, in the past, suffered the reputation of operating on 'hunches'. Indeed, most successful developers are proud of the fact that they have been able, instinctively, to identify an opportunity for the successful development of a site or the redevelopment/ rehabilitation of an existing building. However, there has been little available in the nature of analytical systems or methodologies until comparatively recently.

In the appraisal of housing development proposals, the approach for the speculative developer, usually, has been to make a comparison of the selling price required (based on the cost of land plus the cost of construction plus required profit) with the prices recently achieved in the area for similar properties—a type of 'comparative' appraisal. In the public sector, even this crude technique is unused; the criteria being, primarily, the cost of servicing the loan facility and the extent to which housing need is satisfied within a unit cost allowance.

With the advent and development of computers, the availability of appraisal software means that more detailed calculation of costings can be made and, moreover, the calculations can be repeated with ease until a viable basis for the development is established. 'Feasibility Studies', therefore, can now be carried out with relative ease and (using computer packages) by people who, traditionally, might have felt uncomfortable with the financial calculations. However, it has been argued that such facilities are no substitute for the developer's 'instinct'; the counter-argument being that instinct alone is no substitute for proper research and appraisal.

2 Development Appraisal—feasible and viable?

Traditionally, in Europe and in areas of European influence, the process of investigation of the financial implications of a proposed property development has been referred to as a 'feasibility study'. This study, in the majority of cases, consisted of not much more than the financial calculation itself, the data and design decisions being based on, primarily, the developer's subjective approach—instinct—and some sparse, local investigation. Such studies in the American sphere of influence tend to be based much more on statistical analysis of the local market with predictions of demand being used to support the 'appraisal'.

In fact, a clear distinction should be made in the use of such terminology. It is possible for a project to be perfectly feasible, i.e. capable of being carried through to completion, whilst at the same time being totally unviable, i.e. incapable of producing an adequate financial result, or a result providing the required level of 'satisfaction'. It is suggested, therefore, that the European tendency towards the mis-use of the term 'Feasibility Study' should be arrested and the term Development Appraisal, consisting of a Feasibility Study and a Viability Study, substituted to describe a thorough process which investigates, through market research, proper analysis, prediction and synthesis, the ability of a project proposal to satisfy the criteria against which it is to be tested, having due regard to risk and uncertainty.

3 Appraisal Methods

Whilst not an exhaustive catalogue, the appraisal should cover some or all of the following areas:

i economic background—macro and micro;
ii market potential;
iii locational assessment/site capacity;
iv design feasibility; and
v project viability.

Some of these fall clearly into the area of the feasibility study and some into that of the viability study. However, as a result of their interactions, the distinctiveness of the two areas of the appraisal is not always clear. Nonetheless, it is clear that design feasibility, for example, must be based on an ability to satisfy both the anticipated consumer demand and the requirement for economic buildability. The former of these creates a demand-derived value, the latter results in an identifiable cost. These can then be rationalised, as shown diagrammatically in Figure 1 below, by an iterative process of evaluation.

3.1 Feasibility

Underpinning these considerations must be a thorough feasibility study which, for any proposed property development scheme, and especially a housing development scheme, should commence with market research relating to the proposed product and the specific regional and site location. For example, a general economic analysis of demographic factors, employment trends and housing investment propensities will, in conjunction with a consideration of the economic resources of the local area, facilitate a market study. Market research, nationally, regionally and locally will enable a proper analysis to be made of housing supply, housing demand and resultant market prices and rentals.

The feasibility of satisfactorily achieving the objective of the development relies also on its being adequately accommodated upon and within the site and the region. Here, geographical, topographical, geological, legal and social factors must be considered. The shape, size and adequacy of the site and its spatial relationships are of significance but, also, consideration must be given to such things as local climatology and orientation.

Once all these matters have been considered and properly appraised, the question of design feasibility can be addressed. It is at this point that infrastructure connections, local design considerations, and layout requirements, usually, receive attention and consideration is given to whether the size of the housing layout necessitates its construction in phases. This last point,

Fig.1. Private Sector/ Speculative Developer

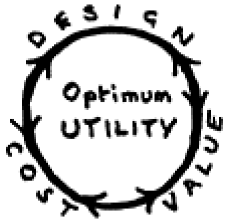


Fig.2. Public Sector/ Owner-occupier Developer

however, must be considered in parallel with a consideration of market factors and of the financial implications for cash flow and funding.

3.2 Viability

During the last two decades there has been a steadily increasing emphasis on the satisfying of those matters considered in the previous two paragraphs. However, most housing developers (including those in the public sector) have seen this as an unnecessary imposition by the financing source which, in view of the ever increasing sums of money involved, has sought confirmation of the developer's instinctive 'feel' for the project by some form of 'feasibility study', preferably independently prepared.

With regard to the viability study, this has traditionally been an area that has had, in housing studies, demonstrable weaknesses in its methodologies. In theory, the process is simple: Total Revenues (in capital terms) minus Total Costs gives the Profitability of the scheme. In practice, this simple approach often leads to some housing developers, in looking at a potential development site, starting by calculating an estimate of the overall development cost (of land, construction and finance charges), adding their required profit and setting a selling price accordingly. Such an approach, without adequate consideration of the market, can lead, ultimately, to financial disaster.

Even in such a simplistic approach, the viability study should commence with an estimate of the market value of the development (in capital terms) based on the market research carried out during the feasibility stage of the appraisal, the objective test then being to see whether the construction costs, land costs and finance charges, etc., can be carved out of the estimated revenue whilst leaving an adequate margin of profit for the developer.

Very rarely do we find a developer, especially a speculative housing developer, carrying out any form of risk analysis as part of the appraisal process and only infrequently do we find an assessment of alternative development proposals as part of the decision justification. All too often, the decision of what type of development to construct pre-dates the appraisal used to justify the profitability and ignores alternative, potentially more profitable, forms of development simply because they are outside the developer's usual range of property types.

4 Viability Studies—methodologies

There are many different techniques of financial appraisal that are available for use in viability study. These range from simple 'rules of thumb' to very sophisticated cash flow analyses. In the context of this paper, it is sufficient only to identify those methods most frequently promulgated in academe and to describe, briefly, their salient points. The objective being to discuss, later, the extent to which such techniques have found favour in practice and at what stage of the appraisal cycle.

4.1 "Conventional" Appraisal

The conventional appraisal methods are frequently referred to as 'rule of thumb' methods. They comprise a collection of easily applied techniques for testing viability and, as asult of their simplicity of operation, are much favoured by accountants and bank managers, in that they facilitate ranking of alternative development opportunities and provide a rough indication of a projector's likely performance.

Suitable only for use in early appraisal calculations (prior to detailed project information being available), the most frequently encountered examples of these methods test/rank projects by:

i the payback period;
ii the return on capital employed; or
iii the average return on capital employed.

4.1.1 The Payback Method

This non-discounted technique, used to appraise viability, takes no account of the opportunity cost of carrying out the development nor does it consider the length or size of any cash flow beyond the payback period. Ranking is based on the shortest period taken to generate sufficient cumulative returns to cover the initial capital cost, i.e. the shorter the payback period, the more attractive the project.

4.1.2 The Return on Capital Employed Method (ROCE)

Again, this method is a non-discounted approach used to establish the 'viability' of an investment or project proposal. Unlike the payback approach this technique can be used to assess profitability. In its basic form it provides a ratio (stated as a percentage) of average profits (generated over the period of the project) to the initial capital cost.

4.1.3 The Average Return on Capital Employed Method (AROCE)

Similar to the ROCE method, this is one of several idiosyncratic variations of the basic technique and, probably, one of the more frequently used. The significant difference is that, in an appraisal by this method, the capital inputs to the project are totalled over the life of the project (ignoring any time effects, opportunity costs, etc.) and the investment return ratio is, thereby, reduced. This, allegedly, provides for a more 'accurate' project review and ranking of alternatives.

Whilst these methods boast ease of use, they suffer from the serious drawbacks present in all non-discounted techniques. The timing of the cashflows is ignored; there is no allowance for the time-value of money; comparative size of project investments is ignored, as are differences in project life. Nevertheless, the techniques are widely used in assessing the 'viability' of housing development schemes.

4.2 Developer's Budget

The developer's budget, or residual appraisal, is a method that is close to the simple approach described earlier in section 3. Where it has enhanced sophistication is that it can be used to provide any of three residual variables, given that the others are known. In all cases the calculation commences with an assessment of the current market (capital) value of the proposed development and, in each case, the calculation is based on presently known costs and values; the assumption of equal inflation-effect on each variable is implicit to the method.

$$GDV-(GDC+LC)=RDP$$
$$GDV-(GDC+NP)=RDV$$
$$GDV-(LC+NP)=RDC$$

where

GDV=gross development value of the project
GDC=gross development cost of project
LC=land costs
NP=normal profit
RDP, V, C=residual development profit, value or cost-ceiling

The advantage, to an appraiser, of using this method is that the detailed make-up of each variable can be increased as more details of the project design, costings, etc., become available. Therefore, what begins life as a very crude viability assessment can end as a very detailed assessment of every financial aspect of the project.

There are, however, still some difficulties in the use of this technique, not least of which is the accuracy of the estimation of the several large variables involved. Any inaccuracies in these will be reflected throughout the remainder of the calculation, as many of the smaller variables are input as percentages of the principal sums.

4.3 Discounted Cashflow

The availability of computers in recent years has made the use of budget calculations much easier, particularly when several alternative schemes are being evaluated. They have also made it easier for cashflows, such as those used in 'conventional' or 'rule of thumb' methods, to be discounted to allow for the opportunity cost of capital investment (the time-value of money) and to allow for the detailed consideration of the 'shape' of the cash flow itself, both during the construction phase and during the investment-holding period and/or subsequent sale.

At its most sophisticated, discounted cash flow can be used to evaluate all inflows and outflows of money over the entire life of a housing project allowing, explicitly, for inflationary effects, taxation and anticipated supply/demand effects. It is, however, usual to carry out a DCF appraisal only to establish the net present value of the initial capital profit to be earned by a proposed development project or, alternatively, its internal rate of return, i.e. that percentage discount rate that provides a balance of the present values of inflows against outflows. In each of these cases, a more realistic measure of comparative viability is provided for the appraiser.

4.3.1 Net Present Value

The net present value of a proposed project is assessed with the aid of the formula:

$$NPV = \sum_{t=0}^{n} \frac{A_t}{(1+i)^t}$$

where

A_t=the project cashflow (+ve or −ve) in time t
n=the last period of the series of periods forming the project's useful life
i=the discount rate

Project alternatives are ranked by the size of their NPVs, that having the greatest NPV being regarded as best. However, the NPV approach does not take account of project size in its ranking.

4.3.2 Internal Rate of Return

In terms of ranking, this variant of DCF allows for a more rational comparison, the IRR of the cashflow not being related to the size of the project. The IRR approach also permits a comparison of the project yield with the finance borrowing rate or with the opportunity cost of money, i.e. the cost of a developer using its own capital funds. The internal rate of return of a project cash flow can be calculated as follows:-

$$IRR = i \quad \text{where} \quad \sum_{t=0}^{n} \frac{A_t}{(1+i)^t} = 0$$

In general, it must be argued that, for larger housing development projects (particularly those being developed or sold in phases), the discounted cash flow approach to appraisal provides a much more accurate and sophisticated study of the viability of a project. It is, however, recognised that lack of familiarity with the technique, combined with aprehensiveness, can lead to perceptions of problems and limitations in its use.

4.4 Risk Analysis

Under this head, we can group together both sensitivity analysis and probability analysis. Both of these additional analyses should be applied to all but the smallest of housing development schemes in recognition of the fact that both risk and uncertainty affect the market for housing and, therefore, the viability of constructing housing developments. The assessment of risk and uncertainty, whilst a task familiar to economists, statisticians and the like, is an area totally unfamiliar to the majority of appraisers (or valuers) dealing with viability assessments of proposed housing developments, particularly in the U.K. As such, a much fuller treatment is necessary than can be given in a short paper such as this. Suffice it to say, at this juncture, that Risk Analysis is, at present, very rarely used in U.K. appraisal practice.

4.5 Cost/Benefit Analysis

Often regarded as an appraisal technique used only in connection with major publicly-funded construction projects, a CBA can often be used, in conjunction with, say, a Life Cycle Cost Analysis, to carry out a full cost/benefit study of a publicly sponsored housing development project. There is also no reason why it should not, also, form the basis of a full investigation and report on a privately instigated housing project.

The CBA provides a review of not only those aspects of a proposed development that can be appraised in terms of money, i.e. cash flow, but also of those effects that can only as sessed i n terms of their probable effect, e.g. on life-style, environment, energy consumption, etc. However, like the use of Risk Analysis, the regular appraisal of housing development proposals by use of cost/ benefit analysis is regarded as being too subjective and too time consuming to provide any useful assessment in all but the largest of project proposals. It is, however, an argument that its use, in connection with a fully market— research—underpinned feasibility and viability study would not only provide the fullest of appraisals but, also, a good base from which to commence a persuasive approach to the regulatory authorities for permission to carry out a proposed development.

5 Use in Practice

A recent pilot study of the use of project appraisal techniques by housing developers in the U.K. was carried out in 1990. A random sample of equal numbers of privately funded and publicly funded housing developers was asked about the extent to which it used the various appraisal techniques available and the extent to which computers were used in the appraisal process.

Although not providing any conclusive evidence, the result of the canvass does give an indication that a large number of housing developers still base their development decisions on past experience and instinct or ‘gut-feeling’. It would appear, therefore, that there is still a substantial gap between current practice and the implimentation of available techniques and theories.

The majority of the developers responding to the survey, especially the small-sized developers, neither used, nor had even considered using, any of the more detailed methods of appraisal; nor had they done any socio-economic analysis or effective market research. DCF methods and computerised appraisal systems had been recognised by some developers as providing a better method and facility for appraisal but were still regarded as ‘new’ and treated with some suspicion. The indications are that there is a considerable amount of room for improvement if residential developers are to become efficient and more effective in their appraisal of proposed housing schemes.

Notwithstanding the developers' various views of what constituted adequate market research and the variety of their approaches to socio-economic analysis and the like, probably the most interesting statistic derived from the investigation was the distribution of the extent of use of the several main methods of viability assessment. This is shown in Figure 3, overleaf.

Significant, by its omission, is the traditional residual approach adopted by most professional valuers and appraisers and this author would suggest that it is not just possible but highly probable that those respondents using what might be termed a traditional residual approach have interpreted it as a form of 'payback' technique rather than as a discrete method.

The attitude towards risk analysis differed significantly as between the privately funded developers and the publicly funded developers. The majority of the

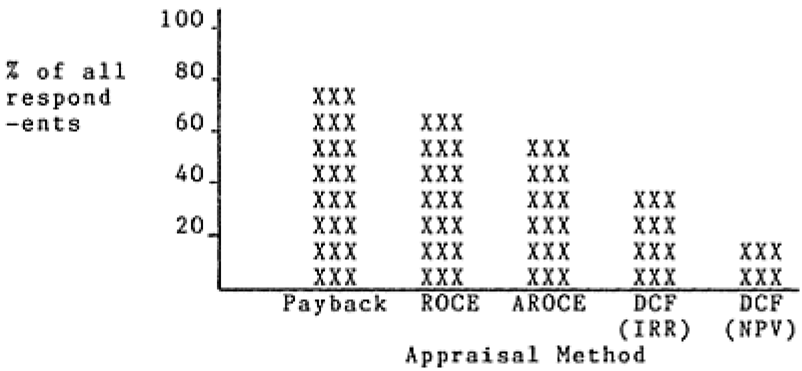


Fig.3. Methods of Viability Assessment used in practice.

publicly funded developers stated that they carried out a form of risk analysis but only 30% of the private sector respondents formally considered risk at all. Even so, the majority of all respondents used a contingency allowance (of an amount based on experience) in the estimate; only 20% used any form of sensitivity or probability analysis (and then only because it was available in their computerised appraisal package). Risk management and use of computerised appraisal were also areas investigated. For risk management the results were as shown in Table 1, below.

Computerised appraisal software was in use by all respondents from the public sector but only 40% of those in the private sector had invested in computer applications for appraisal. The small development companies, using relatively unsophisticated appraisal techniques, considered manual calculation to be economical and adequate. However, 16% of the sample of private developers indicated that they either had no computer or lacked the expertise to perform appraisal confidently using a suitable computer program.

	Always %	Sometimes %	Only as necessary %	Not at all %
Private developers	0	0	20	80

Public developers	63	0	25	12

Table.1. Use of Risk Management Techniques.

6. Conclusion

The pilot study in the U.K. reveals that over 40% of the sample experienced some problems in carrying out adequate appraisals of proposed housing developments and that, of these, three quarters experience most problems in the area of value prediction. No significant problem is admitted in relation to cost estimating.

Of significance is the fact that most of the smaller sized organisations stated that they had encountered no problems in the appraisal of projects. This, however, may only be indicative of the fact that they were unaware of having made any errors of omission or commission.

Overall, the extent of the housing developers' knowledge and use of adequate systems and methodologies for use in the appraisal of housing proposals is somewhat discouraging. There is a substantial gap between theory and practice which, of necessity, needs to be bridged by the development of educational and training packages aimed, especially, at the smaller sized developers. These could be produced in conjunction with associations of developers and should concentrate on explanations of the practical use of DCF techniques and risk analysis, both of which, frequently, have been demonstrated to be most lacking in current practice.

7 Bibliography

Barham, R. (1981) Discounting Fears. **The Valuer,** 50.7, 270–271.

Franks, J.K. and Broyles, J.E. (1981) **Modern Managerial Finance**. John Wiley & Sons Inc., New York.

Korpacz, P.F. and Roth, M.I. (1984) Changing Emphasis in Appraisal Techniques : The Transition to Discounted Cash Flow. **The Appraisal Journal,** 1.

Lumby, S. (1984) **Investment Appraisal.** Van Nostrand Reinhold Co. Ltd., London.

Merrett, A.J. and Sykes, A. (1969) Capital Budgeting and Company Finance. Longman, London.

Merrett, A.J. and Sykes, A. (1974) **The Finance and Analysis of a Capital Project**. Longman, London.

Morley, S. (1979). A Cash Flow approach to Financing. **Estates Gazette,** 251, 445–449.

Speedy, S.C. (1983) Investment by Discounted Cash Flow Methods. **The New Zealand Valuer,** 3, 110.

Wan Mat, W.M. (1990) **Project Appraisal in Housing Development.** Unpublished MSc Dissertation, University of Manchester Institute of Science and Technology, England.

Yates, A. and Gilbert, B. with Barham, R. (1988) **The Appraisal of Capital Investment in Property**. Surveyors Publications, London.

103
The economic evaluation of public housing projects

M.BETTS

Abstract
Research has provided the economic evaluation of new buildings with new and emerging techniques. These have included life-cycle costing, elemental cost planning, cost modelling, and the use of knowledge-based systems. Limitations to the use of these techniques often arise due to us taking a short-term view of construction, the one-off nature of buildings and the lack of continuous workloads.

The Housing and Development Board (HDB) in Singapore have been successful in providing affordable mass public housing to 87% of the population over a period of 25 years. While doing so, techniques of economic evaluation have developed that are particular to the board. Often, these have exploited new techniques to a greater extent than other organisations in Singapore.

This paper examines the extent of this by describing the Construction Cost Management System (CCMS) of the HDB Cost Management Unit. It then evaluates the system against a critical framework developed in the paper to conclude whether the system is effective.

Keywords: Public Sector Housing, Design Stage Cost Control, Cost Modelling, Economic Evaluation, Singapore.

1 Introduction

We subject most building projects to what, at best, are very rudimentary forms of economic evaluation. Compared with the more advanced forms of analysis and decision making of other sectors, construction applies very simplistic techniques that have developed little over a long period. Most of these techniques appear to follow one of two approaches: to design a building and then work out its cost, or to set a cost target for a building and then try to design within that constraint.

In this regard, economic evaluation is usually a support activity to the design and construction process. We usually evaluate based on a series of estimates that we seldom relate back to initial plans or budgets. We rarely approach the adoption of cost strategies, satisficing or optimisation models, or detailed evaluation of cost tradeoffs in practice.

Recognising this, researchers have made much effort to improve the evaluations and estimates made. This has been happening over a long period and has included techniques for planning cost strategies (Ferry, 1964), attempts to take broader views of costs and revenues in building investments (Stone, 1967), attempts to model the trade—offs between cost and design variables (Brandon, 1978 and McCaffer, 1975) and, more recently, to exploit recent advances in technology (Brandon, 1990).

These techniques have been successful as theory. A coherent set of techniques has developed and good attempts made to consolidate the academic discipline of economic evaluation (Brandon, 1982; Bowen and Edwards, 1985 and Raftery, 1987).

The practice of economic evaluation of buildings has not caught up with these valid advancements in theory. There is an implementation gap. The new priorities are to address the reasons for this gap and to explore strategies for implementing the body of knowledge that already exists. One way of doing this may be to examine the extent to which theory can be applied in different contexts.

This paper begins to do this by assessing the effectiveness of methods of economic evaluation for public sector housing projects in Singapore. It compares the level of evaluation with both a critical framework of effective evaluation arising from theory and with practice in the Singapore private sector. It shows that recent theories are applied more fully in some contexts than others. Analysing why this is the case, and learning from it, may help us to apply theory more fully across the board. Additionally, it may show the limitations of existing theories within specific contexts.

2 A critical framework of effective economic evaluation

Before examining the nature and performance of the system evaluated in this paper, it is pertinent to define ‘effective economic evaluation’. The framework presented here largely results from analysis of the body of previous work.

First, economic evaluation should be considered in terms of the broadest range of its activities. In this regard, total building evaluation should be seen as the time, cost and quality and the certainty with which these achievements may be made. Economic evaluation should be judged not in terms of the extent to which it measures expenditure in isolation. Evaluation should be in terms of how it leads to the achievement of value for money in building procurement. We need an effective understanding of the trade-offs between time, cost and quality and ultimately a means of their integration.

This holistic approach to economic evaluation can be extended to apply to the timescale of project activity. So many approaches appear to be oriented to the control of expenditure over finite periods. These periods appear to correlate with the times over which the evaluator holds responsibility. The periods do not appear to correlate with the times over which the owner of a project bears a financial responsibility and interest.

Management implies controlling the outcome of a process through one’s own actions. It is a more proactive role than the reactions that control involve. Whether a true cost ‘management’ system either exists or is workable in practice is debatable. At this point it is pertinent to contrast a true cost management system with one based on the certification, reporting and authorization of expenditure after the cost incurring activity is complete. This latter type of process is more aptly described as cost administration. For effective economic evaluation of buildings, we should seek cost management and not administration.

To complete our description of what ideal economic evaluation should be, we must consider the life time of projects and the part of the life that any system embraces. A building project has several phases: feasibility, design, construction, commissioning, use, retrofitting and demolition. The activities in each phase have a cost in themselves, and contribute to the total cost of the building to its owner and users. An economic evaluation system should therefore cover as many of these activities as possible.

The argument has been made before (Ahuja and Walsh, 1983) that the most effective time to apply economic evaluation is during the early stage of projects. It is at this point that the greatest scope exists for economies and when the consequences of making changes to projects are at a minimum. An ideal economic evaluation system should therefore start at the earliest possible stage in the project.

To summarise, an ideal economic evaluation system should:

A – integrate the requirements for time, cost and quality considerations by allowing informed tradeoff decisions throughout all stages;

B – be managerially proactive rather than administratively reactive;

C – be initiated at the earliest possible stage in a project; and

D – apply to as broad a range of a project’s life cycle costs and revenues as possible.

3 Obstacles to effective economic evaluation in practice

We have set out a framework above for the effective economic evaluation of buildings. In practice we seldom approach any of these four criteria when we evaluate building proposals. The reason for this largely lies with the nature of the design and construction process that continues to haunt attempts to regularise and understand it.

The industry’s particular features pose unique problems for implementation of any innovations over those faced in other sectors. The main features include the problem of different individuals having to come together and relate to each other within the temporary multiple organisation (Bryant and Cherns, 1984) that a project team represents. Other characteristics are; a highly customized product, a lengthy process of design, construction and use, a large diversity in its participants and high fluctuations in its workload (Chow, 1990).

Some particular characteristics that influence economic evaluation are the short-term attitude that organisations take. All appear preoccupied with the projects on which they are engaged and their priorities rather than looking ahead to future projects. This largely arises from the one-off nature of many buildings and the lack of continuous workloads of a repetitive nature and design from single clients.

The above obstacles do not hold true to the same extent for all building projects. We must recognise variability within the nature of our industry and pitch our economic evaluation methods accordingly.

Projects subject to economic evaluation differ in terms of their size, complexity, time for construction, design, function, means of construction, source of staff, labour and major components, and their means of financing. A body of projects is likely to exhibit great variability within these factors that makes economic evaluation a problem. But. there are instances of great repetition in these factors within a set of projects dealt with by a single organisation.

The objectives for all projects can be simplified into a combination of time, quality and cost parameters. The problems for economic evaluation come when the relative priority of these parameters is constantly changing from one project to the next and when cost as a parameter is a low priority. But, this is not always the situation for a single organisation.

There are clearly different types of projects with very different objectives and organisations performing economic evaluation of them. The extent to which our framework of 'effective economic evaluation' can be achieved in all these situations differs considerably. This can be illustrated by case studies from Singapore. These show that the theories that have developed, are implemented to a significant extent in one case and not at all in another.

4 A comparison of economic evaluation practices in Singapore

The Housing and Development Board (HDB)

The HDB is Singapore's public sector housing authority responsible for providing affordable mass housing. Set up in 1960, at a time when the country faced a severe housing shortage, the original aim of the Board was to provide basic housing as quickly as possible and with limited financial resources. As the mass housing programme is now largely complete, the more recent objectives are to provide further good quality and more spacious accommodation, to maintain and retrofit existing housing units and to construct supporting services and amenities to housing developments. All this activity is to be undertaken under the guidelines of existing public sector financial procedures and restraints and with a keen concern for value for money (Wong and Yeh, 1985).

The Board is responsible for large multi-storey residential construction. It has built point and slab blocks of between 15 and 20 stories throughout Singapore's main island in large estates. In the early developments, the units were mainly 3-room. More recently constructed blocks have included 5-room executive units. This mirrors the advancing aspirations of the local population. Some 87% of the population live in HDB housing with the majority having purchased them at below-market prices with the use of funds from a compulsory savings scheme supplemented by loans offered by the Board.

The buildings, estates and therefore the projects are highly homogeneous in terms of their appearance, size, complexity, design and function, means of construction, the contractors that build them, and their other resources.

The balance of time, cost and quality objectives for the projects has been mainly constant with cost a prior-ity. However, as time has passed there has been a gradual change with quality taking on a greater importance. The political prominence of the

Board, and the lack of a large alternative source of housing, means that the economics of the Board's performance is a sensitive local issue.

The organisation is the client authority that also acts as the design and coordinating body through its own specialist staff. It has its own, cost consultant staff who have the title of the Cost Management Unit of the Contracts and Administration Department of the Building and Development Division.

The HDB is a suitable organisation for us to study in terms of effective economic evaluation. Many of the new techniques of economic evaluation mentioned earlier have arisen from developments within large public sector organisations like this one. Within the South-East Asia region and beyond, HDB are widely cited and consulted as a model of effective public housing provision (Ofori, 1989). Within Singapore, the practices of HDB have departed from those of the colonial forms of cost consultancy more substantially than other public agencies. There are no quantity surveyor appointments within the HDB and tendering and project documentation methods are not based on bills of quantities.

Private consultancy firms

The nature of the HDB's projects and its situation are very different from local private sector cost consultancies. Singapore is a major financial, commercial, and retail centre for the region with a modern skyscraper city including many prestigious buildings. Private sector cost consultancy follows the UK quantity surveying approach. The consultant's appointment is late in the process after design is underway. The role of the cost consultant is usually to advise on the economics of building proposals following the taking of design decisions. Since the mid-1980s the quantity surveying profession has been adversely affected by intense fee-based competition. Thus, the role of the private cost consultant in Singapore is characterised by low fees and minimal service.

The diversity of private sector projects is great with some very spectacular one-off designs. Many internationally renowned architects have designed some of the more prestigious buildings as the quality of aesthetic appearance is very important. Owners also appoint Chinese geomancy consultants to advise on the suitability of the design shape and layout from the viewpoint of Chinese superstition. Private owners treat these aspects of a building's design very seriously. Building cost is seldom a priority for such developers. The cost consultant is an independent organisation appointed for a short period. Their responsibility and authority is very small. They see their role as checking and administration.

The cost advice given usually includes; budget estimates, early design estimates, pretender estimates, and advice on post-tender negotiation. The developments in economic evaluation theory are not used at all because they appear inappropriate to the situation of low fees and minimal service by a low profile member of the project team.

5 The HDB cost management system

The system

The system of economic evaluation used by the HDB has been documented (Yeoh et al, 1991). It is a coordinated set of procedures, databases and cost models developed over a period with in-house resources and to be applied to the ongoing programme of housing development. The system has four distinct phases. These correspond to the four stages of HDB evaluation that are applied to all buildings and estates:

– the prototype development stage;
– the planning and design stage;
– the construction stage; and
– the maintenance stage.

At the prototype development stage, the unit evaluates new proposed designs from the Architectural Department before a site or estate is identified. Each proposed design, which will become a new HDB standard, is subject to extensive cost studies aimed at examining effectiveness and seeking optimization. The HDB uses cost models developed by them for design costs, resource costs and lifecycle costs and incorporating feedback from construction and maintenance experiences.

At the planning and design stage, for the estate and its constituent buildings, more cost studies are made for the purpose of diagnosis, planning, budget control and checking. These are more closely related to the details of a site and the requirements of housing provision within an estate and for a project.

At the construction stage, the HDB follows highly regularised procedures as part of cost control. There is much information fed back to future prototype and planning and design stages. This includes formal post-contract design reviews and cost evaluations upon completion.

At the maintenance stage, the HDB applies further cost controls and the resource and life-cycle cost models continue to be applied. Figure 1 shows the complete sequence of processes within the cost management system.

The HDB carries out this economic evaluation activity in a highly structured and formal way. There is widespread use of cost models within a system of relational databases purpose-built within a long-term conceptual framework for total economic evaluation. The contents of, and interrelationships between, these cost models are shown in Figure 2. The Board now has plans to develop an expert system for cost estimation (Yeoh et al, 1991), and continues to reexamine its system and its performance.

Appraisal

In terms of the framework for effective cost control outlined in the earlier sections of this paper, the system performs very well. The techniques and procedures applied by private sector cost consultants in Singapore are, on the whole, very poor by comparison.

With regard to being managerially proactive, the HDB system is highly advanced, with economic studies carried out on prototypes before building estates are planned. When plans and designs are drawn up, extensive use is made of cost models at several levels. The HDB initiates the cost management system much earlier than most systems of cost advice. It gives much greater scope for applying new theories of economic evaluation than the private sector system. The HDB system applies to an extremely broad timescale from the pre-inception stage through to the stage of the use of buildings. The system links cost information and procedures that follow through these stages. The Board's activities are now switching to a much greater emphasis on maintenance and upgrading. Their current plans for enhancing their methods of economic evaluation are concentrated in this area.

With respect to the requirement to integrate the requirements for time, cost and quality, the HDB system does not perform any better than most other systems. This is a serious drawback with the current state of advancement of economic evaluation theory. However, cost is of overriding importance within the objectives of HDB projects and the balance of priorities is so well fixed that the HDB does not consider such trade-offs important. Although quality has, of late, been given increasingly more emphasis, all parties concerned well understand the quality levels for HDB buildings.

6 Conclusion

The body of theory of economic evaluation of buildings is developed and consolidated to a significant extent but lacks a means of integrating time, cost and quality and fails to recognise the constraints of different situations. The plans for implementation of evaluation theory are in need of advancement. We need implementation plans as application strategies for different sectors and for different types of projects.

The type of projects and the situations faced by an organisation such as the HDB are well suited to the current state of the theory. Many features of recent developments are present in HDB practice. Theory is not well suited to projects and the situation of the independent private sector cost consultant because of the diversity of their projects, the lack of continuous workloads, and the place the consultant holds within the project team. We need an implementation strategy to achieve the critical framework of effective economic evaluation within private sector practice.

From the case study outlined in this paper it is clear that the nature of the projects, the owner's objectives, and the place of the cost consultant within the team are three factors that decide the successful implementation of means of economic evaluation. Theories of economic evaluation must refer to the constraints of these three factors and must lead to techniques that can apply across multiple project types, where cost is not a priority and for consultants appointed late in the process.

Alternatively, cost consultants must look to influence the extent to which these three problems inhibit their application of current means of economic evaluation. This may entail consultants specialising in work of a particular type or for a small number of clients and for them to aspire to a more dominant role within the project team.

Failure of either of these two things happening will lead to a continued failure to achieve the framework of effective economic evaluation that is presented here.

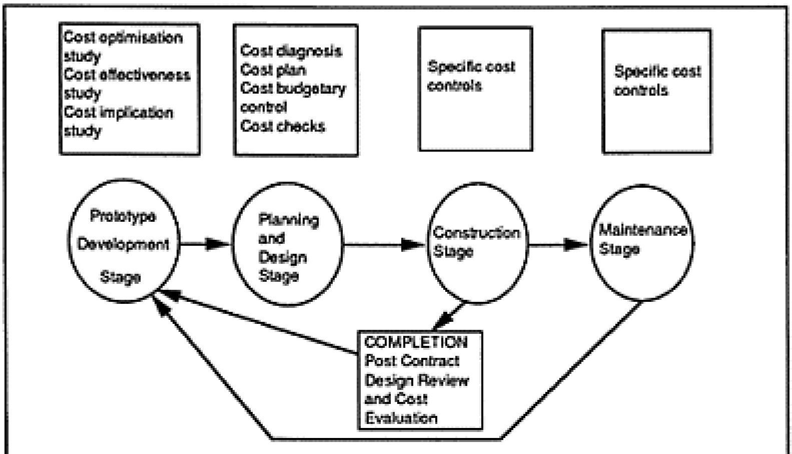


Figure 1: The HDB Construction Cost Management System (After Yeoh , 1991)

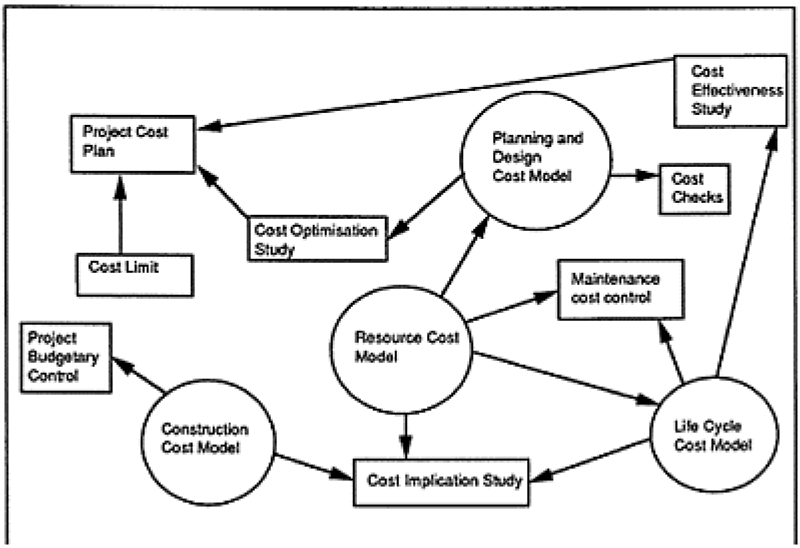


Figure 1: The HDB Construction Cost Management System (After Yeoh, 1991)

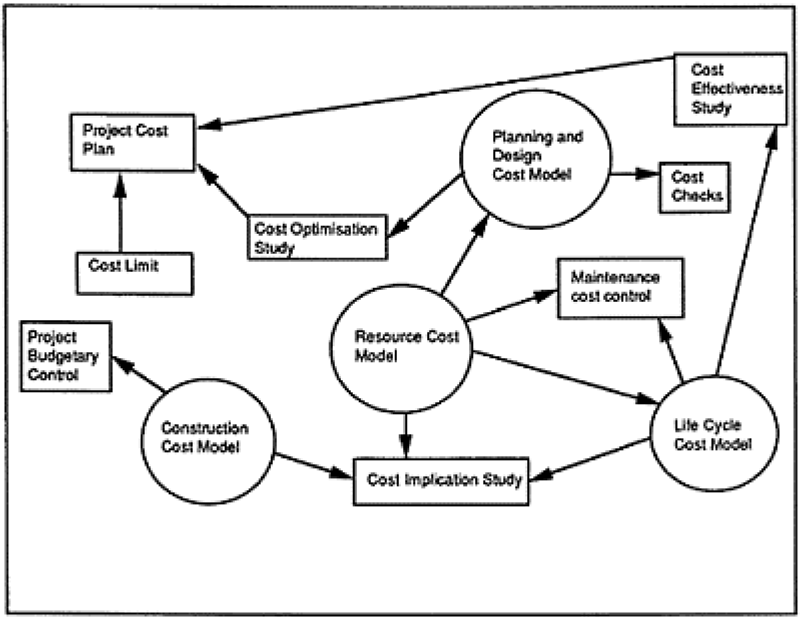


Figure 2: Interrelationship of Cost Models (After Yeoh, 1991)

ACKNOWLEDGEMENTS

I am very grateful for the assistance of my colleagues, Associate Professors George Ofori and Krishan Mathur, from the National University of Singapore, for assistance with the writing of this paper. I am also indebted to Mr Tay Kwee Hian, the head of the HDB Cost Management Unit, for providing information relating to the philosophy and operation of the Construction Cost Management System.

REFERENCES

Ahuja, H.N. and Walsh, M.A. (1983) **Successful Methods in Cost Engineering**. John Wiley and Sons Inc, New York.

Bowen, P.A. and Edwards, P.J. (1985) Cost Modelling and Price Forecasting: Practice and Theory in Perspective. **Construction Management and Economics.,** 3, 199–215.

Brandon, P.S. (1978) A Framework for Cost Exploration and Strategic Cost Planning in Design. **Building and Quan tity Surveying Quarterly.,** 5, 4, 60–63.

Brandon, P.S. (1982) **Building Cost Techniques: New Direc tions,** E&FN Spon London.

Brandon, P.S. (1990) The Development of an Expert System for the Strategic Planning of Construction Projects **Construction Management and Economics** 8, 285–300.

Bryant, D.T. and Cherns, A.B. (1984) Studying the Client's Role in Construction Management **Construction Management and Economics** 2, 177–184.

Chow, K.F. (1990) **The Construction Agenda** Construction Industry Development Board, Singapore.

Ferry, D.J. (1964) **Cost Planning of Buildings** Crosby Lockwood & Sons, London.

McCaffer, R. (1975) Some Examples of the Use of Regression Analysis as an Estimating Tool. **The Quantity Surveyor** December 81–86.

Ofori, G. (1989) Housing in Singapore: Determinants of success and lessons for the developing countries **Construction Management and Economics** 7, pp 135–148.

Raftery, J.J. (1987) The State of Cost Modelling in the UK Construction Industry: A Multi Criteria Approach, in **Building Cost Modelling and Computers** E&FN Spon, London pp 49–71.

Stone, P.A. (1967) **Building Design Evaluation—Costs-in-Use,** E&FN Spon, London.

Wong, A. and Yeh, S.H.K. (1985) **Housing a Nation: Twenty-five years of public housing in Singapore,** Maruzen Asia, Singapore.

Yeoh, H.L., Tay, K.H. and Lim, B.S. (1991) Construction Cost Management System, Housing Development Board, Building and Development Division, **Technical Journal,** No. 1, Singapore.

104
The evolution of construction costs and technological prospects

G.BLACHÈRE

Abstract
Today, in spite of the accent put on management, the building productivity does not rise at the same pace as the national productivity. Three technical ways are offering possibilities: global innovations, industrial components and semi-componenets, increasing productivity on the site (including use of robots).

Technological moves are necessary and not only managerial ones.

During the 1960s, we have had in France the possibility of measuring the increase of productivity of social housing through the comparaison of the "consistence" (what you receive for your money) and of the cost (deduced from the prices observed over large masses).

At that, time the productivity in building—(i.e. social housing) increased by 1.5% more than the national growth which was of the order of magnitude of 5% per year! This figure was both a cause and a consequence of the building boom.

A break in the decrease of the costs took place in 1969: The renunciation, for various reasons, of the building systems, the decrease in the size of the operations, a change in the government policy, led to a stop of the pressure over the costs. The rate of innovations slowed down. Despite the large emphasis put on management, and more recently on quality control, productivity is increasing less rapidly than the mean national growth. In other words, building costs increase comparatively to the costs of the other necessary goods, and to the mass consumption goods.

This circumstance is due to the fact that the share of labor in building costs remains very high, higher than in any other field, including agriculture: To estimate this share at about 30% is acceptable. What is in question here is direct erection labor, not including the labor incorporated in the materials.

Our society cannot afford a continuous relative raise of building costs, and something will necessarily happen. It may be at the client's initiative—lato sensu—as it was the case after 1950 when the founders of social housing undertook many actions to decrease the costs, and achieved some of them.

But, more probably at the initiative of one or the other production sectors, to which the evolution of costs will create opportunities.

As it has been said, the building systems have, some decennies ago, been used to create on the whole building industry a pressure towards the decrease of costs. They have almost all been abandonned but that does not mean that they will never recover an advantageous economic positon. Nobody can predict under what form: The American mobile home has shown that buildings (here as dwellings and offices) very different from conventional buildings may appear unexpectedly: Technology, levels of satisfaction of user's requirements, cost, all is different from convential buildings. Nevertheless, or just for this reason, they have conquered a significative part of the market.

Such an event may be called a "global innovation". Global innovation may be part of the answer to the need of mastering costs by taking a part of the market and by putting a pressure on the other parts. Certainly it is not possible to forecast what may be this global innovation.

Another possibility which already plays a role, is the progress of productivity in elaboration of building materials, semi-components and components. Building products make up for more than 40% of the cost. It is known that to find cheaper materials than sand, gravel, baked clay, cement, or in the semi-noble category: timber or steel, is difficult. This production made such progress in the last fifty years that their cost may be considered as intrinsically stable (not taking into account accidental variations due to peculiarities of the national or world market).

But it is not the same for components and semi-components. The standard definition of a component is that it is a manufactured product which is to play a precise role in the construction. The component is in itself a part of the building, a wall, a roof, etc., whereas the semi-components need to be completed: e.g. a beam, a roof box, etc. Components and semi-components may be produced industrially.

They then benefit from the progress in productivity common to industrial products, induced by mechanization, automation, quality control. The best example is the simple concrete wall block for which incorporated labor decreased by half between 1970 and 1980, not speaking about the savings in materials, the best use of machines, etc.

This concerns the semi-components, usable whatever the design may be, and, as a consequence used, and therefore produced in quantity.

The use of components was first pushed in building systems, and they failed at the same time as the systems themselves failed in the 1970s. Tentatives to push for a rapid generalized use of components also failed for the reason that most of the families of components were not competitively ripe. But this also may change.

Industrially produced, semi-components and components are of interest because they intrinsically bring a diminution of the global labor incorporated in the building.

The use of semi-components though necessarily subject to the resistance of older methodologies does not create problems to architects and contractors, which is not the case of components. The result, as it can be noted, is that the entry into the market of semi-components such as beams, blocks, small trusses, partition units, is easier than the entry of components such as façade panels, roof sections, or even "blocs techniques" or octopuses.*

A third means of increasing the productivity is the improvement of the productivity of the erection, i.e., to make short, the handling, the putting into place/assembly, and the finishing. Handling is, as it can be seen every day, almost totally mechanized. Will it become automated? almost robotized? One may note that one of the great progress of the last years is pumped concrete. It gave a new youth to the in situ concrete which under its simple appearance is nothing less than a mechanization of the putting into place.

The erection will probably see the intervention of robots: putting-into-place robots, pouring robots, finishing robots, or mere assistant robots.

Hence the technological prospects of the necessary increase in building productivity are varied. Some are mere improvements, modernizations of existing technologies, others will bring about deep upheavals of the building world.

Which will win? and when?

It is at least possible to remember that in building, due to its mass, all changes occur slowly. An impressive number of tentatives for modifying the technologies failed because the success was expected within a few years whereas five-fold time would have been necessary.

But it is certain that changes will occur. That is not a very daring forecast!

Here only the increase of productivity by technology has been approached. What about the increase by management? Certainly it exists, and the improvement of management has produced and will produce its fruits, but I don’t believe it is sufficiant to produce the required progresses—which is what we observe today.

* **Octopus:** a set of flexible pipes or wires, precut, pre-assembled at the workshop: electrical octopus, octopus for sanitary hot water, for heating water, etc.

105
Real property portfolio management or what the client of building services needs to do to ensure satisfactory building performance

R.BON

Abstract
This paper outlines the basic concepts of real property portfolio management. It focuses on performance indicators concerning real property required to close the feedback loop between managerial action and property performance. The paper discusses some essential properties of decision-support systems needed to adequately manage real property.

Keywords: Real Property, Portfolios of Real Assets, Real Property Performance Indicators, Statistical Quality Control, Decision-Support Systems.

1 Introduction

The aim of this paper is to outline the basic concepts of real property portfolio management, or RPPM. This field is oriented toward clients of building services, and especially those organizations that are not primarily in the real estate business, but use real property to produce or distribute other goods and services. In the last analysis, it is incumbent upon the building client to ensure satisfactory planning, procurement, management, and utilization of real property at the client's disposal. It is argued in this paper that building clients need to develop management tools for RPPM. In this context, emphasis is placed on decision-support systems that can close the feedback loop between managerial action and real property performance. Such systems will need to be custom-made for each building client with a significant property portfolio.

2 RPPM Definitions and Alternative Terms for RPPM

The term "real property portfolio management," contains three components, where "real property" refers to property in buildings and land; "portfolio" is a collection of real assets held by an organization; and "management" refers to the judicious use of means to accomplish an end. RPPM applies to organizations that are not primarily in the real estate business.

There are several alternative terms for RPPM. The most general terms are "property management" and "estate management." Related terms are "asset management," "fixed asset management," and "operational property asset management." The problem with these terms is that they are too general, and include management of a single property or a property portfolio as the main activity of an organization. Two more specific terms are "corporate real estate management" and "corporate real estate asset management." The problem with these terms is that the adjective "corporate" implies, wrongly, the exclusion of the public sector. Finally, the term closest to RPPM is "real property asset management." Still, the word "asset" has too many meanings that go beyond those intended.

3 The Rationale for RPPM

Just as a fleet of ships requires overall strategy and coordination among individual vessels, so too does a "fleet" of buildings. Although each vessel in a fleet may have a separate mission, the fleet as a whole is informed by a mission common to all. In the case of RPPM, this mission stems from the strategic objectives of an organization.

There are several key reasons for RPPM. First, about one quarter of corporate assets is in the form of real property. Second, during any period of time, activities regarding the utilization and operation of real property typically require greater resources than do new investment projects. Third, the communication gap between top-level executives and middle level managers dealing with real property needs to be closed by means of a common language. Thus far there have been three major surveys of RPPM practices in the US and UK: Harvard survey in 1981 [Zeckhauser and Silverman, 1981, 1983], MIT survey in 1987 [Veale, 1988, 1989], and the University of Reading survey in 1989 [Avis, Gibson, and Watts, 1989]. All three surveys are in agreement that real property is undermanaged, if not mismanaged. There is no reason to believe that the situation is essentially different in other European countries or Japan.

4 Focus and Scope of RPPM

RPPM focuses on the process of utilization and operation of buildings and land, but it also concerns investment and financing decisions associated with real property acquisition and disposition. RPPM focuses on problems facing top-level executives concerned with strategic issues involving real property, as distinct from tactical (facilities management in the narrow sense) and logistic (building operation and maintenance) problems facing middle-and lower-level managers, respectively. As RPPM encompasses all these issues, it may be thought of as concerning the management of facilities management.

RPPM concerns the management of buildings and parcels of land at the disposal of private and public organizations that are not primarily in the real estate business. An organization that occupies space is in the real estate business and needs to manage it properly. RPPM covers the entire range of activities concerning portfolios of buildings and land holdings: investment planning and management, financial planning and management, construction planning and management, and facilities planning and management.

5 Dimensions of Effectiveness in RPPM Practices

According to the 1987 MIT survey [Veale, 1988, 1989], organizations that manage their real property effectively share the following characteristics: (1) they have an organized real estate unit in place, (2) they have a management information system (MIS) for real estate, (3) they use property-by-property accounting methods for real estate, (4) real estate information is reported to senior executives on a scheduled basis, (5) real estate executives have regular exposure to overall corporate strategic plans and objectives, and (6) real estate executives have sufficient information and methodology available for evaluating the performance of real property entrusted to them. Put differently, organizations with successful RPPM functions both possess and effectively utilize the required information concerning real property performance.

6 Aspects of RPPM

RPPM must proceed from an organizational strategy, which is informed primarily by the type of ownership. The strategy has three aspects-physical, financial, and organizational. Physical management focuses on occupant safety, health, and comfort; financial management focuses on the effective utilization of an organization’s resources; and organizational management focuses on occupant efficiency and effectiveness. These aspects inform the performance reports, which in turn inform the RPPM management about the effect that their actions have on real property.

7 Portfolio Structure

The entire portfolio can be thought of as a structured collection of buildings, together with the associated parcels of land, as well as land available for future development. Some are stand-alone buildings distributed over a wide geographic area. Other buildings are grouped into clusters dedicated to a particular shared purpose or mission. These clusters may be concentrated in the same geographic area but on dispersed parcels of land, or they may be well-defined campuses on a single parcel or several contiguous parcels of land. Such a real property portfolio is diagrammatic cally illustrated in Fig. 1.

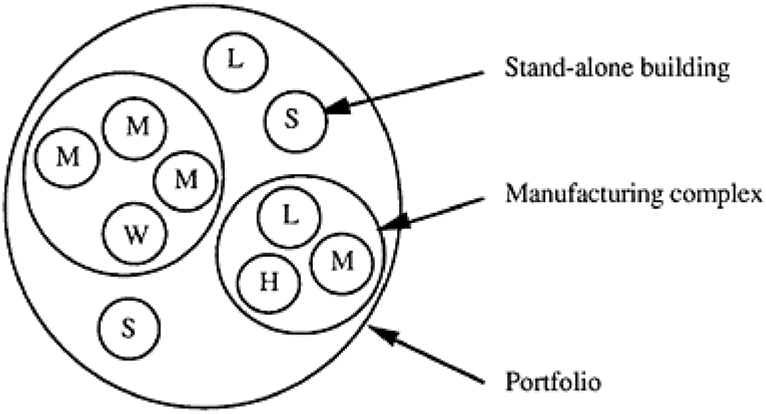


Fig. 1. Real Property Portfolio Structure.

In this example, there are two manufacturing campuses that include several manufacturing buildings (M), research laboratories (L), warehouses (W), and headquarters offices (H), and a number of sales offices and a research laboratory distributed over a wide geographic area. Each building is represented by a small circle; manufacturing campuses are denoted by larger circles; and the largest circle denotes the portfolio as a whole.

The organizational structure of the RPPM functional unit typically corresponds to such a portfolio structure. In other words, each portfolio component is entrusted to the care of a particular manager supported by a staff.

The possible courses of action differ for buildings and parcels of land in different parts of the portfolio. Conversely, the very structure of the portfolio should reflect alternative courses of action that apply to different classes of real property. For example, the options regarding stand-alone buildings are keep, rebuild, lease out, and sell; for buildings in the headquarters complex they are keep, rebuild, and lease out; and for buildings in manufacturing campuses they are keep and rebuild. One of the most important functions of RPPM is to keep a clear account of the options available for various components of the portfolio. This information can be used as the basis for detailed contingency planning for properties that are the best candidates for disposition or significant reconstruction.

Portfolios change through acquisition and disposition transactions. There are three types of change that may face an organization: growth, decline, and geographic shift. However, at any one time a large proportion of real properties will be a stable part of the portfolio.

8 Real Property Cycle

Each property is going through the real property cycle, starting from and returning to “unimproved land.” In some cases the real property cycle involves shortcuts and detours of various kinds. The stage in the cycle in which a particular property may be found needs to be understood in the light of other cycles important to an organization, such as product and/or process cycles. RPPM is concerned with the entire real property cycle of each property in the portfolio, although it focuses on the utilization and operation stage. More precisely, RPPM is concerned with the relationship between the real property cycle and other strategic cycles characterizing the organization in question.

9 Level of Influence on Total Project Cost

The opportunities to influence the total cost of building ownership decline most rapidly in the early phases of the building process. Therefore, RPPM tools need to be applied as early in the real property cycle as possible. Here, the information available to an organization concerning its “good” and “bad” buildings is invaluable in guiding both new construction projects and repair and reconstruction projects. As the real property portfolio of each organization is considerably different than any other portfolio, it is incumbent upon the client to develop and maintain a database with information specific to each organization.

10 RPPM Feedback Loop and Performance Indicators

According to Peter F.Drucker, key physical assets, like all resources, require productivity goals with deadlines and feedback from results to expectations. For this we need a system of building performance indicators. Real property performance ultimately has to do with managerial performance. The RPPM feedback mechanism offers an invaluable “scoreboard for managers” (Peter F.Drucker), which can help identify and promote managers with exceptional long-term records. The primary objective of research in this field should be to provide approaches and tools that facilitate the formation and maintenance of a feedback loop between real property performance across the portfolio and managerial action. The feedback loop will open the road toward continual incremental improvement of real property performance, guided by the everchanging objectives and structure of an organization.

For a given budget, there is a tradeoff between many indicators measured once or a few times, and a few indicators measured many times. This is shown diagrammatically in Fig. 2. The latter is generally preferable to the former, because management is generally more interested in relative change than in absolute values of performance indicators.

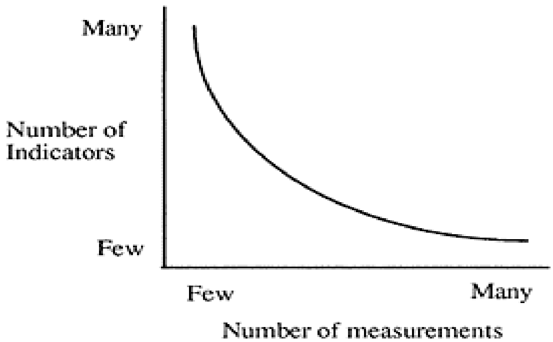


Fig. 2. Property Performance Indicators: Tradeoff for a Given Budget.

11 Performance Indicators and Statistical Quality Control

Like in manufacturing, the objective of statistical quality control (SQC) is to ensure that actual building performance is within the desired bounds-upper and/or lower. Thisis illustrated in Fig. 3. These bounds can be tightened over time. There are two difficulties concerning SQC that are of special interest. First, cross-sectional comparisons of buildings are difficult because of their heterogeneity: even identical buildings at different locations will appear very different. Second, longitudinal comparisons of the same building are difficult because many building processes are very slow: everything will appeal' to be the same even over long periods of time.

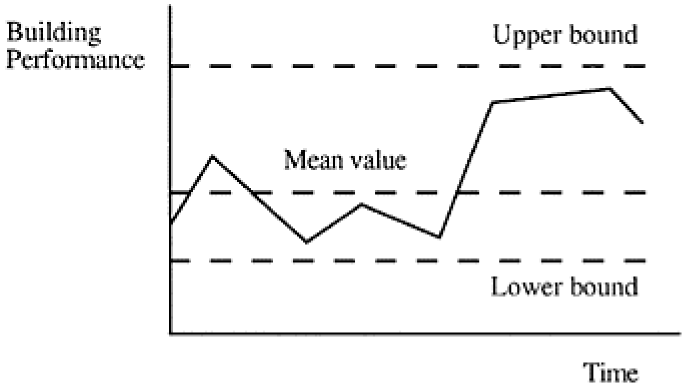


Fig. 3. Property Performance Indicators: Statistical Quality Control.

12 Performance Indicators: Structure

Because one of the key concerns of RPPM is the maintenance of a continual capability to adapt to changing economic conditions, the structure of real property performance indicators should correspond to the structure of the portfolio itself. Therefore, the management of adaptability and flexibility should not be narrowly directed only toward individual buildings. The problem arises on at least two additional levels—that of a cluster of buildings, and that of the portfolio as a whole. Furthermore, on all three levels there are distinct aspects of the problem: physical, financial, and organizational.

Problems of adaptability and flexibility are quite distinct on different management levels, although they are of course interrelated. On the level of individual buildings physical issues predominate. They include, for example, column spacing and bay sizes, ceiling heights, number of floors and area per floor, horizontal and vertical expandability in terms of the site constraints, durability of main building components such as foundations and structure, etc. As the available options are constrained by the site, adaptability and flexibility tend to be perceived in terms of the physical alternatives available.

On the cluster level, physical issues include the site layout, overall expansion strategies, durability of entire buildings, physical connections between adjacent buildings, pedestrian and vehicular access, availability of adjacent parcels of land, zoning regulations, etc. Although physical issues are also very important at this level, the emphasis tends to be on organizational issues. More specifically, management of adaptability and flexibility may involve the overall spatial distribution of various offices, departments, and divisions that require contiguous space for their operations. Organizational units that outgrow a particular building can be moved to a larger building on the same campus, or a building that has been expanded for this purpose. Some space may be provided in temporary buildings, which are adaptable and flexible in the sense that they can be more readily relocated or removed if a major campus must be restructured. On this level, adaptability and flexibility are likely to be perceived as less constrained by individual buildings and their physical characteristics than by the campus itself.

Financial issues tend to predominate on the portfolio level, although they undoubtedly play an important role on all levels. Here, adaptability and flexibility translate into liquidity. For example, the portfolio level involves broad policies regarding the mix of owned and leased facilities. The mix must be able to respond to contingency plans for capital restructuring in case of major changes in economic conditions. Large organizations tend to own their manufacturing campuses, research facilities, and most of their headquarters offices, but they tend to lease a large proportion of their sales office and retail space. A building located in a manufacturing complex cannot be disposed of readily, but a sales office or retail building can. An organization can respond to geographic shifts in the demand for its goods and/or services by acquiring new properties and disposition of old ones. Of course, some "physical" issues, such as the geographical distribution of various facilities, are also very important on the portfolio level.

As the problems discussed above are of considerable complexity, only a simple example of building performance indicators will be discussed here. This example will focus on a collection of indicators based on a very small set of “raw” data, which is typically available in most organizations.

Building performance indicators can be divided into five groups: (1) initial investment indicators, such as planned number of occupants, net productive area, project cost, and initial occupancy date; (2) periodic operation and management indicators, such as actual number of occupants, number of operating personnel, and building operating cost; (3) system indicators, such as present date, building operating period, and building cost escalation index; (4) constant derived indicators, such as variance between estimated and actual project cost, ratio of net productive and gross outside area, ratio of total project cost and net productive area, and construction period; and (5) variable derived indicators, such as ratio of planned and actual number of occupants, ratio of building operating cost and net productive area, escalated total project cost, and occupancy period. A system with not more than 30 pieces of raw data can generate several hundred useful performance indicators [Bon, Joroff, and Veale, 1987; Bon and Joroff, 1988].

13 Strategic Goals of RPPM

Real property performance should be measured with the objective of gradually changing the character of the entire portfolio via continual managerial action bent on improving real property performance. The key objective is to improve the overall performance of the portfolio by shifting the average performance in the direction of improvement, as well as to tighten the variation around that average performance. For example, an indicator can be based on a periodic questionnaire measuring the subjective satisfaction of building users with the overall performance of various buildings in the portfolio. This is illustrated diagrammatically in Fig. 4 in the form of frequency distributions of indicator values for the entire portfolio, measured at two different points in time. Clearly, this is a never-ending process involving continual incremental improvement.

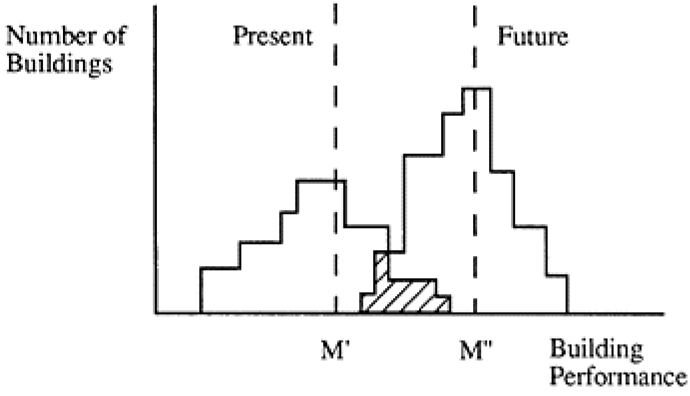


Fig. 4. Strategic Goals of RPPM.

“Good” or “bad” performance is a relative notion. Referring to Fig. 4, the area of overlap between the two frequency distributions shows that best performance in one period may be considered worst in another. Moreover, at any one time there will necessarily exist both “good” and “bad” buildings, represented by the two tails of a distribution.

Continual incremental improvement that is always in line with changing organizational goals is the “theory” behind RPPM [Bon, 1989a: Chap. 5; Bon, 1989b]. It focuses on the provision of tools that would help change an organization’s real property portfolio in the right direction, while refraining from determining what direction is right for an organization.

14 Decision-Support Systems for RPPM

The main concern in the design of RPPM DSS is to investigate ways in which the information available to an organization can be arrayed so as to ensure that its top-level management can learn about the consequences of their actions on real property performance, as well as the effect of real property on the overall performance of the organization. The RPPM feedback loop can be closed via an RPPM DSS. As is shown diagrammatically in Fig. 5, the main software components of a DSS include a knowledge base (KB), user interface (UI), a model base (MB), and a data base (DB).

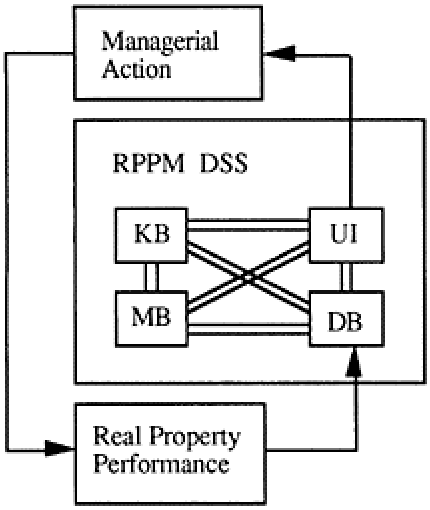


Fig. 5. DSS for RPPM: Basic Architecture.

It is useful to distinguish between intermittent or discrete and ongoing or continual aspects of RPPM. The former can be associated with problem solving or decision making; the latter with problem finding or status assessment. Most management tools available today focus on problem solving or decision making. Problem finding or status assessment are relatively neglected. Here, past decisions need to be monitored, and future problems need to be identified in time for remedial action. Functional architecture of a DSS can therefore be presented as in the diagram in Fig. 6.

Many important decisions regarding real property are made discretely, particularly those involving acquisition and disposition. As considerable resources may be required to acquire buildings and/or parcels of land or dispose of them, such decisions are carefully considered by top-level executives. There is a wide range of tools and approaches for dealing with discrete decisions. Among these, capital budgeting or benefit-cost analysis tools predominate. However, the management of utilization and operation of real property is generally neglected. Here, the focus shifts toward continual monitoring of real property performance, which can inform discrete decisions needed to improve that performance.

Although RPPM DSS development can be a lengthy and costly process, some software tools available in the market can be used to introduce the basic DSS capability into the real property management function. Off-the-shelf spreadsheet and database management software can be used as the core of a simple DSS, whereas expert systems and other knowledge-based systems can be used to guide the user through the operation of the DSS, from basic instructions about how to proceed, to the interpretation of results.

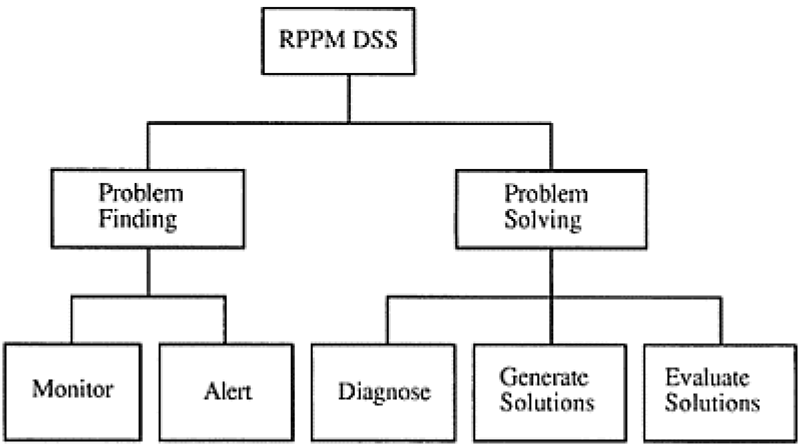


Fig. 6. DSS for RPPM: Functional Architecture.

15 Conclusions

RPPM research must not be understood as an activity that leads directly to decisions or products. The complexity of RPPM issues and tools requires organizational learning as an intermediate step. All successful RPPM research and consulting projects have involved collaborative team work between a research team and corporate management.

Moreover, successful work in this area has involved support by senior executives, without whose involvement RPPM cannot develop beyond several initial steps.

RPPM work generally goes through four stages: recognition, analysis, implementation, and monitoring and development. The initial phase is crucial to the success of this work. If recognition that the real property management function requires significant change does not come from senior executives, subsequent phases tend to be curtailed in their scope and effectiveness.

Although there are some basic principles underlying the development of RPPM DSS for different organizations, each RPPM DSS must be developed with special concern for specific characteristics of each organization. For this reason, the research and development work in this field is considerably more challenging and interesting than is the case with most other fields concerned with performance measurement and evaluation.

16 Acknowledgments

Many organizations have been instrumental in the development of the concept and tools of RPPM. From 1983 to 1990, the following organizations have sponsored this research through MIT: Office of Facilities Management, Division of Capital Planning and Operations, Commonwealth of Massachusetts; Real Estate and Construction Division of the International Business Machines Corporation; Construction Engineering Research Laboratory, United States Army Corps of Engineers; Institute of Technology, Shimizu Corporation; Property Management, and Digital Equipment Corporation. Furthermore, many students from MIT have contributed to the development of RPPM: Marc Maxwell, Rodrigo Brana, Peter Veale, Andres Schcolnik, Jyoti Deolalikar, Koji Ikkatai, and Steven Duckworth. The development of RPPM has been a collaborative effort with several colleagues from MIT and elsewhere: Michael Joroff, Robert Silverman, Kreon Cyros, and Patrice Derrington. Since 1990, RPPM research has been conducted through the Corporate Real Estate Research Unit in the Faculty of Urban and Regional Studies, University of Reading. This work is conducted in collaboration with the Center for Strategic Studies in Construction and the Center for European Property Research.

17 References

Avis, M., V.Gibson, and J. Watts [1989], *Managing Operational Property Assets,* Department of Land Management and Development, University of Reading, Reading.

Bon, R. [1989a], *Building as an Economic Process: An Introduction to Building Economics,* Englewood Cliffs: Prentice-Hall.

Bon, R. [1989b], "Real Property Portfolio Management: Economy, Quality, and Time," in *Quality for Building Users Throughout the World,* Proceedings of the Eleventh CIB Congress, Paris, June 19–23, Theme 3, Vol. 2, pp. 211–221.

Bon, R., and M.L.Joroff, eds. [1988], *Real Property Portfolio Management: Shimizu Corporation Research Program,* prepared for the Institute of Technology, Shimizu Corporation, by the Laboratory of Architecture and Planning, MIT, Cambridge, Massachusetts, August.

Bon, R., M.Joroff, and P.R.Veale [1987], *Real Property Portfolio Management,* Real Property Portfolio Management Symposium Discussion Paper and Summary, Laboratory of Architecture and Planning, MIT, Cambridge, Massachusetts, Spring.

Veale, P.R. [1988], *Managing Corporate Real Estate Assets: A Survey of U.S. Real Estate Executives,* Laboratory of Architecture and Planning, MIT, Cambridge, Massachusetts.

Veale, P.R. [1989], "Managing Corporate Real Estate Assets: Current Executive Attitudes and Prospects for an Emergent Management Discipline," *The Journal of Real Estate Research,* Vol. 4, No. 3, Fall, pp. 1–22.

Zeckhauser, S., and R.Silverman [1981], *Corporate Real Estate Asset Management in the United States,* Report prepared by Harvard Real Estate, Inc., Cambridge, Massachusetts.

Zeckhauser, S., and R.Silverman [1983], "Rediscover Your Company's Real Estate," *Harvard Business Review,* January-February, pp. 111–117.

106
A maze of measurement methods

C.W.J.BOS

Abstract
With a view to calculating the costs which are related to the work on the painting, it is necessary to measure the quantity of the paintwork. Despite of a Standard Measuring Method in existence, published by the Netherlands Normalisation Institute, there are a big number of measuring methods in use. The exchange of information is therefore doomed to a Babel-like confusion.

The ministry of Education and Science has developped a new measurement method which gives reliable results in a simple way. In this article a effort will be made to make order out of chaos in the measurement methods of painting.

Keywords: Measurement methods, Painting, Door and window frames

1.0 Introduction

To calculate the cost of paintwork, it is necessary to measure the amount of material and work required. The measurement of door and window frames and other variously shaped building components is an awkward task, especially if very accurate figures are required. The property manager or painting firm can choose between several measurement methods, which can be divided into two basic groups: area methods and linear methods.

Not every method allows a balance to be struck between accuracy and simplicity. The wide range of methods hinders the exchange of information. This paper examines the pros and cons of the various methods and practical experience of a new method which seems to offer a way out of this maze.

“Measurement is knowledge” is a saying which is widely subscribed to in the world of property management and maintenance. Measurements are required, for example, for the preparation of a maintenance plan or for calculating the cost of maintenance projects.

This often involves consultants, managers and contractors swarming round the buildings or poring over drawings, each making their own assessment, often according to their own measurement methods. As a result, the exchange of information can soon lead to a confusion of tongues worthy of Babel.

Specific measurement methods, tailored to the situation in practice, have been developed for the most common building components, depending on the type of the work to be carried out. This includes carpentry, roof slating and tiling, and also painting. In the Netherlands there is a Standard Measurement Method, published by the Netherlands Normalisation Institute, which describes a method for the systematic measurement and calculation of the amount of material and work on the basis of a specification and drawing.

Despite this Standard Measurement Method, which is intended to introduce an element of unity into the multitude of measurement methods, old habits appear to be more powerful in some cases than theory, for a large number of measurement methods have continued to be used alongside the Standard Measurement Method, especially as regards the measurement of paintwork on door and window frames, where combining accuracy with speed proves an arduous task. Reason enough to devote a paper to methods and myths concerning the measurement of paintwork on door and window frames.

2.0 Area versus linear methods

Several measurement methods are used in the painting sector, each having its own characteristics. Despite the major differences between them, these methods can be divided into two families, which in this paper are termed "area measurement" and "linear measurement".

In the case of the area method, a frame is regarded as a continuous surface with no openings, and its surface area is expressed in square metres, (tabel 1)

In the case of the linear method, a frame is considered to be composed of a collection of narrow sections, whose lengths are measured and expressed in metres, possibly accompanied by an additional classification.

Table 1: Measuring frames according to the area method or the linear method.

	length of vertical member		length of horizontal member		total
area method	1.80 m	×	2.00 m	=	3.60 m2
linear method	(3×1.80 m)	+	(3×2.00 m)	=	11.40 m

Before the experience gained by the Ministry of Education and Science with a new measurement method is described, a summary will first be given of the results of an investigation of the various measurement methods which have been used to date.

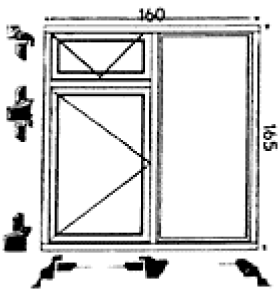
3.0 Area measurement

Empirical research shows (lit. 4) that the “unrefined” area method gives results which do not agree sufficiently with the actual amount of paintwork. This means that the accuracy of the cost calculation based on the method cannot be fully guaranteed (table 2).

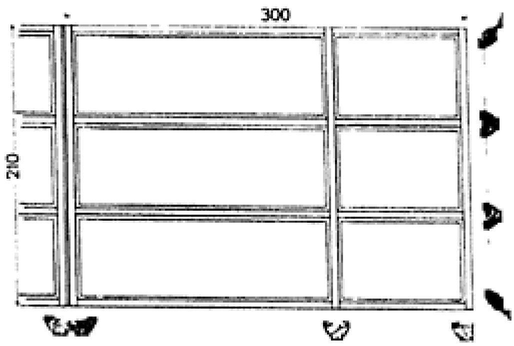
Table 2: The relation between the surface area measured according to the area method and the actual amount of paintwork.

surface area	frame A	frame B
area	2.27 m2	18.90 m2
actual	1.50 m2	5.80 m2
ratio	1.51	3.26

frame A



frame B



For this reason, all sorts of refinements have been developed over the years to enable the area method to give more accurate results. Although these variants vary widely in nature, they seem to fall under the following main headings:

1. correction factors
2. standard frames
3. reference frames
4. fixed and moving parts.

Re 1. The variant which is probably most commonly used is the one in which the surveyor multiplies the surface area measured by a correction factor which he estimates himself, this being an expression of the complexity of the paintwork. The correction factor assigned is subjective, as is the result.

The unsatisfactory nature of this method is recognised in practice and various attempts have been made to keep the level of subjectivity within reasonable proportions.

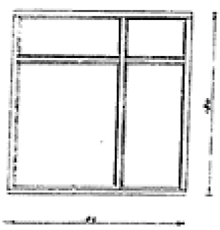
Re 2. The next step is for the surveyor to estimate the complexity of the paintwork on the basis of a set of guidelines. Such guidelines may take the form of a catalogue containing drawings of door and window frames found in practice (lit. 2). This catalogue can help the surveyor to assess the amount of paintwork required. The catalogue gives both the actual area of paintwork for the standard door or window frames and the value according to the area method (table 2).

Since reality is more complicated than anything the imagination can come up with, it is relatively difficult to find the appropriate standard frame and the result is always fairly arbitrary.

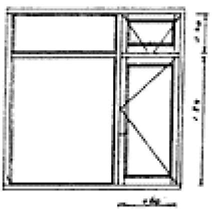
Table 3: The fixed and moving parts method produces a better approximation of the actual surface area to be painted. However, the result remains heavily dependent on the size of the frame.

surface area	frame 1	frame 2	frame 3
fixed and moving parts	3.24 m2	4.22 m2	6.19 m2
actual	1.59 m2	2.18 m2	3.92 m2
ratio	2.04	1.93	1.57

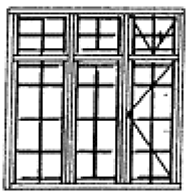
frame 1



frame 2



frame 3



Re 3. Another, more direct approach is to choose a specific frame in the building concerned which is considered typical of the other frames, and to use it for reference purposes. The amount of paintwork on this one frame is measured accurately. The other frames are measured according to the area method.

This approach is based on the assumption that similarity of design means a corresponding amount of paintwork. On the basis of geometrical considerations, such as size and complexity, however, it can be shown that this method gives a distorted picture (lit. 4).

Re 4. In the case of the fixed and moving parts method, the surface area of the fixed and moving parts of the frame is measured according to the area method and added to the surface area of the “bare” frame. Fixed and moving parts include windows, doors and panels, along with any inner frames, which often contain mullions.

Although this method produces better results than the unrefined area method, the influence of differences in cross-section, size and the pattern of vertical and horizontal members is not fully expressed in the measuring results (table 3).

The first three variants of the area method attempt to produce a better approximatation of the actual amount of paintwork, but this is accompanied by a reduction in the objectivity which originally characterised this method. The fourth variant, however, retains its reproducible character.

4.0 Linear measurement

“Area” methods are diametrically opposed to “linear” methods. Well-known examples of the latter category are the Standard Measurement Method and the method used by the Painting Industry Board, whose measuring results, however, are not always consistent due to the different ways in which the measurements are classified.

Table 4: Classification of narrow sections according to three different linear measurement methods.

Painting Industry Board’s method	**Standard Measurement Method**
– seven section shapes A to G – incl. or excl. opposite side – track of a frame (rebate) – mullions – window opening inwards – window opening outwards – sash window – pivot-hung window – fixed window	– <0.1 m – 0.1 to 0.2 m – 0.2 to 0.3 m
COT method	**COT-plus method**
– <0.3 m	– <0.2 m – incl. or excl. grooves – track of a frame (rebate)

The Standard Measurement Methode (NEN 3699) requires measurement not only of the length but also of the “developed” width (i.e. the width including contours) of vertical and horizontal members, following which these sections may be classified under the following three width categories: less than 10 cm, 10 to 20 cm, and 20 to 30 cm. (table 4) Larger widths are not counted with the narrow sections, and should be included under square metres.

The Painting Industry Board has followed a different approach, based on work studies which revealed that the time required for paintwork is determined not so much by the width of horizontal and vertical members as by their degree of detail. As regards the degree of detail of the frame sections, a distinction is made not only according to the presence of otherwise of mullions and rebates, but also, for example, according to seven section shapes, which may, if required, be combined with the opposite side (table 4). The time required to paint the window sections is also determined by five principles of movability. As a result, the Standards Book (lit. 2) gives no less than 21 different work times for one and the same activity, depending on the varying degrees of detail normally found in vertical and horizontal members.

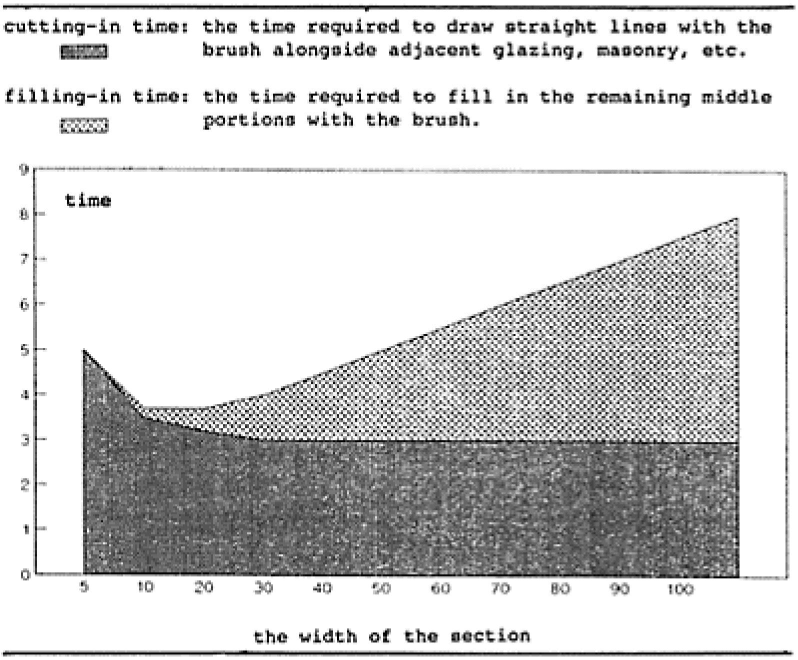


Figure 1: Relation between cutting-in time and filling-in time and the “developed” width of a section.

Unlike the Standard Measurement Method, which uses “reproducible” widths, the seven section shapes used in the Painting Industry Board’s method seem to be particularly open to interpretation, especially as the Standards Book only includes drawings of the vertical sections. On the other hand, the division of narrow sections into 10, 20 or 30 cm categories which is used in the Standard Measurement Method is not only arbitrary but also ill-chosen since the most common widths range from 7 to 15 cm.

In addition to the Standard Measurement Method and the method used by the Painting Industry Board, there is a third method which has recently become important. This is the method developed by the consultancy firm, COT, in Haarlem for the Ministry of Education and Science (lit. 1, 4 and 5).

On the basis of its research, COT comes to the conclusion, on ergonomic grounds, that painting can be divided into cutting-in and filling-in. In the case of narrow sections this means that since filling-in takes relatively little time, the most costly item is cutting-in.

Since the time involved in cutting-in does not, in principle, depend on the width of the section, it can be deduced from work studies (figure 1) that narrow sections up to 30 cm only need to be measured in linear metres in order to obtain a relatively reliable calculation of the costs, especially since factors such as climbing time, the quality of the surface, and scale, also affect the cost.

An evaluation has shown that the COT method can be improved in certain respects, and this has led to a proposal for the COT-plus method, in which the upper limit of narrow sections is reduced to 20 cm, while rebates are classified separately according to the method used by the Painting Industry Board. Finally, extra work time is added in the COT-plus method (table 4) for sections which are heavily grooved.

5.0 Practical experience

On the basis of the principles of the COT method, the Ministry of Education and Science, in cooperation with the International Information and Development Centre for Building and Housing, has developed a measuring form (figure 3), in which the measurement of outdoor paintwork is integrated with other building characteristics. During the preparation phase of the measuring campaign, however, a difference of opinion arose concerning the simplicity and speed of the COT method in relation to the area method. Eventually, the Gordian knot was cut, after the surveyors, by way of a test, were asked to measure the frames not only according to the linear method but also according to the area method and to apply a correction factor. For this purpose the surveyors used a series of drawings of standard frames in which the relation between linear metres and square metres was expressed in the form of a correction factor.

Evaluation of the tests showed that it took the surveyors quite a long time to estimate the correction factor. The standard frames were found to provide too little to go on, with the result that the surveyors felt that they had to measure the frames not only in square metres but also in linear metres. The correction factor was obtained by dividing these two figures. Obviously, this is equivalent to putting the cart before the horse!

The tests also showed—and this remark will raise many eyebrows—that measuring frames in linear metres takes hardly any more time than area measurement. This conclusion can be demonstrated by the following example.

In general, the full surface area of a rectangular frame is obtained by multiplying the length of an upright member by the length of a horizontal member. Although the multiplication itself takes little time, the measurement of these lengths with the aid of a rule or measuring tape is a fairly labour-intensive activity. Once these measurements are known, however, the following step towards the determination of the amount of paintwork in linear metres is simply to add up the number of vertical and horizontal members of that length included in the frame. And this can be done on one hand.

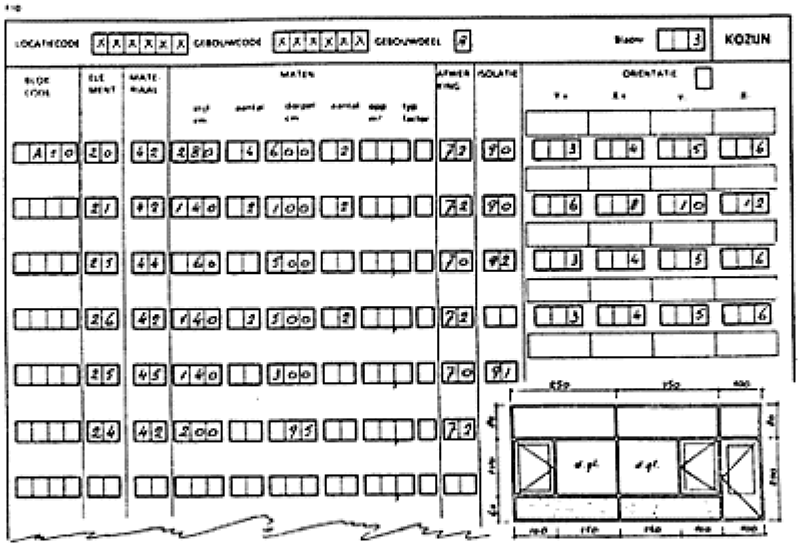


Figure 3: Measuring form in which the COT method is integrated with the fixed and moving parts method for the measurement of paintwork on frames in educational buildings.

On the basis of this experience, it was decided that in the national version of the measuring campaign frames should be measured in linear metres according to the COT method. This method is only departed from in special situations, such as in the case of frames with arches.

6.0 Synthesis

The Tao diagram (figure 2), which shows apparent contradictions which can nevertheless be combined into a harmonious whole, illustrates the conflict which exists between the measurement methods discussed in terms of simplicity and accuracy. Both “area” and “linear” methods are included in the diagram.

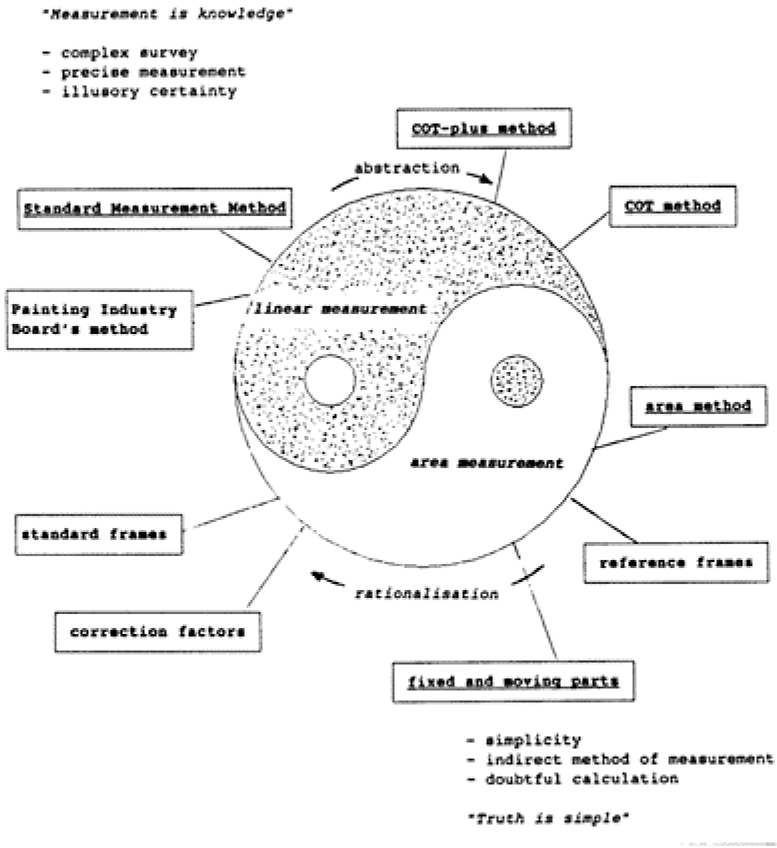


Figure 2: The broad spectrum of measurement methods for paintwork, consisting of two main groups: area measurement and linear measurement.

The measurement methods which embody a harmonious balance between simplicity and accuracy are grouped around the vertical axis. Around the horizontal axis are grouped on the one hand the measurement methods which provide more accurate measuring results with a view to producing a reliable cost calculation, and on the other, the measurement methods in which the main emphasis is on simplicity and speed.

The measurement methods are assessed not only according to simplicity and accuracy, but also according to a third criterion—verification—which expresses the degree of reproducibility of the measuring data. The methods which achieved a positive score for this characteristic (table 5) are underlined in the diagram.

7.0 Synergy

Although half a word is often sufficient for a good listener, it is impossible to avoid the impression, after what has been said in this paper about measuring paintwork, that the exchange of information on this matter quickly leads to a Babel of tongues.

Table 5: Assessment of measurement methods with regard to three aspects: simplicity and speed of measurement, accuracy of the results with regard to cost calculation, and the verifiability of the measurements.

measurement method	simplicity	accuracy	verification
1. area method	++	– –	++
2. correction factors	++	+/–	– –
3. standard frames	––	+/–	–
4. reference frames	+	–	––
5. fixed and moving parts	+	–	++
6. Standard measurement method	○	+	++
7. Painting Ind. Board’s method	––	++	–
8. COT measurement method	++	+	++
9. COT-plus measurement method	+	++	++

+/– depends on the surveyor’s experience and conscientiousness

In addition to the Standard Measurement Method, nearly ten other measurement methods are used. The gulf between area and linear methods seems to be almost unbridgeable. Which method is chosen depends on whether the emphasis is placed on simplicity and speed on the one hand or greater accuracy on the other. A further important criterion is the verifiability of the measurements, and this cuts across the division between area and linear methods. Certain measurement methods in both camps fail to comply with objective criteria.

The gulf between area and linear methods could be bridged, however, by applying the principle of the COT method in a differentiated manner, distinguishing between horizontal and vertical work, and combining it with the basic principle of the fixed and moving parts method, which draws a distinction between frames and moving parts. By integrating these two methods, one measuring procedure can be used to collect information which can be expressed in both square metres and linear metres.

This symbiosis of methods, which has been successfully applied in the measuring campaign carried out by the Ministry of Education and Science, makes it possible to exchange information expressed in square metres and linear metres, with the result that a differentiation can be made according to frame sections to produce refined cost calculations and account can be taken of intermediate figures expressed in square metres.

Literature:

1. de Meer, D.W. Funktionelere meetmethode voor schilderwerk, Bouwwereld no. 2, January 1989.
2. Normenboek onderhoudsschilderwerk, 5th edition, 1989, Painting Industry Board, Rijswijk.
3. NEN 3699 Meetmethode voor netto hoeveelheden van materialen en werkzaamheden voor gebouwen, Nederlands Normalisatie Instituut, 1976, Delft.
4. de Meer D.W. and Jellema H., Rapport kosten onderhoudsschilderwerk voorbeeldkozijn, 1998, Centrum voor Onderzoek en Technisch advies, Haarlem.
5. Bos C.W.J., Synergie meetmethoden schilderwerk is geen utopie, Renovatie en Onderhoud, no. 2, February 1991.

107
Contribution to the estimation of the rehabilitation cost for housing buildings

M.M.BRAGA, A.A.BEZELGA and J.A.S.APPLETON

Abstract
Nowadays rehabilitation of housing buildings is a deeply felt need in Portugal.

This paper presents a method of rehabilitation cost estimation for housing buildings, particularly fit for application in the Lisbon old quarters; however, it can also be used in other parts of the country, or, even abroad.

The method developed is based on the concept of “standard cost structures” and on procedures of diagnosis of the degree of deterioration in buildings, inspiration having come from methods adopted in France and Switzerland and from the analysis of building rehabilitation in Lisbon typical quarters.

Keywords: rehabilitation, cost structure, pathology, cost estimation, standard building typologies.

1 Introduction

The Portuguese housing stock, particularly in large cities, displays marked deterioration in the oldest urban zones.

A consensus of opinion has been reached as to the need of rehabilitating, at least in some specific zones or cases, that housing stock, and some steps and projects have already been undertaken with that aim.

The lack of methodologic tools, fit for Portugal, that would help in preparing quick cost estimates based on local inspection of the degree of deterioration, prompted a preliminary research work for that purpose, which is presented hereinafter.

The estimation method proposed [1], which we tried to simplify as much as possible for the required degree of accuracy, has been inspired on methodologies used in other countries, particularly in France [4] and in Switzerland [3, 4] .

Moreover, the method resulted from the analysis of specific cases of rehabilitation of buildings in Bairro Alto and Mouraria old quarters (Lisbon), and from the authors’ experience in evaluating housing buildings, either the new buildings or, particularly, the deteriorated ones.

Thus the method developed is particularly suitable for use in the rehabilitation of old buildings or building complexes in Lisbon, though it seems possible to extrapolate it in other urban centres of Portugal, or, even abroad.

2 Bases of the method

The method proposed presents as the main and original feature, with reference to the other few methods known in this domain, a link between:

a) A standard building elements structure, specifically devised for this method.
b) Standard cost structures, based on the building elements structure (a), of building typologies representative of the building stock to be rehabilitated.
c) Specific procedure of diagnosis of the deterio-
d) Association of the levels of physical degradation of the different elements with the corresponding levels of economic deterioration.

The definition of the cost structure of the typologies mentioned in b) is based on:

> Selection of the representative building types. Idealization of reconstruction of the entire building in order to make it as good as new, to a basic level of quality, taking into account the initial level and the present conditions.

The basic level of quality should be equivalent to the initial level from the point of view of the quality of the building solution, increased by the introduction of extra-equipments for improving comfort and health up to reaching a quality level close to that prescribed in present regulations (namely by additional construction of bathroom).

Higher quality level than the basic one may be accepted, by introducing a supplementary quality coefficient.

Association of the diagnosis procedure with the levels of costs referring to the different deterioration led to define, as much as possible, typical pathologies or forms of deterioration of each item of the standard structure of elements.

3 Method of estimation proposed

The method of estimation proposed is based on the following procedures:

a) Selection of the cost structure typologies closer to that of the building under study.
b) Determination of the “reference cost structure” for estimating the cost of the rehabilitation of the building studied, on basis of weighing the closest cost structures (the determination of the “reference cost structure” implies the corresponding determination of the cost percentages π_{ij} corresponding to elements E_{ij}).
c) Survey of the degree of physical deterioration φ_{ij} of the different elements E_{ij}.

d) Determination of the quality coefficient, c_Q (in common cases it is equal to 1—corresponding to the basic quality level).
e) Determination of the coefficient of additional elements, CA (corresponding to an extra improvement on quality, in terms of equipments or other additional elements, namely lifts, improvement on kitchen equipment and others).
f) Determination of the coefficient of “conditions of work execution” CR.
g) Calculation of degrees of economic deterioration, ε_{ij}, corresponding to the different elements E_{ij} of the standard element structures (Table 1); ε_{ij} will represent the relative percentage of the cost of element Eij rehabilitation as compared to the cost of total rehabilitation of that element (up to the basic quality level); determination of ε_{ij} from φ_{ij} is carried out through a function of relation (by manual or computer means).
h) Estimation of the weight of the rehabilitation cost for each element E_{ij}, in the total rehabilitation cost, given by:

$$Pij=\varepsilon_{ij}\times\pi_{ij}.$$

i) Estimation of the degree or percentage of total economic deterioration of the building, given by

Table 1—Building Element Structure

—Diagnosis of Degree of Deterioration

Chapter	Items		Conditions	Degr. Phis. Det (φ_{ij})
1 External envelope	1.1	Ground floor		
	1.2	External wall covering		
	1.3	Openings		
	1.3.	Casing and glasses		
	1.3.2	Blinds		
	1.4	Roof		
	1.4.1	Structure		
	1.4.2	Others		
2 Structural elements	2.1	Vertical load bearing structure		
	2.1.1	Frames		
	2.1.2	Load bearing walls		
	2.2	Foundations and retaining walls		
	2.2.1	Foundations proper		
	2.2.2	Retaining walls		
	2.3	Structures of staircases and floors		

	2.3.1	Slab (structure)		
	2.3.2	Staircase (structure)		
3 Inside works— Common spaces	3.1	Coverings		
	3.1.1	Corridors		
		Floor		
		Walls and Ceilings		
	3.1.2	Others		
	3.2.	Services		
	3.2.1	Water supply		
	3.2.2	Drainage		
	3.2.3	Electricity and Telecommnications		
	3.3	Others		
4 Inside works— Dewllings	4.1	Partitions		
	4.2	Coverings		
	4.2.1	Floors		
	4.2.2	Walls		
	4.2.3	Ceilings		
	4.3	Equipment		
	4.3.1	Kitchens		
	4.3.2	Bathrooms		
	4.4	Services		
	4.4.1	Water supply (including cocks)		
	4.4.2	Drainage		
	4.4.3	Electricity and Telecommunications		
	4.5.	Internal openings		
5 Extra works and equipment	5.1	Equipment not considered in the standard building		
	5.1.1	Lifts		
	5.1.2	Others		
	5.2.	Support elements		
	5.2.1	Scaffolding		
	5.2.2	Others		
6				

Work execution conditions				

$$\varepsilon=\Sigma(\varepsilon_{ij}\times\pi_{ij}).$$

j) Estimation of the total cost of the operation, i.e. total cost for all elements to be rehabilitated, C_t, given by

$$C_t=\mathbf{[\Sigma(\varepsilon_{ij}\times\pi_{ij})]\times[(C_n\times A_b)\times(cQ\times cA\times cR)]}$$

where

C_n – Cost/m^2 of gross area of the standard building corresponding to “reference cost structure”, assuming total rehabilitation of all elements E_{ij} (i.e., assuming total rehabilitation up to the basic quality level).

Ab – Gross total area of the building under study.

4 Cost structures

4.1 Building element structure conceived

The building element structure conceived, which serves as a base for the standard cost structure, was established upon the following principles or objectives:

Number of elements or sub-elements required for estimation objectives.

Grouping as main elements and sub-elements in order to make the degree of detail in applications more flexible, according to different situations.

Division into functional construction elements of several types-primary, secondary and others—without holding back to specific materials specifications or building solutions.

Structuring into large elements (external envelope, structural elements, common spaces, etc.) and component elements (coverings, door and window spaces, etc.), allowing easy analysis of the degree of deterioration in the course of the inspection of the building.

To attain the objectives mentioned, besides a specific reflection on the issue, an analysis was also made of some other structures of elements, established for other purposes, of note being:

Structures of elements of new buildings [2].

Structures of elements corresponding to rehabilitation works, including cost estimates for works done in Lisbon old quarters.

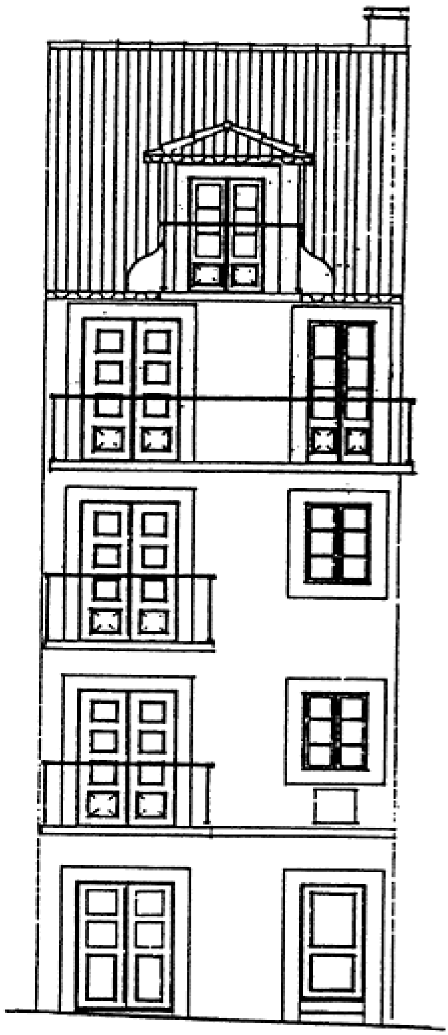


Fig.1—Standard Typology 4—General

For these rehabilitation works, in general the grid of elements used in practice is in general the following:

A – External works (common)
Roof.
Main façade.
Back façade.
Side façade.

B – Inside works (common)
Staircase well and entrance hall.
Installations (rise pipes and connections to outside systems).

C – Inside works (dwellings)
Description of works per dwelling.

The elements structure proposed, based on what was explained before, is shown in Table 1.

4.2 Standard building typologies

The typologies of the overall building stock in old Lisbon quarters that were considered more representative or standard, after a general analysis of the existing types were as follows:

– Typology 1

3 – storey building (ordinary building, 200 m^2/storey of average gross area).

– Typology 2

4 – storey building (ordinary building, 80 m^2/storey of average gross area).

– Typology 3

4 – storey building (higher rank building, 420 m^2/storey of average gross area).

– Typology 4

5 – storey building (ordinary building, 50 m^2/storey of average gross area). (Figs. 1, 2 and 3).

– Typology 5

6 storey building (ordinary building with 60 m^2/storey of average gross area.

Further analyses suggest that the number of typologies may be reduced if the cost structures for the corresponding re-constructed buildings are not stratified as was considered here.

In follow-up works, a coefficient of area may possibly be defined, allowing more accurate determination of the reference cost structure, by considering the effective area of the building studied.

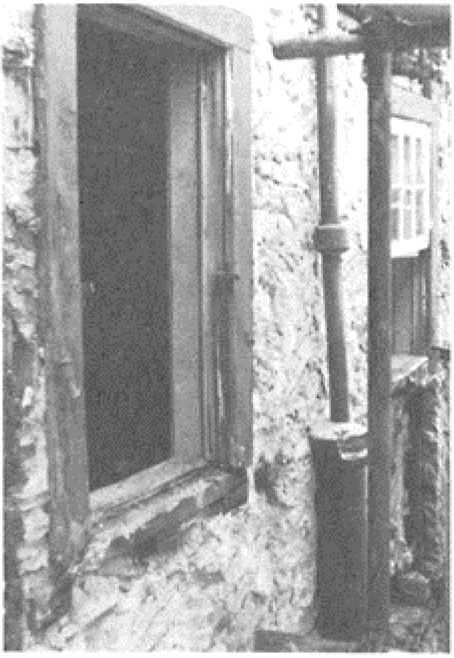


Fig.2—Standard Typology 4—Detail I

Fig.3—Standard Typology 4—Detail II

4.3 Determination of standard cost structures

The model developed and the corresponding software are already ready for the inclusion of 5 standard typologies.

The user is invited to compare the building (or the operation, as a complex of buildings) under study and to select the closest standard typology. He can also give approximating weighings to two typologies or more, in order to obtain the reference cost structure as a weighing of the closest typology structures.

Nevertheless the standard cost structures are still being developed and so far only a cost structure was defined for what was considered the most typical places in old Lisbon quarters, so that it can be immediately applied to a sufficient number of cases.

5 Diagnosis of degree of deterioration

As already said when presenting the method proposed, in 2., one of the phases of its application consists of the determination of the degree of physical deterioration φ_{ij} for the different elements E_{ij}.

Obviously this determination is essential for the application of the estimation method and may also be an important step in a rehabilitation project.

The questionnaire proposed consists of the same items of the standard element structure, completed with two additional columns. (Table 1):

> One of the columns is intended for a summary description of the physical deterioration conditions.
>
> The other column is intended for indication of the degree of physical deterioration as established by the technician who surveyed the place, on basis of the deterioration conditions of E_{ij}.

φ_{ij} values may range from 1 to 4, with 0.1 approximations, the limiting values being as follows:

1 – Element in very bad condition (non-existing).

2 – Element in bad condition (considerable repair).

3 – Element in reasonable condition (light repair).

4 – Element in good condition (no need of repair).

These limits are being detailed in the handbook for the application of the method, as regards each element Eij, in order to guide the technician in building observation.

This handbook is being developed on basis of several documentation, namely [3] and [5] and upon the analysis of specific cases taken from the old quarters of Lisbon, and from the authors' experience.

6 Computerization and testing

The model proposed was processed on computer in a simple way, using a common calculation sheet (SYMPHONY).

The method was tested In 10 typical situations, 3 of which are exemplified in Figs. 4 to 10. Results obtained proved satisfactorily for buildings similar to the standard building.

7 Application

At present an application of the method is starting for the determination of the degree of physical deterioration and estimation of the cost of rehabilitation of a block of buildings at the Alfama quarter in Lisbon.

Although the conception behind the method developed is quite simple, it seems the method may be very useful in Lisbon and in other zones of the country.

Experiments made and the interest raised to come to apply to the method suggest that it should be more thoroughly developed, particularly through improvement of the survey handbook, extension of the statistical information base, determination of coefficient of improvement on quality and marked evolution of computer use including possible introduction of relational data bases and expert systems.

References

1—MOREIRA BRAGA, M.—**Reabilitação de Edifícios de Habitação—Contribuição para a Estimação de Custos**. Lisboa, Institute Superior Técnico, 1990. Dissertação de Mestrado.

2—BEZELGA, Artur—Edifícios de Habitação—**Caracterização e Estimação Técnico-Económica**. Lisboa, Imprensa Nacional—- Casa da Moeda

3—CENTRE D'ÉTUDES TECHNIQUES D'ARCHITECTURE (CETA)—**Elements pour l'Elaboration de Methodes d'Estimation du Coût de Renovation** (2 vol.). Geneve, CETA, 1976.

4—CENTRE D'ÉTUDES TECHNIQUES POUR L'AMELIORATION DE L'HABITAT—**MER—Manuel de l'enquêteur-Méthode d'Evaluation Rapide**. Géneve, CETAH-Université de Genéve, 1981.

Situation 1—R.S. Pedro Mártir—Mouraria

Fig. 4

Fig. 5

Situation 2—Calçada da Rosa—Mouraria

Fig. 6

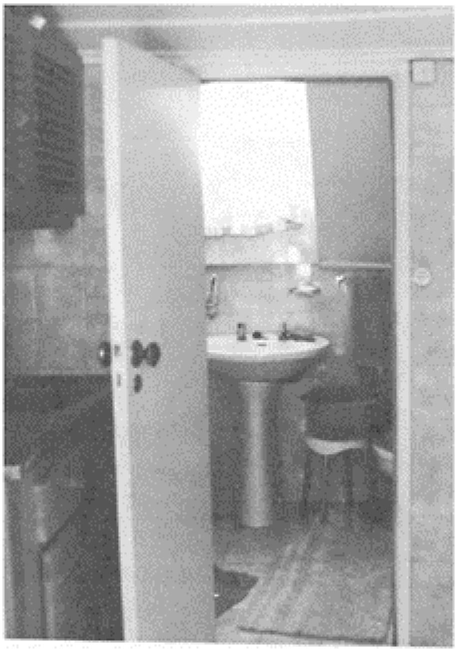


Fig. 7

Situation 3—Rua da Rosa—Bairro Alto

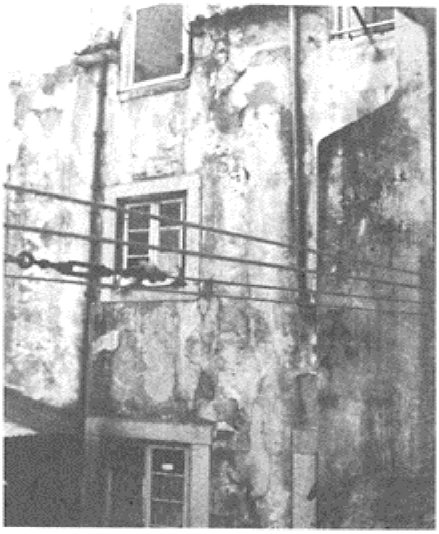


Fig. 9

Fig. 8

Fig. 10

5—LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL—**Manual de Apoio a Reabilitação de Edifícios do Bairro Alto**. Lisboa, LNEC, 1990.

108
Renewal theory and its application in the comparison of housing maintenance strategies

T.BRIGGS

Abstract

Some of the basic ideas of renewal theory are explained and some generally applicable results given.

Transparent do-it-yourself calculations, which may be done by hand, or by spreadsheet on a personal computer, are described; these may be used to help in the search for the most appropriate housing maintenance strategy and its parameters, regard being paid to practical constraints and difficulties.

Key words: Maintenance Strategy, Renewal Theory, Spreadsheet.

1 Introduction

Renewal theory may be regarded as a branch of reliability theory. It was developed by mathematical statisticians in the years immediately following the Second World War in response to practical problems concerning the renewal of faulty components. The subject expanded so rapidly that it soon became unintelligible to the people it was meant to help. However, the ideas involved are quite simple, and many useful results may be obtained by straightforward arithmetic, which may most conveniently be incorporated in a spreadsheet developed on a personal computer.

Here, the more fundamental concepts of renewal theory are explained and then applied to a comparison of alternative maintenance strategies. In another paper in this volume, Briggs (1991), it is shown how renewal theory can be used to deduce the distribution of component lifespans from maintenance records.

2 **Component** lifespan

Much of what we do has an annual cycle, reflecting the seasons of the year: inspections, budgets, maintenance. So it is perfectly natural to want the data to be given in years; this simplifies the calculations relating to maintenance issues, particularly if whole numbers are used. Thus it would suffice to say that a component was serviceable for, or had a lifespan of, 32 years.

Unfortunately, it is necessary to pause for a moment in order to clarify exactly what is meant by saying that a component was serviceable for 32 years. It is open to different interpretations. Unless precision is given to such a simple statement, I shall not really know what I am talking about, nor will the audience, despite hazy impressions to the contrary.

Consider the following scenario. A component is inspected regularly precisely at the start of each year of service by a surveyor who is never wrong, Briggs (1988). At the start of the thirty-second year of service (which a person would call his thirty-first birthday) the component is found to be serviceable, but at the start of the thirty-third year of service (the thirty-second anniversary of installation) it is discovered to be unserviceable. It would be said that the component had a lifespan of 32 years. In an eagerly maintained world, the component would then and there be immediately renewed, or replaced by a brandnew but otherwise identical component. If the brandnew replacement were itself a dud, it would be immediately replaced; rarely, this would have to be repeated until a serviceable component was found. Subsequently, the serviceable component which replaced the old one would not be looked at again for a whole year, so that whatever happened it would be said that it was serviceable for one year at least.

Similarly, a dwelling would be said to be 32 years old at the very start of its thirty-third year of tenancy, that is to say, on the thirty-second anniversary of the keys being first handed over.

If desired, shorter time units than a year may be employed, perhaps corresponding to an accountancy period.

Within the lifetime of a dwelling, a particular component may have to be renewed a number of times. Renewal may be either by replacement or appropriate treatment. In this paper it is supposed that at each renewal, the component becomes as good as new: not better than the original and not worse.

It is also supposed that there is no delay between recognition of a failure and the renewal of the affected component. This leads to the words ‘failure’ and ‘renewal’ being used interchangeably to refer to the same double event. Considerations of delay in replacement, or time necessary to effect a renewal, may be handled by queuing theory, Cox and Smith (1961) or the theory of alternating renewal processes, Cox (1967).

2.1 Lifespan probabilities

The lifespan of a component is variously known as its service life or useful life or as the failure time, the time between failures, the age at which failure occurs or as the renewal interval. The probability of something will be written as P{something}.

Let $f(x) = P\{\text{component lifespan is } x \text{ years}\}$
and $F(t) = P\{\text{component lifespan is not more than } t \text{ years}\}$

$$= f(0) + f(1) + f(2) + f(3) + \ldots + f(t-1) + f(t)$$

$$= \sum_{x=o}^{t} f(x).$$

Let $R(t) = P\{\text{component lifespan is more than } t \text{ years}\}$

$$= f(t+1) + f(t+2) + f(t+3) + f(t+4) + f(t+5) + \ldots$$

$$= \sum_{x=t+1}^{\infty} f(x).$$

Note that for every value of t, $F(t) + R(t) = \sum_{x=o}^{\infty} f(x) = 1.00,$

since the total of the probabilities of all possible lifespans must add up to unity; in other words, it is 100% certain that a component has one of its feasible lifespans.

f(x), the probability mass function, shows the proportion in a large number of similar components which could be expected to have failed at the xth anniversary of their installation; equivalently, it is the probability that the lifespan will be x years. F(t), the cumulative probability distribution function, is sometimes called the unreliability function: it indicates the proportion which could be expected to become unserviceable after t years service at the latest. R(t), the reliability function or survivor function, shows the proportion which could be expected to be serviceable or to survive beyond t years. The age-specific failure rate, $\phi(x)$, is defined by:

$$\phi(x) = f(x)/R(x-1);$$

it shows the fraction of the survivors from last year which will perish this year. If no component lasts forever, eventually there must be some x at which $\phi(x) = 1$, after which $\phi(x)$ will remain zero. When $\phi(x)$ is increasing as x increases, there is positive ageing: the component is not as reliable as it was before. When $\phi(x)$ is decreasing as x increases, there is negative ageing: the component is more reliable than it was before. If $\phi(x)$ is constant, there is no ageing: the component grows not old as we grow old. Only components which show positive ageing should be replaced.

2.1.1 Numerical example

Suppose that past evidence shows that of a particular type of component, 30% will be found to be unserviceable after three years service (that is, at the third anniversary of installation), 50% after four years and the remaining 20% after five years. This is tabulated in Table 1.

Table 1. Probability distribution of lifespan

x	0	1	2	3	4	5	Total
f(x)	0 .00	0 .00	0. 00	0.30	0.50	0.20	1 .00
x.f(x)	0 .00	0 .00	0. 00	0.90	2.00	1 .00	3 .90

F(x)	0 .00	0 .00	0. 00	0.30	0.80	1 .00	
R(x)	1 .00	1 .00	1 . 00	0.70	0.20	0.00	3 .90
$\phi(x)$	0.00	0.00	0.00	3/10	5/7	2/2	

In Table 1, the x.f(x) row represents the usual method of calculating a mean, in this case the mean lifespan, otherwise known as the mean time between failure or MTBF; it shows this to be 3.9 years. The summation of the R(x) also yields the MTBF.

This numerical example is used throughout the paper.

2.2 Convolutions

Fundamental to the study of renewal processes is the need to deduce the probability distributions for the total of two lifespans, the total of three lifespans, the total of four lifespans and so on.

First of all, consider the total of two lifespans. In the numerical example, a single lifespan may be 3, 4 or 5 years, hence the total of two lifespans may be 6, 7, 8, 9 or 10 years. To obtain a total of 8 years, there are three possibilities: the first could be 3 years and the second 5 years, or the first could be 4 years and the second 4 years, or the first could be 5 years and the second 3 years.

Let $f_{(2)}(8)$=P{Total of two lifespans is eight years},
$= f(3)\times f(5)+f(4)\times f(4)+f(5)\times f(3)$
$= 0.3\times 0.2+0.5\times 0.5+0.2\times 0.3$
$= 0.37$.

The complete probability distribution of the total of two lifespans is called the two-fold convolution of f(x) with itself. It is as if f(x) were intertwined (convolved) with a clone which is facing in the opposite direction.

The three-fold convolution, the probability distribution of the total of three lifespans being 9, 10, 11, 12, 13, 14 or 15 years

respectively, is calculated by convolving f(u) with $f_{(2)}(x-u)$ to yield $f_{(3)}(x)$. For example:

Let $f_{(3)}(12)$=P{Total of three lifespans is twelve years},
$=f(3)\times f_{(2)}(9)+f(4)\times f_{(2)}(8)+f(5)\times f_{(2)}(7)$
$= 0.305$

If f(x) is positive for x=a to b, then the two-fold convolution ranges from x=2a to 2b, the three-fold convolution from x=3a to 3b, and so on. The greatest overlap occurs with distributions which begin at x=0, for in that case, all convolutions begin (with diminishing probability) at x=0.

In the calculation of convolutions it is assumed that the individual variables are independently (but identically) distributed, consequently the means and variances are additive. Thus, for example, the mean of the four-fold convolution is four times the mean of f(x) and its standard deviation is twice that of f(x).

In these calculations, it has been assumed that a component which is found to be unserviceable is eagerly replaced by a brandnew serviceable one in no time at all.

There is a cumulative probability distribution function corresponding to each convolution. For example:

$F_{(2)}(t)$=P{Total of two lifespans does not exceed t years}
$=f_{(2)}(0)+f_{(2)}(1)+f_{(2)}(2)+\ldots+f_{(2)}(t)$.

Table 2 is a complete tabulation of f(x) and those of its convolutions and corresponding distribution functions which are positive at any time in the first twelve years of the dwelling's life. The columns headed h and H are discussed later.

Table 2. f(x), convolutions, distribution functions and their sums

t	f	f(2)	f(3)	f(4)	h	F	F(2)	F(3)	F(4)	H
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0.3	0	0	0	0.3	0.3	0	0	0	0.3
4	0.5	0	0	0	0.5	0.8	0	0	0	0.8
5	0.2	0	0	0	0.2	1.0	0	0	0	1.0
6	0	0.09	0	0	0.09	1.0	0.09	0	0	1.09
7	0	0.30	0	0	0.30	1 .0	0.39	0	0	1.39
8	0	0.37	0	0	0.37	1 .0	0.76	0	0	1.76
9	0	0.20	0.027	0	0.227	1.0	0.96	0.027	0	1.987
10	0	0.04	0.135	0	0.175	1.0	1.00	0.162	0	2.162
11	0	0	0.279	0	0.279	1.0	1.00	0.441	0	2.441
12	0	0	0.305	0.0081	0.3131	1.0	1 .00	0.746	0.0081	2.7541

3 The number of renewals in the first t years and their probabilities

The probability that a component requires no renewal within a dwelling's first t years is the probability that it is actually serviceable over t years at least; this probability is the reliability, R(t), which is equal to 1—F(t).

Let N_t be the number of renewals of a particular component in a dwelling's first t years, then:

$P\{N_t=0\}=1-F(t)$,

furthermore, the probability that the component requires one renewalwithin a dwelling’s first t years is the probability that it requiresat least one renewal less the probability that it requires at least tworenewals, thus:

$$P\{N_t=1\}=P\{N_t\geq 1\}-P\{N_t\geq 2\}$$
$$= F(t)-F_{(2)}(t),$$

and generally, for r>0,

$$P\{N_t=r\}=F_{(r)}(t)-F_{(r+1)}(t).$$

4 The mean number of renewals during the first t years

Let H(t) be the expected number of renewals of a particular component in a dwelling’s first t years, then:

$$H(t)=E(N_t)$$
$$= 0.P\{N_t=0\}+1.P\{N_t=1\}+2.P\{N_t=2\} \quad (1)$$
$$+ 3.P\{N_t=3\}+4.P\{N_t=4\}+\ldots$$
$$= 1.(F(t)-F_{(2)}(t))+2.(F_{(2)}(t)-F_{(3)}(t))$$
$$+ 3.(F_{(3)}(t)-F_{(4)}(t))+4.(F_{(4)}(t)-F_{(5)}(t))+\ldots \quad (2)$$
$$= F(t)+F_{(2)}(t)+F_{(3)}(t)+F_{(4)}(t)+\ldots$$

In Table 2, H(t) has been calculated using equation (2).

5 The mean number of renewals discovered at t years

Assuming an infallible inspector, the expected number of renewals which would have to be made when the dwelling was t years old would equal precisely the expected number of fresh component failures discovered when the dwelling was t years old, which in its turn would be the expected number of failures in the first t years less the number expected up to the end of the preceding year. Let h(t) be this expected number of renewals, then:

for t>0,

$$h(t)=H(t)-H(t-1) \quad (3)$$
$$= F(t)-F(t-1)+F_{(2)}(t)-F_{(2)}(t-1)+F_{(3)}(t)-F_{(3)}(t-1)$$
$$+F_{(4)}(t)+F_{(4)}(t-1)+\ldots$$
$$= f(t)+f_{(2)}(t)+f_{(3)}(t)+f_{(4)}(t)+\ldots \quad (4)$$

and at t=0, h(0)=H(0). (5)

In Table 2, h(t) has been calculated for the first twelve years using equation (4); it could have been calculated using equations (3) and (5). Eventually, if the table were extended to higher and higher values of t, h(t) would settle down to a value not far removed from 1/3.9≈0.2564 components per year, in other words, to the reciprocal of the MTBF.

6 Maintenance strategies

Maintenance is undertaken for some very good reason, such as to ensure an acceptable return on investment, to preserve the value of the housing stock or to maximise lettable life, Colston (1987). It makes perfect sense to consider revenues as well as costs, and indeed, in many cases it may be a matter of policy that revenues must at the very least cover all costs, including maintenance costs; on top of that, the private landlord will seek a profit, part of which may be used to finance other housing developments, Kennerley and Oxley (1990). Taxation and subsidies must also be taken into account.

At the investment appraisal level, the future cost of maintenance is but one cost in many to be considered. Some providers of public housing widen their field of enquiry to include the maintenance of the infrastructure, such as sewers and roads, Tuts (1990), Jones (1990).

For a corporation with a large housing stock, it makes sense to compare the expected costs and benefits of alternative maintenance strategies; for the individual owner-occupier, averages are not particularly helpful, but there are other decision-theoretic criteria which could, in principle at least, be applied.

Where legislation permits a corporation to have a sinking fund to provide for future maintenance costs, the rate of contribution ought to be related to an estimate of these costs and of when they might be expected to occur, Gow (1990).

In Britain, the Audit Commission has extolled the virtues of programmed maintenance as against response maintenance and has suggested that 70% should be programmed. Holmes (1990) has argued cogently that this is not necessarily true wisdom.

In what follows, only the maintenance costs will be considered, so as not to make the comparisons seem unwieldy. The maintenance costs may be taken to include transport, labour, materials and overheads. A more thorough treatment would include the costs associated with loss of amenity, inspection and routine maintenance (such as fettling and painting) and also the scrap value (if any). Consequential costs might also have to be considered. The reader himself can easily incorporate the formulations given here into his own more global deliberations.

Using the same numerical example, three alternative maintenance strategies will be considered and their expected costs compared, without and with discounting.

6.1 Strategy I: only renew components on failure

It will be supposed that the emergency replacement or corrective maintenance of a component costs C_E. The mean annual cost per component, $E_I(t)$, averaged over the first t years will be:

$$E_I(t) = \frac{C_E\ H(t)}{t} .$$

Eventually, as the years go by, H(t) will tend to approach an asymptotic limit of t/MTBF, so that

$$E_I(\infty) = \frac{C_E}{MTBF} .$$

If selected, this strategy would be used indefinitely and so, unless it is decided to use a shorter time horizon, this simple limiting result may be compared with the costs of alternative strategies.

6.2 Strategy II: renew all components at planned intervals of t years, no matter what their state or age, and in addition make emergency renewals as necessary

It will be supposed that the emergency replacement or corrective maintenance of a component costs C_E and that its planned replacement or preventative maintenance costs C_p. Since all maintenance work is presumed to be on an annual cycle, occurring only at anniversaries, the last emergency renewal (if any) will take place at the (t−1)th anniversary, thus the expected number of emergency renewals will be H(t−1). The mean annual cost per component, averaged over planned intervals each of duration t years will be $E_{II}(t)$, where:

$$E_{II}(t) = \frac{C_p + C_E\ H(t-1)}{t} .$$

6.3 Strategy III: renew components when they reach a predetermined age, and in addition make emergency renewals as necessary

It will be supposed that the emergency replacement or corrective maintenance of a component costs C_E and that its age replacement or preventative maintenance costs C_A. Suppose the predetermined age is set at a years, the n:

P{Component has planned renewal}=P{Not renewed before age a}

=R(α−1).

P{Component has emergency renewal)=F(α−1).

Expected useful life of component

$$= 0.f(0) + 1.f(1) + 2.f(2) + 3.f(3) + 4.f(4) + \ldots + (\alpha-3).f(\alpha-3) + (\alpha-2).f(\alpha-2) + (\alpha-1).f(\alpha-1) + \alpha.\{f(\alpha) + f(\alpha+1) + f(\alpha+2) + f(\alpha+3) + f(\alpha+4) + f(\alpha+5) + \ldots\}$$

$$= \sum_{u=1}^{\alpha-1} u\, f(u)\, du + \alpha.R(\alpha-1)$$

$$= 0.\{1-R(0)\} + 1.\{R(0) - R(1)\} + 2.\{R(1) - R(2)\} + 3.\{R(2) - R(3)\} + 4.\{R(3) - R(4)\} + \ldots + (\alpha-3).\{R(\alpha-4) - R(\alpha-3)\} + (\alpha-2).\{R(\alpha-3) - R(\alpha-2)\} + (\alpha-1).\{R(\alpha-2) - R(\alpha-1)\} + \alpha.\{R(\alpha-1)\}$$

$$= R(0) + R(1) + R(2) + \ldots + R(\alpha-2) - (\alpha-1).R(\alpha-1) + \alpha.R(\alpha-1)$$

$$= R(0) + R(1) + R(2) + \ldots + R(\alpha-2) + R(\alpha-1)$$

$$= \sum_{u=o}^{\alpha-1} R(u).$$

Expected total cost per component over its useful life

$= C_A\, R(\alpha-1) + C_E\, F(\alpha-1).$

Hence the expected annual cost per component, $E_{III}(\alpha)$, if components are renewed when they are a years old, is:

$$E_{III}(\alpha) = \frac{C_A\, R(\alpha-1) + C_E\, F(\alpha-1)}{\sum_{u=o}^{\alpha-1} R(u)}.$$

6.4 Numerical comparisons of strategies without discounting

Suppose that the lifespan distribution is as in Table 1.

Calculations show that Strategy II is worth considering when compared with Strategy I used indefinitely if $C_p<0.77\ C_E$, and Strategy III is worth considering compared with Strategy I used indefinitely if $C_A<0.93\ C_E$

6.5 Numerical comparisons with discounting

Consider a scenario in which the estate is to be sold in twelve years time as a going concern, with no component in a failed state. This means that the time horizon is twelve years: the aim is to minimise the nett present value of the costs over the next twelve years. All things considered, let the nett discount rate be 4% per annum. As discounting is on a year by year basis, the number of renewals and whether they are emergency or planned must be considered one year at a time.

Relative rather than absolute costs are all that are needed for a comparison of strategies. Economies of scale may be expected to cause C_p and C_A to be positive but less than C_E. Let C_E=1.00, for convenience.

Suppose that the lifespan distribution is as in Table 1.

6.5.1 Strategy I: only renew components on failure

Let the nett present value of the expected costs of maintenance over the next twelve years be $N_I(12)$, then:

$$N_I(12) = C_E \sum_{u=o}^{12} \{h(u).(1.04)^{-u}\}$$

$$= C_E \{h(0) + h(1)/1.04 + h(2)/1.04^2 + \ldots + h(12)/1.04^{12}\}.$$

$$= 2.0825 .$$

The necessary calculations are set out in Table 3, which also shows what the expected cost over the next twelve years would have been if the discount rate had been zero.

Table 3. Discounted h(u)

u	1.04^(−u)	h(u)	h(u).(1.04^(−u))
0	1.0000	0	0
1	0.9615	0	0
2	0.9246	0	0
3	0.8890	0.3	0.2667
4	0.8548	0.5	0.4274
5	0.8219	0.2	0.1644
6	0.7903	0.09	0.0711
7	0.7599	0.30	0.2280
8	0.7307	0.37	0.2704
9	0.7026	0.227	0.1595
10	0.6756	0.175	0.1182
11	0.6496	0.279	0.1812
12	0.6246	0.3131	0.1956
Totals		2.7541	2.0825

6.5.2 Strategy II: renew all components at planned intervals of t years, no matter what their state or age, and in addition make emergency renewals as necessary

By way of illustration, suppose that the cycle length is set to four years; this means that three cycles will fit exactly into the twelve years. Let the nett present value of the expected costs of maintenance over the next four years be $N_{II}(4)$, then:

$$N_{II}(4) = C_p/1.04^4 + C_E \sum_{u=o}^{3} \{h(u).(1.04)^{-u}\}$$

$$= C_p/1.04^4 + C_E \{h(0) + h(1)/1.04 + h(2)/1.04^2 + h(3)/1.04^3\}$$

$$= 0.8548\ C_p + 0.2667\ .$$

The nett present value of the maintenance costs in three such cycles, covering the first twelve years, would be:

$N_{II}(4)+N_{II}(4)/1.04^4+N_{II}(4)/1.04^8$,

$= \{0.8548\ C_p+0.2667\}\{1.0000+0.8548+0.7307\}$

$= 2.2101\ Cp+0.6896$.

However, rather than renew all the components in twelve years time, at the end of the third cycle, since the intention is to sell the estate at that time, it may be thought more expedient merely to replace the h(4) components which may be expected to require renewal then. In other words, Strategy II could be used for each of the first two four-year cycles, but Strategy I could be used for the third four-year cycle, this would give a nett present value of maintenance costs of:

$N_{II}(4)+N_{II}(4)/1.04^4+N_{I}(4)/1.04^8$,

$= \{0.8548\ C_p+0.2667\}\{1.0000+0.8548\}+\{0.6941\}\ \{0.7307\}$

$= 1.5855\ C_p+1.0019$.

Table 4. Calculations for Strategy III with discounting

Sequence	Prob	Discounted	cost	Prob×discounted cost	
		C_A	C_E	C_A	C_E
3 3 3 3	0.0081	0.000000	3.006495	0.000000	0.024353
3 3 3(4)	0.0189	0.000000	2.381898	0.000000	0.045018
3 3 4(3)	0.0189	0.675564	1.679311	0.012768	0.031739
3 3 4(4)	0.0441	0.675564	1.679311	0.029792	0.074058
3 4 3(3)	0.0189	0.759918	1.564561	0.014362	0.029570
3 4 3(4)	0.0441	0.759918	1.564561	0.033512	0.068997
3 4 4(3)	0.0441	1.409499	0.888996	0.062159	0.039205
3 4 4(4)	0.1029	1.409499	0.888996	0.145037	0.091478
4 3 3(3)	0.0189	0.854804	1.435482	0.016156	0.027131
4 3 3(4)	0.0441	0.854804	1.435482	0.037697	0.063305
4 3 4(3)	0.0441	1.504385	0.759918	0.066343	0.033512
4 3 4(4)	0.1029	1.504385	0.759918	0.154801	0.078196
4 4 3(3)	0.0441	1.585494	0.649581	0.069920	0.028647

4 4 3(4)	0.1029	1.585494	0.649581	0.163147	0.066842
4 4 4(3)	0.1029	2.210091	0.000000	0.227418	0.000000
4 4 4(4)	0.2401	2.210091	0.000000	0.530643	0.000000
Totals	1.0000			1.563758	0.702049

6.5.3 Strategy III: renew components when they reach a predetermined age, and in addition make emergency renewals as necessary

By way of illustration, suppose that emergency renewals are made as necessary and any component which reaches four years of age, no matter what its state, is also renewed. The time horizon is twelve years, so that it is a matter of listing and calculating the probability of every feasible sequence of lifespans extending over twelve years, costing each renewal according to whether it is an emergency or an age renewal, discounting each cost and multiplying each discounted cost by its probability: the result is the nett present value of the maintenance costs over the twelve year period. For these particular calculations, it has been assumed that at the start of the twelve year period all the components are brandnew. It has also been assumed that there will be an age replacement at the end of the twelve year period, if, for a particular sequence, one falls due. The calculations could easily be modified to cater for different assumptions.

As can be seen from Table 4, the nett present value of the expected maintenance costs over the twelve years is 1.5638 C_A+0.7020, assuming that C_E is 1.000 .

7 Conclusion

Given the technology, maintenance has to be managed to best advantage. Renewal theory may be applied not only to the management of housing maintenance but also to the maintenance of the plant and equipment used in housing construction or in the manufacture of building materials.

8 References

Brandon, P.S. (1987) Life cycle appraisal—further considerations, in **Building Maintenance Economics and Management** (ed A.Spedding), E. & F.N.Spon, London, pp.153–162.

Briggs, T. (1988) A mathematical model of the management of condition surveys, in **Whole-life Property Asset Management** (ed D.S.S.Then), Proceedings CIB W70 International Seminar, Edinburgh, pp. 174–182.

Briggs, T. (1991) The distribution of service lives deduced from housing maintenance records: an application of renewal theory, in **European Housing: Management, Quality and Economics** (eds P.S.Brandon and A.Bezelga), E. & F.N.Spon, London.

Colston, A.E. (1987) The maintenance of public housing assets—SSHA practice and developments, in **Building Maintenance Economics and Management** (ed A.Spedding), E. & F.N.Spon, London, pp. 331–344.

Cox, D.R. and Smith, W.L. (1961) Queues. Methuen, London.
Cox, D.R. (1967) Renewal Theory. Methuen, London.
Gow, H.A. (1990) Sinking funds and housing asset management, in **Building Maintenance & Modernisation Worldwide,** Volume One (ed L.K.Quah), Longman, Singapore, pp. 234–238.
Holmes, R. (1990) The changing nature of maintenance management—factors affecting efficiency and cost effectiveness, in **Building Maintenance & Modernisation Worldwide,** Volume One (ed L.K.Quah), Longman, Singapore, pp. 288–297.
Jones, E.M. (1990) The development of an estate management information system, in **Building Maintenance & Modernisation Worldwide,** Volume Two (ed L.K.Quah), Longman, Singapore, pp. 1182–1190.
Kennerley, W.J. and Oxley, M.J. (1990) Economic analysis and property maintenance, in **Building Maintenance & Modernisation Worldwide,** Volume Two (ed L.K.Quah), Longman, Singapore, pp. 1288–1298.
Tuts, R. (1990) Evaluation of design alternatives through computer-aided life cycle costing for low-cost housing projects in Nairobi, in **Building Maintenance & Modernisation Worldwide,** Volume Two (ed L.K.Quah), Longman, Singapore, pp. 1106–1115.

109
The distribution of service lives deduced from housing maintenance records: and application of renewal theory

T.BRIGGS

Abstract
A large number of housing maintenance records, actually generated by tenants' requests for maintenance action, indicate when a component failed and also the age of the affected dwelling; the problem is to determine the distribution of lifespans of such components.

Since the records do not indicate whether the component has ever failed previously, an analysis based on Renewal Theory is required in order to disentangle the underlying distribution embedded in the data.

The special problem of attempting to determine the lifespan distribution when some initial components have yet to fail is also investigated.

Transparent do-it-yourself calculations, which may be done by hand, or on a spreadsheet on a personal computer, are described: these are used to support the logical deductions leading to the discovery or estimation of the lifespan distribution.

Key words: Housing Maintenance Records, Lifespan Distribution, Renewal Theory, Spreadsheet.

1. Introduction

Maintenance records are seldom archived; the reasoning is that the space, effort and other resources can be better employed for more important things, such as maintenance itself. To have records showing renewals generated by the housing stock over a short period is good, particularly if the age of the dwellings concerned can be discovered. To have the complete maintenance history of the housing stock would be better still.

Not everyone sees a need to obtain information about lifespans. Certainly, at an operational level, condition surveys indicate what action is required now or will be required later.

At the management level, however, a knowledge of the predicted pattern of occurrence of costs can form part of the database for investment appraisal or the planning of whole-life asset management.

Maintenance costs are of course only one thing to consider. For the landlord seeking a return on his investment, the earning power of the building may be paramount, but this too will in part be affected by the maintenance strategy, because a poorly maintained asset quickly becomes a liability, Then (1988).

In this paper, it is assumed that there is no delay between recognition of a failure and the renewal of the affected component. This leads to the words ‘failure’ and ‘renewal’ being used interchangeably to refer to the same double event. Cases where this is not even approximately a valid assumption may be handled by queuing theory, Cox and Smith (1961), or by the theory of alternating renewal processes, Cox (1967).

1.1 Notation

Some of the basic principles, nomenclature and notation of renewal theory were introduced in another paper in the present volume, Briggs (1991). A summary of the notation is given here.

The probability of something is written as P{something}.

f(x) = P{component lifespan is x years}

F(t) = P{component lifespan is not more than t years}

R(t) = P{component lifespan is more than t years}

H(T) = mean number of renewals of a particular component in a dwelling’s first T years

h(T) = mean number of renewals of a particular component in a dwelling’s Tth year

p(T) = P{dwelling is T years old}

$f_{(n)}(x)$ = P{Total of n lifespans is x years}.

2 Sampling and bias

Data may be obtainable from samples which in the time domain are either longitudinal or cross-sectional.

A longitudinal sample comprises the full maintenance history of selected dwellings; from this data, component lifespans can be directly calculated and a tally built up to yield the lifespan distribution.

A cross-sectional sample comprises individual maintenance job records. If these contain the address of the affected dwelling and the date of component renewal, the count of the number of renewals can be classified by dwelling age. Given the age profile of the housing stock, renewal theory may be used to deduce the component lifespan distribution from the renewal count, the nature of the analysis depending on whether the job records are archived or kept for only a short period.

Bias can be introduced into cross-sectional samples. This arises if a researcher, having knowledge of when each component which is currently in service came into service, chooses to investigate their lifespans. Such an investigation would extend over several or many years, until all these components had failed. Obviously, the researcher would then know the lifespan of each component in the sample. Usually, the sample can be shown to be biased in favour of longer lifespans. If none of these components is one of the original components and if the sample comprises those components in service when the associated dwelling is T years old, the probability of the inspected lifespan being x years, is given by $i_T(x)$, where:

$$i_T(x) = f(x) \sum_{r=1}^{x} h(T + r - x) \ .$$

If the dwelling is very old, since h(long time)→1/MTBF, this simplifies to:

$i_T(x)=x.f(x)/MTBF$.

However, if the researcher chose the original components, there would be no bias, $i_T(x)$ would simply be f(x). There would also be no bias if a sample of components which failed were taken. It may be likened to selecting eels by their heads or tails, compared with grabbing them blindly at any cross-section; the latter procedure, on average, favours catching longer ones.

Building components mostly have relatively long lifespans compared with the length of research projects. Consequently, the problem for the researcher, but not for the tenant, is that even when data is available, it is likely to be incomplete in the sense that not all initial components have yet failed and so the shape of the lifespan distribution is not fully known.

In the space available, this paper concerns itself with the analysis of three different cross-sectional samples in order to deduce the distribution of component lifespans.

3 The number of component renewals generated by the housing stock to date

Consider a scenario, reflecting changing political direction and/or economic circumstances, in which the age profile of the housing stock is as shown in the first two columns of Table 1. Each maintenance job has generated an individual record showing, amongst other things, when the failure occurred and when the dwelling was completed; however, the record does not indicate whether the component has been renewed on a previous occasion. One such database, showing the year of failure and the year of completion of the dwelling, has been described by Hegvold et al. (1990).

The third column in Table 1 is simply a count of the maintenance records, classified by the age of the dwelling. There is no more information to hand: it would seem to be the absolute minimum data set to which Holmes (1990) makes reference. From it, as will now be demonstrated, the component lifespan distribution can be deduced.

Table 1. Analysis of jobs to date

Dwelling age (years)	Cohort size	Failures to date	H(T)	h(T)
2	1000	0	0.0	
3	2000	600	0.3	0.3
4	10000	8000	0.8	0.5
6	2000	2180	1.09	
9	14000	27818	1 .987	
10	1000	2162	2.162	0.175
	30000	40760		

The ultimate aim is to try to deduce f(x) from the data; as a first step, it is a matter of estimating H(T) and some h(T). In Table 1, for each age group, H(T) is obtained by dividing the number of failures by the cohort size; some h(T) are deduced from $h(T)=H(T)-H(T-1)$.

Rather like a detective with scant evidence, one has to deduce as much as possible. Now, H(T) is the expected number of renewals over time T, therefore it tends to increase as T increases; certainly it can never decrease. It is said to be monotonely increasing (even if not strictly so). Consequently, since H(2) is zero, H(1) and H(0) must also be zero; hence h(0), h(1) and h(2) are also zero.

Since H(3) is the first nonzero H(T), it must be true that the failure distribution, f(x), begins at three years, that the least sum of two lifespans is six years, the least sum of three lifespans is nine years, and so on.

Since the sum of two lifespans begins at six years,

for T=0 to 5, $f_{(2)}(T)=0$

therefore $h(3)=f(3)=0.3$,

$h(4)=f(4)=0.5$

$h(5)=f(5)$, which is unknown.

Also, $h(6)=f(6)+f_{(2)}(6)=f(6)+f(3)xf(3)=f(6)+0.09$,

and $H(6)=H(4)+h(5)+h(6)$,

thus $1.09=0.8+f(5)+f(6)+0.09$,

therefore $f(5)+f(6)=0.20$.

Moreover, $f(3)+f(4)+f(5)+f(6)=0.3+0.5+0.20$

thus $f(x)=0$, for $x>6$.

The two-fold convolution therefore ends at twele years. Let $f(6)=\alpha$, then $f(5)=0.2-\alpha$, since $f(5)+f(6)=0.20$.

With this information, the two-fold convolution may be calculated, as set out in Table 2.

Table 2. Calculations to deduce two-fold convolution

u	3	4	5	6	Total
$f(u)$	0.3	0.5	$0.2-\alpha$	α	
$f(6-u)$	0.3	0	0	0	
$f_{(2)}(6)$	0.09	0	0	0	0.09
$f(7-u)$	0.5	0.3	0	0	
$f_{(2)}(7)$	0.15	0.15	0	0	0.30
$f(8-u)$	$0.2-\alpha$	0.5	0.3	0	
$f_{(2)}(8)$	$0.06-0.3\alpha$	0.25	$0.06-0.3\alpha$	0	$0.37-0.6\alpha$
$f(9-u)$	a	$0.2-\alpha$	0.5	0.3	
$f_{(2)}(9)$	0.3α	$0.1-0.5\alpha$	$0.1-0.5\alpha$	0.3α	$0.2-0.4\alpha$
$f(10-u)$	0	a	$0.20-\alpha$	0.5	
$f_{(2)}(10)$	0	0.5α	$0.04-0.4\alpha+\alpha^2$	0.5α	$0.04+0.6\alpha+\alpha^2$
$f(11-u)$	0	0	a	$0.2-\alpha$	
$f_{(2)}(11)$	0	0	$0.2\alpha-\alpha^2$	$0.2\alpha-\alpha^2$	$0.4\alpha-2\alpha^2$
$f(12-u)$	0	0	0	α	
$f_{(2)}(12)$	0	0	0	α^2	α^2

The next step would be to deduce the three-fold convolution in the same way, but as no values of h(T) beyond h(10) are known, there is no point in going beyond $f_{(3)}(10)$. The working is shown in Table 3.

Table 3. Calculations to deduce start of three-fold convolution

u	3	4	5	6	Total
$f(u)$	0.3	0.5	$0.2-\alpha$	α	
$f_{(2)}(9-u)$	0.09	0	0	0	
$f_{(3)}(9)$	0.027	0	0	0	0.027
$f_{(2)}(10-u)$	0.30	0.09	0	0	
$f_{(3)}(10)$	0.09	0.045	0	0	0.135

Now	h(10)	=	$f(10)+f_{(2)}(10)+f_{(3)}(10)$,
therefore	0.175	=	$0+0.04+0.6\alpha+\alpha^2+0.135$

	0	=	$0.6\alpha+\alpha^2$
	0	=	$\alpha(\alpha+0.6)$
so that	α	=	0, since $\alpha=-0.6$ is not feasible.
Hence,	f(6)	=	$\alpha=0$
and	f(5)	=	$0.2-\alpha=0.2$.

Thus the underlying distribution has been fully determined, as set out in Table 4.

Table 4. Deduced lifespan distribution

Lifespan, *x*	0	1	2	3	4	5	6	Total
Probability, f(x)	0	0	0	0.3	0.5	0.2	0	1.00

4 The number of component renewals which the housing stock has generated this year

The data in this section resembles that in section 3, but with one important difference. There, the maintenance records had been meticulously archived so that the number of renewals to date for each cohort in the age profile of the housing stock was known; here, the data in essence is similar but covers only a twelve-months period. Such data, involving over six thousand records regarding dwellings which were built between 1913 and 1982 and now needing maintenance action was made available to McDermont (1988). The assumption was made that the dwellings were similar, or sufficiently so. The sort of information available is illustrated in Table 5; this may be compared with the data in Table 1.

Table 5. Analysis of jobs this year

Dwelling age (years)	Cohort size	Failures this year	h(T)
2	1000	0	0.0
3	2000	600	0.3
4	10000	5000	0.5
6	2000	180	0.09
9	14000	3178	0.227
10	1000	175	0.175
	30000	9133	

It is a straightforward matter to estimate h(T) from the data by dividing the number of failures generated by a particular age of dwelling by the number of dwellings of that age in the housing stock.

h(T), unlike H(T), cannot be expected to be monotone increasing. It is always nonnegative, but it fluctuates in a fashion reminiscent of a damped oscillation, eventually settling to a value close to 1/MTBF as T increases. In order to deduce the underlying lifespan distribution, it is necessary first to deduce h(T) as far as possible, and certainly as far as the full range of possible lifespans. Table 5 has entries for T=2, 3, 4, 6, 9 and 10 only. With no great confidence but not unreasonably, since h(2) is zero, let it be supposed that h(0) and h(1) are zero. On this supposition it is then possible to build up H(0) to H(4), and also to claim that the least lifespan is three years, consequently the least sum of two lifespans is six years, the least sum of three lifespans is nine years, and so on. It follows that:

f(0), f(1), f(2) are all zero

$f(3)=h(3)=0.3$

$f(4)=h(4)=0.5$

f(5)=h(5), but is unknown

$h(6)=f(6)+f_{(2)}(6)=f(6)+f(3).f(3)$

therefore,

$0.09=f(6)+0.3\times 0.3$

so, f(6)=0.

Assuming that f(x) is unimodal, and in particular will not become positive for x>6, since it is zero at x=6, it follows that f(5)=0.2 .

Having determined f(x) completely for all x, all associated distributions can be calculated. In particular, h(T) and H(T) can now be extended and ought to agree well at h(9) and h(10). The MTBF can also be directly calculated from f(x).

If there are no gaps in the data, that is to say, the dwellings were built year in and year out, then the table of h(T) should be complete. The larger the property base, the more credence can be given to the results.

5 Generalisation of the above

If p(T) is the age profile of the housing stock, this is statistically equivalent to saying that T has the probability mass function p(T).

The expected number of component failures generated to date by that section of the housing stock which is now T years old is p(T).H(T). Thus H(T) may be estimated from:

$$H(T) = \frac{\text{Nr of failures so far at all dwellings T years old}}{\text{Nr of dwellings which are T years old}} .$$

If there have been no gaps in the building programme, there will be no gaps in H(T). Moreover, since H(T) is a cumulative total it is likely to be little influenced by unexplained ‘random’ fluctuations in the data, good years being balanced by bad years in the cumulative total.

Similarly, h(T) may be estimated from:

$$h(T) = \frac{\text{Nr of failures this year at all dwellings T years old}}{\text{Nr of dwellings which are T years old}},$$

or it may be calculated as: h(T)=H(T)−H(T−1).

The next step is to notice the smallest value of T for which H(T) is positive. Let this smallest value be s, it follows that:

for	T<s,	h(T)=0
for	s=T<2s,	h(T)=f(T)
for	T=2s,	h(T)=f(2s)+f(s).f(s)
for	2s=T<3s,	$h(T) = f(T) + \sum_{u=o}^{T} f(u).f(T-u)$

and so on.

It will be useful to bear in mind that f(x) sums to unity, as does each convolution. Moreover, if lifespans are fairly short, the fact that h(T) tends eventually towards a value close to 1/MTBF as T increases may be helpful.

6 Renewal data available from relatively new dwellings

Consider the scenario in which the data is such that some original components are still in service.

6.1 Estimation of the mean lifespan (MTBF)

If the year is known in which half the original components have failed, this gives the median lifespan. If the number of failures of original components per annum has already peaked, this gives an indication of the modal lifespan. Bearing in mind that mean, median and mode can be expected to lie in dictionary order, the mean can be estimated. Without more ado, the population mean can be assumed to equal this estimate. Table 6 is too short for these ideas to be of use, however, the mean can be estimated from the fitted distribution as in section 6.3.

6.2 Estimation of the spread of lifespans

If it is known by which years 25% and 75% of the original components have failed, the spread may be represented by the value of the interquartile range. Since, on average, a sample tends to underestimate spread, it might be decided to adjust these figures slightly. Consideration of the positions of the quartiles and median will also give an impression of the skew of the distribution of lifespans. Table 6 is too short for these ideas to be of use, however, the spread can be estimated from the fitted distribution as in section 6.3.

6.3 Estimation of the distribution of lifespans

For instance, the data might be for four years only, which for the illustrative example would be as in Table 6.

Table 6. Lifespan data from quite new dwellings

Dwelling age (years)	Cohort size	Failures to date	H(T)	h(T)
2	1000	0	0.0	
3	2000	600	0.3	0.3
4	10000	8000	0.8	0.5

From H(T) in Table 6 it can be deduced that the least lifespan is three years, which implies that the renewals at T=3 years are entirely due to initial failures, so that f(3)=0.3. Moreover, the least sum of two lifespans is six years, which in its turn implies that f(4)=0.5. Beyond that, all that can be said is that R(4)=0.2. Since the records do not stretch beyond the longest possible lifespan, the righthand tail of the lifespan distribution (covering T=5, 6, 7, …) would have to be guessed or estimated.

There are alternative methods of estimating this righthand tail.

One is to estimate the numerical value of f(x) for each and every value of x, possibly with some upper limit on x; in this approach there is no need to consider the function f(x) as anything other than a tabulated sequence of values corresponding to the values of x, but it could mean that quite a large number of values have to be estimated. For the example given, using this approach, it may be decided somewhat arbitrarily that the lifespan distribution extends to ten years: numerical estimates of f(5), f(6), f(7), f(8), f(9) and f(10) totalling 0.2 would then be required, perhaps 0.10, 0.05, 0.03, 0.01, 0.007 and 0.003 respectively might be the choice, and maybe these too would be rather arbitrary choices. Although open to criticism, such figures could be produced from an extension of the graph of R(x) by an artistic hand; whether such a creative extension of the truth turns out to be correct, only time will tell. A consideration of whether the component is likely to be positively ageing would help in guessing plausible values, Briggs (1991).

The alternative approach is to suppose that lifespans have some theoretical distribution; this requires that only a small number of (parameter) values be estimated. Using the second approach, it might be decided to fit the Adel distribution defined by its reliability function as:

$$R(x) = p^{(x+1)^a} .$$

This distribution allows for the possibility of dud components, since at x=0, F(x)=1−p. If the very thought of such a possibility is anathema, the translated distribution,

$$\text{for } x \ge x_o, \quad R(x) = p^{(x-x_o+1)^a}$$

$$\text{otherwise} \quad R(x) = 0$$

may be used. In practice, the Adel distribution often gives probabilities which are virtually zero for small x. If a=1, the geometric distribution is obtained. Other distributions, such as the Pascal distribution, might also be considered; this is essentially the a-fold convolution of the geometric distribution and defined by its probability mass function:

$$f(x) = \frac{(x-1)!}{(x-a)!\ (a-1)!}\ p^{(x-a)}\ q^{a} \ .$$

A convex combination of theoretical distributions should also be considered if the lifespan distribution has the classic bathtub shape. This enables due regard to be given to the corrective work which so often has to be performed on quite new dwellings, Brandon (1987).

The advantage of this more mathematical approach is that only two values have to be estimated, namely the parameters p and a, but its disadvantage is that it is less flexible than the first approach.

Whichever approach is used, one would be aiming to produce a distribution with a similar shape which will tend therefore to have a similar mean and similar variance. A fashionable alternative is to try to estimate the mean and variance and then fit a distribution having these same moments. As there may be many shapes with the same mean and variance, but with rather different (perhaps opposite) skewness, kurtosis and higher moments, the aim of finding a good fitting shape makes much more sense. In any case, seeking agreement on moments is ultimately motivated by the desire to find a good fitting shape.

Although it is not recommended here, two parameters can be deduced from two data points, for example, if it were decided to try to fit the Adel distribution to the R(x) deduced from the data in Table 6, then:

$$0.70 = p^{4^{a}} \quad \text{and} \quad 0.20 = p^{5^{a}}$$

whence, 4 ln(p)=ln(0.70) and 5 ln(p)=ln(0.20) and therefore a=6.7526729 and p=0.99996932. These parameters define the distribution in Table 7.

The data in Table 6 relates to only the lefthand side of the lifespan distribution, from it, Table 7 covering the whole of a fitted distribution has been obtained. The shape appears to be a good fit to the known left. The mean and standard deviation of the fitted distribution are 3.85 and 0.81 years respectively; the corresponding moments for the lifespan distribution are unknown, although one might hazard guesses, and lower bounds can be placed on them by assuming all the probability to the right is concentrated at the next available point to the right, namely at x=5. If this is done, it will be found that the mean cannot be less than 3.9 years and the variance cannot be less than 0.49 square years (standard deviation 0.7 years).

Table 7. Complete fitted distribution based on two data points

x	0	1	2	3	4	5	6	Σ
R(x)	1.000	0.997	0.950	0.700	0.200	0.004	0.000	3.851
f(x)	0.000	0.003	0.047	0.250	0.500	0.196	0.004	

In practice, however, more data points than parameters are likely to be available and should be used. The problem then arises as to how to make use of all this data. It requires some thought to decide whether to attach equal weight to all the data or not.

It is also necessary to consider which family of functions might best fit the data.

In some sense, a best fitting function is required: one popular sense, borrowed from regression calculations, would be to seek to minimise the sum of the squares of the differences (usually the vertical distances) between the actual data and the corresponding values of the proposed mathematical function. Another sense, would be the minimax sense; in this, the aim would be to minimise the largest difference between the actual data and the mathematical function. Yet another sense would be that in which the aim would be to minimise the sum of the differences ignoring signs, that is, to minimise the sum of absolute differences. The differences must be calculated over the whole range for which the observed and/or theoretical values are not negligible.

One must also consider whether to get a best fit for f(x) or F(x) or R(x) or h(T) or H(T); any of these functions can in principle be estimated and the other functions derived from it. F(x) and H(T) are monotone increasing, R(x) monotone decreasing, and by the Principle of Swings and Roundabouts these are much less influenced by deviations of an actual sample from its population than their counterparts f(x) and h(T). In practice, it is usually most convenient to estimate f(x) or R(x). It is unnecessary to have any definite idea of the range when working with R(x): it is essentially open-ended to the right of the last available data point. So as to ensure that the righthand tail contains the correct probability, this final data point may be given extra weight.

It is fashionable to seek parameters which minimise the sum of the squares of differences when approximating f(x), and to seek parameters which yield the minimax absolute difference when approximating R(x). Having made all the above choices, the values of the parameters for the best fitting function may be determined by a hill climbing technique. The simplest such technique is the univariate method in which all parameters except one are held constant; here, there are only two parameters. The varying one is increased (or decreased) steadily for as long as there is an improvement in the objective function. The next parameter is then treated in the same way. The process is repeated over and over again until there is no further reduction in the objective function. If desired, the process can be started again, from the best set of parameter values so far found, with much smaller steps for the parameters. In the case of the Adel distribution, for instance, p must be a number on the range zero to one: the initial step size might be 0.01, and the process might be restarted with a step size of 0.0001, say. The second parameter, a, must be greater than zero; for such a parameter, if desired, the step size can be multiplied up by a factor at each step for as long as there is a reduction in the objective function to be minimised. The multiplier may be any number greater than one, it could be 4/3 which leads to a ten-fold increase in the step size after eight steps.

Having obtained these best parameter values, for the chosen theoretical distribution, another family of distributions may be sought and the value of the objective function for the best fitting member of each family compared. Graphs of the functions would also be helpful in making a final choice. Using this approach, there is no particular merit in applying a statistical test of goodness of fit.

7 Conclusions

It has been demonstrated that a knowledge of renewal theory is helpful in seeking to deduce from maintenance records the lifespan distribution of components, particularly when it is not clear whether or not a component has been renewed on a previous occasion.

Given a count of renewals, classified by age of dwelling, a tentative lifespan distribution can be hypothesised and its convolutions deduced, provided that the age profile of the housing stock is known. The pattern of renewals flowing from this hypothesis may be compared graphically and numerically with the recorded pattern; this is most conveniently done on a spreadsheet.

8 References

Brandon, P.S. (1987) Models, mortality and the ghost in the machine, in **Building Cost Modelling and Computers** (ed P.S.Brandon), E. & F.N. Spon, London, pp. 3–14.

Briggs, T. (1991) Renewal theory and its application in the comparison of housing maintenance strategies, in **European Housing: Management, Quality and Economics** (eds P.S.Brandon and A.Bezelga), E. & F.N. Spon, London.

Cox, D.R. and Smith, W.L. (1961) Queues. Methuen, London.

Cox, D.R. (1967) Renewal Theory. Methuen, London.

Hegvold, L.W. McGeorge, W.D. and Davies, V.F. (1990) The development of a building faults database for Perth, Western Australia: a case study, in **Building Maintenance and Modernisation Worldwide,** Vol. Two (ed L.K.Quah), Longman, Singapore, pp. 1191–1200.

Holmes, R. (1990) The changing nature of maintenance management—factors affecting efficiency and cost effectiveness, in **Building Maintenance and Modernisation Worldwide,** Vol. One (ed L.K.Quah), Longman, Singapore, pp. 288–297.

McDermont, F. (1988) Service life of housing elements and components—data requirements perspective, in **Whole-Life Property Asset Management** (ed D.S.S.Then), Proceedings of CIB W70 International Seminar, Edinburgh, pp. 133–139.

Then, D.S.S. (1988) Maintenance feedback and the management of information, in **Whole-Life Property Asset Management** (ed D.S.S.Then), Proceedings of CIB W70 International Seminar, Edinburgh, pp. 345–359b.

110
CEEC: the organisation and activities of European construction economists

B.E.DRAKE and M.HARTMANN

1 Foundation

CEEC, The European Committee of Construction Economists/ Comité Européen des Economistes de la Construction, was founded 1979 by the Royal Institution of Chartered Surveyors, the Society of Chartered Surveyors in the Republic of Ireland, and Union Nationale des Techniciens Economistes de la Construction.

2 Aim of the Committee

According to Article 1 of the Statutes of the Committee, the aim is:

1.1 …to facilitate the exchange of experience and information between professionally qualified persons who are responsible for construction economics in the EEC member-states and to initiate studies with a view to:

- i) promoting the training and qualification of persons who are responsible for construction economics and drawing up proposals for the harmonization and acceptance of standards of training and qualification;
- ii) establishing guide-lines for the definition, content, control and practice of construction economics;
- iii) ensuring adequate representation of qualified persons who are responsible for construction economics in the EEC Commission and in other European institutions;
- iv) studying existing and proposed legislation and regulations relating to construction economics, with a view to their harmonization;
- v) co-ordinating working methods;
- vi) establishing European statistics relating to costs and types of construction, procedures and materials.

3 Definition of Construction Economics

Adapting a famous definition one might say that Construction Economics is concerned with ends and scarce means in the Construction Industry.

A less cryptic view would suggest that architecture is the art of optimizing the needs of clients, functions, construction technique, and economics in an aesthetic synthesis, and as such involves a variety of professionals within the construction industry. Construction economics deals with:

- ○ Project management
- ○ Risk management within construction
- ○ Feasibility studies and investment appraisal
- ○ Cost information, calculation and control
- ○ Bills of quantity and specifications
- ○ Contracts between Client and Contractor
- ○ Time scales
- ○ Quality management
- ○ Monitoring progress, payment and accounting
- ○ Management of facilities and maintenance

4 The members of CEEC

At the moment CEEC has the following members:

Belgium	The Union Belge des Geometers Experts	
	76 rue du Nord	
	B-1000 Bruxelles	2–218 07 13
Denmark	PAR byggeϕkonomer	
	The Danish Association of Construction Economists	
	Bredgade 66	33 91 18 80
	DK-1260 KϕbenhavnK	fax: 33 91 18 17
Federal Republic of Germany	Bund Deutscher Baumeister Architekten und Ingenieure BDB Kennedyallee 11	
	D-5300—Bonn 2	228–37 67 84/85
Finland	Rakennusalan Kustannus-insinööriyhdistys (RAKI) ry-	

	(Finnish Value and Cost Engineering Association)	
	c/o Juva Ltd.	
	Itätuulenkuja 2	358 0 757 0674
	SF-02100 Espoo	fax: 358 0 799 350
France	Union Nationale des Techniciens Economistes de la Construction 8 Avenue Percier	
	F-75008 Paris	1–45 63 30 41
Ireland	Society of Chartered Surveyors in the Republic of Ireland 5 Wilton Place	
	IRL—Dublin 2	1–765500
The Netherlands	Nederlandse Vereniging van Bouwkostenderkundigen Staalstraat 4	
	NL-5344 KG Oss	4120–24071
Portugal	Sindicato dos Agentos Técnicos de Arquitectura e Engenharia Calcada do Combro 127	
	P-1200 Lisboa	328416
Spain	Consejo General de Colegios Officiales de Apraejadores y Arquitectos tecnicos	
	Paseo de la Castellana 155 270 15 357	
	E-28046 Madrid	270 55 88
United Kingdom	Royal Institution of Chartered Surveyors (RICS) 12 Great George Street	
	Parliament Square	44 1 222 70 00
	GB-London SW1P	3AD fax: 44 1 222 94 30
		telex: 915443 RICS G

4.1 Corresponding members

Switzerland	PBK Projektmanagement Bauadministration und Kostenplanung Hurdnerstrasse 117	
	CH-8640 Hurden	055 48 63 63

○ Mr. Martin Wright fax: 055 48 63 72

5 Professional background of Construction Economists

In France, Great Britain, and Ireland the quantity surveyor is a more than 100 years old profession. Great Britain has 22,000 quantity surveyors, France 6,100, and Ireland 360.

In the Federal Republic of Germany the construction economists are either architects or engineers by professional training. In Spain and Portugal the construction economists are trained as technical architects—16,000 in Spain and 2,000 in Portugal.

In the Netherlands the construction economists are architects and engineers who have founded a new organisation attached to the Dutch association of consultants dealing with project management. There are 5,400 construction economists in the Netherlands.

In Finland the construction economists are engineers who have founded a special association of cost engineers covering 40 construction economists.

In Denmark the consultant architects traditionally perform construction economics, but all in their own individual way. The Danish Association of Construction Economists was founded 1985 in order to create a national Code of Professional Conduct dealing with construction economics. At the moment there are 46 construction economists trained by the Association.

6 Harmonization of Training Programme

The role of the construction economist in the various countries is different from country to country, and the professional training differs even more.

As a consequence, CEEC has started a desk study to explore the possibilities of harmonizing—over a period—methods, training, and procedures among the member bodies.

The origin of construction economics is quantity surveying. But the total cost of construction depends on hard as well as soft data. Hard data are specification of construction products, bills of quantity, etc. The soft data are the quality of management, the impact of governmental regulations, environmental considerations, etc. Consequently, quantity surveying within the construction industry is under transformation from quantity surveying into construction economics.

The impact of information technology, the need to secure a planned rate of return from a project, and the growing demand for quality assurance is speeding up this transformation.

7 The organization of CEEC

Each member body has a maximum three representatives on the Committee. Every three years the Committee elects a president, a senior vice-president, and a junior vice-president .

Between meetings of the Committee which take place in April and October by turns in the member countries, day to day business is taken care of by the president, the honorary secretary, and the administrative secretary.

The address of CEEC is in Paris c/o the honorary secretary, while secretarial services are performed by the administrative secretary who is head of the European section of RICS in London and only part time working as a secretary to CEEC.

Honorary secretary	Gordon Wheatley Thorne Wheatley Associés Chartered Quantity Surveyors 266 rue du Faubourg	
	St. Honoré	009 33 1 47 64 17 27
	F-75008 Paris	fax: 009 33 1 47 66 90 17
Administrative secretary	Mrs. Marianne Tissier Royal Institution of Chartered Surveyors (RICS)	
	12 Great George Street	44 1 222 70 00
	Parliament Square	fax: 44 1 222 94 30
	GB-London SW1P 3AD	telex: 915443 RICS G

8 The Work Programme

As can be seen from Article 1 of the Statutes, CEEC was not conceived as in any way a mere lobbying body. In consequence, once the early meetings had established procedures and begun to extend membership, attention turned to the organisation of a work programme.

This has taken two forms; a series of desk studies of topics of particular interest to the Committee undertaken by individuals and the establishment of four working commissions to study specific subject areas.

The desk studies have included:

A comparison of professional education.
A sample case study.
An approach to a code of conduct.
A comparison of professional liability.
Public procurement of services.
Methods of measurement.
Comparison of fee scales.

One of the great difficulties in Pan-European cooperation is. that the various labels cover different contents, procedures, and traditions from country to country.

This is the reason why the sample case study has been launched. In the study is a comparison of general conditions of contracts, detailed time scale information, and description of the role of the construction economist, in each country, dealing with six different cases:

○ A block of 50 local authority flats
○ An industrial building
○ A leisure centre
○ An office block of 10,000 sq.m. plus floor area
○ Sheltered homes of 26 units
○ A secondary school of 500 pupils

The sample case study illustrates how a construction process is planned, designed, and managed in the member countries. It is also the basis of the Fee Scales desk study.

The desk study dealing with a CEEC Code of Professional Conduct is a result of the first EC workshop on Improvement of the Quality of Business Services, held in Brussels December 1988.

The purpose of this desk study is to identify and specify the services to be performed by construction economists on a business service basis. Specification is to be done in such a way that it offers the industry as a consumer of these services transparency and adequate guaranty of professional service.

Transparency means that the consumer has a fair possibility of establishing an over-all view and making his own choice without the risk of nasty surprises later on. Guarantees mean that the consumer, by way of adequate liability insurance, is assured the means to correct failures caused by the construction economist company.

The desk study is—although not solely—based on ISO-standards 9001 and 10004. ISO 9001 deals with quality management systems: planning, design, production, and service; while ISO 10004 deals with guidelines for services in quality management.

The Cost Information Commission had terms of reference:

> To advise the Committee on all matters pertaining to construction cost data.
>
> To harmonise working methods so as to allow cost information to be exchanged without ambiguity.
>
> To assemble a library of cost information in a format accessible to all members.

A first report was made to the Committee following the meeting in Dublin on 25th April 1985. The report described the priorities and definitions which had been agreed by the Commission and went on to describe the lines of progress that had been made:

– Concordance Document—a conversion protocol to convert all the national forms of cost analysis to the same base.
– Concise Concordance analysis—an abridged (single page) version of the full Concordance Document.

– Unit Rates—descriptions of some 60 items for which members agreed that they could produce prices.
– Preliminaries—clarification on which items one would expect to find priced in unit rates and which items would be priced in a preliminaries section.
– Building Cost Exchange Rate—a cost model which uses the unit rates to derive an exchange rate between countries which is independent of monetary exchange rates.
– Methods of Awarding Contracts—the existing methods in use in member countries.
– Methods of Payment—the different methods which have evolved in member countries.

A further report was made at Helsinki in October 1990 and this covered the development of the work noted in the first report together with the new work undertaken.

The unit rates data base has been extended to 10 countries and weighted to represent an office block. These weighted price data has allowed the Cost Commission to develop a set of Purchasing Power Relatives for the Construction Industry—in effect a set of exchange rates for the construction sector.

A study has been made of the use of factor cost indices and the much superior tender price indices. The Committee feel that more reliance should be placed on tender price indices and the use of factor cost indices should be sharply reduced.

The techniques employed to provide early cost advice have been compared and include:

Measured approximate estimate.
Systems of cost planning.
Cost models
Expert systems.
Costing by room function.

Computer programs are available and employed in many of these approaches.

Functional unit costings are widely used for budget preparation and the Cost Commission have suggested that a European defined list of functional units would be beneficial and this is to be explored.

A universal model for the analysis of labour rates has been agreed this includes basic weekly wage, bonuses and inducements, social costs, holiday payments and extra payments.

The Time Scale Commission was asked to carry out a comparative study of the respective time scales for the realization of projects in the member countries from inception to occupation.

The Commission divided their tasks into two parts, a comparison of general time scale information and a detailed time comparison for a selected number of projects. The general comparison comprises the responses to 32 questions about timescale matters and the detailed study compares the time required in each country for 16 distinct operations during the design and construction process.

The Global Costs Commission defined Global Costs as:

> “The sum of the approximate costs of construction and operation of a building during a specific period.”

The Commission then produced a detailed framework and set of definitions for the analysis of Global Costs within which each country can develop its own detailed method adapted to its customs and usages.

The Computer Application Commission has done a survey of EDP systems in use within construction economics in the member countries. At the moment the Commission is dealing with the impact of CAD systems, the use of expert EDP systems, and the technical possibilities of creating a European Construction Cost Data Base with online access. The British quantity surveyors already have such a data base: BCIS, mainly containing cost information about construction in the UK, but also cost information derived from all over the world.

Copies of the desk studies and the reports of the commissions can be obtained by application to the Administrative Secretary.

9 Future of the CEEC

The increasing size of CEEC and the interest now being shown in Construction by the Commission of the E.C. has substantially increased the workload of CEEC. This problem will be addressed at the next CEEC meeting in Dublin in April 1991 and is likely to result in certain changes.

We hope to find additional funds to increase our administrative secretariat resources. We expect also to move toward a more “cabinet” style of government where the elected officers have a substantive role to play between, and in preparation for, meetings.

We also expect to adopt a modified approach to our work programme. Obviously an organisation meeting only twice a year for 2 days can scarcely conduct research. What it can do however is to discuss a topic, agree a questionnaire likely to obtain a clear picture of current practice throughout Europe, and then to identify where harmonisation would be useful and possible and the most fruitful direction for further work.

We may well decide to adopt 4 subject areas:

Construction economics;
Technological development and its impact on
Construction Economists;
European Community and External Matters;
Matters of Practice and Law;

and to appoint one of the elected officers to act as chairman for each area. A work programme will be agreed for each area, the draft programme to be approved or amended in Dublin is attached at Appendix A, and individuals will be identified as having personal responsibility for a particular topic, these individuals, together with the relevant chairman, will meet twice a year to act as assessors for the projects in their subject areas and to approve final reports for submission to the Committee. CEEC will no doubt wish to find some suitable vehicle for publishing these reports.

In addition to these structural adjustments the Committee may feel that the time has come to take a major initiative in respect of research in construction economics.

10 An Institute of Construction Economics Research for Europe

Construction is an important industry. It is important economically employing 60 million people worldwide and accounting for 6% of G.D.P. in the E.C. In the U.K. building maintenance expenditure alone exceeds that on health or education.

In addition to its economic dimension, large though this is, the construction industry of Europe satisfies a fundamental human need for shelter and in doing so serves social, psychological, and aesthetic purposes.

Quite certainly we dealing we an industry of the first importance both absolutely and relatively and yet it is an industry largely taken for granted both by the E.C. Commission and by its constituent member governments.

Of course this is principally because the industry is widespread geographically and cannot deliver votes as can agriculture or some concentrations of heavy industry. Nevertheless the fundamental nature of the services provided by the industry; shelter, sanitation, communications, are such as to justify a substantial investment in the study of its economic processes.

In addition to its functions internal to the E.C. the European Construction Industry forms an important third force in major world projects in competition with the U.S. and Far Eastern countries. There is a view that many Development Bank funded projects, including some promoted by the World Bank, are unduly influenced by the rather narrow views of U.S. civil engineers as to appropriate contract procedures. A strong European Institute of Construction Economics could bring a more balanced approach to project definition, effective cost control during design and a sophisticated system of tender and contract documentation.

But the principal function of such an Institute would be to act as an authoritative voice on all matters pertaining to the European Construction Economy.

It would eliminate the need for the E.C. Commission to have recourse to ad hoc studies commissioned from individuals, it would be available to give expert and objective advice to E.C. member governments, it could provide market analysis data to commercial undertakings and could perhaps provide a suitable home for a European Construction Cost Data Bank.

We are talking about an Institute of the standing of say the National Institute of Economic and Social Research in the U.K. or the “Bureau d’information et de Prévision Economiques” in France. One might have looked for such advice from National Building Research Stations but their interests seem centred on physical chemistry rather than economics.

It is possible that CEEC may decide to adopt this theme and to set itself to examine and compare the various models which might be adopted and the possible financing mechanisms.

APPENDIX A

WORK PROGRAMME GROUP 1

Subject: Construction Economics

Chairman: Gerard Meganck

Continue and develop the series of Construction Purchasing Power Relatives and the related series dealing with Wage Rates and Material Prices.

Prepare a European Standard for the Analysis of Building Costs to be followed by standards for Civil Engineering analysis and Rehabilitation Work.

Establish a European Construction Cost Data Exchange System.

Prepare a code of practice for the application of Value Engineering techniques to construction.

Consider the economic significance of Health and Safety Regulations.

Describe the extent of the use of functional unit costs and the type of units employed.

Examine the ways in which life cycle costing techniques can provide a workable, economic framework for the appraisal of intelligent building systems.

WORK PROGRAMME GROUP 2

Subject: Technological development and its impact on Building Economists

Chairman: Michael Hartmann

Consider the impact of advanced telecommunications on the acquisition, management and ownership of construction economics data with particular regard to the ability to access data held at remote locations.

Review the development of computer-aided design and computer-aided measurement, considering the need for standardisation on the model provided by EDIFACT.

Review the possible applications of expert system technology in construction economics and report on the types of legal entity and organisation required to realise its potential.

Examine the probable impact of the large scale introduction of off-site prefabrication and on-site automation systems, incorporating robotic devices, on the methods and procedures of construction economists.

Review the general nature and direction of the impact of green issues on the Construction Economist and consider the possibility of developing a calculus for green issues.

WORK PROGRAMME GROUP 3

Subject: European Community and External Matters

Chairman: Gordon Wheatley

Prepare a commentary on obstacles to the practice of construction economics in non E.C. member states for use by E.C. Commission in GATT negotiations.

Prepare a report on real (as opposed to theoretical) obstacles to the practice of construction economics within the E.C.

Report on the expected effect of the Single Market on the construction economies of member countries.

Follow up the consequences of M.Mathurin's report on liability and insurance.

Renew and develop CEEC liaison with EUROSTAT.

Report on the extent of the development of Building Economics in Eastern Europe.

WORK PROGRAMME GROUP 4

Subject: Matters of Practice and Law

Chairman: Alois Aschl

Complete the comparative study of Fees and Terms of Appointment.

Prepare a comparitive report on the functions connected with construction management, design, specification, administration, supervision and maintenance detailing "who does what" in the various member countries.

Review the systems of procurement in use in member countries with special reference to the distribution of risk between client, design team, contractor, subcontractor and supplier.

Extend the comparative study of the use of Bills of Quantities to include the use of other types of contract documentation including specifications and schedules of rates.

Describe and compare the arbitration systems in use in member countries.

Review the role of Construction Economists in project management in the member countries.

Review the systems of appraisal of building condition, safety and performance currently in use.

111
The general building preservation plan (GBPP)

P.FLEURANT

ABSTRACT
The General Building Preservation Plan (GBPP) is a sofware developed for the automated management of buildings, and equipment for the University of Québec à Montréal. This modular system composed of 12 sub programs evolved over three years of research and application by the university Building and Equipment Service department.

The system allows for the input of information from several sources. This information is then used for establishing 5, 10 or 15 years budgets (constant dollars) for the maintenance and conservation of real estate and fix assets. This high level system provides a productive solution which has been verified by daily application at UQàM. The GBPP is applicable to both small and large organizations with building portfolios to manage.

This paper will focus on the design process, the components of the system and the implentation methodology used at UQàM. It will also look at the lessons learned in daily application of the technology at UQàM.

Keywords: Maintenace management, Facility management, Preservation plan, Budget

1 Introduction

Given the recent growth in large urban centers and the complexity of buidings being constructed, conservation of both the physical assets and the equipement use to run them has gone beyond simple management techniques. Today we must focus on life cycle planning including budget projections. To this end Facility Managers need at their disposal maintanance methods and automated tools which allow them to develop budgets and programs spanning several years.

2 A city within a city

Building and Equipement Services at UQàM manage 2,235,000 square feet of space located in 17 buildings spread over the downtown core of Montreal. A population of 40,000 people have at their disposal a framework of 7,000 rooms and offices within which they create an academic life. These facilities must meet current standards of comfort and public safety.

A staff of 120 is responsible for the maintenance and preservation of these UQàM assets valued at about $185 million dollars.

In 1987, after three years of preparation, management of Building and Equipment Services adopted a General Building Preservation Plan (fig. 1. General Building Preservation Plan) allowing them to implent a global approach to their building management activities.

The objectives of the general building preservation plan are:

to maintain the premises in good condition,
to distribute evenly, over time, the expenses related to building maintenance,
to prolong the useful life of the buildings and electrical and mechanical equipment,
to reduce the frequency of interruptions in the operation of critical equipment,
to ensure that electrical and mechanical systems function at maximum efficiency,
to reduce and eliminate hazardous situations,
to plan corrective action, and
to maintain and improve the aesthetic aspect of the buildings.

In addition to managing 22,000 service calls per year, the General Building Preservation Plan allows the managers to evaluate, plan, organize and perform required tasks or have them performed by outside contractors. It is also meant monitor all the operations in accordance with the mandate of the Building and Equipment Services.

The system contains many technical files including all the plans and specifications for each of UQAM's buildings. It is also used to manage rented buildings.

For whom is the system designed?
industrial, commercial and professionnal Facility Managers,
government administrators, large business firms,
industrial plants,
banking and other financial institutions and organizations,
schools, colleges and universities,
real estate developers, engineering firms, and architects.

The system allows for the accumulation of information from six different sources:

the environment,
the users,
the reports on deferred work,
the technical files,
progress reports, and
miscellaneous sources.

This mass of information is constantly updated and is distributed among 15 specific action plans that cover in detail all fields of activity of the facility management.

The specific plans are the hub of the system. They keep track of

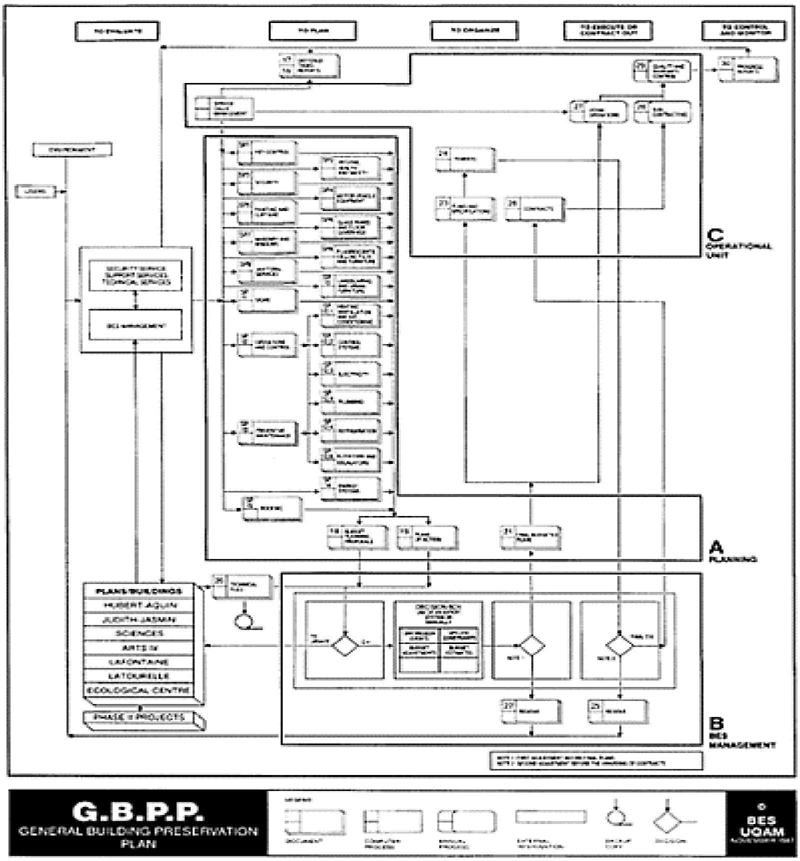


Fig. 1. General Building Preservation Plan.

a variety of factors, such as the shelf life of materials, conservation and restoration costs, the frequency of replacement and maintenance, and the deterioration of equipment.

As an example, Plan 15 (roofing) keeps structural data on each of the 148 drainage basins located on the roofs of UQàM’s buildings. Included in this database is a report of current conditions obtained during an annual inspection. This information allows the manager to precisely determine frequency, cost, and types of action available for inspections, repair work and restorations also taking into account current technology and matrerials to be used.

This type of operational research is available in all the planning modules. It allows a planning supervisor to elaborate and present to management timely budgetary proposals and plans of action to fill the users’ needs in relation to the constraints of each building. With the aid of a central database and 12 management software packages, the managers simultaneously analyse the impact, over a period of 5 years, of the 15 plans of action submitted by each specific plan manager.

This type of regular planning, supplied with annual budgetary proposals and plans of action, facilitates the uniform distribution of expenses over time and the proper scheduling of major projects.

It is now possible for the administrators to put together final budgeted plans that will be performed or supervised by their employees.

Progress reports will make it possible to follow work being carried out and to report all modifications to the technical files, the specifics plans, and finally to the general plan.

By managing and directing the efforts of staff, the plan helps optimise conservation and maintenance activities while maintaining comfort for all buildings users.

3 Concerns to be addressed in the maintenance and the preservation of buildings

3.1 Buildings are structures that must be maintained…

The external and internal components of the buildings require periodic maintenance. As well remodeling of interiors (ceilings…) and restoration of exteriors (roofs, walls, doors and windows) require planing.

What should be inspected and when? What should be done and when? And at what cost?

3.2 Buildings are real estate. They have commercial value…

Some buldings are owned; others are rented. They must conform to various government regulations.

What should be inspected and when? What should be done and when? And at what cost?

3.3 Buildings fill various needs…

As a result of the activities housed in buildings (classrooms, workshops, laboratories, offices…) and the normal use of these premises, the structures and support systems (electricity, heating,

air-conditioning) will eventually wear out, and occasional or continuous servicing will be necessary. In addition, mail, messenger, and transportation services are required.

What should be done and by whom? Is the available personnel sufficient to meet needs? And how should needs be forecast and met?

3.4 Buildings effectively protect goods and people…

The safety of people within the buldings is of the utmost importance. Who and what should be protected and insured?

How, when, and by whom? What should be done in emergencies, for example, fire or flooding?

These are some of the many questions that must be answered every day in order to maintain the safety and comfort of all the occupants of one or more buildings, whether these assets are owned or rented.

In short, the life of a building depends on its owners and users. A well-maintained building is a safe and productive workplace; if it is better preserved its value increases. A building is an investment.

4 Architecture of the GBPP system

Conceived for use on IBM or on IBM-compatible computers, the GBPP software makes it possible to forecast and solve problems dealing with the maintenance and preservation of buildings. This is possible due to the integration of its three basic elements: the general plan, the specific plans, and the technical files.

4.1 The general plan

The general plan is the frame of reference for job planning. It is a reference guide of all tasks to perform: evaluate, plan, organize, execute or contract out, and control. The methodology proposed is as follows:

> first of all, the manager identifies the needs and resources (he evaluates),
>
> he determines the fields of intervention and estimates their budgets (he plans),
>
> he selects certain plans of action (he organizes),
>
> he initiates activities (he executes or contracts out), and finally, he ensures that the tasks are performed and ckecks the quality of the results (he controls).

4.2 The specific plans

Each specific plan is a tool for detailed planning and budgeting of maintenance tasks. It keeps track of the unexpected additional work ordered by the service calls and inspection tours.

The specific plans deal with the following 15 aspects:

key control,
hygiene, health and safety,
security,
motor vehicle equipment,
painting and curtains,
glass panes and floor coverings,
masonry and windows,
fluorescents, ceiling tiles and furniture,
janitorial services,
landscaping and urban furniture,
signs,
opreations and control,
preventive maintenance,
energy systems, and
roofing.

The specific plans include the annual budget proposals, the equipment life cycle history, the costs of maintenance and repairs and the cost of parts and equipment replacement.

4.3 The technical files

Produced from automated information banks, each technical file characterizes an owned or rented building according to the 15 specific plans.

The building status file includes the specifications for each building, and the floor plans or graphic plans for each building.

5 Software systems

New and efficient, the General Building Preservation Plan is an efficient tool designed to assist in making strategic decisions concerning planning and execution of all the tasks related to the maintenance and preservation of real estate assets including office equipment and furniture (Fig. 2. GBPP—Software systems).

In order to maximize service to occupants, increase maintenance productivity (by better sceduling activities), maintain equipment, and increase property values, managers must have complete knowledge of recurring costs and adjust budgetary plans accordingly be able to. The GBPP is a decision-making tool for these operational and budgetary planning of activities.

The system's modules are integrated or independent, according to whether or not they are linked to the central data banks and the architectural, electrical, evacuation, and mechanical plans of the buildings. Some software modules make use of the specific plans; others do not.

Designed for the manager with a limited knowledge of computers, the GBPP system comes with technical documentation and a user's guide. It is easy to learn since the learning process is the same for all programs.

The GBPP system is modular and can be connected to a local area network. It can accept CADD software drawings and can process large amounts of management data. It also has the advantage of maximizing the various computer systems available.

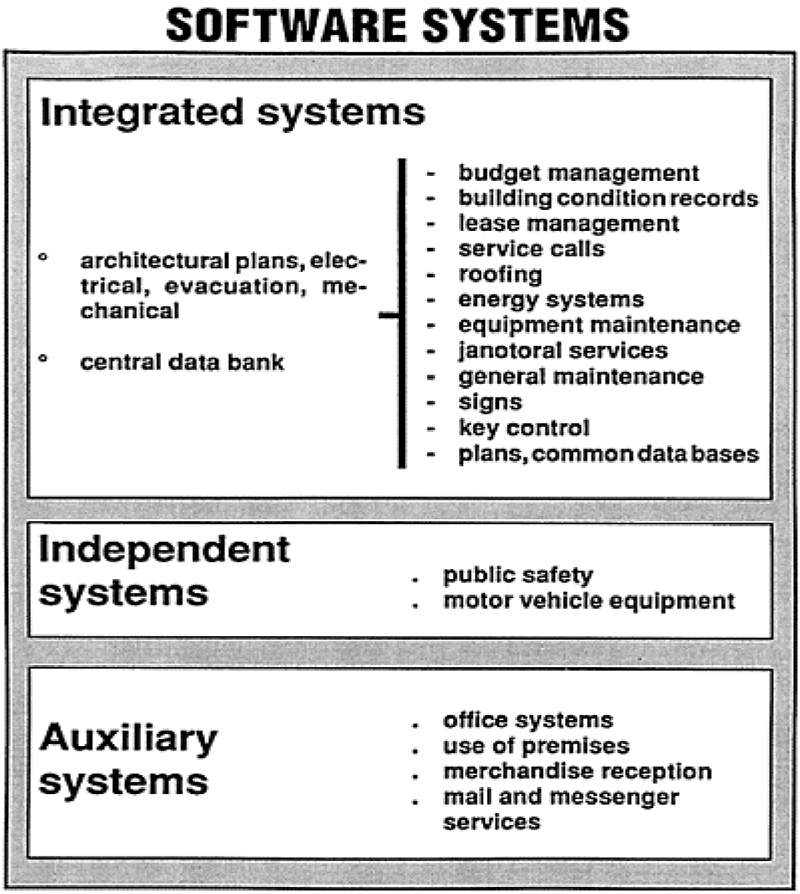


Fig. 2. GBPP—Software systems.

6 A look at the integrated modules

Now, we will take a brief look at the integrated modules which represents an important part of the general plan.

6.1 Budget management

This program prepares a zero base budget estimate, breaks down the different costs, and controls the activities, such as major contracts, spread over a long term.

6.2 Building condition records

This program describes each building according to the 15 specific plans and captures room inventory data in corporate files. From this data, it calculates the annual cost of each preservation activity and stores the results in a technical file.

6.3 Lease management

This program controls the rental budget. It registers the clauses and contractual obligations of leases, their analytical and descriptive elements (address, occupied area and other details). It gives the schedule of obligations (beginning and expiry dates, deadlines of escalatory clauses, cancellation, billing payments, and mailing of notices). It separately evaluates various fees.

6.4 Service calls

This program rationalizes maintenance management and optimizes service to occupants. It registers service calls by category (electricity, floor repairs, water) and immediately sends work orders to appropriate staff. On a weekly basis, it updates room occupancy. It tracks the actions taken in answering each call. It produces statistics.

6.5 Roofing

This program rationalizes maintenance management and maximizes the preservation of materials according to needs for roofing maintenance. It records the characteristics of the roofs (composition, joist membrane, insulation material) and produces the annual budgetary cycle of the maintenance (from visual inspection and balance sheet to the budgetary estimate of work to be done). It ensures supervision and manages warranties. It formulates a maintenance budget, taking into account selected maintenance methods and required materials.

6.6 Energy systems

This program facilates energy management and maximizes the supply of various sources of energy. It records and manages the energy supply (electricity, fuel oil, gas) according to demand as shown on the meters. It compares the suppliers' invoices with actual consumption. It produces statistics and graphs of consumption.

6.7 Equipment maintenance

This program plans and orders equipment maintenance (wiring, filters, oil, air vents, air-conditioner) and maximizes the useful life of equipment. It identifies stock levels, determines plans of action, and records work performed. It evens out the work loads of the various trades and produces statistics.

6.8 Janitorial services

This program plans and orders the janitorial maintenance of the premises (washing, wiping, sweeping, waxing, dusting, emptying the ashtrays). It records data for various inspection tours. It updates, on a weekly basis, the surface area to be maintained, produces reports on the frequency of daily work loads per week, and validates the progress of the work. It adjusts the costs forecast in the budget in relation to real costs.

6.9 General maintenance

This program facilitates the administration of the general maintenance of the premises. It records general maintenance activities (stone-work, painting, curtains), does the budgetary follow-up, produces the frequency of work reports, and validates the progress of the work.

6.10 Signs

This program retrieves data for the fabrication of indentification plates and engraves these plates according to particular specifications.

6.11 Key control

This program identifies all keys and locks as well as the individuals in whose possession keys are to be found. It manages the distribution and control of keys to the premises.

6.12 Plans, common data bases

It is here that we find the entire collection of data belonging to the fifteen specific plans and the integrated systems.

7 Profitability of the system

The General Building Preservation Plan is user-friendly and enhances productivity by making information exchanges easier.

It makes for better planning and data access, optimises space use,

eliminates safety hazards for occupants, and cuts down in service breakdowns.

The General Building Preservation Plan permits you to accurately plan and budget the maintenance and preservation of all types of properties. It eliminates extraordinary expenses, and reduces operations costs.

8 Development milestones of the GBPP

The Build and Equipment Service Division of UQàM conceived, developed, and now utilizes the GBPP system. The following are major milestones in the life of the GBPP system:

8.1 In 1979

Installation on mini-computer the first version of an automated preventive maintenance management system for equipment.

8.2 In 1984

Implementation of the first autonomous systems on microcomputer: the janitorial maintenance system and the service call system.

8.3 In 1985

Build and Equipment Service undertakes a three-year program for the development of computer systems to meet the University's facilities management needs, which lead to the implementation of other autonomous systems.

8.4 In 1987

Completion of the design of the General Building Preservation Plan and the methodology for integrating activities.

8.5 In 1988

L'Université du Québec à Montréal and the Epix compagny signed a joint venture for the marketing of the General Building Preservation Plan in order to make it accessible other and thus further its development.

8.6 Since 1989…

The General Building Preservation Plan is gradually expanded into new buildings expansion projets estimated at 200 million dollars.

9 REFERENCES

ASTM, **ASTM Standards on Computerized Systems,** 1987, Philadelphie, États-Unis, 2e édition.

Benchimol, Guy, Levine, Pierre, Pomerol, Jean-Charles, 1986, **Systèmes experts dans l'entreprise,** Hermes, Paris, France.

BOMA, **BOMA Experience Exchange report,** 1988, États-Unis.

Davis, Gordon B., Olson, Margrethe H., Ajenstat, Jacques, Peaucelle, Jean-Louis, **Systèmes d'information pour le Management,** 1986, G. Vermet inc., Éditions Économica, vol. 1 et 2, Boucherville, Paris, Canada, France.

112
Computer assisted conceptual and parametric estimating

J.D.GILLEARD

Abstract
Conceptual and parametric cost estimates for construction projects may be prepared by using a variety of methods and techniques, from the simplistic, back-of-an-envelope, single unit cost based systems, e.g cost per employee, per hospital bed, per square foot/metre of floor area etc., through to an approximate quantities take-off for the project. Typically, the accuracy of the cost estimate will be dependant upon the amount of time applied and the quality of the data utilized. However, the dictates of time do not always enable the designer, developer or contractor the luxury of a carefully researched cost estimate. As a consequence, a reliance upon rules-of-thumb may be condoned in the interest of expediency. In such cases, a dependence on published unit cost data may also be adopted, eschewing company generated historic data. Nevertheless, with the increasing availability of powerful microcomputers it is now possible to access reliable historic cost estimation data, whether supplied by a third-party agency or generated in-house, and to quickly manipulate the data within a structured format. This paper illustrates a number of these computer-assisted conceptual and parametric cost estimation techniques.
Keywords: Construction, Cost Estimation, Conceptual, Parametric

1 Introduction

Ask any residential contractor or architect the average cost of building a house and they will give you a typical cost per square foot/metre. And then they will probably qualify their answer. “It depends upon the overall size/location/quality etc,” they might add. The same general response would probably apply to those professionals who concentrate in the commercial sector. In other words, they have their rules-of thumb based on experience, but they are sufficiently knowledgeable of the construction industry to realize that global unit costs are, at best, merely approximations based on average conditions. However, at the initial design stage, where detailed information about a future building’s configuration or its probable fabric is often vague, such figures are likely to be the first indication to a client about a building project's anticipated cost.

However, once the new project's configuration and fabric has matured beyond the speculative it is possible to apply a variety of cost estimating techniques that provide the client with a more accurate budget estimate for the work. These techniques are known as conceptual and parametric cost estimating. As a illustration of these techniques the paper describes three computer-assisted conceptual cost estimating procedures. All three examples are based on the "Eagle Park Project", a 2-storey speculative office building constructed on the outskirts of Atlanta, GA, USA, during 1989, plate 1.

Plate 1. Eagle Park Speculative Office Complex

The following broad scope information applies to the Eagle Park project, i.e. overall gross enclosed floor area equal to 51,000 square feet; the building was constructed as a steel framed shell with an exterior cladding of decorative facing bricks and extensive glazing; no HVAC equipment or other major mechanical services were initially installed; finishes were kept to a minimum. (The majority of interior work was completed under separate contract after the tenant was selected.) The contract for the construction work was awarded to a local medium sized general contractor. The bid price for the work was $1,136,984, i.e. $79,055 direct materials; $44,635 direct labor; $878,941 subcontract; 8% overhead ($80,210); 5% profit ($54,143). Groundwork commenced February 1989 and the shell was completed late September 1989.

2 Square foot estimating

Square foot cost estimating is the simplest technique to apply. A number of commercial services publish annual unit costs for a wide range of building types (Means, Dodge). These services are designed to provide a reliable base cost of construction for projects given a minimum of design details related to dimensions, technical data and specifications. The cost figures typically reflect average conditions. They do not normally take into account any unusual or special requirements that may form part of the building project, e.g. custom designed fixtures or equipment, the need for special foundations and substructures etc. Nor do they generally include for possible variations with cost data due to, say, an abnormal shortage of labor or materials. However, most published figures typically include cost coefficients, or adjustment factors, for site location and time. In addition, cost adjustments for quality may also be included by citing low average, average and high average cost figures.

Using one published source (Dodge), an overall cost per square foot of floor area for the “Eagle Park” office was assessed to be $64.71.[1] Thus the initial budget cost estimate, excluding land acquisition and site-work costs, may be said to be equivalent to 51000 (the gross floor area) * $64.71 (unit cost per square foot), i.e. $3,300,060, a figure almost 300% greater than the successful bid price. However, no cost relaxation has been applied for specific work excluded from the original contract, e.g. HVAC etc.

Therefore, in an attempt to determine a more refined square foot budget estimate for the project it is necessary to subdivide the global square foot cost into a set of clearly defined divisions, e.g. the 16-division Construction Specification Institute (CSI) format, table 1. Reviewing the information shown in table 1., it is evident that specific divisions have an important impact on the overall unit cost for the project. For example, division 15, mechanical, a division that includes HVAC

1 The $64.71 square foot cost was determined by initially noting the low average cost per square foot of floor area given in the “1988 Dodge Assemblies Cost Data” reference guide for office buildings (approximately 20,000 sq ft), i.e. $72.31. Subsequently an Atlanta location cost index, i.e. 86.4%, and a time cost index, i.e. 103.6% were applied. The latter index was used to extrapolate the 1988 cost figures to the 1989 financial year. Thus $72.31 * 86.4% * 103.6%=$64.71.

this work is specifically excluded from the original Eagle Park contract and therefore the division needs to be excluded from the revised cost estimate.

Hence, amendments to the original “Dodge Square Foot Cost” data may be applied by reference to not only the time and city cost indices but also to user determined job coefficients for each CSI sub-division. (The last coefficient is typically determined by the estimator with regard to his experience of local conditions or prior knowledge related to explicit design requirements.) For example, with regard to the Eagle Park Office project, a number of CSI cost divisions have been withdrawn from the cost estimate by setting the job coefficient to zero. In other instances, an inflation factor has been adopted, e.g. division 5, metals, has a coefficient of 200%. This last figure is adopted to adjust division 5 for the extra steelwork included with the project. Thus the spreadsheet format outlined in table 1. allows the estimator to adopt a “what-if” questioning style with regard to the interrogation of the data. Therefore, the gross building cost of the Eagle Park Office using this very simple spreadsheet technique has been estimated to be $**1,207,565** at a gross unit cost of $**23.68** per sq ft.

DODGE AVERAGE BUILDING COSTS: 1988
BUILDING SYSTEM:OFFICE BUILDINGS (20,000 SQFT)
Eagle Park Project amended by City Cost Index=86.40%
Eagle Park Project amended by Time Cost Index=103.60%
Gross Floor Area of Eagle Park=51,000 sqft

	Dodge Low Average	Elemental % Breakdown	Time & Location Average	Eagle Park Job Coefficient	Eagle Park Elemental Cost
1 GENERAL CONDITIONS	$4.41	6.1%	$3.95	0.0%	$0
3 CONCRETE	$10.63	14.7%	$9.51	25.0%	$121,316
4 MASONRY	$15.47	21.4%	$13.85	100.0%	$706,210
5 METALS	$2.96	4.1%	$2.65	200.0%	$270,250
6 WOOD	$0.00	0.0%	$0.00	100.0%	$0
7 THERMAL & MOISTURE PROTECTION	$0.22	0.3%	$0.20	100.0%	$10,043
8 DOORS & WINDOWS	$0.36	0.5%	$0.32	100.0%	$16,434
9 FINISHES-LATH & PLASTER	$0.00	0.0%	$0.00	0.0%	$0
DRYWALL	$4.63	6.4%	$4.14	0.0%	$0
ACOUSTICS	$2.53	3.5%	$2.26	0.0%	$0
FLOORING	$3.40	4.7%	$3.04	0.0%	$0
PAINTING & STAINING	$3.25	4.5%	$2.91	0.0%	$0
10 SPECIALTIES	$0.65	0.9%	$0.58	0.0%	$0
11 EQUIPMENT & FURNISHINGS	$2.46	3.4%	$2.20	0.0%	$0
13 SPECIAL CONSTRUCTION	$0.00	0.0%	$0.00	0.0%	$0
14 CONVEYING SYSTEM	$5.78	8.0%	$5.17	0.0%	$0
15 MECHANICAL & PLUMBING	$3.18	4.4%	$2.85	25.0%	$36,292
HVAC	$8.24	11.4%	$7.38	0.0%	$0
SPRINKLER	$0.00	0.0%	$0.00	0.0%	$0
16 ELECTRICAL	$4.12	5.7%	$3.69	25.0%	$47,020
GROSS BUILDING COST	$72.29	100.0%	$64.71		$1,207,565

Table 1. "Dodge Assembly Square Foot Cost Figures" (1988) amended with reference to time, location and job coefficient.

3 Parametric Estimating

A second method of conceptual estimating, called "Parameter Costs in Building", or parametric estimating, may also be used by the project developer to assess the likely cost of his project. Parametric estimating was developed in conjunction with the Engineering News Record (ENR) as a means of utilizing "as-built" cost figures. The cost data is characteristically generated from contractor-reported costs. These cost figures are regularly published, in detail, for various projects in the journal. The technique differs from square foot estimating in two distinct aspects. One, the estimator can determine the average unit cost per element by applying the most appropriate parameter measure, e.g. gross enclosed floor area for general conditions; total basement floor area for the site-work excavation; area of facing brick for the external masonry etc. Secondly, the technique allows for division elements to be measured in the most appropriate unit, e.g. square foot, cubic yard, each, tons etc.

Table 2. indicates a typical spreadsheet layout for parametric estimating. The top two main divisions indicate the project description data, e.g. the contractor's name followed by a general description of the **base** project and the **target** project. (In this example, the base project is represented by an office built in 1972 in Albany, New York (Adrian), and the target project is the Eagle Park Office in Atlanta.) The data represented by the main section of table 2. indicates the parameter code, column one, and its description, column two. This is followed by the specific project descriptions, i.e. the Albany Office, columns three and four, and the Atlanta project in columns five and six.

CONSOLIDATED CONSTRUCTION				Pg 1 of 3	
INDUSTRIAL COMPLEX, NE HOOVER, GA 30332				(404)894–8736	
Type of Building		Base Office		Target Office	
Location		Albany, NY		Atlanta, GA	
Construction Start/Complete		January 1972		January 1989	
Type of Owner		Private		Private	
Frame		Structural Steel		Structural Steel	
Exterior Walls		Metal Curtain Wall		Brick	
Special Site Work		None		None	
Fire Rating		2-A		2-A	
PARAMETRIC MEASURES		BASE		TARGET	
1	Gross Enclosed Floor Area	650,000	sf	51,000	sf

2	Gross Area Supported (excluding slab on grade)	608,400	sf	52,500	sf
3	Total Basement Floor Area	41,600	sf	0	sf
4	Roof Area	70,000	sf	26,250	sf
5	Net Finished Area	500,000	sf	47,000	sf
6	Number of Floors Including Basements	26		2	
7	Number of Floors Excluding Basements	25		2	
8	Area of Face Brick	0		12,000	sf
9	Area of Other Exterior Wall	150,000	sf	12,000	sf
10	Area of Curtain Wall Including Glass	221,000	sf	23,800	sf
11	Store-Front Perimeter	300	sf	425	sf
12	Interior Partitions	30,000	sf	0	sf
13	HVAC	1,700	tons	133	tons
14	Parking Area	890,000	sf	20,000	sf
OTHER MEASURES					
15	Area of Typical Floor	19,400	sf	25,500	sf
16	Story Height, Typical Floor	152	in	156	in
17	Lobby Area	2,000	sf	500	sf
18	Number of Plumbing Fixtures	460		50	
19	Number of Elevators	12	ea	0	ea
DESIGN RATIO					
20	A/C Ton per Building sq ft	0.0026		0.0026	
21	Parking sq ft per Building	0.3922		0.3922	

Table 2. Parametric Cost Data for the “Base” Project and the “Target” Project.

Continuing, table 3. represents the published data for the Albany Office Project by CSI division. Column one indicates the division number; column two the division description; and column three the parametric code. These are followed by the unit cost, column four; the unit description, column five; the overall division cost, column six; and, lastly, column seven indicates the average % total. At this stage it should be clarified that unlike gross square foot estimating, where the division cost is determined from the unit cost multiplied by the overall gross floor area, the division cost of the base project is a given, i.e. the contractor’s “as-built” information is used to determine this value.

Subsequently, the unit cost is calculated by reference to the established division cost and the set parametric measure. Thus, for division 6, Carpentry, with an “as-built” cost of $90,000, the unit cost is determined by dividing that number by the parametric measure.

In this instance, a parametric code of 5 was assigned to the Carpentry division, i.e. the net finished floor area. Thus the unit cost for Carpentry for the Albany Office Project may be determined to be $90,000/500,000, or $0.18 per sq ft.

	CONSOLIDATED CONSTRUCTION				Pg 2 of 3	
	INDUSTRIAL COMPLEX, NE HOOVER, GA 30332			(404)894–8736		
	PARAMETRIC ESTIMATE BASE ESTIMATE			ALBANY, NY PROJECT 1972		
	PREPARED BY JDG			23-NOV-90		
	CITY COST INDEX=100.00%			TIME COST INDEX=100.00%		
	TRADE or CSI DIVISION	PARAMETRIC	UNIT		DIVISION	AVERAGE
		CODE	COST	UNIT	COST	% TOTAL
1	General Conditions and Fee	1	$2.19	sf	$1,423,500	9.11%
2	Sitework (clear & grub)	1	$0.35	sf	$227,500	1.46%
	Excavation	3	$4.57	sf	$190,112	1 .22%
	Foundation	2	$0.67	sf	$407,628	2.61%
3	Formed Concrete	2	$2.71	sf	$1,648,764	10.55%
4	Masonry	12	$6.20	sf	$186,000	1.19%
5	Structural Steel	2	$1.23	sf	$748,332	4.79%
	Misc Metal, Incl Stairs	2	$0.38	sf	$231,192	1.48%
6	Carpentry	5	$0.18	sf	$90,000	0.58%
7	Water & Damp-proofing	10	$0.10	sf	$22,100	0.14%
	Roofing & Flashing	4	$1.64	sf	$114,800	0.73%
8	Metal Doors, Frames, Windows	5	$0.11	sf	$55,000	0.35%
	Hardware	5	$0.12	sf	$60,000	0.38%
	Glazing	11	3$33.33	sf	$99,999	0.64%
	Curtain Wall	10	$3.96	sf	$875,160	5.60%
9	Lath & Plaster	5	$0.08	sf	$40,000	0.26%
	Dry Wall	12	$0.75	sf	$22,500	0.14%
	Tile Work	5	$0.10	sf	$50,000	0.32%
	Acoustical Ceiling	5	$0.18	sf	$90,000	0.58%

	Resilient Flooring	5	$0.04	sf	$20,000	0.13%
10	Carpet	5	$0.03	sf	$15,000	0.10%
	Painting	5	$0.17	sf	$85,000	0.54%
14	Elevators	19	$70,000	ea	$840,000	5.38%
15	Toilet Partitions	5	$0.03	sf	$15,000	0.10%
	Plumbing	1	$5.15	sf	$3,347,500	21 .42%
	HVAC	1	$5.15	sf	$3,347,500	21.42%
16	Electrical	1	$1.77	sf	$1,150,500	7.36%
	Parking, Paved	14	$0.25	sf	$222,500	1.42%
	TOTAL	1	$24.04	sf	$15,625,587	100.00%

Table 3. Parametric Cost Data for the Albany Office Base Project

Extrapolation of the base project's unit costs to the target project, table 4., indicates that an initial cost estimate of $3,375,368 would apply, i.e. Albany project unit cost adjusted by the Atlanta city cost index and by a time (inflation) cost index, These figures are 89.7% and 254% respectively. In addition, as with the previous example, job coefficients may also be applied to the target. Thus column 7, table 4, indicates that the total cost of the Eagle Park project has been assessed to be $**1,079,298** at a gross cost of $**21.16** per sq ft.

CONSOLIDATED CONSTRUCTION						Pg 3 Of 3
INDUSTRIAL COMPLEX, NE	HOOVER,	GA 30332	(404)894–8736			
PARAMETRIC ESTIMATE TARGET ESTIMATE			EAGLE PARK OFFICE COMPLEX			
ATLANTA CITY COST INDEX=99.00% TIME COST INDEX=254.00%						
TRADE or CSI DIVISION		UNIT		DIVISION	JOB	ELEMENTAL
	CODE	COST	UNIT	COST	COEFF	TOTAL
1 General Conditions and Fee	1	$5.51	sf	$280,856	0%	$0
2 Sitework (clear & grub)	1	$0.88	sf	$44,886	100%	$44,886
Excavation	3	$11.49	sf	$0	0%	$0
Foundation	2	$1.68	sf	$88,451	0%	$0
3 Formed Concrete	2	$6.81	sf	$357,765	25%	$89,441

4 Masonry	12	$15.59	sf	$0	100%	$187,086
5 Structural Steel	2	$3.09	sf	$162,380	200%	$324,760
Misc Metal, Incl Stairs	2	$0.96	sf	$50,166	100%	$50,166
6 Carpentry	5	$0.45	sf	$21,274	50%	$10,637
7 Water & Damp - proofing	10	$0.25	sf	$5,985	100%	$5,985
Roofing & Flashing	4	$4.12	sf	$108,254	100%	$108,254
8 Metal Doors, Frames, Windows	5	$0.28	sf	$13,000	100%	$13000
Hardware	5	$0.30	sf	$14,182	100%	$14,182
Glazing	11	$838.19	sf	$356,231	0%	$0
Curtain Wall	10	$9.96	sf	$236,996	50%	$118,498
9 Lath & Plaster	5	$0.20	sf	$9,455	0%	$0
Dry Wall	12	$1.89	sf	$0	100%	$22,631
Tile Work	5	$0.25	sf	$11,819	0%	$0
Acoustical Ceiling	5	$0.45	sf	$21,274	0%	$0
Resilient Flooring	5	$0.10	sf	$4,727	0%	$0
10 Carpet	5	$0.08	sf	$3,546	0%	$0
Painting	5	$0.43	sf	$20,092	0%	$0
14 Elevators	19	$176,022	ea	$0	0%	$0
15 Toilet Partitions	5	$0.08	sf	$3,546	0%	$0
Plumbing	1	$12.95	sf	$660,460	5%	$29.921
HVAC	1	$12.95	sf	$660,460	0%	
16 Electrical	1	$4.45	sf	$226,993	25%	$51,417
Parking, Paved	14	$0.63	sf	$12,573	0%	$0
TOTAL	1	$66.18	sf	$3,375,368		$1,079,298

Table 4. Eagle Park Base Parametric Cost: Amended for time, location and job coefficient.

4 Phase, Line-item and Work Package Estimating

Over the last five years a number of integrated construction cost estimating programs have become widely available within the construction industry. One (Timberline Precision Estimating Plus (PE+)) allows for a rapid take-off of a proposed building by utilizing a comprehensive database of workpackages and phase/item descriptions. The Advanced General Contractors Database (AGCD) numbering scheme is based broadly on the CSI 16-division codes and currently contains approximately 670 phase records, 3,300 line items and 70 work packages.

PE+ uses two major classifications: group phases (or divisions) and phases (sub-divisions). Group phases provide a means of organizing groups of related tasks, e.g. group phase 1.000 General Conditions; or 2.000, site work etc. Phases classify tasks, or types of work, e.g. 2.012 soil testing; 2.050 demolition; 2.110 clearing and grub etc. Once a phase number has been selected, the estimator is able to take-off the quantities either by item take-off or work-package take-off. With individual item take-off each item, as the name implies, needs to be determined separately. With work-package take-off, bundles related items that make up a particular aspect of construction, e.g. the work-package for a slab-on-grade allows for either/or sand and gravel underneath the slab; 4 or 6 mil polyethylene vapor barrier; 3000 or 4000 psi concrete; wire-mesh; curing compound; forming. The estimator is required to specify the length, width and depth. Thickened slabs & turned down edges can be accommodated. All items in a work package may be taken off with a single set of variables or dimensions. For example, the length, width and depth dimensions can generate labor, material and equipment costs for gravel, forms, visqueen, rebar, concrete, finishes etc. In addition, crews made up of specific labor and equipment classes may be allocated to tasks and their direct and overhead costs applied to the estimate sheet.

Using PE+ as a conceptual estimating tool, broadly defined dimensional parameters were associated with workpackage descriptions. The costs were derived from the PE+ 1989 database. The total estimate was determined to be $**1,199,438,** table 5, or $**23.52** sq ft.

Estimating Standard Report

GROUP	DESCRIPTION	LABOR	MATRL	SUB	EQUIP	OTHER	TOTAL	COST/sqft
1000	GEN CONDITIONS					$1,150	$1,150	$0.023
2000	SITEWORK	$10,390	$7,647	$484	$7,764		$26,286	$0.515
3000	CONCRETE	$127,007	$70,612		$2,344		$199,963	$3.921
4000	MASONRY			$150,791			$150,791	$2.957
5000	STEEL	$2,474	$27,216	$298,860			$328,550	$6.442
6000	WOOD & PLASTICS	$3,051	$6,649				$9,700	$0.190
7000	THERMAL-MOIST PR			$125,050			$125,050	$2.452
8000	DOORS & WINDOWS			$152,242			$152,242	$2.985
9000	FINISHES			$4,000			$4,000	$0.078
15000	MECHANICAL				$18,223		$18,223	$0.357

16000	ELECTRICAL	$45,495	$45,495	$0.892

ESTIMATE TOTALS

$142,923	Labor	14,466.213	hrs
$112,124	Material		
$795,145	Subcontractor		
$10,108	Equipment	487.032	hrs
$1,150	Other		
$1,061,450	Sum		
$84,916	Office Overhead (All Categories) 8.00%		
$53,072	Profit (All Categories) 5.00%		
$1,199,438	TOTAL ESTIMATE @ $23.52 sqft		

Table 5. Conceptual Estimate for the Eagle Park Office Project using the PE+ Cost Estimating Program.

5 Review

The three methods illustrated demonstrate that the generation of a conceptual or parametric estimate is possible using a variety of simple computer-assisted techniques. Each method relies upon the availability of historic data. With the first technique, i.e. square foot estimating, the unit cost information may be obtained from a variety of published sources. This information may subsequently be modified in terms of construction complexity, and related location and time cost indices. Only very general information is required by the user in terms of the building's materials, configuration and form. Parametric estimating, the second technique reviewed, is a development of square foot estimating.

However, a number of significant modifications are utilized over the former system. For example, cost figures are determined from historic "as-built" dollar values. Thus a contractor should have more confidence in the final cost figures. In addition, measurement parameters most appropriate to a category of work are applied to each broad division. In this way the cost estimate may be tailored to the job. However, as with square foot estimating, job coefficients are generally required to "customize" the procedures. The third method, incorporating a commercially available construction cost estimating program and an AGCD, may be thought to be a hybrid technique between the "broad-brush" square foot cost estimate and a full quantities take-off estimate.

Each method has its own distinct advantage. With the first approach simplicity is the key. Very little information is required from the user. The second technique works best with a template spreadsheet in order to accommodate the variety of math and "lookup" functions, formulae and macro print facilities. In addition, the user is required to maintain a historic database of previously completed projects. Data input is not complex and most parameters may be determined by a broad review of the blue-prints. The last method is perhaps the most interesting. The AGCD supplied with PE+ is sufficiently flexible to allow for a significant user input in terms of modifications to the database, e.g. user determined addons (profit/overheads etc); job specific labor, material and equipment rates; customized workpackages. All three techniques showed evidence of good correlation between the contractor's "live" cost estimate and the "theoretical" cost estimates. The simple square foot cost figures indicated a +5.07% plus rate; the parametric cost figures a −6.21%; and the PE+ a—5.49% over the actual bid estimate.

6 References

Adrian, J.J. (1985) Microcomputers in the Construction Industry, **Reston Publishing Company Inc,** 134–139.

ENR, Engineering News Record, **McGraw Hill, Inc**.

R.S. Means (1989), Means Square Foot Costs: 10th annual edition, **Robert Snow Means Company**.

Dodge Assemblies Cost Data (1989), **McGraw Hill**.

Timberline Precision Estimating Plus (1990), **Timberline Software,** Beaverton, Oregon, USA.

113
Framework to appraise and prescribe for rehabilitation ills

B.L.GOLTON

Abstract
This paper starts by suggesting that responses to urban decay address the symptoms of the problem of urban renewal. It suggests that approach leads to unsatisfactory solutions. It posits a conceptualisation of the problem and develops a framework of those concepts. It then considers the issues of time and value as they bear on the understanding of the problem. It follows with a consideration of the structural, economic, use and social perspectives which make up the framework. It concludes by suggesting that approaching the problem of urban renewal with a structured and holistic methodology will lead to better decisions.

Keywords: Urban renewal, Obsolescence, Technology, Design, Finance, Management, Law.

"'Forty-two!' yelled Loonquawl. 'Is that all you've got to show for seven and a half million years' work?' 'I checked it very thoroughly,' said the computer, 'and that guite definitely is the answer. I think the problem, to be quite honest with you, is that you've never actually known what the question is.'" Adams (1980)

1 What is the question?

"'TO HELL WITH URBAN RENEWAL,'…'WE WILL DEFEND OUR HOMES WITH OUR LIVES,'" Those words from a sign in Boston, Massachusetts and quoted by Goodman (1972) represented the views of a group of poor white families They were protesting the city's plan to demolish their homes to facilitate the private development of luxury housing. For that group the answer was undoubtedly wrong.

I would suggest that none of us set out to deliberately destroy that which is good to replace it with something less acceptable. Our motivation is improvement. Yet many of our decisions are not seen to improve the situation. In Britain, as in many other countries of the world, planning procedures and public enquiries into development proposals provide the forum in which the arguments are recited. People of good intent, on all sides of the issue, find themselves defending positions against arguments which often when analysed do not address the position being defended. The recited and much rehearsed statements, taking clearly tenable but incompatible stances, stand independent of each other. Dennis (1972) and Davies (1972) observed and documented this phenomena between the protagonists during the rebuilding of two English cities in the 1960’s.

What then is the essence of the problem? What is the question? Each observer couches the argument in terms which reflect the utility, or degree of obsolescence, of the building or environment to that observer. Newman (1973) and later Coleman (1985) ascribed the problem to building form. As Coleman put it, “None of the factors studied detracts from the conclusion that design can be a powerful influence for bad—and also presumably for good, if different designs were used.” Yet in my own work in Oldham for the British Home Office, Community Development Projects, Golton (1974) (1977a) (1977b) and Lane (1977), it was apparent that housing estates of a form, which Coleman (1985) was later to presume were a powerful influence for good, were cause for serious concern. Decay, dereliction and maintenance problems, functional and social ills were all associated with two storey semi-detached and terraced houses. Each house was well constructed and had its own front and back garden. They did not accord with the Newman/Coleman thesis of housing which was likely to be problematic.

The processes developed to address the problems of rehabilitation of these dwellings in accord with the occupiers expressed views was initially hailed as the way forward. It addressed the physical condition of the properties and the methodology was widely adopted. However, the long term outcome of the approach was not consistent. In some areas the improvements were maintained in others, sometimes part of otherwise successful estates, the problems of disrepair and dereliction rapidly reappeared. Why was this so? We addressed the symptoms, not the disease. We need to have an understanding of the nature of the problem, the disease itself. That is the ill to which rehabilitation is the prescription and that is the essence of the question.

2 Concepts of building obsolescence

We are concerned with obsolescence. Obsolescence is the process whereby a commodity moves between perfect utility and obsolete, completely useless. Kirby (1979) in his review of obsolescence noted a profusion of terms, differing objectives of authors and, in some cases, the equation of financial value with degree of obsolescence. All of which, he argued, tended to confuse the concepts. He categorised the studies into those concerned with the physical process, those studies which concentrated on the economic life of buildings and those which adopted a behavioural approach. He had summarised the consensus of these views on obsolescence in an earlier paper, Kirby (1971), as “a lessening of use efficiency resulting from the introduction of more desirable systems into the technology or social organisation of human functions”. This summary is helpful in that it draws our attention to the dynamics of technology and social organisation as a focus for the process of obsolescence. It is, however, misleading, in that it excludes decay as one of the determinants of obsolescence. Decay is neither a function of technology change nor of change in social organisation, although both may influence the rate of decay. Kirby’s summary also excludes the concept of something being obsolete, unwanted, because it is old fashioned. That was a very powerful motivator for change with the groups with which I worked in the 1970's. A Collins English Dictionary definition of utility as "The ability of a commodity to satisfy human wants" is more widely drawn and therefore more helpful. Utility being that which is changed by the process of obsolescence.

The process of obsolescence on a particular building is determined both by internal (that is, to the building) and external dynamics. The internal dynamic is an absolute change in utility of the building itself, decay, structural obsolescence. It is a unidirectional process in that it always produces degradation of the building, moving inexorably, but not necessarily uniformly, from perfect utility to obsolete. The external dynamics, are those which change the relative utility of the building with respect to others or from that which is expected of it. It is not unidirectional in that the external changes may either improve or detract from the utility of the building under consideration. There are also problems with objectivity. The degree of obsolescence depends upon the perspective and the goals of the observer. It is these concepts, that obsolescence is multifaceted, has absolute and relative value and is subjective, dependant upon the perspectives of those involved in rehabilitation, which are central to the question. Obsolescence then, is the disease. What are the symptoms? How do they relate to form a framework to assist with the appraisal?

3 Framework

I have in a previous paper, Golton (1989a), constructed a conceptual framework of building obsolescence, figure 1.

It classifies the perspectives, the symptoms of our disease. The perspectives are structural obsolescence Central to those of us who are concerned with the condition of buildings and concerns the decay in the fabric and systems of the building. The economic perspectives of site, financial and locational obsolescence are concerned with, respectively: the relative value of site to the combined value of building and site with respect to use conditioned by the relative rates of return between the existing use and alternatives; the absolute rate of return and; the implications of location on value. The use perspectives focus on the impact of technological, functional and environmental change. Technological obsolescence concerns change and development in technology and its impact on the fabric and systems of buildings. Functional obsolescence addresses the degree of match between use and building form. Similarly, environmental obsolescence addresses the degree of match between building use and the external environment. The social perspectives of control, style and perception obsolescence are concerned with, respectively, the legal and statutory definition of the state of a building. Aesthetic considerations and the influences of fashion are the issues of style and preconceived images of desirability, those of perception.

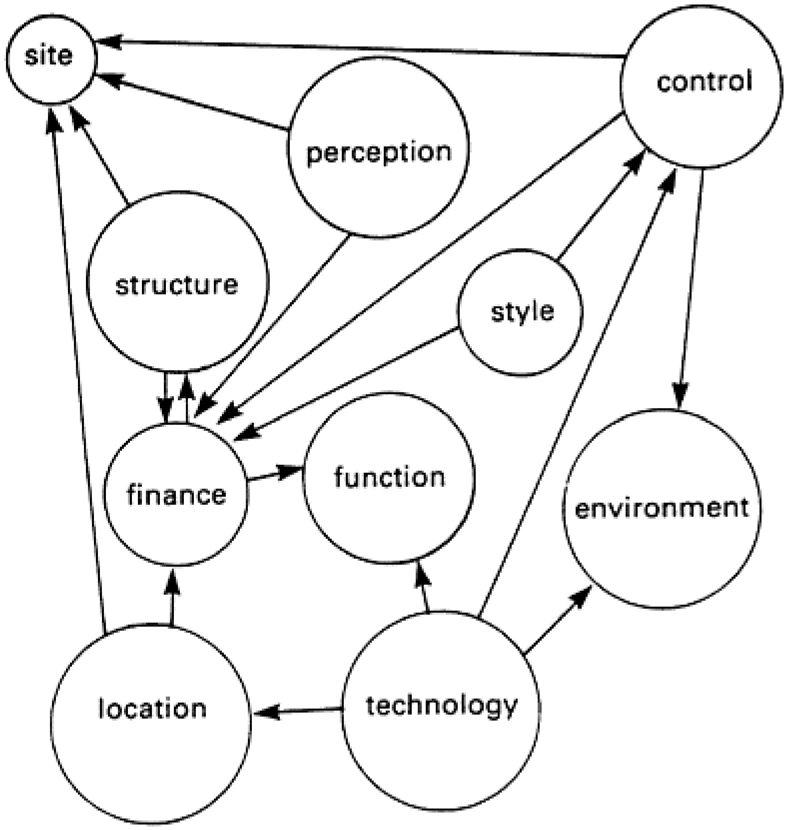


Figure 1. A conceptual framework of obsolescence

There is a complex, overlapping and sometimes iterative set of relationships and influences operating between these perspectives. The precise and relative strengths of the interactive influences and of the pattern of the relationships vary from building to building, from economy to economy and may change over time. It is this dynamic pattern of influences and relationships which determine the unique character of each and every building at any one time. A chaotic model. The perspectives therefore are not mutually exclusive discrete packages as the diagram implies. However, accepting these deficiencies, it is a useful tool to explore and appraise buildings or an area of buildings in order to illuminate the issues which need to be addressed in their rehabilitation.

Essentially the framework enables the intuitive reactions of those involved to be placed in context and assists in the understanding of those views. It also forms a check list for issues which may not have been voiced but which may condition the degree of obsolescence of the building. Before considering the different perspectives in greater detail I need to look at the elements of time and value.

4 Value

Kirby (1979) had observed that many authors equated financial value with obsolescence and, he argued, that confused the issue. What is value? Kirby did not pursue this question. I think it is important not to leave value equated exclusively with financial value for the reason put forward by Kirby. It is a term on which, when attempting to define it, Laird (1928) observed "…it should not be at all surprising if the attempt to bring precision into the idea of value should end with a less extensive but more acute ambiguity." However, I don't want to be side tracked into a long discussion on the meaning of value. Collins Dictionary defines it as "The desirability of a thing, often in respect of some property such as usefulness or exchangeability: worth, merit, or importance" It lacks precision, as predicted by Laird, but its breadth is helpful and supportive of the concepts required when considering obsolescence.

5 Time

The time factor is critical. Toffler's (1970) exploration of the issue lead him to conclude that rate of change, not the physical change, in our urban environment was the more significant influence on the degree of acceptability of those changes. He argued that if great changes occurred at great speed then many of those associated with the area, undergoing that change, suffered symptoms of distress and disorientation the symptoms of shock. He termed it "future shock" and slowing the rates of change were, by implication, desirable. Bobic (1990) observed a different aspect of the time factor. He suggested "…that the essential difference between the characteristics and richness of form in the traditionally and modernly designed city results from the current priority of time over space…especially in the unproportional size and complexity of spatial structures compared to the activated time budget in the processes of building and transforming the city." In other words our obsession with speed, especially related to large complex schemes, is degrading the quality of the environment. Clearly quality and acceptability are not only functions of time but also of other issues. However pursuing the time dimension a little further.

Our appraisal of buildings, subject to rehabilitation, takes the form of a snapshot. A frozen moment in the continuum of the building's existence. The building has history and future. Indeed the prediction of the future and the influences of prescribed actions are the substance of the exercise. A snapshot, therefore, taken out of the context of time, is an inadequate base from which to proceed. We need to know, for each perspective, where on the continuum it resides and the nature of the continuum for that perspective. We need know whether it is necessary to disturb the stability of the trend. To redirect it in a positive direction or perhaps reinforce a weak but already positive trend. A series of snapshots over time will give us that information. The implications of this approach are that it may be that change, of the rate that will induce future shock in the population, is the only practical solution. In which case we need to be mindful of the negative effects observed by Toffler (1970) and Bobic (1990). To consider then the different perspectives which make up our picture of obsolescence.

6 Structural Obsolescence

Structural obsolescence is the degree of decay of the building. It is the visible sign of distress in a building and a central issue for those involved with the technology of buildings. The tendency is for urban renewal activity to be judged on the quality of the response to this problem. There are recognised methodologies for the observation, measurement and recording of the extent of decay. What is subject to debate is the interpretation of observations and measurements. The differences spring from the personal expectation and perception of building quality. Porteous (1985) argued that there are three levels of building condition. A defect occurs when the condition falls below perfection but does not require remedial action. Building failure occurs when the condition declines to such an extent that, indisputably, remedial action is required. Between those two extremes there is a range of condition where the need for remedial action is qualified by personal expectation. A defect becomes a failure when a response is required to remedy the problem. Clearly the boundaries between the categories are fuzzy. One factor which conditions whether a problem is to be remedied is cost. The cost, relative to benefit, of the remedial works.

7 Economic Perspectives

I earlier categorised these as financial, site and locational obsolescence. In a market economy these are the perspectives which are the significant determinants of the dynamic. Financial obsolescence concerns the financial returns of a building with respect to the costs. It is the relationship between capital and the liability costs of the asset on one side and income and capital appreciation on the other. The mechanisms of conventional accounting processes illustrate that much public housing, in Britain, is obsolete within this perspective. A rent, adequate to balance the equation is well beyond the market rent. That is a rent which prospective tenants are prepared, or able to pay. Manipulation of the equation by subsidy income or tax or maintenance cost reduction is necessary to balance the equation. The first two options are clearly issues which fall within the control perspective. The latter will have significant effect on the dynamics of structural obsolescence with knock on effects in other areas. I have discussed these issues in greater depth elsewhere (Golton 1989b) but the simple relationship between returns and outgoings is central to this perspective. For the building not to be obsolete returns must exceed outgoings. That however is not the situation within the perspective of site obsolescence.

Site obsolescence concerns the relationship between building and site value. If the value of the cleared site is greater than the total value of the building and site (together with the clearance costs) the site is obsolete for its present use and it will be demolished or converted. That is, ignoring the statutory control issues which I will turn to later. Typically that occurs with housing on the edge of an expanding business district. What then influences use characteristics?

In Von Thunen’s model of 1826 this was considered to be a function of transport costs. Commerce and industry put a higher value on the land at the centre than at the periphery of urban development. At the centre that would tend to outstrip residential values but towards the edges residential interest would be more significant. There are, of course, later and more developed urban land value models than Von Thunen's but as Harvey (1987) observed, the principles remain the same. As activities expand the sites become more valuable for the new uses and the existing use becomes obsolete in capital value terms. There is a natural decay and followed by renewal with a new use. However that fails to explain the decay and abandonment of some of our inner cities. For an explanation of and consequent response to that phenomena we need to look elsewhere, initially to the use perspectives.

8 Use Perspectives

Functional obsolescence of a building concerns the degree of mismatch between the form of the building and the spatial needs of the activity carried on within it. In housing demographic changes together with technological changes signal the functional obsolescence of dwellings. In Britain changes in family size, young people establishing independent households and increasing divorce rate, created a changing pattern of dwelling size. The introduction of more domestic machines has lead to the need for enlarged kitchen and utility spaces. Attitudes to housework and the relationship of the members of the household to those activities has meant that the kitchen has now become part of a family room. (Matrix 1984) The modus vivendi of many families has also led to a desire to have much smaller garden areas than in the past. These changes are concerned with the internal environment but changes occur in the external environment which condition the acceptability of a building for its use.

Environmental obsolescence, the effect of the external environment on the activity within a building is a significant problem. In essence, of course, it is the raison d' etre for building. The enclosure of space to create a micro climate. However, the focus here is what might be called the “nimby” (Not In My Back Yard) syndrome. It is the problem of other activities happening, or about to happen, in the adjacent areas which are incompatible with the current use. It concerns the siting of industry, commerce, leisure and transport facilities in relation to each other and in relation to social and housing facilities. It may not be all negative. Improved communications may bring an enhanced view of the desirability of a property outweighing the disadvantages. Urban change in these circumstances will be seen by some as desirable and by others detrimental. The argument is couched in economic terms as a measured response to the devalued environment or to improved communications.

Technological obsolescence, within the structure of this analysis, concerns the impact of technological change on the fabric and systems of buildings. That is not to say that the examples so far used are not involved with technological change, clearly they are, but their impact is more satisfactorily considered within the other perspectives.

Buildings are erected to enclose space to create a micro-climate within that space. The efficiency with which that micro-climate is maintained is a function of the technology of the fabric and the services of the building. Developments in those technologies which increase the efficiency of the building will increase the obsolescence of building already erected. Difficulties arise when the life of the services are shorter than the life of the fabric. A normal occurrence. The efficiency of the system as a whole may not be improved by installing new high efficient services. There may be mismatch between the response times of the services and those of the fabric. These are the issues which are often entangled with those of structural obsolescence mentioned earlier. It may be necessary then to consider whether this mismatch is so great that the whole structure should be considered obsolete. This draws into the efficiency equation issues of embodied energy. That is the energy required to win, form and erect the materials into a building. The embodied energy issue is significant when considering the physical life expectancy of a building and its services but is often overlooked. However it is becoming apparent that changes in fashion and on attitudes to safety and other ecological issues may be more significant in the determination of the life expectancy of buildings. These are the social perspectives.

9 Social Perspectives

The social perspectives are concerned with peoples attitudes to buildings. These attitudes may not be conditioned by use perspectives but as with all these views there is overlap.

Buildings as with all manufactured artifacts, are subject to the whims of fashion. Buildings reflect the fashion of the time and culture in which they are built. They will also reflect the purpose for which they were built although there are exceptions to this latter statement. It may be that the image projected by the buildings becomes stigmatised (Newman 1972) or by simply ageing becomes less acceptable. They are old buildings but not antique. If a building does not otherwise become obsolete within the perspective of those that have control of it and it survives until its merits, usually as an historic object, are once again generally valued, then its future will be secure within this perspective. This is one of the factors central to the phenomenon of gentrification of decaying urban environments. That however may not happen. To preserve its architectural or historic characteristics may prevent its adaption to a current use or it may be inappropriately located. It may be a perception problem.

We are conditioned by our perception of places. Certain label or images provoke responses based on previous conditioning. For every individual, experience, pleasant or unpleasant will be linked with a physical environment; it is, as Rapoport (1974) argued a symbolic environment conditioning the perception of new images. We have an emotional response to what we see. The challenge in urban renewal is to change the perception so that the area becomes desirable. It is the stuff of advertising. It may be that the use of statutory powers could assist that change.

Control obsolescence concerns those issues where the dynamic is conditioned by decree. In a command economy this is the perspective which is the significant determinant of the dynamic. In Britain, there are powers to designate dwellings as unfit for human habitation a process which leads to demolition. In defending their homes residents often argue that they are convenient, cosy and affordable and that there is a good community spirit in the area. The authorities argue that these are not criteria defined by law on which the dwellings are represented as unfit. They are often both right but if legislation is to assist in the resolution of urban renewal problems it needs to support and be interpreted to run with the grain of the community’s wishes.

Safety legislation, concerning such issues as structural stability, fire protection or means of escape from the building can change the degree of obsolescence. Either by forcing costs to upgrade existing building or by making them less desirable than new buildings. It may be that to carry out the works would be in conflict with the requirements of other legislation. Legislation which is enacted to protect buildings which are seen to be of cultural, historic or architectural importance creates such problems. However, by protecting the physical characteristics of the building, adaptation to changing uses and needs are restricted and often hasten functional obsolescence. The legislation is primarily intended to blunt the effect the economic determinants of change which is where I started this tour of the determinants of obsolescence.

10 Conclusion

The framework I have set out in this paper is a structure within which our observations and intuition can be placed. It also enables us to identify and explore other influences which may be contributing to the urban ills we see before us. It should enable us to gain greater understanding of the issues leading to the problems we are being called upon to resolve. I do not argue that this will lead to easier decision making, on the contrary it may be more difficult, but it may lead to better decisions. Decisions which are directed at a holistic approach to the disease.

11 References

Adams, D. (1980) The Hitch-Hikers Guide to the Galaxy. Pan Books.

Coleman, A. (1985) Utopia on Trial Vision and Reality in Planned Housing. Hilary Shipman.

Bobic, M (1990) The Role of Time Function in City Spatial Structures Past and Present. Avebury.

Davies, J.G. (1972) The Evangelistic Bureaucrat. Tavistock Publications.

Dennis, N. (1972) Public Participation and Planners Blight. Faber & Faber

Golton, B.L. (1974) Feasibility Report on the Improvement of Abbeyhills Estate Oldham. New Abbeyhills Tenants Association.

Golton, B.L. (1977a) The Architect's View of Abbeyhills, in Building Technology and Management. October 1977.

Golton, B.L. (1977b) Community Shock—A paper concerning an approach to Urban Renewal, in Yorkshire Architect. July/August 1977.

Golton, B.L. (1989a) Perspectives of Building Obsolescence. In Land and Property Development: New Directions, edited by Grover, R.Spons (1989)

Golton, B.L. (1989b) Issues of Economic Obsolescence in Building, in Architect and Surveyor. September 1989.

Goodman, R. (1972) After the Planners. Pelican Books.

Harvey, J. (1987) Urban Land Economics. Macmillan Education.

Kirby, D.A. (1971) The Inter-war Council Dwelling: a study of Residential Obsolescence and Decay, in Town Planning Review, vol. 42 no. 3

Kirby, D.A. (1979) Slum Housing and Residential Renewal the Case in Urban Britain. Longman

Laird, J. (1928) The Idea of Value. Reprinted by Augustus M Kelley (1969).

Lane, K. (1977) A case of Better Treatment: the Storey of a Rehabilitation Project, in Building Technology and Management. October 1977.

Matrix (1984) Making Space—Women and the Man-made Environment. Pluto Press.
Newman, O. (1973) Defensible Space. Architectural Press.
Porteous, W.A. (1985) Perceived Characteristics of Building Failure—A Survey of the Recent Literature. in Architectural Science Review. June 1985.
Rapoport, A. (1974) Conflict in a Man-made Environment. Penguin Books.
Toffler, A. (1970) Future Shock. Pan Books.

114
The use of project information manuals in the asset management of housing

H.A.GOW and M.A.ROSS

Abstract
This paper explains the need for and development of a project information manual for the use of housing associations in Scotland. Its contents are based on earlier guidance developed in the 1960's by the government. Many details are lost in the hand-over between the design team and the building managers and the purpose of the manual is to gather all this often vital information together for easy reference and use in maintenance planning and financial projections.
Keywords: Project Information Manual, Building Elements, Maintenance/Asset Management, Specification/Project Data.

1 Introduction

The use of project information manuals is not a new idea for there have been very good examples available for many years. However in the 1970's there was a new awareness of the volume of housing stock requiring continual upkeep not only in the United Kingdom but elsewhere in Europe. (1)

The author became aware of the discrepancy when taking part in a Scottish Federation of Housing Associations workshop on maintenance practices and planning. The purpose of the workshop was to aid the development of planned maintenance programmes by the members of the SFHA. In the summing up session at the end of the day it became apparent that a lack of knowledge of the owned stock of houses was the greatest barrier to its proper upkeep. From these discussions the Federation set up a working party to develop a suitable manual which all its members could use and this was published in 1987 (2)

2 The Structure of the Project Information Manual

The manuals structure is based on seven sections which deal with information to do with the design and construction of the housing project.

2.1 Section One

This section deals with the contractual and legal details of the project. It lists the client, the professional consultants, the main contractor and the sub-contractors and those that have been nominated by the architect. Various important dates are detailed e.g. the completion date and the period of defects liability. Finally the addresses of the local public utilities are given with a precis of the scheme and the dates of the planning permission and building warrant to build the project. A draft page is detailed in Appendix Nr.1.

2.2 Section Two

Site and project details are gathered together under this heading with considerable specification detail. Often it is a good idea to take photographs of external works for ease of reference in the office. Again the section is illustrated in Appendix Nr.2.

2.3 Section Three

The building element analysis is detailed in this part of the manual. The structure used in the example is based on the ten sections suggested by the Department of the Environment in the early 1970's and developed in Scotland by the SSHA and the Scottish Local Authorities Special Housing Group Research Unit (SLASH, Edinburgh) in their Housing Maintenance Manual for the Scottish Housing Authorities. This complete section is detailed in Appendix Nr.3.

2.4 Section Four

As fitted drawings are an important source of reference not only for maintenance staffs but for use in the production of tenant guidance documents on closing down systems such as water, electricity and heating. Alteration works at later dates can be confidently carried out without the potential of breaking into another system or accident to the tradespeople. It is illustrated in Appendix Nr. 4.

2.5 Sections Five, Six and Seven

These areas deal with the details of the equipment supplied with each housingunit and communal equipment like TV installations and Group Heating systems.

An example is given of the details in section five and the type of items listed in sections six and seven are indicated at the bottom of the page. The headings indicate the very large range of materials and components normally used in housing and other projects and the intention is that such information be gathered as the works proceed. See Appendix Nr. 5.

3 Conclusions

The project information manual has now been in operation for two years and already indications are that a computerised form would be welcomed by thoseassociations now introducing that facility. The Scottish Office has also recently published a Housing Maintenance Kit to encourage the planned maintenance of housing associations stock. Those organisations with little or no information on their existing stock are having to employ surveyors to carry out condition surveys in order to correct the deficiency. The use of project information manuals for all new housing and their continual upkeep will ensure asset management personnel will operate from a position of knowledge rather that ignorance of the assets managed.

4 References

CIB/W70 Proceedings of the Seminar, Heriot-Watt University, Edinburgh, 1983.

Project Information Manuals for new build and rehabilitation, Scottish Federation of Housing Associations, Edinburgh, Scotland, 1987.

HND Diploma project Mark A.Ross, Dundee Institute of Technology, Dundee, 1988.

APPENDIX NR 1

CONTRACTUAL & LEGAL DETAILS: **SECTION ONE**

PROJECT INFORMATION

- **Parties to the Contract:**

Client: HILLCREST HOUSING ASSOC. DUNDEE

Main Contractor: MESSRS HALLIDAY CONST. LTD.
KING WILLIAM ST., DUNDEE
TEL. 200062

Sub-Contractors: (Name: Trade: Telephone No.:)

Plumber: FACSTON PLUMBING + HEATING T: 28410
Rooftiler/Roughcaster: MARLEY CONTRACT SERVICES 041-772 6201
Electrical: McGILL ELECT. LTD. T. 455837
Glazier: A. DAILLY LTD. T. 825370
Painter: SCOTT + SIMPSON T: 0592 756340

Nominated Sub-Contractors: FLOOR FINISHES : VEITCH LTD
T: 89252

Nominated Suppliers: STRUCTURAL STEEL
- ANGUS MCMURTIE 052-625 301

Type of Contract: JCT '80 - FIXED PRICE

Possession of Site: 14.03.88 Practical Completion Date: 08.09.89
Defects Liability Period: Building: 12 Services: 12 MONTHS
Schedule of Defects Issued: 28.11.90 + 6.12.90
Certificate of Making Good Defects Granted: 28.02.91

- **Contract Consultants and Public Utilities**

Architects: MESSRS BAXTER, CLARK + PAUL
Quantity Surveyors: DUGUIDS
Services Consultants: -
Structural Designers: FAIRHURSTS
Landscape Architect: -

Public Utilities:
Gas: SCOTTISH GAS DUNDEE T: 454545
Electric: NORTH OF SCOTLAND HYDRO ELECT BD.
Water: TAYSIDE REGION - WATER DEPT T: 23281
Sewerage: " " - DRAINAGE DEPT.
GPO: DUNDEE AREA T: 23171

- **Description of Project: Consents, Approvals, Easements and Covenants**

General Description: FLATS AND DOUBLE STOREY DWELLING
ON SLOPING SITE WITH ROAD
ACCESS + CAR PARKING

Planning Permission: 12.12.87
Building Warrant: 15.12.87
Listed Buildings/Grade/Conservation Area Applications: N/A
Legal Liabilities: N/A

APPENDIX NR 2

SITE & SCHEME INFORMATION **SECTION TWO**

2.1 House Types, Sizes and Density

BLOCK ONE = 11 x 4 PERSON 3 APT. FLATS AND
3 x 1 PERSON 2 APT FLATS in
L-SHAPED FOUR STOREY HIGH AT
STREET + 3 STOREY RETURN.
BLOCKS TWO + THREE = 1 x 4 PERSON 3 APT WHEELCHAIR
6 x 6 PERSON 5 APT. HOUSES
+ 1 x 6 PERSON 4 APT HOUSE FOR
WHEELCHAIR USER.

2.2 Boundaries of Site (See Attached Plan)

ALL AS ATTACHED SITE PLAN

2.3 External Environment: Liabilities Division (i.e. Tenant/Owner/Association)*

Garden Area .. ASSOCIATION LIABLE*
Paths .... DITTO.
Fences/Walls .. MUTUAL TO WEST / REST ASSOC. L*
Boundary Division .. MUTUAL AGAINST EXTG. BLDGS.

Landscaped Areas Liabilities (i.e. Association/Local Authority/Others)

Grass Areas .. ASSOC.
Shrubberies .. ASSOC.
Walls .... ASSOC - NOTE MUTUALITY
Pathways ..... ASSOC.
Courtyard Areas . ASSOC.
Roads ..... ADOPTED BY L.A.
Drainage ..... DITTO.
Bin Stores ..... ASSOC.
Drying Areas .... ASSOC.

2.4 Mutual Areas Liabilities (i.e. Tenant/Owner/Association/Others)

Common Stairs ..... ASSOC.
Bin Stores .... ASSOC.
Drying Areas .... ASSOC.

APPENDIX NR 3

AS FITTED DRAWINGS **SECTION FOUR**

Full Set Building Warrant Plans ☑ Blank Bill of Quantities ☑

Underbuilding Plan Drg. No.		
Ground Floor Plan		
First Floor Plan		
Roof Plan		
Sections		
Elevations		
Services Drawings		
Plumbing		
Drainage		
Electrical		
Gas		
Heating + Ventilation		
Fire Fighting Equipment		
Special Equipment or Installation Drgs.		
Warden Call		
Door Entry		
Fire Alarm		
Specialist Works		
D.P.C.'s		
Rot Treatment		
Fungal Attack		
Infestation		
Additional Schemmatic A4 Drawings Requested and Supplied		
Electrical		
Flat Layout		
Plumber Layout		
Heating Layout		
Additional Information		
Fire Access Points		
Exit Routes		
Fire Drill Procedures + Collection Areas		

BUILDING ELEMENTS ANALYSIS: **SECTION THREE**

1.0 External Decoration

1.1 Roof .... STAINED RW. ....

1.2 Dormers .... DITTO ....

1.3 Gutters, Downpipes .. PLASTIC PVC. ....

1.4 Windows ...... STAINED RW. ....

1.5 Fabric .... N/A. ....

1.6 Doors .... GLOSS PAINT ....

1.7 Common Areas .... GLOSS ON CEMENT PLASTER ....

2.0 Interior Decoration

House Interiors	2.1 Walls	2.2 Ceilings	2.3 Doors	2.4 Window	2.5 Woodwrk	2.6 Rads	2.7	2.8	2.9
Living Room	MV	A	G	St	V	G.			
Bedroom	MV	A	V	St.	V.	G			
Bathroom	MS	A	V	St	V	G			
Kitchen	MS	A	V	St	V	G			

Common Areas	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Corridors	VS	A	G	St	V	-			
Lounge	VS	A	V	St	V	G			
Kitchen	VS	A	V	St	V	G			

Key: A = Artex, G = Gloss Paint, W = Wallpaper, W + E = Woodchip + Emulsion, PW = Plastic Wallpaper, VS/P = Vinyl Silk Paint NB. St = Stained RW.

3.0 Main Structure

3.1 Foundations ... STRIP ....

3.2 Stair/Frame .... PRECAST CONCRETE ....

3.3 Ext. Walls/Chimneys . FAIR FACED BLOCK / BRICK + ROUGHCT.

3.4 Ext. Windows, Doors + Glazing STAINED RW. WDS. / SERAYAH DRS. FLOAT GLASS GW. Polish Plate

3.5 Roof Structure TRUSSES/SARKING/FELT. / C-BATTENS ....

3.6 Roof Coverings MARLEY MODERN CONC. TILES + 38x25 Batten

3.7 Roof Lights + Glazing ... NONE ....

3.8 Gutters + Downpipes .. MARLEY 'DEEPFLOW' PVC ....

3.9 (Spare) .... 68mm UPVC downpipes ....

4.0 Internal Construction

4.1 Ground Floor .. WW. Sawn Joists / 20 Chipboard ....

4.2 Upper Floor .... Cast in Situ Concrete/Battens/Chipbd. ....

4.3 Staircase + Steps ... Pine in houses / P.C. concrete common stairs.

4.4 Internal Walls:

Loadbearing .... BLOCKWORK / 2 CTS. PLASTER ....

Non-loadbearing ...... DITTO / STUD + PLASTERBD + ARTEX ..

BUILDING ELEMENTS ANALYSIS: **SECTION THREE**

1.0 External Decoration

1.1 Roof ....STAINED RW.
1.2 Dormers ....DITTO
1.3 Gutters, Downpipes ..PLASTIC PVC.
1.4 Windows .....STAINED RW.
1.5 Fabric ....N/A.
1.6 Doors ....GLOSS PAINT
1.7 Common Areas ....GLOSS ON CEMENT PLASTER

2.0 Interior Decoration

House Interiors	2.1 Walls	2.2 Ceilings	2.3 Doors	2.4 Window	2.5 Woodwrk	2.6 Rads	2.7	2.8	2.9
Living Room	MV	A	G	St	V	G.			
Bedroom	MV	A	V	St.	V.	G			
Bathroom	MS	A	V	St	V	G			
Kitchen	MS	A	V	St	V	G			

Common Areas	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Corridors	VS	A	G	St	V	-			
Lounge	VS	A	V	St	V	G			
Kitchen	VS	A	V	St	V	G			

Key: A = Artex, G = Gloss Paint, W = Wallpaper, W + E = Woodchip + Emulsion, PW = Plastic Wallpaper, VS/P = Vinyl Silk Paint NB. St = Stained RW.

3.0 Main Structure

3.1 Foundations ...STRIP
3.2 Stair/Frame ....PRECAST CONCRETE
3.3 Ext. Walls/Chimneys .FAIR FACED BLOCK / BRICK + ROUGHCT.
3.4 Ext. Windows, Doors + Glazing STAINED RW. WDS. / SERAYAH DRS. FLOAT GLASS GW. Polish Plate
3.5 Roof Structure TRUSSES/SARKING/FELT. / C-BATTENS.
3.6 Roof Coverings MARLEY MODERN CONC. TILES + 38X25 Batten
3.7 Roof Lights + Glazing ...NONE
3.8 Gutters + Downpipes ..MARLEY 'DEEPFLOW' PVC
3.9 (Spare) ....68mm UPVC downpipes

4.0 Internal Construction

4.1 Ground Floor ..WW. Sawn Joists / 20 Chipboard.
4.2 Upper Floor ....Cast in Situ Concrete/Battons/Chipbd.
4.3 Staircase + Steps ...Pine in handrails / PC. concrete common stairs.
4.4 Internal Walls:
Loadbearing ...BLOCKWORK / 2 Cts PLASTER
Non-loadbearing ......DITTO / STUD + PLASTER BD + ARTEX

APPENDIX NR 4

AS FITTED DRAWINGS — **SECTION FOUR**

Full Set Building Warrant Plans [✓] Blank Bill of Quantities [✓]

Underbuilding Plan Drg. No. ....
Ground Floor Plan ....
First Floor Plan ....
Roof Plan ....
Sections ....
Elevations ....

Services Drawings ....
Plumbing ....
Drainage ....

Electrical ....
Gas ....
Heating + Ventilation ....
Fire Fighting Equipment ....

Special Equipment or Installation Drgs. ....
Warden Call ....
Door Entry ....
Fire Alarm ....

Specialist Works ....
D.P.C.'s ....
Rot Treatment ....
Fungal Attack ....
Infestation ....

Additional Schemmatic A4 Drawings Requested and Supplied
Electrical ....
Flat Layout ....
Plumber Layout ....
Heating Layout ....

Additional Information
Fire Access Points ....
Exit Routes ....
Fire Drill Procedures + Collection Areas ......

APPENDIX NR 5

APPENDIX NR 5

EQUIPMENT LIFE PROJECTIONS + GUARANTEES — SECTION FIVE

Equipment Supplied and Service Recommendations

Particular	Maker	Model	Projected Life	Service Interval
Gas Cooker				
Electric Cooker				
Air Extractor				
Bathroom Ventilator				
Washing Machine				
Tumble Dryer				
Gas Central Heating				
annual service				
rads, pumps + valves				
Electric Central Heating				
annual service				
check fittings etc.				
Communal Equipment				
TV installation				
cabling				
boosters				
Washing Machines				
Tumble Dryers				
Specialist Installations				
Boilers				
Pumps				
Radiators				
Additives				
Tanks (State capacity)				
Timers/programmers				
Thermostats				
Control Panels				

Building Materials + Components
(List Manufacturers Literature, note special maintenance and upkeep recommendations: e.g. Asbestos Products).

Service Materials + Components
(List Manufacturers Catalogues and Consultants Recommendations for Use)

List all enclosed leaflets and User Instructions for all Equipment supplied.
DPC Specialist Treatments, etc. extended warranties

115
Building ownership and the timing of redevelopment

R.HAM

Abstract
This paper examines the effect of multi-ownership of a building on the timing of redevelopment. The paper shows that whilst the conditions for efficient redevelopment are met, redevelopment may be delayed beyond the optimal time for redevelopment due to inefficiency in the assembly of title. The nature and source of this inefficiency will be examined through the use of game theoretic conditions for voluntary exchange. Predictions around the kind of residential buildings affected by this issue will be made with respect to the nature of ownership of title.

Keywords: Ownership, Title, Assembly, Optimal Timing, Redevelopment.

1 Introduction

The management of buildings, whether residential or not, in terms of the quality of services provided to the tenants is determined by two broad factors. First the criterion that management uses in making decisions results in the quality outcomes. Also the rights of owners and managers in these buildings must direct and frame outcomes. Economics has, in the main, approached theorising around building management within the paradigm of private property. It is assumed that exclusive property rights in buildings are held singly and that there is no conflict between the objectives of owners and managers. Owners' interests override any managerial self-interest and that the criterion used to assess the provision of building services is to maximise profits.

Within this framework two important management decisions have been examined. The decision to maintain buildings, which has normally resulted in identifying those factors that are influential in setting an optimal maintenance path. The problem has been dealt with as an optimal control issue. The control variable is the level of maintenance used to determine the objective function, the capital value of the building. This is the present value of the expected stream of profit from leasing the building. Secondly the decision to replace completely existing capital, redevelopment, has been an area of interest. Here the control variable is the timing of the decision and the objective is to maximise the stream of profit created by the site (land and capital).

The aim of this paper is to examine the effect of multi-ownership of a single building, by independent profit maximising units, on the timing of redevelopment. Section two examines the meaning of multi-ownership of residential buildings, with particular reference to the New South Wales Strata Titles Act 1973 No.68. The next section compares the first order conditions for the optimal timing of redevelopment under single and multi-ownership of the building. Part four then examines the problem that multi-ownership poses in terms of the smooth transition to single from multi-ownership necessary for effective site redevelopment. An approach, utilising some ideas found in market games, shows that self-interested owners may find, that delaying disposal of title in any proposed assembly of ownership by a redeveloper, to be a dominant strategy.

2 The nature of multi-ownership

For the purpose of the paper multi-ownership of a building is ownership of separate freehold titles within the building. This should not be confused with joint ownership of a building under single title, such as a partnership. Here there is a single legal entity having title to the building. A prospective purchaser of the complete building would have to deal with a single legal prospective vendor. Multi-ownership in this paper conforms with the subdivision of freehold in the building as defined in the New South Wales Strata Titles Act. Using the provisions of the Act a developer of a residential building containing many dwelling units can sell the freehold of each dwelling unit to separate and independent persons. These freeholds are titles over space in the building, Robinson (1989). The building structure containing this space is common property to be administered by a Body Corporate, which is a legal requirement for each strata-titled building. Thus, exterior walls, interior walls lining corridors, the corridors, floors and ceilings are common property. The Body Corporate is the managing agent for the owners and membership of this consists of owners of title in the building. The Body Corporate finances the management of the building from two funds both of which are determined by levees on the owners. There is an administrative fund for short term planning and expenditure. The second is a sinking fund devoted to longer term, large scale capital outlays associated with ‘lumpy’ maintenance and refurbishment expenditures. The titles to the residential units are freehold and untrammelled. They are therefore marketable commodities.

Developing residential units in this way has certain advantages. It allows for a freehold interest in high density residential space. This is an important consideration in a state where owner occupation accounts for 68% of occupied dwellings (Australian Bureau of Statistics (1989)), but also land planning authorities are concerned about low density residential sprawl. It provides a quicker return on capital than developing and managing the building for rent from residential tenants. This short term liquidity gain for the developer may be bought at some long run cost. Whilst the New South Wales Strata Titles Act appears to have addressed the issues of daily management and medium term maintenance and refurbishment decisions the long run land management problem associated with redevelopment of the building has not been recognised. To redevelop strata-titled buildings, these many titles must be assembled into one. There are provisions to ‘wind-up’ the Body Corporate, but these legal procedures have no relationship with the efficient redevelopment of the building. Powers of assembly have not been vested in the Body Corporate, nor are there any clauses in the freeholds that provide for or encourage assembly through trade. Under these conditions it is possible to conjecture that the problem of assembling title to the building in the free market will defer redevelopment beyond economically efficient times. This problem is not restricted to strata-titled residential buildings in New South Wales, but could occur wherever buildings are multi-owned and there is no provision to encourage assembly of titles .

3 Optimal timing of redevelopment

Defining the optimal timing of redevelopment of a building that is owned by a single company or person is straightforward. The objective of such a company, if the building is rented for profit, will be to maximise the capital value of the site in its existing form and any potential future redevelopment. Equation (1) defines that objective.

$$V = R_1 \int_0^T e^{-rt} dt + R_2 \int_T^X e^{-rt} dt - Ce^{-rt} \qquad (1)$$

Where:

V is the capital value of the site in its existing and potential redeveloped use;

R_1 and R_2	is the net rent associated with the existing building, subscript 1 and a potential redevelopment project, subscript 2;
C	is the cost of demolishing the building and developing a new one;
r	is the discount rate;
t	t ime; and
T and X	the date of redevelopment and the planning horizon over which the owner discounts the future redevelopment respectively.

Equation (1) is simplified to a limited planning period, 0 (today) to X (some future date), with only one potential replacement of the building. Henderson and Quandt (1980) write a more general objective function over an infinite time horizon with multi-replacement of any income yielding asset. Bentick and Pogue (1988) use an infinite time horizon with one proposed change in land use.

Carrying out both integrations in (1) over the intervals 0 to T and T to X gives:

$$V = \frac{R_1}{r} - \frac{R_1}{r} e^{-rT} + \frac{R_2}{r} e^{-rT} - \frac{R_2}{r} e^{-rX} - Ce^{-rT} \qquad (2)$$

The first two terms on the righthand side of (2) give the capital value of the existing building from time 0 to T. The last three terms give the residual value of the cleared site associated with the redevelopment at time T.

Differentiating (2) with respect to T, setting the first derivative to zero, simplifying and rearranging terms gives the first order condition for the timing of redevelopment that maximises the value of the site, V:

$$\frac{R_2 - R_1}{r} = C \qquad (3)$$

(3) has some economic meaning. The left hand side is the capitalisation of the net rental gain to redevelopment. When this is equal to the costs of redevelopment, C, it pays to undertake the redevelopment project.

There is an alternate form to equation (2), Moorhouse (1972). The last three terms can be consolidated into a single term S, the residual value of the cleared site for redevelopment. This is a useful form, because it allows for the analysis of redevelopment timing in two separate ways. First the previous format can be repeated, and restates the conditions for optimal timing of redevelopment when the redeveloper is the existing owner. Alternatively those same conditions can be looked at where the redeveloper acquires the existing building from the current owner for redevelopment. This is important because it is contended that, where buildings are multi-owned, ownership rights have to be assembled. A condition for redevelopment here will be market transactions over titles prior to redevelopment. Rewriting (2) with the consolidated site residual term and dropping redundant subscripts for R gives:

$$V = \frac{R}{r} - \frac{R}{r}e^{-rT} + Se^{-rT} \qquad (4)$$

where R refers to the net rental of the existing building. Differentiating (4) with respect to T, setting to zero and simplifying gives an alternate form for the first order conditions of redevelopment timing:

$$\frac{R}{r} = S \qquad (5)$$

(5) states that for redevelopment to take place, the residual value of the cleared site, S, must equal the capital value of the existing building. If the current owner of the building is not the redeveloper then (5) gives the optimal timing for the disposal of the existing building. S will be that sum of money paid to the owner by a purchaser at time T. Optimal disposal timing can be defined in terms of periodic income by dividing (5) by r. Optimal time T is now defined as when the periodic rent equals the interest return on investing S in the bond market. If the purchaser happens to be a redeveloper then S is a residual valuation of the cleared site based on normal profit. Exchange will take place if competition prevails.

These conditions have been well established in the literature on urban and housing economics, see for example Henderson (1985) . The condition in (5) is a minimal condition for land development/redevelopment. If owners are allowed to speculate around rising future bid prices, S, for the building, redevelopment timing can be deferred (see Neutze (1973) and Ham (1990a)). Monopolistic elements in the land market will affect the quantity of and therefore the timing of land development, (see Scheffman and Markusen(1977)). Redevelopments associated with this optimal timing rule need not be

efficient if externalities are associated with new buildings, Mills (1979) and Ham (1990b)
.

Whilst the conditions for optimal timing seem well founded, there has been little reference to the affect of ownership on redevelopment timing. If a building is jointly owned, the optimal timing rule becomes more complex. Redevelopment can only take place if ownership rights are assembled under one title. For such an assembly to take place, each owner must be compensated at least the capital value of their rights and the summed compensations must be less than or equal to the developer's residual valuation of the cleared site. If a building is owned by n owners, for each jth owner, equation (5) becomes the weak inequality:

$$\frac{R_j}{r} \leq s_j \qquad (6)$$

where the left hand term is the jth owners capital value of his holding and the right hand term is the money received in exchange for this holding. (6) must be summed over the j owners for effective assembly to take place, so that:

$$\sum_{j=1}^{n} \frac{R_j}{r} \leq \sum_{j=1}^{n} s_j \leq S \qquad (j=1,\ldots,n) \qquad (7)$$

Where S is the capital value of the cleared site to the redeveloper. (6) and (7) are necessary conditions for the exchange and redevelopment of a multi-owned building. Alone they are not sufficient to ensure that exchange will take place.

4 Multi-ownership and voluntary exchange

Game theory defines the 'core' of an economy as those states where it is impossible for an individual or a group of individuals to improve on those states, Hildenbrand (1989). Market games show that competitive markets will force economic states into the core through voluntary exchange. If it is possible for the owner of an object to receive a price for that object more than his minimum personal valuation and for a potential buyer to pay a price less than his personal limit valuation of that object, then the economy is not in the core. Exchange of the object for a sum of money within the two limit prices ensures both parties gain from trade and an actual Pareto improvement is achieved. Telser (1971) and Weintraub (1975) show that competition between all potential traders ensures that all possible exchanges will take place and that the economy will be in the core. Therefore equation (5) in a competitive environment is sufficient to lead to exchange and redevelopment.

When a building is multi-owned a free market exchange may not be achieved so readily though (6) and (7) may apply. Inequalities (6) and (7) show that the current state is not in the core. There will be a set of exchange prices sj that will result in an actual Pareto improvement. Each jth owner and the buyer will enter into negotiations with the objective of maximising gains from trade. The objective of the buyer will be to depress

Σsj, his aggregate exchange price for the building, subject to the unknown minimum $\Sigma R_j/r$. The objective of each jth seller will be to maximise sj by taking as much of the surplus implied by inequality (7). This unknown surplus is M in equation (8) below:

$$M = S - \sum_{j=1}^{n} \frac{R_j}{r} \qquad (j=1,\ldots,n) \qquad (8)$$

Outcomes to this bidding game are not as definitive as in a traditional competitive market. It is possible to replicate competitive market outcomes in bi-lateral negotiations between the single buyer and individual sellers by restricting information on the sellers' side. If each seller is not aware that assembly is taking place then existing competitive market prices for units will referee such negotiations. In this way exchanges will take place and not affect optimal timing. This changes when some or all sellers are aware that assembly is taking place. Though exchange outcomes would be in the core, negotiating with individual owners will be a lengthy and protracted process. Posner (1977) suggests that under these conditions the optimal strategy for each seller is to 'hold-out' in negotiation with the buyer to increase bargaining power. The ultimate objective of hold-out is to be the last one to sell if ownership of the last title is essential to the redevelopment. The last seller would have great monopoly power in exchange. Examination of hold-out seems well established in labour market studies (see McCormick (1969)). In extreme cases hold-out can manifest itself in strikes or lock-outs. There is an end to holdout in wage negotiations because hold-out imposes opportunity costs on both parties. Hold-out defers but does not block agreement, if both parties can gain from bargaining. Similar arguments could apply to title assembly in multi-owned buildings. Hold-out by seller will impose costs on the buyer, partially assembled titles held by the buyer will not yield highest possible return to the redeveloper. There are costs to the seller in hold-out, the opportunity costs of foregoing present money. If these costs are increasing in time there must be an end to holdout, but now the vector of exchange prices will not necessarily be the same as those achieved under competitive conditions and the timing of exchange will be later than under competition. It could be that the risk associated with hold-out may deter a redeveloper from attempting assembly until the difference in (7) is large enough to warrant that risk. If the left hand term in (7) is decreasing in time and the right hand term is increasing, Harvey (1987), then this will defer redevelopment beyond the timing conditions of (5).

Limiting seller strategies to hold-out in the assembly of title may be too restrictive. The potential for cooperative coalitions among sellers also must be examined. Game theory has shown that agreement between conflicting parties can be achieved within certain games. For example mutual agreement on the division of a sum of money amongst more than two people can be achieved by adding the caveat that the donor places a time limit on the formation of coalitions. A successful coalition also must contain all donees. If a coalition is not formed by the time limit the gift will be withdrawn. This is analogous to a potential purchaser being open with all relevant owners in the building. The owner could make an undertaking to purchase each individual unit when an agreement is reached between all unit holders over the division of the as yet unknown aggregate price for the building. When the agreement is reached negotiation over the aggregate exchange price can begin in bi-lateral trade. Game theory shows that, if (7) applies under these conditions, exchange will take place, Aumann (1985). For this to result in a stable coalition of all sellers, the buyer must place a time limit on reaching the division agreement and refuse to negotiate with individuals. The seller coalition will not be stable if individual sellers feel that independent negotiation is a better strategy. This potential failure is enhanced if seller price division agreements require unanimity rather than majority agreement.

5 Conclusion

All buildings will be redeveloped if it is economically feasible to do so and all parties are well informed. Not all buildings will be redeveloped at times which maximises the use of land. Redevelopment timing will be suboptimal in face of monopolistic elements in the land market. Multi-owned buildings of the strata-developed type in New South Wales offer potential monopolistic power for existing owners. Hold-out in assembly is a strategy that could be adopted by such owners in negotiation to achieve a stronger price bargaining position. Delay in redevelopment through hold-out depends on sellers' hold-out costs relative to the buyer's hold-out costs. If such costs are slowly increasing in time, there will be a limit to hold-out, but it could be significant in delaying redevelopment. If a multi-owned building has a joint managing body representing all owners, this body may form a suitable venue for bilateral negotiations between all sellers and a buyer. Such negotiations would reduce redevelopment delay through holdout . These negotiations rely on the use of binding contractual arrangements about fair division amongst all sellers before any joint price negotiations. These contractual arrangements will fail, if any seller can refuse to participate in prior fair division arrangements where the management body does not have majority power.

Given the potential risks associated with assembly of multi-owned buildings, redevelopers may require wide margins between limit prices, wider than those that would be acceptable under normal bi-lateral negotiations. This will defer redevelopment beyond the optimal time, if the capital value of the building to the owners and the capital value of the cleared site to the redeveloper, are functions of time. High density, multi-storey buildings, which provide dwellings, may suffer from delayed redevelopment, if these buildings are subject to multi-ownership. Where such buildings have adopted joint management bodies representing all buyers, these may form a venue for bilateral negotiation. If any individual owner has the right to veto negotiation decisions made by the management body, it is possible that bi-lateral negotiations between sellers and a buyer will fail to bring about timely redevelopment.

6 References

Aumann, R.J. (1985) What is Game Theory Trying to Accomplish?, in **Frontiers of Economics** (eds. Arrow, K.J. and Honkapohja, S.), Basil Blackwell, Oxford, pp. 28–76.

Australian Bureau of Statistics. (1989) **Census of Population and Housing, 30th June 1986, Cross Classified Characteristics of Persons and Dwellings, New South Wales**. Australian Bureau of Statistics, Canberra, ACT.

Bentick, P.L. and Pogue, T.F. (1988) The Impact on Development Timing of Property and Profit Taxation. **Land Economics,** 64, 317–324.

Ham, R. (1990a) The Timing of Building Renewal, in **Building Maintenance and Modernisation Worldwide Vol. One** (ed. Quah, L.K.), Longman, Singapore, pp.259–265.

Ham, R. (1990b) Land Development, Externality and Market Structure, in **Building Economics and Construction Management Volume 1** (ed. Ireland, V. Morgan, D. and Plat, H.T.), University of Technology Sydney, Sydney, pp. 424–431.

Harvey, J.(1987) **Urban Land Economics: The Economics of Real Property**. Macmillan Education Ltd., London, 2nd ed.

Henderson, J.M. and Quandt, R.E. (1980) **Microeconomic Theory: a Mathematical Approach**. McGraw-Hill International Book Company, New York, 3rd ed.

Henderson, J.V. (1985) **Economic Theory and the Cities**. Academic Press Inc., Orlando FLA., 2nd ed.

Hildenbrand, W. (1989) Cores, in **The New Palgrave Game Theory** (eds. Eatwell, J. Milgate, M. and Newman, P.) Macmillan, London, pp.108–116

McCormick, B.J. (1969) **Wages**. Penguin Books, Harmondsworth Middlesex, UK.

Mills, D.E. (1979) Interdependencies in the Urban Land Market. **Journal of Urban Economics,** 6, 1–11.

Moorhouse, J.C. (1972) Optimal Housing Maintenance Under Rent Control. **Southern Economic Journal,** 39, 93–106.

Neutze, M. (1973) Land Prices and Urban Land Market Policy. **Urban Economics Conference**. Centre for Environmental Studies, UK.

Posner, R.A. (1977) **Economic Analysis of the Law**. Little, Brown and Co., Boston, 2nd ed.

Robinson, L. (1989) **Strata Title Units in New South Wales**. Butterworths, Sydney, 4th ed.

Scheffman, D.T. and Markusen, J.R. (1977) **Speculation and Monopoly in Urban Development: Analytical Foundations With Evidence For Toronto**. University of Toronto Press, Toronto.

Telser, L.G. (1971) **Competition, Collusion and Game Theory**. Macmillan, London.

Weintraub, E.R. (1975) **Conflict and Co-operation in Economics**. Macmillan, London.

116
The impact of research on the marketing process for builders

J.M.HUTCHESON

Synopsis
This paper develops a model of the marketing process with a view to highlighting the impact of market research in determining what should be built for whom and when. While the marketing mix is seen by many as the core of the marketing process, the paper shows that the target market and audience are the key elements which are overlooked. The paper concludes that market research is critical to maximising the profits and satisfaction in the Building Industry.

Keywords: Marketing Process, Management of Buildings, Economic Life.

1. Introduction

Buildings are long term assets. The space in buildings is occupied or influenced by people. Therefore, the marketing of buildings is the assessment of the long term needs of people for space. Hence, the requirement for market research is to analyse the long term (imputed) financial return on buildings in terms of their economic life as seen by prospective and actual tenants or owners.

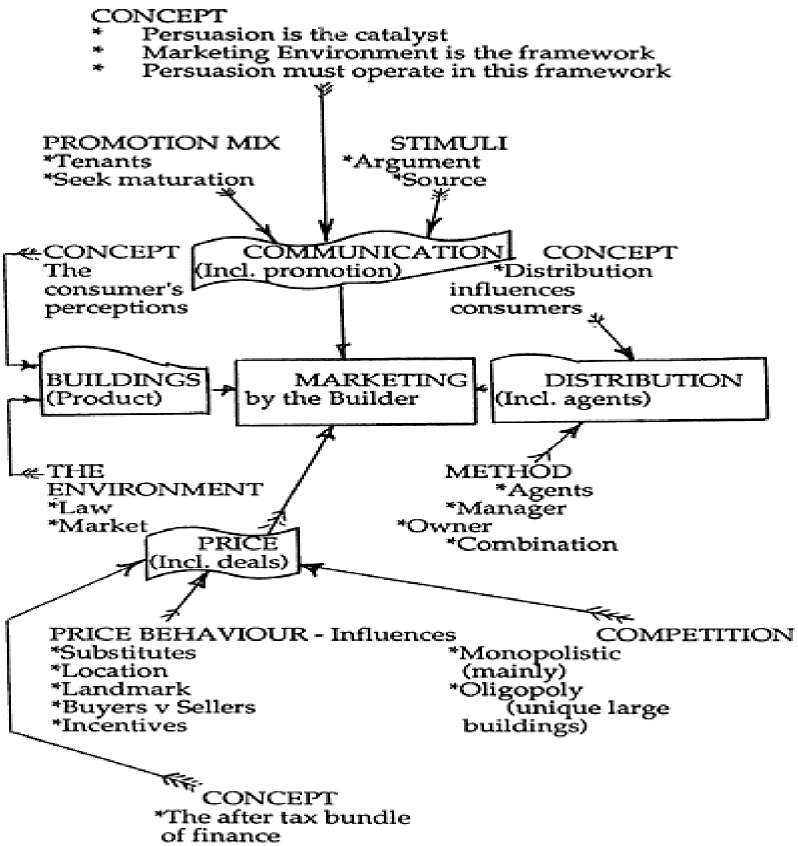
This paper develops a model of the marketing process which incorporates a marketing mix model which correlates the product, price, distribution and communication as they relate to buildings. This theme is developed to indicate that market research determines the design and economic life of buildings as investments.

2. The Marketing Mix

2.1 The Concept

A model of the marketing mix as applied to buildings is given in Figure 1. This model illustrates that the marketing mix is the total package of those elements which have an influence on the leasing and leaseability of space in buildings. Each of these elements will have different influences in different subcultural and geographical sectors. Hence, the need to research the specific spatial needs of prospective and actual tenants to determine the correlation of the specified space in a building to meet those needs. The elements of the marketing mix which are product, price, distribution and communication are described in the following paragraphs.

FIGURE 1—A MODEL OF THE MARKETING MIX



2.2 The Product

The product includes everything that people perceive about space in a building and how that space fits into the building as well as how the building fits into the environment. The space is seen in terms of its location within the building and the building's location relative to the tenants, clients, transport and other facilities including shopping, banks etc. Like most products, buildings and the space in buildings have life cycles. Therefore, there is a need for builders to research the market continuously to maximise the economic life of buildings, and, in particular to establish them as landmark products (viz. always leaseable and saleable).

The consumers (tenants and their clients) have the long term power to accept or reject the building spaces in the market. Each group of consumers is a market niche seeking, or able to be motivated, to occupy particular space. The dynamics of the consumer's wants are compounded by the economic, psychological and sociological aspects of consumption. Therefore, there is a need to research the way that consumers arrive at their decisions to lease space or be clients to tenants who have leased space.

Technology improves and may change buildings. Research is required to ascertain how much of that change is required by tenants and owners. For example, how much of the Building Maintenance System(s), Communication and other high tech facilities incorporated in intelligent buildings are required and will be paid for by tenants in extra rent. The building should be designed and adjusted to suit the current and future demands of the target market after that target market has been determined and analysed.

2.3 The Price

Most domestic, industrial, office and to some extent retail buildings form part of a monopolistic market although some particular buildings may be sufficiently unique to be in an oligopoly. Differentiation in standards of finish, services, management, timing, location, landmark features etc will determine the consumer's acceptance, in particular in monopolistic competition.

Pricing policies are determined by supply and demand interfaced with the other elements of the marketing mix. These pricing policies may incorporate such matters as discounts for cash, rent free periods, gross/net rents, refurbishment, terms, options, rent review, default(s), onus, reconstruction, provision of fitouts etc. Hence, pricing (rent)

differentiation to be considered by the owners/managers in marketing their buildings.

2.4 Distribution

Distribution or marketing logistics associated with buildings takes place in an ever-changing total marketing environment which influences logistics which in turn influences the environment. Logistics may be the effort required by a managing/selling agent or an owner/manager to maximise the long term financial return on a building(s) based on the final "sale" price. This effort will vary with the perception the buyer has of the seller. Some consumers prefer to deal with certain major agencies while others seek a boutique agency or the builder. Hence, there is a need for builders to find out consumers' preferences by research. At all times, but in particular, when the market is deteriorating or flat, there is a need for extra logistics to be employed to influence the environment, so that consumers are attracted to a particular builder.

2.5 Communication

Persuasion facilitates the decision by a consumer (buyer) to accept the product, price and distribution (selling) system to own/occupy space in buildings and remain in that ownership/occupation. Persuasion is not readily quantifiable. Research is needed to ascertain how much communication is required and the nature of the communication which finalises the consumer s decision.

3. The Marketing Process

3.1 Concept

A model of the marketing process is given in Figure 2. It will be noted that the marketing (product) mix is incorporated in this marketing process. Many researchers and authors limit their examination to the marketing mix. However, there is a need to establish that mix from a target market and the inventory of the builder's business which develops or owns the buildings in the mix. There is a danger that the derivation of a mix independent of the target market will result in the wrong mix or a poor compromise.

3.2 The Target Market

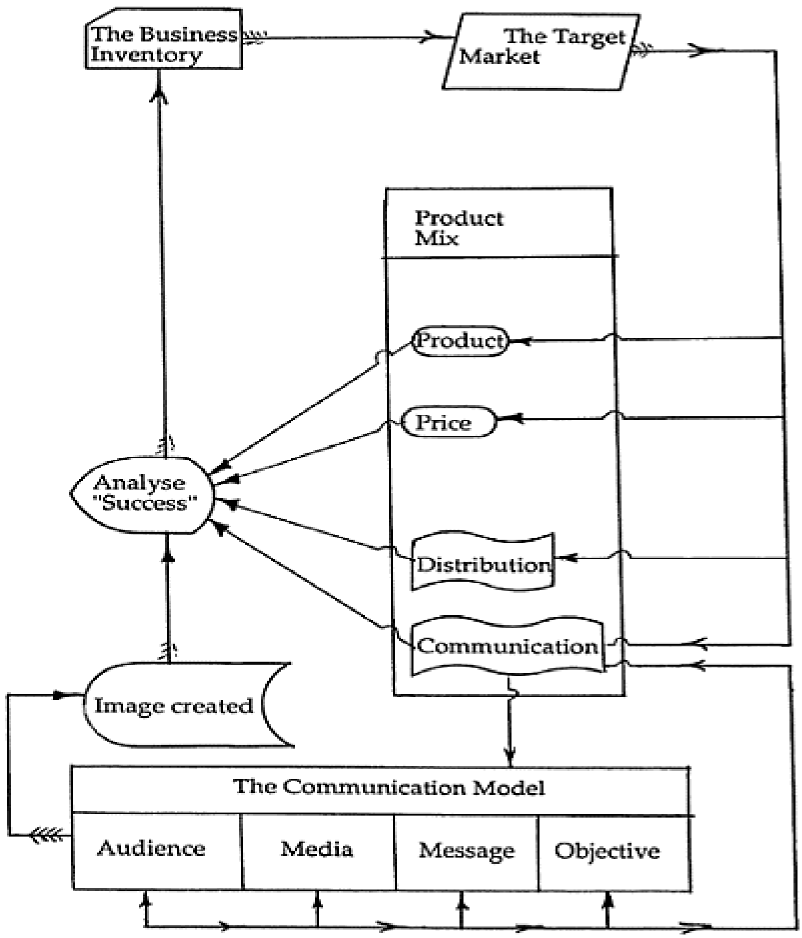
The determination of the target market can only be achieved by valid and reliable research. Until that target market is ascertained, the product mix cannot be determined accurately. Therefore, it is a fallacy to consider that marketing is composed solely or the product mix. The business inventory is composed of such elements as the builders' perceptions of the market, their goals, their financial exposure, attitudes to change/research, experience, history etc. In spite of and because of research there is a balance established between the product mix, the target market and the business inventory. This balance, in particular the target market, should have an influence on each of the four segments of the product mix.

3.3 Communication

Communication which optimises the costs in gaining and maintaining tenancies is guessed by many builders rather than researched. One of the reasons for this situation is the cost of effective research. As shown in the communication model, communication needs an objective which is engrossed in a message to be promulgated to the audience within the target market by an effective media. These four items within the communication model are very closely related to themselves and to the target market. A critical example is the audience viz who really makes the decision to lease or buy buildings—the property officer, the chief executive or the chairman's wife.

Often the message is contained in a brochure which is used to blanket contented owners in existing buildings. This tends to be a futile and expensive exercise. Therefore, research is required to find the target market and its audience. The Commercial Economic Advisory Service's Survey revealed that the expenditure on advertising in Australia in 1989 was as follows: newspapers (41.8%), magazine (8%), television (33.1%), radio (8.8%), outdoor/transport (6.9%), and cinema (1.4%). Such macro data is almost irrelevant to the selling of space unless the effectiveness of each media is assessed against a spectrum of available space. Classified advertising in newspapers increased from 21% (1976) to 35% (1983) and 41% (1988). Hence,

THE MARKETING PROCESS



the apparent current saturation of the press with ineffectual copy.

The marketing process is a dosed loop system in which the elements of the communication model feed back to adjust the segments of the product mix. At the same time an image of the building(s) is being established by the key player, the audience. Analysing the success of the marketing process in long term financial terms involves continuing the loop by ascertaining the effectiveness of the management of the asset (building) in leasing up and retention of appropriate tenants with a view to meeting the needs of buyers. The process is continuous. Therefore, those who form the builder's business inventory need to adjust to changing markets and adjust their analysis to the existing success or lack of success in selling or leasing their product (mix).

4. Case Studies

4.1 Industrial Building—Modifying for Sale

A well designed and constructed industrial building with about 30% office space and good car parking on the edge of a major suburban office precinct was placed in the hands or three major property agents for sale. One of the agents co-ordinated promotion of the property. All agents agreed with the rent, leasing terms, eight page brochure, newspaper copy and placements. The agents distributed four thousand brochures and selected the dates and advertising location in the newspapers. Over a three month period no prospective buyer, indeed no-one inspected the building. Over a further three months these "order-taking" agents found no-one to even inspect the building.

The owner-manager sought new advice at the end of the first three months. He, then, reacted by appreciating that the product may need changing once he had a response from an audience within the target market. Secondly, that research was required to find the target market within a blanket of mailing lists to high-tech businesses etc to narrow down who really needed space. Thirdly, a personal letter was sent to the apparent audience together with a four page folder/brochure which could be "scan" read. Fourthly, the telephone was used to contact each of the selected potential tenants. A tedious but rewarding task which modified the selection of the audience within the target market was made and a viable buyer found.

The ultimate long term buyer occupied the existing space and the building was modified to suit their long term needs. Hence, this builder has reacted to market research not "order-taken" hunches.

4.2 Industrial Building

This second building has five units of industrial space. Three with ten percent office component, one with twenty percent and the fifth with thirty percent. This building was completed at the beginning of the 1990's downturn.

The builder, in conjunction with a property (land economist) consultant, carried out market research to ascertain appropriate rents, tenants and rate of lease/sale. Segregations within this monopolistic market were very difficult. Hence, the research sought the consumers' expectations in terms of space and price. Based on this research, the third step was to seek tenants to occupy each of the units. Fourthly, the building was adjusted in accordance with the terms of the lease options, together with some minor capital improvements to enhance the building as a landmark. Consequent upon finding tenants for the building a buyer was found. The resultant return is twenty percent higher than the builder's original expectations.

4.3 Office Building

A high rise office building was built two blocks from prime office space. The services and the finishes were consistent with the precinct. The building could not attract a buyer at cost price at the beginning of the 1989 slump. There is a need for the owner to consider the marketing process, and research to find the true target market and the product mix that the target market wants. Then continue the research to develop the communication model and hence find the audience which will indicate the image they require of the building. Only after this research should funds be expended to sell this asset in the market place.

5. CONCLUSION

The three case studies are simple examples in the utilisation of market research in the sale of buildings. Other case studies are available against which the Model of the Marketing Process can be used, evaluated and developed. Likewise, the Marketing Mix Model can be used, evaluated and developed. Research is required to develop the design and target market the audience of buildings for sale/lease. Thereby, removing the hunch designs and order-taking managers who survive in booms and fade away in property busts. The maximisation of the financial return on buildings as assets with long term economic lives is determined by market research rather than the "Luck of Boom(s)". Find the market, then build and sell/lease the asset.

117
Risk analysis in economic evaluation for residential building projects

J.da ROCHA LIMA Jr

Abstract
When using deterministic models, economical analysis for residential developments define performance indexes. These provoke decision making at a risk level much higher, than that which is apparent when manipulating these models. This text discusses, in its general sense, the concept of risk analysis, and then, in sequence, using a computerized model and a {CASE}, speculates about its capacity of supporting, within conditions valid for the Brazilian economy, variances in its behaviour variables, stressing the factors that have the most influence in the development's risks. In developed economies, with more stable conditions, this analysis will continue to be valid, since, for obvious reasons, the risk factors will be fewer.

Keywords: Real Estate, Economic Evaluation, Risk Analysis, Housing Projects.

1 Foreword

This paper is a short summary of a monograph, specially prepared for the symposium, which is 140 pages long in its complete version in Portuguese, previously sent to the event's co-ordination.

All economical analysis must be subjected to a critical procedure, since, although expected situations are handled, they will have, during the course of action, their own conduct. The outcoming variances will result in different performances than the expected ones. What is necessary to know beforehand, in order to decide, is, what will be the relationship between the deviation levels and the development's loss of quality.

Nevertheless, the go ahead decision can only take place when the developer accepts the hypothesis that he has the capacity to control the variables that might provoke the biggest behaviour deformation, whitin limits that will not compromise the required minimum quality. This is not always manageable, because certain conjunctural variables cannot be manipulated at will, such as inflation factors and market behaviour. In these cases, risk analysis is even more important than ever, since, through it, we will determine the protection mechanisms, necessary to guarantee the required minimum quality for the development, such as, performance bonds for construction costs and indexation of sales contract's payments.

2. Risk analysis in its general sense

Economical analysis consists of a simulation process, that has to respect a specific configuration, that comprehends three basic elements:

.**Performance evaluations,** represented by **performance indicators,** which will be the result of the simulation process. With this indicators, that also analyse risks, the decision making is done.

.**The model,** which is the simulating tool, is composed of a organized set of mathematical relations, representing, in a simplified way, the different financial transactions that will occur during the project's course.

.**The scenario,** in which the behaviour expectations of the conjunctural and structural variables, required by the model for processing, are present.

2.1. Support capacity

Risk analysis will result from consistent criticism of the simulation process, resumed in the two following steps (Through the scenario and the model, the result indicators will be reached. These will, alledgedly have, a deterministic charatcter, but shall suffer mutations, for the simple reason that reality, necessarily, will diverge, from what was simulatively established):

a. Description of the probable performance indicators distortions, on account of introducing, within the simulation model, simplifications, to determine how to overcame, bypass or limit them, by adopting specific protection mechanisms or managerial procedures.

b. Evaluation of alternative performance indicators, if certain variables' forecast, established in the expected scenario, are not confirmed.

Assuming that the simulation model has the required quality, the procedure described in **(a)** shall result in implementing managerial postures for control.

Insofar as **(b),** a very primary reasoning shall lead to the conclusion that it would be enough to stretch the scenario forecasts to more adverse positions, in order to have the performance indicators showing what the risk conditions are. However, nothing is more incorrect, specially in the Civil Construction sector, since, there are no ways of establishing a pessimistic behaviour pattern with sufficient technical quality, because, even the diverse expected conditions for the variables are low quality, fluctuating greatly. Therefore, there will always be criticism, whether the intensity of the deformation was enough, as to offer a certain standard of confort for decision making.

On the other hand, how shall the decision be reached, when analysing the performance indicators? Comparing the expected results, measured by these indicators, with boundaries previously defined, characterized as follows:

.In order to invest, whatever the developer understands as "conditions without risk", will position the indicators in its point of minimum performance (ex. in {CASE} I use minimum attractive rate of return [mrr]=12% y). Minimum performance standards.

.How will the developer guide himself, in relationship to its minimum performance expectations, considering the economy sector's structural risks (ex. in {CASE} I use minimum sectorial attractive rate of return [msr]=40% y). Sectorial performance standards.

.What was the performance of other developer's projects already finished, or that are being compared with the one under analysis, as alternatives to choose from. Companies wish to perpetuate their success stories, through continuous repetition of their best performances, that will, always, tend to appear as minimal proposed goals. Minimum desired performance standards.

If the decision, taking into account the risk analysis, is based on those performance standards, then, its aim will be to show the developer in which situations, with what sensitivity and with what speed, the performance indicators tend to shift, from their expected points, to the boundary position. This processing implies in working the simulation from its outputs (performance indicators), in order to discuss the state of the variables that produce said outputs. The simulation is processed bottom-up, and the risks identification will be associated to the development's sensitivity to absorb changes in the behaviour variables, that will take the indicators to their limit positions. This procedure I name analysis of the project's **support variance capacity {SVC}**.

{SVC} will be connected to each particular behaviour variable. We have to analyse each chosen variable in an isolated way. Their choice will be linked to the expected information quality, existing in the scenario, as well as, previously, identifying its influence in the development's performance.

It will be, thus, characterized how each variable influences the development's behaviour and, these informations, will allow the developer to make a go ahead decision, which means to undertake risks, however not in a passive way. The {SVC} will be the principal induction of how the development's managerial and control system must be. Once the analysis is processed, we verify that :

.Performance is less affected by certain variables, which signifies that they can suffer greater stretches, in order to provoke significant quality losses, pushing the project's results to extreme positions. Over these variables a **"flash"** control system has to be installed. This system measures the variables during the construction period and releases a correction process when the deviation enters in the **"flash control zone"**.

Other variables, that could be called critical, through analogy with network programming methods, are those to which the project’s performance sensitivity is great. Little distortions alter significatively its performance. For these, **“monitoring”** systems of control have to be installed, in such a way that, any course deviation will feedback the programming system, looking for behaviour adjustments and corrections.

3. The Model and the {CASE}

It’s my understanding that the discussion of certain influences becames richer, when associated to an example, hence, the {CASE}.

I don’t describe the model in detail, not even its input/output matrixes, with the exception of some performance indicators (Table 1), that have to be used for the {SVC} and risk discussions. Fig 1 shows all financial transactions, considered for the construction of the different cash flows, through it the model measures the performance indicators.

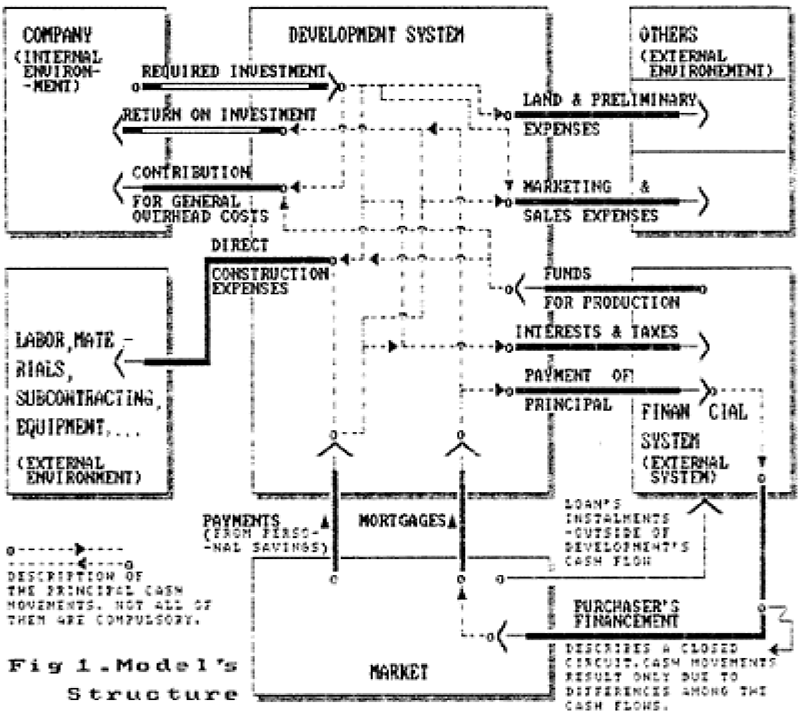


Fig 1-Model’s Structure

I use the {CASE}’s {SVC} analysis exclusively to enhance for which variables the developments, in general, are more sensitive, that is, have lower {SVC}.

Table 1 contains the performance indicators, delivered by the model, taken in accord with the expected scenario's variables behaviour.

Table 1 Performance indicators for {CASE} project

Performance Indicator		values in [UM 1 000]	
Total Sales		14 592	TOS
Construction financement amount		6 370	FIN
Production costs		(9 712)	TOC
Net sales revenues		13 064	NSR
Expected Profits		3 352	ROP
Required Investment		3 531	INV
Return on investment		(6 883)	RET
Financial leverage	TOC/INV	2.75	alv
Profit on sales	ROP/TOS	23.0%	ros
Profit on investment	ROP/INV	94.9%	roi
Rate of return (% y), measured under the "restricted rate" concept (mrr=12%y)		56.8%	rrr
Pay back for INV (months) .according to purchase power increase,			pri
stable		19	prz
increased of [mrr]		19	prc
increased of [msr]		20	prt

The most relevant aspects of the scenario and the {CASE}, that will allow to speculate over the risks, are :

.The {CASE} is a 96 unit building, with an 13 246 m2 area of construction. Direct construction costs [DCC], and others, such as, land [LAN], marketing [MKC] and sales [SCO], are within market standards, and the analysis is done, using a standard currency designated as [UM]. Indirect costs, company derived, correspond to a certain rate over direct costs [mca], as contributing margin for overhead costs payments.

.The general program for developing the project includes pre-operational activities that will require investments, be it in construction or marketing.

.Sales are divided in two volumes, in order to facilitate risk analysis; one (80%), with a sales program during construction and another (20%) stock, which will be sold only after completion.

.Production will be financed with a flat rate [t=4.5%] and a monthly payed interest rate [j=12% y]. A portion of the sales price will be financed to the buyers, through a purchaser's loan, that will generate a mortgage for payment of the production financing principal.

.The expected scenario defines that the price will be paid (24%) during construction and (76%) financed. These percentages are previously defined, taking into account the payment capability of the target market.

.The scenario for the economy considers a detachement between the inflation rate for the specific sector (with incidence over [DCC] and [mca]) and the global economy inflation rate (which reflects on the purchase power of the currency [UM]), [delta=9.4% y].

4. Risk in developments—An exploration of the {CASE}

The risk factors, that have to provoke the most startling reflexes in the performance are shown in Fig 2.

I will show in this chapter the {CASE}'s behaviour for some parameter deformations of the expected scenario, through some graphics. Their shape shows a trend that can be generalized.

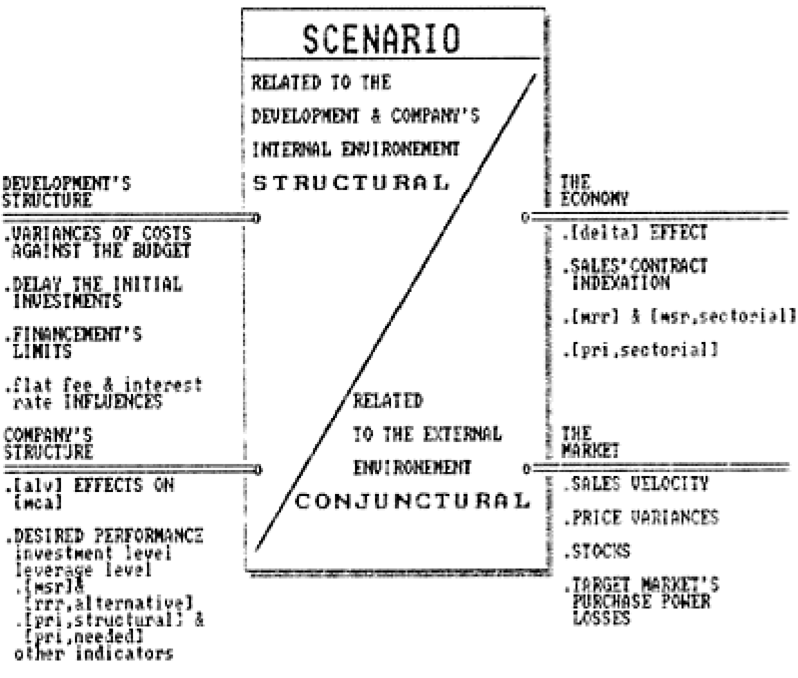


Fig 2 .

This possibility of generalization, means that the risk factors, that in the {CASE} are most sensitive, will probably behave exactly in the same way in other housing projects. The reader should look at these curves in order to distinguish the most important factors that influence the development's performance. When analysing other specific cases, the same factors should be the foremost to worry about, without leaving aside the other scenario parameters, since the particular case being analysed by the reader, might suffer other types of perturbations. In principle, **"everything must be object of criticism, specially those parameters that the planner understands that are defined with less quality, in the expected scenario"**.

4.1. The economy—[delta] effect

The [delta] factor is described in the scenario as the measure of detachement between the sector's inflation rate and the inflaction rate that affects the purchase power of [UM]. As the analysis is processed in a stable currency [UM], without inflationary effects, [delta] will act over construction costs, provoking in {CASE} an increase of (9.4%), wich represents (16%) of profits [ROP]. Development's, in general, with a low [alv], don't have in [delta] an important risk factor, however, for those that finance amounts, that, traditionally are investments, such as land and pre-operational costs, will be more influenced. In {CASE}, the flash control zone for [msr] considers a [delta]=25% and for [mrr], (53%), therefore signalizing a high {SVC}.

4.2. The economy—Sales contract indexation

There exists a strange paradox that allows entrepreneurs to work, in certain underdeveloped economies, with less risks than in the developed world. In those economies, which use, either strong currencies (ex. dollar), or "parallel currencies", automatically indexed, contract payments are simultaneously adjusted to inflation, in such a way that inflation forecast, in itself, within the expected scenario, will not be a risk inductor agent, besides [delta].

If this possibility does not exist, the risk can never be analysed. It can be bypassed by: producing first, in order to sell once ready, then lowering [rrr], or transfer ing the risks by insuring, previously, the construction costs, before sales take place.

4.3. The economy—[mrr] & [msr]

The entrepreneur and not the planner is responsible for defining the "zero risk conditions", [mrr] is a function of conjunctural phenomena of the econony, in such a way that, in sectors where pay-back is usually long, like in real estate ventures (in {CASE}, [pri] is in the last month), a [mrr] used to decide the go ahead in a specific venture, might not be enough, since by the time of completion, the entire economy has changed. For [msr], the phenomena of the economy have an identical influence, moreover combined with liquidity factors of the market. These risks are impossible to bypass, unless, deals with very low investment cash-flows are found, wich will result in very high [rrr]. In this case other risk factors will intervene.

This is one of the vectors that explain why the sector is so vulnerable to speculative capitals.

4.4. The economy—[pri, sectorial]

Pay-back for investments in this sector oscilates very little and its directly connected to mortgage generation and payment of production loans. Trying to enhance this performance, might provoke risks, because it will be done at the expense of lowering investments: marketing deficiently, lacking quality in planning, searching for ways to delay initial investments, balancing them out with, wishful thinking non existing sales, or even dreaming with a market reaction much powerfull than the existing one, specially with respect to payment conditions.

4.5. Development's structure—actual costs variances in relation to the budget

It's obvious that the biggest influence in generating risk conditions for the development lays on the direct construction costs, wich has the highest weight in pricing. In {CASE}, direct costs, including [delta], represent (66%) of total costs and (51%) of price.

The cost of construction does not originate in its budgeting, which is just a cost control standard. Costs have to be monitored and the [delta] effect account, which cannot be monitored (it derives from inflation), will be agregated in the miscellaneous account. This special account, must be created in order to absorb structural variances, wich result from the oversimplifications that the budget presents, regarding the actual costs. Fig 3 shows the behaviour of indicators from {CASE} ([rrr] and investment increase [inag]) for budget variances [bvar] **(1)** and alterations of [mca] **(2)**.

4.6. Development's structure—delay initial investments

This procedure alters [pri], rising [rrr], but risks are extremely increasead, because the entire venture will be dependent upon sales cash in, in order to guarantee the required funds to fulfil with the delayed investment parcels. This is a high risk attitude, only admissible in speculative deals.

4.7. Development's structure—limits of financing

Traditionally, financement in this sector is limited to construction costs, as in {CASE} example.

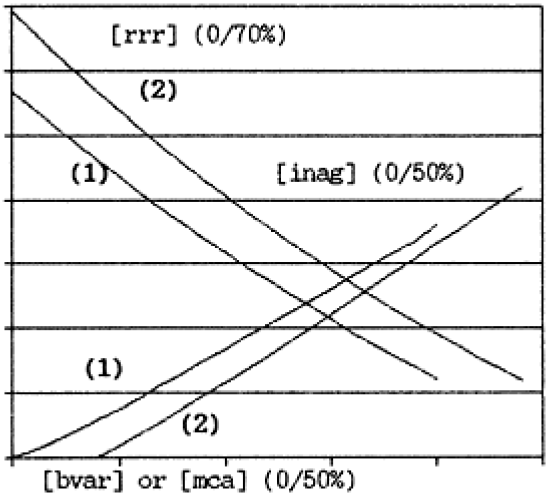


Fig 3

However, these amounts can be raised, allowing investment extensions and, therefore, increasing [rrr]. In this cases, there is nothing to analyse with respect to risk, since we will be in the same situation as refered in 4.6.

4.8. Development's structure—flat & interest rate's influence

When [alv] is augmented, because of financing increase volume, the rates envolved will eat up part of the profits, however, [rrr] will be bigger, because financial costs are under [rrr, expected scenario]. Insofar as risk evaluation, 4.6. and 4.7. are valid considerations.

For ever growing rates, the venture only loses quality if [rrr] gets closer to the financing effective rates. This situation allows a big margin of confort to define the "flash zone", for control purposes.

4.9. The Market

Sales velocity [velov], prices markdown, loss of purchase power of target market, are the factors of major sensitivity in real estate ventures, and, somehow, there is a feedback mechanism, which closes a loop among them. In this topic, risk analysis has to deal with isolated effects, to reach, later on, conclusions, that will determine de "flash zones" for commercialization. Obviously, there is, absolutely no way, to create monitoring systems to control de market.

Fig 4 illustrates one of the risk analysis stages, in {CASE}.

This graphic shows how [rrr] behaves for raising stock volumes [svo] and stocked unit price discounts [dpr]. The high risk envolved, agravated by the fact that cannot be monitored, is evident.

Without taking into consideration [velov] variances (play with different [velov] would be a false procedure, because of the unforced low quality of this parameter), the best way to analyse these type of risks, envolves four steps:

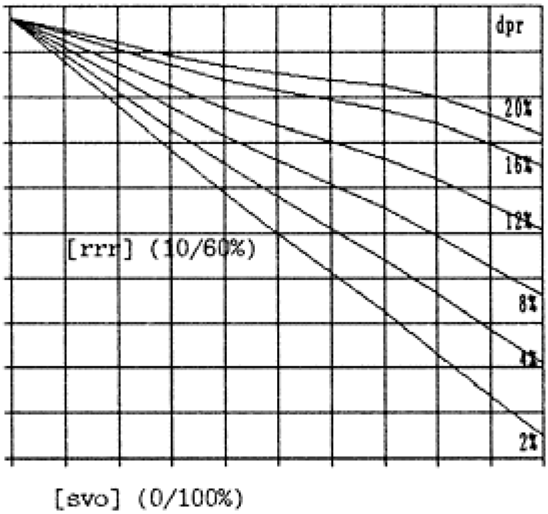


Fig 4

.raise the stock volume, selling without price discounts.

.within the expected [velov], sell with price discounts, reflected in payments

.all sales are processed as stock, with discounted prices (Fig 4)

.within the expected [velov], sell with price discounts, reflected in mortgages

These topics analyse risks, from the following view points:

.loss of liquidity during construction, recovered close to end of construction

.market prices markdown, beeing the developer obliged to follow the trend, in order to mantain the desired liquidity

.extreme commercialization condition, that measures the development's {SVC} for [velov]. Price discount has to be understood as a price markdown, or the financial cost to transform future payments in present cash values.

.target market loss of purchase power, that will indicate the capacity to absorb a lower purchaser's financing.

4.10. Company's structure

Under this view point, instead of risk analysis, I formulate two recommendations, insofar as risk introduction, on account of developer's behaviour errors:

> .Using as a departure point, the estrategic definition of the company, insofar as its investment's capability and policies, a prodution capacity is defined. From this definition, derives the company's structure, with its costs, that will help establish the [mca] rate and the desired ventures' [alv]. If that production goal is not achieved, the defined [mca] rate will be low, then, all development's profit calculations are false, because a part of them will be used to pay overhead costs.
>
> .Attractive rates and, specially, pay back periods, characterized under the sectorial view point, can, hardly, be improved, because the supply side action of this market is pulverized. To plan [pri] or [mar] too far off the sector standards, belongs to the realm of fantasy, or great speculation, that happens with complete lack of risk control.

5. Final words

.Decision process in each company is very particular, and characterized by its culture. Simulations and models must respect this culture, not the planner's !

.Economical analysis using deterministic models, acquire a certain probabilistic character, through decision making based on risk analysis. This character is conditioned by the culture of who decides.

.Risk analysis have (as all planning procedures), only the capacity to generate information. The planner should not decide and not even induce decision. Only he, who runs the risks, should decide.

.There is no risk analysis theory. I accept that some principles exist, and, in this paper, in a very short summary, I have set forth some of my principles, that I assume can be generalized. In the monograph that originates this summary, the speculations are much deeper and the {CASE} enriches several concepts.

.Each decision maker, has the possibility to choose his own roads and principles, this done within his risk standards.

Sao Paulo, february, 1991

118
Housing in Turkey: a case study, Batikoy, Istanbul

B.KARATAS

Abstract
Turkey, is facing a serious housing problem awaiting urgent solutions like many other countries in the developing world. Its population is over 55 million and urban housing demand is 400.000 dwelling units per year. Approximately, one eighth of the total population live in Istanbul that is the largest city of the country. The demand for housing continues to exceed the supply and the imbalance between needs and services is growing every year. Various models of housing has been tried during the last three decades to solve this problem in Turkey, especially in big cities.

This paper reviews the current state of the housing in Turkey and presents the Batikoy project as a recent and typical example of the large scale housing projects linked to a large city, Istanbul. Its successes and failures on the base of location, organization, technology and financing are discussed and the conclusions derived from this evaluation are stated.

Keywords: Housing, Large Scale, Mass Housing, Housing Act.

1 Introduction

The fast increase of population, industrialization, migration with the employment expectation in cities and mechanization in agriculture have caused a housing defficiency in Turkey that becomes a matter of growing concern every year.

The population increase is 2.16 % per annum. Although housing is one of the basic elements in the development of human settlements, the number of units which may be produced annually is limited by the resources of the construction industry and the available credit facilities. Therefore, the speed of housing construction has always lagged behind the demand. To overcome this def ficiency, annual average speed of housing construction must be increased to 400.000 housing units.

2 Housing policies implemented in Turkey

Although the housing problem in Turkey has gained momentum in the 1950's; the basic policies leading to partial solutions had been implemented up to 1960's. These policies are mentioned below:

Regulation of urban growth
Regulation of housing standards
Increasing housing supply
Upgrading of the sub-standard dwellings.

In 1981, the Mass Housing Act was enacted (no.2487) with a view to reduce housing costs as far as possible, to provide minumum standards in area utilization, infrastructure and structure, to contribute to financing of housing.

Mass Housing Act also provided such as;

Land; land needed for new settlement will be designated and confiscated by the state or local authorities.

Land development; The Ministry of Reconstruction and Resettlement and the local authorities will prepare the partial plans for the proposed settlements on the confiscated land. Developed land will be distributed among the Ministry, cooperatives, union of cooperatives and social security institutions.

Building construction; Building will either be constructed by the state or the private construction firms on condition that the lower limit of the number of houses must be 200 dwelling units. Later on this limit has been reduced to 7 units for cooperatives.

Finance; Each year at least 5% of the State Budget will be allocated to the 'Collective Housing Fund'. Furthermore, the national deposit banks will provide credits for the savings accounts opened for this purpose (*).

The Mass Housing Act. enacted in 1984 (no.2985) suppercided Act no. 2487. The Mass Housing Act. (no.2985) is effective today and it is an important step towards the formulation of consistent housing policy. Following the Act. the Mass Housing and Public Partnership Administration was formed as a body responsible for the allocation of the fund to housing projects. The credit resources under Act. no. 2985 were exclusive taxes on fuel and state monopoly goods such as tobacco and liquor, duties charged upon travel abroad, levies on Treasury bonds and structures constructed on Treasury land, direct credits to the Fund, and levies on products imported by the state monopolies. Repayments for Fund loans will go directly back to the Fund itsel.

* Ayan, M. (1984) Housing policy in Turkey and the future of mass housing act. Seminar procedings, I.T.U. Istanbul Turkey.

With the establishment of the new leqistative framework in 1984, important improvements have been recorded from organizational and financial points of wiew.

3 Batıkoy Project

Batıkoy project is being realized in the Buyuk çekmece district that is located on the European part of Istanbul City. It is 30 km. far from the city center and one of the recent examples for the large scale housing projects developed in Turkey.

Aiming the creation of a satellite town, Batıkoy was planned on a land covering an area of 250 ha. It is being developed for meeting housing requirements of 72000 inhabitants in 18000 dwelling units. Parking, shopping and educational facilities (kindergartens, primary schools and high schools), green areas, playgrounds, parks, health center, cultural center are all provided for the residents,

The construction of Batıkoy project started in 1989 and will be completed in 1993. It is financially supported by the Corporation of Real Estate Bank and the investment opportunities of the private enterprise. Using advanced construction technology, mass production, faster construction and standardization are aimed.

Since the land was purchased ahead of use the elimination of the speculative prices in the provision of land will reduce the cost of housing units.

As Fiscal policy applied for selling the houses; when the houses are completed, the prospective owners are asked to pay at least 25% the estimated cost of dwellings in a certain time. At the end of this time they will be allocated a house. The rest of the price will be paid as a credit. Repayment of the loan will be made in 15 to 20 years at 25% to 35% interest rate depending on the size of the dwelling unit.

4 Conclusions

Batıkoy has been planned in accordance with the basic principles of the Master Zoning Plan. The main principle, besides housing the people, is the provision of an isolated area from heavy traffic creating opportunities for recreation and sports. It was planned and implemented within the general framework of the effective Mass Housing Act (no. 2985) that helps to solve the housing problem in Turkey. The precise comments about the success of this project will be given in the coming years after the project is being implemented completely and the houses used by their owners.

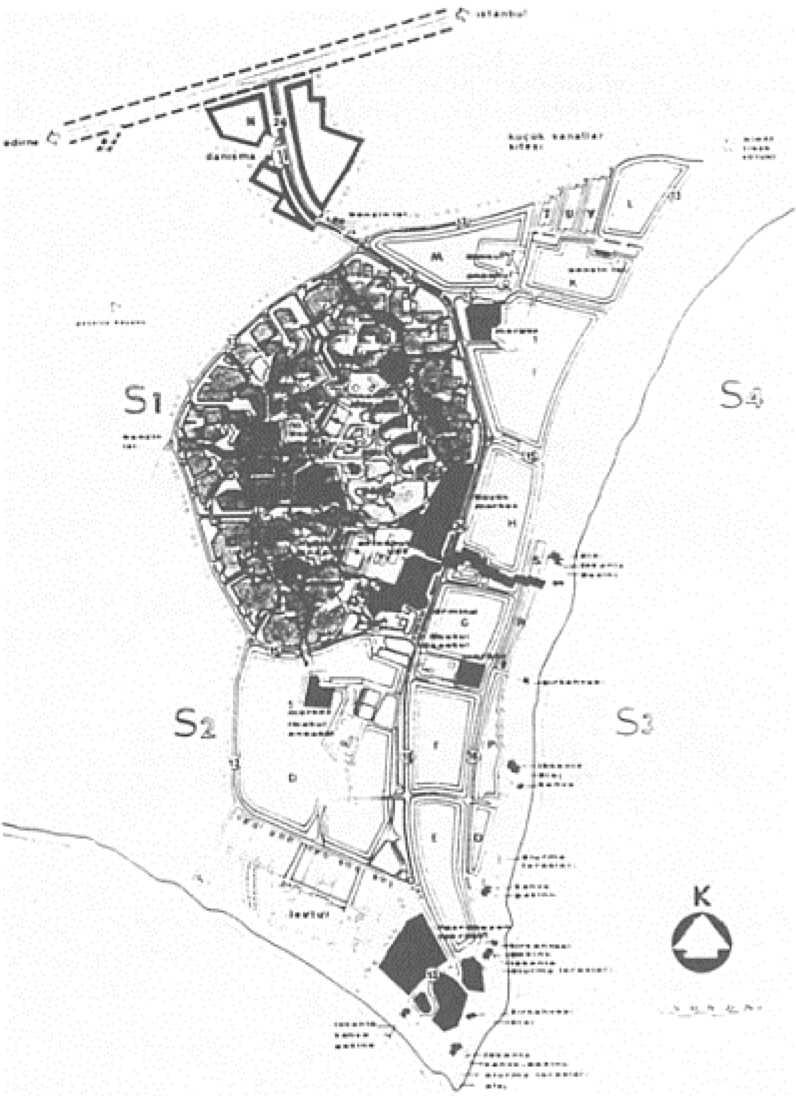


Fig.1. Site plan of Batıkoy

5 References

Ayan, an, M. (1984) Housing policy in Turkey and the future of mass housing act. Seminar proceedings, I.T.U. Ist., Turkey.

Prime Ministry, State Planning Organization (1986) Fifth five year development plan.

Sinankent A.Ş. (1989) Batıkoy project documents.

119
The determination of demand and location for hospitals

B.KARATAS

Abstract
This paper is a part of the research project proposes a methodology generated for the new general hospital facilities. Before making any decision relating to the expansion of the existing facilities or having new ones, the health care demand of the community and the respective locational efficiencies of the existing facilities must be known. This has been the major consideration in the preparation of this research. The study is presented in the following parts.

Firstly, the problem and the objectives are introduced. For the accomplishment of the specified objectives; the data requirements, the size of the study area and the assumptions for the proposed methodology are also outlined in this part.

Secondly, the general structure of the model, that can be applied to the evaluation of the existing general hospital system and its growth in a given area, its steps and substeps are explained and the conclusions derived from the methodology and its application are given.

Keywords: Demand, Location, Hospitals, Patient Origin Areas, Accessibility Measurement.

1 Introduction

An efficient health service system is one of the major challenges facing societies and the demand for a uniform system is increasing continuously. It was shown that this need cannot be satisfied merely by expanding the number of facilities at the most rapid rate possible. Due to the complex interrelationships of a comprehensive health care delivery system, hospitals have to be viewed in relation with the overall system and to meet the increasing demand, the productivity of the system must also be increased by making better use of available facilities.

2 The Basis of the Analysis

The problem is to determine the bed need and locations of the new general hospital facilities in a given area. As it can be followed from the Fig.1., the general structure of the model consists of two main steps.

The first step is devoted to the determination of the general hospital need. The evaluation of the existing general hospital system and the planning of the new hospital facilities distribution are carried out in the second step.

2.1 The Objective of the Study

The main objective of the study is the evaluation of the existing general hospital system and the planning its growth in a specified area. The following are the component objectives.

The determination of the health care demand of the area according to its social, demographic and economic characteristics.

The definition of the population that is not served by the existing general hospital system in the area. The control of the distribution of the existing facilities to obtain a better distribution model.

2.2 Data needed

The following data is required for the accomplishment of the objectives.

An inventory of an urban area with an existing network of the general hospital facilities for a base year. The population of the study area and its patient origin areas and their projections for a specified future year. The subareas are called as “patient origin areas’. The social and economic characteristics of the population in the patient origin areas for a base year. The travel distances from each patient origin area to each existing general hospital in the study area.

2.3 Assumptions

The following assumptions are made in order to achieve the analysis .

The city level is defined as the study area and its districts as the patient origin areas. All the statistical data are collected for a base year and the analysis is carried out for a specified future year. The size of the general hospitals in the study area are different from each other and the size or the capacity of any hospital is not limited.

The quality of the services which are provided by each existing hospital in the study area is the same, but

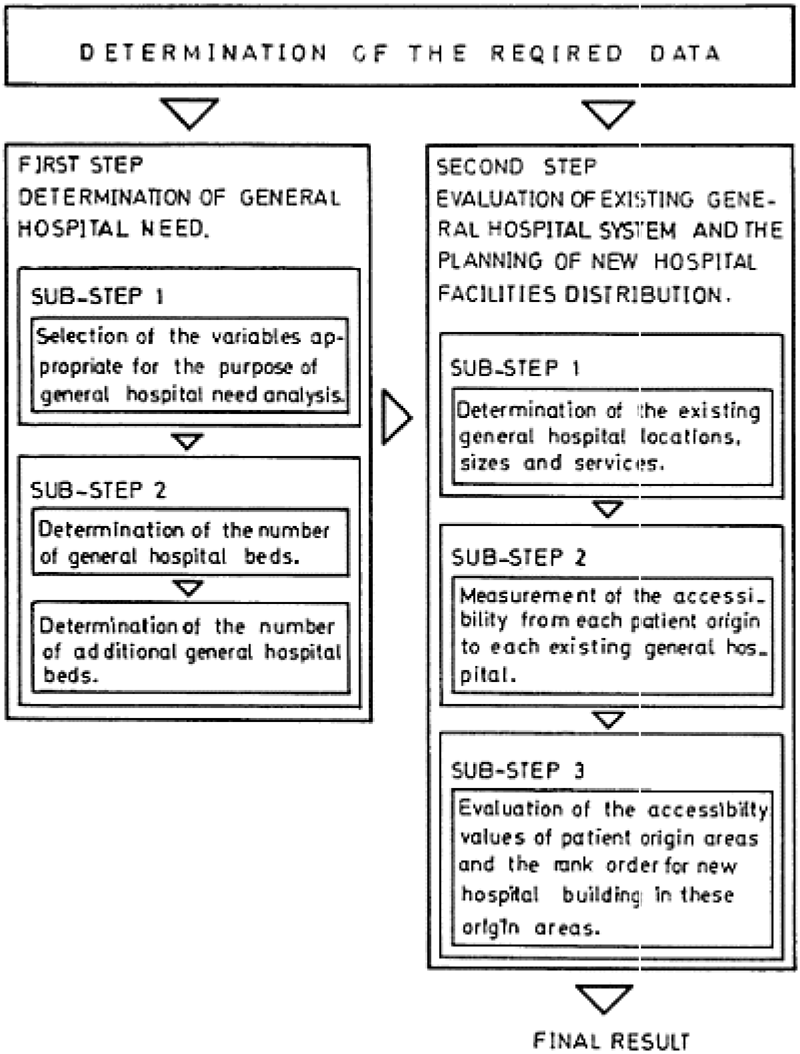


Fig.1. General structure of the proposed methodology

their numbers are different.

This study determines the approximate areas for the general hospital facilities and the general hospital locations are determined seperately according to the locational criteria.

Travels from or to the hospitals follow the shortest distance, and the travel distances from patient origin areas to the existing general hospitals are measured on the official road maps.

3 Formulation of the proposed model

3.1 Determination of general hospital need

The demand, or general hospital utilization, is assumed as a function of numerous factors, such as socioeconomic status, educational level, age, urbanization, etc. This relationship can be formulated in the following way:

$$Y=f(X_1, X_2, X_n) \tag{1}$$

Where:

Y = Health status or hospital utilization,

$X_1 \ldots x_n$ = Area characteristics.

(1) can be expressed in linear multiple regression equation.

$$Y_i=a+b_1X_1+\ldots+b_nX_n+e \tag{2}$$

Where:

Y_1 = Hospital utilization in area i,

$X_1, X_1 \ldots X_n$ = Characteristic variables in area i,

a, b = Parameters of the hospital utilization,

e = Some error variable.

3.1.1 Selection of the appropriate variables

In this substep, the variables to estimate the hospital utilization are investigated. Since the numerous variables create difficulties, here, the following three criteria are taken into consideration in the selection of these variables? firstly, its popularity in the literature, secondly, observed relations between each variable and hospital utilization, and thirdly, its suitability with the area character.

The variables selected for the analysis:

Y_1 = Number of hospital admission per 1000 population in a given area,

Y_2 = Average length of stay in hospital for a given area.

Independent variables:

Sociodemographic variables:

X_1 = The population of each patient origin area,

X_2 = The percantage of population over 64 years of age,

X_3 = The percentage of population under 15 years of age,

X_4 = The percentage of females who are married,

X_5 = The percentage of population 14 years of age and older that is male,

X_6 = The percentage of population that is illiterate,

X_7 = The percentage of population living in urban areas,

X_8 = The population per housing unit.

Economic variables:

X_9 = The percentage of population living in houses that have less than two rooms,

X_{10} = The percentage of population living in houses that have five rooms and more,

X_{11} = The percentage of population with insurance .

The values of dependent and independent variables in the patient origin areas are determined and listed on Table 1.

Table 1. The values of the variables

Patient origin areas	Variables
	Y_1 Y_2 X_1 X_2...X_n
I_1	
.	
.	
.	
.	
.	
.	
.	
.	
.	
.	
.	
.	
I_i	

3.1.2 Determination of the number of general hospital beds

Using multiple regression analysis, hospital utilization is analysed according to the sociodemographic and economic structure of a given area. From the analysis, hospital utilization is determined in the following way:

$$Y_1=a+b_1X_1+\ldots+b_{11}X_{11}+e \quad (3)$$

$$Y_2=a+b_1X_1+\ldots+ b_{11}X_{11}+e \quad (4)$$

In equation (3) and (4), using area characteristics, the values for a, b_1, …b_{11} parameters are determined for each equation with the help of computer. Putting the area variables in their places in equation (3) and (4), the real values of Y_1, the number of hospital admission per 1000 population, and Y_2, average length of stay in the hospital for each admission, are calculated for the patient origin areas. These values are listed on Table 2

Table 2. The number of patients and hospital admissions.

Patient Origin areas	Population (Base Y.)	No. of patients (Base Y.)	No. of hosp. adm Per 1000 Pop. (Base Y.)
I_1			
.			
.			
.			
.			
.			
.			
.			
.			
I_i			

The estimation of the number of patients for a future year is calculated in the following way.

$$\begin{bmatrix}\text{The number of}\\ \text{patients need}\\ \text{hospital service}\\ \text{in area i for a}\\ \text{future year}\end{bmatrix} = \begin{bmatrix}\text{The number of}\\ \text{hospital}\\ \text{admission per}\\ \text{1000 population}\\ \text{in area i for a}\\ \text{base year}\end{bmatrix} \times \begin{bmatrix}\text{The estimated}\\ \text{population of area}\\ \text{i for the future}\\ \text{year}\\ \text{(in thousands)}\end{bmatrix}$$

The number of patients for the future year, according to the patient origin areas, are listed on Table 3.

Table 3. The population and the number of patients.

Patient o.areas	No. of patients per 100 pop. (base Y.)	Estimated population (Future	No. of patients (Future Y.)	No. of patient days (x) (Future

		Y.)		Y.)
I_1				
.				
.				
.				
.				
.				
.				
.				
.				
.				
I_i				
(x)=The number of= patient days		The number of patients		× Average length of stay in hospital

The calculation of the number of general hospital beds: The estimation is carried out by using the values in Table 3.

The number of annual patient days	=	The number of patients	×	Average length of stay in hospital
The number of daily patient days	=	The number of annual patient days	/	365
The number of required hospital bed	=	The number of daily patient days	/	Occupation rate of hospital beds
The number of required additional hospital beds	=	The number of required hospital beds		The number of existing hospital beds

3.2 Evaluation of the existing hospital system and the planning of the new hospital facilities distribution

An inventory of the existing context of general hospital facilities is carried out and their locations, sizes and the services they provide are determined with a survey in the study area. The patient origin areas and the existing hospital locations are listed on Table 4.

Table 4. Existing general hospitals in patient origin areas

Patient origin areas	Existing general hospitals	General hospital locations
I_1		L_1
.		.
.		.
.		.
.		.
.		.
.		.
.		.
.		.
.		.
I_i		L_j

The services provided by the existing general hospitals are identified in the following way.

S_1=Inpatient units
S_2=Surgical suites
S_3=Obstetrical facilities
S_4= Pediatric facilities
S_5= Occupational therapy
S_6=Public health
S_7=Clinical laboratory and pathological services
S_8=Radiology
S_9=Physical therapy
S_{10}= Emergency department
S_{11}=Outpatient department
S_{12}= Blood bank
S_{13}=Service department

Table 5. The context of the existing general hospitals

Hospital locations	Hospital size (No. of beds)	Services provided
L_1		S_1, ..., S_{13}
.		
.		

.	
.	
.	
.	
.	
.	
L_j	S_1,....................................., S_{13}

3.2.2 Measurement of the accessibility

For the measurement of the accessibility, from each patient origin to each existing general hospital, the following factors are defined:

The number of patients in each patient origin area (Table 3);
The size of the each existing general hospital in the study area (Table 5);
The travel distance between the center of each patient origin area and each existing hospital (in km);
The number of services provided in each existing general hospital (Table 5);
A utilization restriction multiplier to reflect the influence of the hospitals which can be used only by certain groups of people on the measurement of the accessibility. In this study, this multiplier is taken as the ratio of the population covered by the hospital insurance. The value of this multiplier changes from 0 to 1.

Accessibility measurements are achieved using the following formula:

$$A_i = P_i \sum_{j=1}^{n} \left[\frac{S_j}{d_{ij}} (s_j)(k_{ij}) \right] \qquad (5)$$

where,

A_i = The value of the accessibility in the patient origin area i;

P_i = The number of patients who need general hospital services in the patient origin area i,

S_j = The size of the hospital in location j (in terms of hospital beds);

d_{ij} = The travel distance between the patient origin area i and the hospital location j (in km);

s_j = The number of services provided by the hospital in location j;

k_{ij} = A utilization restriction multiplier;

i = The number of the patient origin areas;

j = The number of the existing general hospital locations.

Table 6. Accessibility values

Patient origin areas	Accessibility values
I_1	
.	
.	
.	
.	
.	
.	
.	
I_i	

3.2.3 Evaluation of the accessibility values

This sub-step, using the accesibility values, gives the patient origin areas and specifies the priorities of the areas in which the hospital expansion or building a new one is more urgent (Table 6).

Table 7. Hospitals to be built or expanded

Patient origin areas	Accessibility values	Rank order of accessibilities	Priorities for the hospitals
I_1			
.			
.			
.			
.			
.			
.			
.			
.			
.			
I_i			

4 Conclusions

An application of the proposed methodology is carried out for the Istanbul Metropolitan Area in Turkey. The following conclusions are derived from the model and its application:

With the approach presented in this study, instead of proposing a completely new general hospital system for a given area, a model is generated for the evaluation of the existing general hospital system and planning its growth.

Although earlier studies in this field dealth with health facilities on the base of need and distribution seperately, in this study both general hospital need and the distribution of the additional capacity in an optimum way are investigated together to make possible an efficient utilization of these facilities.

While the model is developed for planning new general hospitals in a future year, it can be applied in the planning of other health care facilities and even other public facilities without major modifications.

The application of the model is possible at country and regional levels as well as city level.

The results obtained from the application of the model in the Istanbul Metropolitan Area are quite reliable with respect to the socioeconomic structure of the city.

5 References

Eddleman, B.R. (1972) Areawide planning for optimum location of hospital facilities for rural people. Southern Journal of Agricultural Economics 7, pp. 89–95.

Ingram, D.R. (1971) The concept of accessibility; A search for an operational form. Regional Studies, 5, pp. 101–107.

Karatas, B. (1979) A method for the determination of needs and locations for new general hospital facilities to provide data for architectural programming. Ph.D.thesis (in Turkish). Dept. of Arch. Istanbul Technical University, Turkey.

Karataş, B. (1981) The relationship between housing unit size and hospital utilization. IAHS Vienna Congress on Housing Proceedings. Vienna, Austria, pp. 203–209.

Karatas, B. (1982) A quantitative analysis of the relationship between housing unit size and hospital utilization. International Journal for housing science and its applications, 6/3, pp. 271–278.

Rosental, G.D. (1964) The demand for general hospital facilities. Hospital monograph series 14, AHA, USA.

120
A method for determining a user's value system and its application to briefing through functional specification

J.R.KELLY

Abstract
This paper examines value engineering practices in the USA with particular reference to functional analysis. A distinction is drawn between manufacturing and construction related functional analysis. Construction oriented functional analysis is seen to be especially relevant in the composition of a functional specification to be used as a briefing document for the design team. It is argued that the functional specification has to be highly correlated to the building user's value system. The paper proposes a method for the determination of a value system.

Keywords: Value Engineering, Value Analysis, Value Management, Functional Analysis, Functional Specification, Value System, FAST, Cost Modelling.

1 Introduction

The analysis of "function" in the design of buildings has been considered important for at least two thousand years. Vitruvius [1st century BC] devotes considerable energy to the proper description of spaces within a dwelling considering; their function, their position and orientation and their purpose as required by house owners of differing professions or businesses. The analytical description of function is more recent and is attributed to the developing techniques of value engineering in the latter part of this century. Value engineering techniques were derived for use within the manufacturing industry of the USA although they are now applied worldwide. The techniques have been transferred to the construction industry with mixed success. However, a re-examination of the basic philosophies gives clues on the application of new techniques to the briefing stage of construction projects.

In this paper the words "component", "assembly" and "element" are given specific meanings. A "component" is defined as a single manufactured item for example, a brick, a hinge, a gear wheel, a length of pipe, a switch. An "assembly" is defined as a unit comprised of a number of components for example, a window, a roof truss, a wash basin, a kitchen unit. An “element” is defined as a unit of construction which may comprise a number of assemblies and components such as, a window including sill, vertical and horizontal damp proof membranes, the window casement, glass and frame, lintel, and other incidentals such as plaster beads. Included in the cost of the element is the labour and plant resources necessary to install it.

2 Value Engineering

Miles [1961] first explored the possibility of linking functional analysis within a structured programme of cost evaluation and termed this value analysis, later called value engineering. In the context of a manufacturing organisation Miles took individual components and analysed their characteristics as a basis for the provision of their required function at the lowest cost. The programme which Miles devised had seven steps and was known as the job plan. The seven steps are:

* Orientation: answering the questions, what is to be accomplished, what does the customer need or want, and what are the desirable characteristics with respect to size, weight, appearance, durability, etc.
* Information: realising the prime function of the component and associated costs, manufacturing methods, etc.
* Speculation: the bringing together of a group of people who contribute specialist knowledge on aspects of the prime function. The group brainstorm solutions to the prime function.
* Analysis: the sorting of the above ideas into feasible solutions and the calculation of the cost of each solution.
* Programme Planning: Set up a plan for implementation of the most cost effective idea including consultation with suppliers, vendors, etc as appropriate.
* Programme Execution: Progress the plan which will require imaginative problem solving amongst suppliers and manufacturers.
* Status Summary and Conclusion: Sell the idea and implement manufacture.

The plan evolved by Miles was officially endorsed in the US Department of Defense Handbook 5010.8–4, Value Engineering [1963]. The process was further refined by others although, these refinements left the basic principles essentially the same.

Further official recognition came with specific reference to construction with the publication of the US General Services Agency—Public Building Service Manual P 8000.1, Value Engineering [1972] and the GSA-PBS VM Workbook [1974], Authors, Dell’Isola [1974], O’Brien [1976], Macedo, Dobrow, and O’Rourke [1978], Zimmerman & Hart [1982], Parker [1985], and Snodgrass & Kasi [1986], have all sought to relate the process of functional analysis within value engineering to the construction industry.

3. Functional Analysis

Although functional analysis has remained the cornerstone of value engineering for almost fifty years many US practitioners find its structured use of little value in the performance of a construction oriented value engineering exercise. The reasons for this can be explained as follows:

3.1 Manufacturing oriented functional analysis

Manufacturing industry is concerned with the manufacture of components and the assembly of products. All products can be broken down into components. All products and components perform a function. Some products are themselves sub-assemblies of a larger product. For example, consider a hand operated drill, Figure 1. The function of the drill is to produce a hole which is carried out by rotating a drill bit. The hand drill has therefore a facility for holding it in the hand, a means of rotating, by hand, the drill bit and a means of securely holding the drill bit, the chuck. The chuck is an assembly of components, i.e. springs, metal shims, etc.

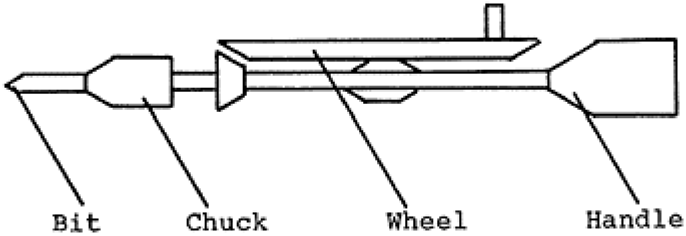


Figure 1—A hand held, hand powered drill

In a functional analysis the function of each assembly or component is examined by asking the question "what does it do?" For example, in the hand operated drill the large gear wheel on the side of the drill transfers hand generated torque to the shaft. In a value engineering exercise the next question would be "how else can this be achieved?". A brainstorming exercise is held and other technical solutions generated for example, pump action (mechanical, air, hydraulic), ratchet action, etc. These ideas may be refined, for example, a pump action may be through a foot pump leaving both hands to guide the tool.

However the problem is solved, one major fact should not be ignored and that is the scale of the savings or sales opportunities which may flow from the idea. If a small tool manufacturer is producing one million hand drills per year and a value engineering exercise saves £1 on the manufacturing costs and/or creates a marketing opportunity which generates £1 per drill sold then that company gains £1 million per year. The costing of the alternatives may be complex but will involve the analysis of familiar materials and production methods. The process is therefore attractive to manufacturing because it highlights an effective means of generating alternative technical solutions relevant to components and products which in the main have large production runs.

There is another highly relevant feature of manufacturing oriented functional analysis which is that the component or assembly is designed and manufactured by the client organisation. The acceptance or rejection of ideas flowing from the functional analysis will be taken by those partaking in the exercise.

3.2 Construction oriented functional analysis

Construction is concerned with the provision of accommodation (building) or a community utility (civil engineering). The function of a building is to provide an environmentally controlled space suitable for the activity to be carried out within that space. The design of the building is a technical solution to the functional requirements of the space. Herein lies one major difference between the manufacturing industry and the building industry, manufacturing providing products and building providing environmentally controlled space.

The other major difference lies in the scale of production. Manufacturing, with the exception of industries such as aircraft and shipbuilding, provides a large number of identical products for sale. Building, with perhaps the limited exception of housing, provides single products to order. Generally a £1 saving on a building or a £1 gain through a marketing opportunity is of no consequence.

Functional analysis within building, to be worthwhile, must therefore deal with functions of a higher order or more significance and unlike manufacturing must precede even the production of a prototype.

3.3 Post design analysis

Recognising the above point US construction based value engineers have taken the tools and techniques of manufacturing oriented value engineering and have applied them to the design stage in construction. This is arguably valid for the components of construction, bricks, blocks, pipes, electric wire, etc since these are manufactured items. It is also arguably valid for elements of construction such as external walls, suspended floors, roofs, etc. since these correspond to manufactured products as defined above. It is observed by Kelly & Male [1990] that the majority of US value engineering studies do concentrate on elements but tend to be driven by technical substitution based upon experience of an alternative solution rather than functional analysis. There is therefore a move away from the textbook presentation of functional analysis. Further, the lack of cost models mean that new technical solutions are economically evaluated by a time consuming costing of approximate quantities of resources.

It is also noted that much of what is carried out could be applied on an industry-wide and not a project specific basis. For example, the function of a foundation is always to distribute load, the function of a window is always to permit one or more of the following:

Provide light
Permit ventilation
Prevent access
Retain heat
Insulate from external noise
Permit view (one way or both ways)

Kelly and Poynter-Brown [1990] highlight the application of US value engineering techniques with reference to a window. The functional analysis exercise is useful in that it highlights that the consequences of a glazed window also allow solar heat gain, distracting sunlight and the generation of cold radiation. These features are termed secondary functions.

It therefore may be useful to record the results of brainstorming on elements of construction in a widely distributed format as a checklist at the design stage of a building. Alternatively, these results could be reviewed prior to brainstorming other technical solutions for an element in a post design check or audit.

The final application of post design analysis is directed at the spaces themselves. The most spectacular achievements of value engineering reported from the USA relate to the reorganisation or rationalisation of space and the environmental control of space. There is an unavoidable inefficiency where the analysis of the function of spaces is made after the sketch design is complete.

3.4 The use of Functional Analysis System Technique (FAST)

In writing on functional analysis Snodgrass and Kasi [1986] highlight the Functional Analysis System Technique diagramming method proposed by C W Blytheway in 1964. They present two types of FAST diagram which they entitle "Technical FAST" and "Task FAST".

A Technical FAST diagram is one, such as that for the hand drill below which tends to be linear and answers the question HOW? when reading from left to right and WHY? when reading from right to left.

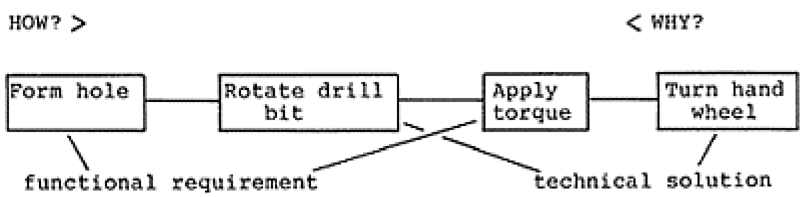


Figure 2—A FAST diagram of a hand held, hand powered drill

Experiments undertaken at Heriot-Watt University have revealed that in a technical analysis of a component or assembly the diagram must be composed from right to left, i.e. the technical attribute of the component or assembly under review is entered on the right and the functional requirement to the left. Having realised the functions the diagram may be used as a basis for brainstorming alternative technical solutions to the functional requirements reading from left to right. Experiments have also revealed that those partaking in a brainstorming exercise generally suggest a technical solution and rarely another sub-function. This is opposed to the experience of Snodgrass and Kasi who increment from left to right towards a technical solution through a logical analysis of function and sub-function.

A Task FAST diagram is described as having a primary function and four supporting functions, namely; assure convenience, assure dependability, satisfy user and attract user. The illustrations given by Snodgrass and Kasi relate more to manufacturing than to construction. In a Task FAST diagramming exercise a concept is taken and developed from left to right this method has been confirmed by experiment.

3.5 Proposal

It is concluded that the textbook approach to value engineering is very relevant to manufacturing and aids, such as FAST are obviously useful. However, because building is organised differently, the application of the techniques described are less appropriate. This is recognised by Kelly & Male [1990] and by Palmer [1990] in their observations of the lack of use of functional analysis by US construction value engineers.

There are, however, a number of clues which allow the hypothesis of the components of a workable functional analysis method for construction. These are:

* The structuring of the functional analysis of elements of construction with appropriate cost models which will react quickly to changes in the arrangement of spaces.
* A method for the functional analysis of spaces and their associated environment and the derivation of a functional specification.
* The incorporation of the client's value system into the procedure.
* A method for clear objective evaluation.

4. Functional Specification

Janin [1989] introduces a functional specification technique for manufactured products which measures the manufacturer's objectives in terms of growth, risk aversion, profit demand, etc. and matches these with the proposed product and market. This form of strategic analysis results in a clear definition of the problem and its solution in functional terms.

Kelly [1990] analysed the building client's information processes prior to contact with a representative of the construction industry. He states that one of the most crucial stages in construction is the point at which the client appoints a representative or committee within his own organisation to identify the nature of a problem which may have a built solution. It is hypothesized here that the integration of a construction industry representative to assist with the definition of a perceived problem in functional specification terms would assist both the client and the design team. The correct definition of the problem is seen as being vitally important, for example, a house is defined as "an environmentally controlled space for living in". An attempt at representing this concept would reveal that there are two functions namely; an environmentally controlled space, and a space for living in. This leads to the construction of two diagrams as given below. The space for living in is divided according to Vituvious into public and private space and thereafter divided according to the functional use of that space. The environmental characteristics of the space and the furniture or appliances to be accommodated completes the functional description. Any further description beyond this point is a technical solution which should not be made without reference to the client's value system.

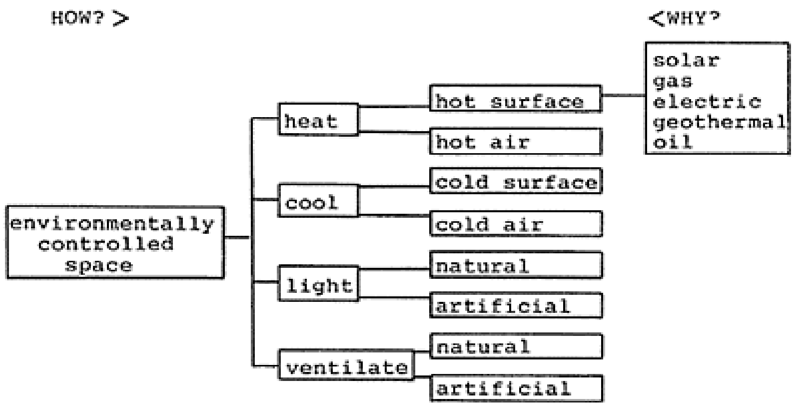


Figure 3 - An illustrative part of a FAST diagram for environmentally controlled space

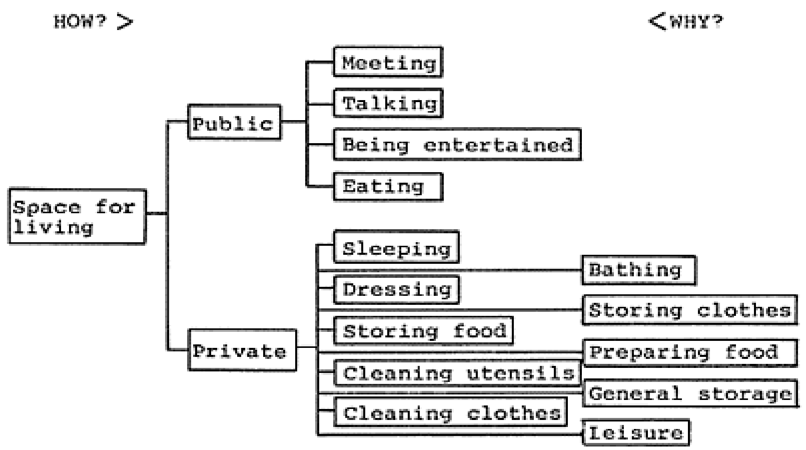


Figure 4—An illustrative part of a FAST diagram for space for living

5 The Client’s Value System

Kelly [1990] hypothesized that the client’s value system can be realised by identifying location, aesthetic aspirations, space requirements, environmental requirements, timing of the project and cost limits. Each of these factors should be correlated by questioning the client as follows:

* What are you prepared to sacrifice i.e. are you prepared to sacrifice space and at what point would this sacrifice mean that your objectives can no longer be achieved?
* At what point is a gain, for example in space, no longer of any use or interest?
* Are you prepared to sacrifice one factor for a gain in another, for example would you sacrifice location for more space?

Early experiments at Heriot-Watt University have revealed the complexity of this exercise particularly the third question which calls for a large number of interrelationships to be examined. However, it is anticipated that a significant proportion of these inter-relationships may be deduced by inference. Housing may be a useful subject for analysis because of the large sample size in both constructed units and users. There is therefore a good opportunity to evolve a value system for housing and test the accuracy of deductions through inference.

6 Conclusions

This paper describes functional analysis, functional specification and a means of determining a user’s value system. The methods applied by US value engineers and described in value engineering text books are highly applicable to the procedures adopted by manufacturing industry. It is concluded in this paper that parts of these procedures are applicable to the construction process. As described above the manufactured construction components and assemblies can be functionally analysed as a manufactured product. Elements of construction may be analysed in functional terms although it is difficult to argue in favour of this exercise for each construction project. However, thought should be given to a published definitive functional analysis of each construction element.

In building, functional analysis is best applied to environmentally controlled space. This analysis should precede any drawing work and should be based upon a study of the building user’s organisation and value system. It is proposed that the value system can be understood by asking the questions detailed in this paper. A functional analysis of the user’s required space as illustrated in the examples and evaluated by reference to the value system will give a functional specification which may be used as a briefing and also a design control tool.

7. References

Dell’Isola A.J. [1974], Value Engineering in the Construction Industry. Construction Publishing Co. New York.

Janin L.F., [1989], Functional specifications, Proceedings of International Conference—Society of American Value Engineers, June 11–14, Indianapolis, Indiana, USA V XXIV, 112–117.
Kelly J.R. and Male S.P. [1990] A critique of value management in construction. Proceedings of CIB90 Building Economics and Construction Management, Sydney, Australia, Vol 2, 130–139.
Kelly J. and Poynter-Brown R. [1990] Value management, in Quantity surveying techniques—new directions (ed Brandon P.S.). BSP, Oxford. 54–74.
Kelly J.R. [1990] Building design optimisation. Proceedings of CIB90 Building Economics and Construction Management, Sydney, Australia, Vol 2, 1–13.
Macedo M.C., Dobrow P.V., and O'Rourke J.J. [1978], Value Management for Construction. Wiley Interscience. New York.
Miles L.D. [1961], Techniques for Value Analysis and Engineering. McGraw-Hill. New York.
O'Brien J J., [1976], Value Analysis in Design and Construction. McGraw-Hill. New York.
Palmer A. [1990] A critique of value management. CIOB technical information service paper 124.
Parker D.E. [1985], Value Engineering Theory. Lawrence D. Miles Foundation. Washington D.C.
Snodgrass T.J., & Kasi M., [1986], Function Analysis. University of Wisconsin. USA.
Zimmerman L.W. & Hart G.D. [1982], Value Engineering: a practical approach for owners, designers and constructors. Van Nostrand Reinhold. New York.

121
Building maintenance and modernisation—research and practice trends

Q.L.KIANG

Abstract
This paper presents the state of the art in building maintenance and modernisation and directs attention to the need for increased research in the multi-disciplinary and multi-faceted considerations required for efficient and effective upkeep of built assets.

Keywords; Building Maintenance, Building Modernisation, Practice, Research, Trends.

1 Introduction

Building maintenance and modernisation work, once a largely ignored sector of the building industry, has progressively gained predominance in the wake of a slowdown in new building programmes and a corresponding strong building conservation movement. In developed countries, this sector accounts for at least half of the total building market.

The growth in maintenance and modernisation (m&m) work has unfortunately not been matched by sufficient research and development interest; attention having been concentrated in the then, bigger and more glamorous new build market.

Working Commission 70 of the International Council for Building Research Studies and Documentation (CIB) has been concerned with the need to elevate expertise in the management and care of buildings since the late seventies. This paper seeks to review research and practice trends in m&m in this last decade, with a view to directing future research interests in this increasingly important facet of built asset management. Further details on these trends can be found in the proceedings of the series of W70 symposiums listed under References in this paper.

In the context of this paper, building maintenance is used as a generic term to describe all work both planned and unplanned necessary to retain a building to an acceptable standard and to prevent and delay its progressive deterioration due to age and usage. On the other hand, building modernisation is used as a generic term to describe all work necessary to upgrade, update and improve the facilities of an existing building to current standards. This work is necessary because, despite planned programmes of maintenance, existing buildings will, with the passage of time inevitably fall behind current living standards and technology, necessitating major capital expenditure for modernising the buildings to prevailing standards.

2 The Building Maintenance and Modernisation Industry

In it's preoccupation with building anew, many developing countries tend to lose sight of the fact that the provision of an adequate stock of buildings in response to national development needs is not a means to an end. It signifies the beginning of the next set of problems of maintaining and modernising these habitated buildings in order to prolong their economic, functional and physical life; these activities being necessary as it will be extremely difficult to find sufficient resources to rebuild completely again.

Building maintenance and modernisation work in a developing country usually starts off with small scale repair and replacement work. Its volume then, is small in relation to the new build sector. However, as the built stock increases and demand for new buildings becomes progressively satisfied, this sector of work will begin to take prominence, signifying a country's transition from a developing to a developed state. It is generally difficult to ascertain the size of the m&m industry as most countries do not differentiate between new build and m&m in statistics collection. In the United Kingdom, where such data is available, m&m works, without taking into account the non-housing sector, the so called black economy and DIY work, accounted for about £14 billion or 46% of the total construction output in 1986. For a developing country like Singapore, with about 50% of its building stock below 10 years of age, such works made up about S$1,140 million or about 21% of the total construction output in 1990. The m&m industry can hence be expected to play an increasingly significant role in reducing fluctuations in the overall construction activities in a country.

The m&m sector of the building industry has traditionally been regarded as a "poor cousin" of the new build sector. Lacking the prestige and public interest accorded to new buildings, it has not been able to attract building professionals to work in it. It became a sector of work associated with lesser known professionals and older tradesmen, projecting the image that the expertise and skills required in such work was less demanding. Larger contractors shunned this market, preferring to occupy themselves with the deemed more lucrative new build market. The less capital intensive requirements of m&m work favoured the existence of smaller sized contractors, which were often one-man operations supported occasionally by a casual labour force. Owners attitude towards m&m is by and large apathetic. Expenditure to upkeep and prolong the life of building assets was deemed unnecessary in times of rising capital values. It was accorded low priority in budget allocation. Even so, this budget was the first to be trimmed in difficult times.

Cyclical and/or response based maintenance systems prevail over the more cost effective condition-based systems. Attempts to implement condition based systems is beset with problems such as the shortage of qualified inspectors and the lack of objective methods for assessing the condition of the buildings, leading to conflicting views on the condition and required maintenance action. As a result, maintenance costs adopting cyclical maintenance systems can be high due possibly to over-maintenance, premature replacement and unexpected failures between cycle times. On the other hand, maintenance costs may be artificially low in response based maintenance systems until such time defects are reported or become intolerable; it is then often found that costs have escalated exponentially because of the undue delay in attending to the defect. The derivation of an appropriate maintenance strategy for a building/s is thus thwarted by inaccuracies relating to condition assessment and costs predictions of the required remedial work. As such, rational decisions relating to maintenance expenditure continue to be largely dependent on the presence of accurate historical records and/or the personal judgement of the decision maker.

The non chalant attitude of building owners, coupled with the trend to rely more on the use of the smaller and often less organised contractors in preference to direct labour, results in very little structured information being available on maintenance operations. These records would have formed valuable feedback both for monitoring the efficiency of the work and for providing the new build sector with information on the durability and performance in use of buildings/building components.

The combination of the state of the m&m industry, it's practices and procedures and the unique nature of the work has contributed to the traditionally lower productivity in this industry. This situation could at least have been tolerable if the m&m sector of work remains small and insignificant. However, economic, social, environmental and technological forces continue to provide impetus for increased demand in m&m work, particularly in the more developed countries in the West. In difficult and uncertain economic times, m&m activities are viewed as useful and generally more economical short term solutions to provide a new life to old premises. Socially, they are seen as a means to close the gap between housing of the different economically active groups. Socio-demographic patterns create urgency to adapt existing buildings for ageing populations. Environmental forces taking the form of a strong building conservation movement and attempts to preserve the green belt will lead to even more intensified urban renovation and inner city regeneration which, are also viewed as socially and politically desirable. Changes in space, thermal and comfort standards and, rapid technological advances will dictate that older buildings be modernised to accommodate more advanced building services and, energy saving materials and techniques of construction.

The m&m industry which is ever present in a country will continue to grow with the ageing of the built stock therein. There yet remains imperfect knowledge of the m&m process within an industry which has traditionally been geared to new build work. It will be necessary to continue efforts to promote and assist m&m work through more research so as to improve the state of knowledge and understanding of the needs of this sector of construction work.

3 Information Needs for Building Maintenance and Modernisation

The primary prerequisite for planning m&m work is, information on the attributes and physical condition of the buildings. Whilst attributes such as size, location, constructional details and age are normally obtainable from building plans; the condition of a building/s can only be ascertained by systematic and periodical physical surveys of the building in order to assess and monitor its performance and rate of deterioration over time. Such surveys are commonly termed building condition surveys. The information so obtained provides the important basis upon which future decisions in relation to existing building/s can be made. Performed nationally, it provides information upon which fiscal policies and manpower planning can be made, besides aiding longer term decisions regarding planned modernisation and replacement of the built stock. At micro level, it provides owners with information for the effective planning and execution of work.

A building condition survey requires firstly the establishment of what would be deemed an acceptable standard or norm for the building/s. This standard could be expressed in terms of a single or a combination of technological, space, safety, comfort, hygiene, visual and financial standards. The physical survey that follows would then reveal the proportion of built stock that falls below these established norms, thereby allowing the amount of m&m work to be determined and remedial actions to be planned.

Problems arise in defining objective measurable standards which are acceptable by most occupiers when, standards themselves are generally by and large subjective. The development of random sample field survey methodology which allow statistical generalisation of the condition of the buildings; the establishment of objective condition assessment methods and, efficient data collection procedures present research challenges as well.

Countries such as Greece, Germany, Sweden, Denmark, Belgium and India have embarked on national building condition surveys whilst countries such as the United Kingdom and Holland are already embarking on their second national survey, improving on the previous methodology. The experiences of these countries provide valuable information to shorten the learning curve of those intending to embark on such surveys. Nevertheless, research must still continue in addressing the problems and refining the methodology used for such surveys. It was for example reported in the most recent W70 symposium that, surveyors variability in the 1986 English house condition survey, caused by subjective judgement during inspections resulted in one third of them providing an assessment of disrepair, the calculated cost of which differed from the mean value by more than 30%. Research into the development of objective condition assessment procedures and survey techniques utilising mechanical aids/robotics would assist in overcoming some of these problems.

W70 has established two task groups on Maintenance Standards and, on Methods of Surveying and Describing the Building Stock, in an effort to serve as a focal point for co-ordinating and exchanging research and practice experiences in these two aspects of m&m work.

4 Building Maintenance and Modernisation Strategies for Buildings

As condition assessment information becomes more objective and accurate with the refining of the methodology for undertaking condition surveys, it’s value as a primary input in the m&m strategy decision making process will be further enhanced. Other endogenous information required for deriving an appropriate strategy include ownership/lease of the building; expected period of holding/occupation; occupiers needs; m&m policies and standards; organisational and execution procedures and, budget available and cost recovery procedures. Exogenous information to be considered include national wealth and reserves available; the economic and political climate; socio-demographic trends; the presence of grants/ incentives and, the state of technology prevailing.

The formulation of an appropriate cost effective m&m strategy requires the assimilation and integration of this myriad of information, comprising historical data and projections, to meet often conflicting financial, occupier and technological demands. Among the issues to be decided are the appropriate level of expenditure, prioritisation and allocation of resources and, the economic/social/technical consequences of ignoring/ deferring/ delaying m&m activities.

Research and practice trends are already well established in the development and use of computerised management information systems to help support the planning and execution of maintenance work but remains under developed for modernisation work. The use of these management information systems to serve as structured feedback systems to aid the design and construction of more manageable and maintainable new buildings has yet to be fully realised. More research is also needed to further develop the management information systems into expert systems capable of enabling different scenarios of "what if" situations to be compared clearly in order that the "best" m&m strategy within the existing constraints can be evolved. It would require amongst other things, the assimilation of knowledge bases on maintenance practices and procedures; the improving of the accuracy and reliability of the information on data bases and, the validation of relationships between the different variables in the expert system.

5 Organisational and Management Problems in Building Maintenance and Modernisation Work

The problems and low productivity currently faced in executing m&m work can be attributed to a large extent to the unique nature of the work.

Maintenance and modernisation work differs from new build work in several ways. A basic difference is that the former needs to be executed in an existing building that is often occupied whilst the latter begins on a cleared site; this effectively constrains the extent of mechanisation and presents access and material handling problems. New build work proceeds in a logical sequence and is hence capable of more positive planning. On the other hand m&m work consist of small scale diversified operations scattered within a building/s. The uncertain nature of work emanating from sudden failures requiring emergency response and/or unforseen work arising from the opening up of the existing building militates against planning the best work sequence for effective utilisation of resources. There is also the underlying requirement that construction operations should not interfere with the normal usage of the building. It often necessitates working unsociable hours; requires measures to reduce noise and dust and, the uninterrupted supply of services to the building.

Frequently, techniques and methods of repairs have to be uniquely developed for each building, notwithstanding the fact that an estate of similar buildings could have been built in the same period. This arises because of differences caused by workmanship during the initial construction. "As built" drawings and maintenance manuals are often not available or non-existent. Surveys to determine the information so essential in structural repair or alteration work is difficult as the building is often occupied.

It is doubtful that the current planning and organisational techniques which have been developed more specifically for new build work are capable of applying directly to m&m work. There is a need to develop techniques which are more responsive to the out-of-sequence multi-trade construction operations and, the often ‘fluid’ and ‘unknown’ nature of work. Research into finding solutions for the unique technical and organisation problems in m&m work remains limited to date. W70 has initiated a task group on Refurbishment and Rehabitation. It will, in combination with CIB W65(Organisation and Management), initiate and direct more attention to these issues in the forthcoming 1993 W65 symposium in Trinidad.

6 Procurement of Building Maintenance and Modernisation Work

The vagaries of m&m work, coupled with the general lack of information on the condition of the building makes it difficult to determine, specify clearly and estimate accurately the cost of the work. This entails those responsible for work procurement to attempt to allocate these difficulties to the contractor by incorporating such uncertainties in the traditional lump sum fixed priced tender documentation.

Ad-hoc adaptation of tender documents will give rise to wide variations in the notation, description and format of tender documentation. Research in the United Kingdom by the author has shown that unfamiliar and obscure tender documentation leads to unpredictability in tender bids. This is because of the effect of different perceptions of what is required to be done and the method of pricing uncertainties/risks in the tender.

The lack of established cost yardsticks for m&m work makes it difficult to determine whether the lowest tender has been unnecessarily inflated by risk averse contractors or, whether it has been under-estimated in terms of risk exposure. Unless risk and liability can be reduced through better specification of the required work in tender documentation, the current high reliance on lump sum priced based tendering arrangements would not preclude risk to the client. He either pays too much or, gets sub-standard work in cost cutting measures and/or unpredictable final accounts figures in claims.

There is a need to establish reliable cost data bases and indices for m&m work. This may prove difficult due to the lack of structured information on such activities. Furthermore, the non-repetitive nature of such operations and uniqueness of existing buildings could prevent attempts to standardise costs as is possible in new build work. Improvements must also be made to existing methods of presenting and communicating information to the contractor. The use of non-traditional work procurement methods such as fee contracting, management contracting or design and build contractual arrangements should be explored, particularly for the more difficult modernisation projects. However, the over-riding consideration in any work procurement system is the contractors for whom the system exists.

7 Building Maintenance and Modernisation Contractors

Despite the increasing global trend to reduce the reliance on direct labour to execute m&m work, contractors in the main, have not shown much interest in this type of work. The situation is expected to change as m&m work begin to occupy a bigger share of the building market. Contractors, including the larger ones, will begin to move into this market, bringing along better management expertise to a market traditionally dominated by their smaller sized counterparts. Research by the author has shown that the effect of different sized contractors competing for m&m work could result in either the smaller sized contractors being outpriced due to the competitive advantage enjoyed by their larger competitor or, the smaller sized contractors remain excessively competitive due to their inability to appreciate the managerial and technical problems associated with such work.

The current problems faced with building defects is attributed in part to sub-standard materials and workmanship within a procurement system which generally favours award to the lowest tenderer regardless. It is essential that m&m work, especially maintenance work involving preventive measures and repairs be executed properly, failing which even more accelerated deterioration of a building/s could occur. It must be recognised that m&m work is more labour intensive. This raises the need to re-examine the traditional capitalisation mode of classifying contractors and prompts reconsideration of the criteria for selecting a contractor for such work. Quality assurance procedures and performance evaluation measures for this very different type of work needs to be developed as well.

On the part of contractors considering entry into this market, it is essential to appreciate that the skills required in m&m work are more people orientated than technology or mechanically orientated. Work for a significantly higher labour force has to be scheduled productively. Liaison will be necessary to ensure minimum inconvenience and maximum co-operation from the occupiers. If properly managed, m&m work because of its lower capital outlay and relatively shorter project time carries less risk and generally gives a higher return on the capital invested. Contractors should put in more concerted efforts to organise themselves to meet and manage the challenges in executing m&m work so as to receive the better rewards that often goes with it.

8 Education and Training for Building Maintenance and Modernisation Work

There is a need to educate the general public on the proper use of the buildings in which they live and work in. Occupiers involvement in the m&m process should be positively encouraged. This would create an environment for practising self-help in undertaking minor m&m work, thereby reducing the dependence on external financing, at the same time, creating a social culture and pride in partaking in the upkeep of buildings.

The short sighted attitude building owners currently have towards m&m work must be changed. This change should be easier to effect when more information on, and experiences of the financial, social and technological consequences of neglect/delay in m&m activities become more widely disseminated and reported.

Formal education and training for m&m work has yet to feature strongly in manpower planning in developed countries let alone developing countries. First and second-line managers and a multi-trade workforce must be taught to appreciate and understand the unique nature of m&m work in order that they can exercise initiative and make almost immediate “the best under the circumstances” decisions on the work front. There is also a need to train property managers in the multi-faceted and multi-disciplinary skills required for executing m&m work efficiently and cost effectively.

The construction industries worldwide continue to face shortages of personnel at all levels. Competition will occur between the new build and m&m sector for scarce labour resources, especially in the more developed countries. The manpower requirements for m&m needs to be examined separately as this type of work by it’s very nature is more difficult to automate and mechanise. Plans must be immediately launched to attract and retain both professionals and tradesmen into this traditionally ignored sector of work.

9 Conclusion

Existing buildings in a country form sizeable national assets which, from an economic viewpoint requires m&m to retain it’s value and utility and, extend it’s service life. From a social viewpoint, keeping buildings in a good state of repair and abreast with technological advancements reflects the prosperity of the country, the quality of life and contributes towards preventing antisocial behaviour. As the size of the m&m industry continues to chart a steady growth, the need to strive towards developing systems which ensure that maximum return is achieved from investments made to preserve existing buildings must continue with even greater urgency.

Owners attitudes toward m&m needs to be changed. Occupier participation and involvement in the process must be encouraged. Governments could play a bigger role in this national responsibility by providing direct and/or indirect financing via tax incentives and, by investing more in education and training and research and development work.

Research and development efforts must continue to be directed relentlessly at the economic, sociological and technological problems unique to m&m work. Acceptable standards of living and working have to be defined more objectively and unambiguously; information needs, in particular condition assessment information require more accurate determination and effective methods of collection; management information and decision support systems must be further developed to assist with the planning and execution of the work and the derivation of effective maintenance strategies; organisational and managerial techniques need to be evolved for the normally “out-of-sequence” work within occupied buildings; procurement systems have to be re-examined in the light of the “unknown nature” of the work and the competitive mix of contractors; the increased use of information technology, automation and robotics should be actively pursued to raise the prevailing low state of technology in this sector of work.

The importance of using information from m&m work to serve as the valuable feedback link in the Design-Construction-User-Maintenance construct should not be overlooked. As research and development efforts continue to achieve efficiency and raise productivity in the m&m industry, the accuracy and reliability of feedback information from such work will improve. It will enable a clearer understanding of the performance in-use of buildings and permit improvements to be made in the design, construction and maintenance of new buildings. The acceptance of the Property-Maintenance Manager as a member of the building team from project inception to completion and, the production of maintenance manuals as an integral part of project documentation will no doubt contribute towards reducing maintenance costs and make the realisation of more manageable and maintainable buildings more attainable in the next century.

10 References

Damen T, ed (1980) **Research on Maintenance and Modernisation,** Proceeding of the CIB W70 1979 Rotterdam Symposium, CIB Publication 54.

Wilhelmsen A M, ed (1982) **Methods for Surveying and Describing the Building Stock,** Proceedings of the CIB W70 1981 Sweden Symposium, Swedish Council for Building Research.

Systems for Maintenance Planning, Proceedings of the CIB W70 1983 Edinburgh Symposium, Heriot Watt University, Scotland.

Careful Modernisation, Unpublished proceedings of the CIB W70 1984 Gent Symposium, Belgium.

Then D S S ed (1988), **Whole Life Property Asset Management,** Proceedings of the CIB W70 1988 Edinburgh Symposium, Heriot Watt University, Scotland.

Quah L K ed (1990), **Building Maintenance and Modernisation Worldwide Vol I & II,** Proceedings of the CIB W70 1990 Singapore Symposium, Longman Singapore Publishers.

123
Economics of the residential areas

T.KIVISTÖ

Abstract
Since 1975 Technical Research Centre of Finland has conducted extensive research into the costs of residential areas. It covers 24 actual residential areas in different parts of Finland, and studies all the building, energy, operating, transport, etc., costs of these areas. The following choices made during the town planning and implementation process have the largest influence on the costs and their variation in a residential area: the location of the area, building density, house type distribution, service level, the size of the area, soil condition, microclimate, transportation system, process of implementation. The difference between the relative building costs of the study areas is about 40% (FIM/ floor sq.m) and about 80% (FIM/dwelling). The difference between the relative energy costs is 40% (FIM/floor sq.m) and 125% (FIM/dwelling). The annual operating costs of the residential areas are an average 4% of the building costs. An average 5% of the building costs and about 8% of the energy costs of the residential areas can be saved with cost-conscious planning without lowering the quality of the environment. When proportioned to the annual house production in Finland it means an annual saving of over FIM 1500 million. An analysis of the economic factors should form an essential part of the urban and town planning process.

Keywords: Town Planning, Residential Areas, Costs, Economy

1 ASTA-research series

1.1 General

The ASTA-research series into the costs of residential areas was carried out in Finland during time period 1975–1988. In the first phase (ASTA I) 24 residential areas in different parts of Finland were selected for study areas (Appendix 1). Besides this the buidling costs of these areas were investigated extensively and thoroughly. The subresearch ASTA II deals with the energy, maintenance and other operating costs of the same 24 areas. In the summary research (ASTA III) the buiding, energy, maintenance, reparations etc. costs are combined in order to bring out the total costs of the areas.

Altogether 30 man years have been used for the ASTA-research series. So it is the largest research project which ever carried out in Finland in the field of urban planning. The main financiers have been the Ministry of the Environment, the Ministry of Trade and Industry and the Technical Research Centre of Finland (VTT). The research series have been conducted under the leadership of the undersigned in the Laboratory of Land Use and in the Laboratory of Urban Planning and Building Design of VTT. Besides these several other VTT laboratories have been involved in the project as well as the municipalities of the study areas and the Finnish Meteorological Institute. The ASTA-research series has resulted in about 2000 pages of reports (1–11).

1.2 Goals

—The aim of the ASTA-research series was:

—To determine the factors affecting the building energy, maintenance etc., costs of different types of structure in a residential area. Further it aimed at giving cost models for different types of structure where especially the planning factors chosen in town and other related planning are taken into account.

—To determine as reliably and thoroughly as possible how the town plans affected costs and how these varied in the study areas.

—To determine how costs were affected by physical planning after town planning and by the decisions on the order and timing of construction.

—To provide recommendations for and views on the consideration of costs in town and other connected planning, as well as in the implementation planning of residential areas. At the same time the qualitative goals for the areas and the living environment were taken into account.

On the basis of the ASTA-research series all essential is known about the costs of the residential areas in the Finnish circumstances. The following cost results are presented at the price level of April, 1989 (1 USD=4,30 FIM, 1 FIM=0,23 USD).

1.3 Study areas

The research areas (Appendix 1) were selected from the areas proposed by the municipalities on the following grounds:

—Location in the urban structure, soil conditions, distribution of building types, grouping of plots, systems of networks and other planning factors vary as much as possible so that the cost effects of the factors may be brought out in a variety of forms.

—The areas lie in various parts of Finland so that the cost effects of different local factors such as living space (floor sq.m/inhabitant), climate factors, dimensioning of networks, and construction stage of the plan are clearly and variously brought out.

—The extensive basic information involved in ASTA-research series is available according to the research schedule and with sufficient accuracy.

The floor area planned in the study areas is from 26,000 to 262,000 floor sq.m, the average being 112,000 floor sq.m. There are six areas of solely small houses and three of solely blocks of flats. There are fifteen “mixed areas” with small houses and blocks of flats. The number of inhabitants of the study areas varied in the beginning of 1980’s from 500 to 8000 the average being 3000 inhabitants.

2 Building costs of residential areas

2.1 Cost variation in the study areas

The building costs of the study areas vary from 124 to 1070 million FIM, the average being 480 million FIM in the areas studied. The corresponding figures of the types of structure to be paid by the municipality (sevices, networks, parks and fields) are 18 to 258 million FIM and 75 million FIM (Appendix 2, figure 1). Most of the costs arise from residential buildings and public and commercial services. Second in importance are the networks needed in the residential areas(networks of traffic, heating, water supply, sewage and drainage, electricity and telephone). The cost significance of the other structures (yards, parks and fields) is minor. The municipality pays 9 to 26 % of the total costs, the average being 15%.

Table 1. Variation in the total relative costs of the study areas

Type of area	Relative costs, FIM/floor sq.m (control figures in brackets)		
	Cheapest area	Most expensive area	Mean
Small house areas	5042 (100)	5514 (109)	5264 (104)
Mixed areas with a majority of small houses	4191 (100)	5446 (130)	4693 (112)
Areas with a majority of blocks of flats	3941 (100)	4484 (114)	4171 (106)
All areas	3941 (100)	5514 (140)	4640 (118)

The results show that the total relative costs of the most expensive area are about 40% more than those of the cheapest. The most expensive area is an incomplete area of solely small houses where a considerable part of the planned floor area has not been used. The cheapest area is one with solely blocks of flats, the planned floor area being almost 100% complete. In different types of area the most expensive areas cost 9 to 30% more than the cheapest ones. Cost variation is especially great in the group of mixed areas with a majority of small houses.

The total costs of the areas divided by the number of dwellings give the following extreme and mean values (control figures in brackets):

–	cheapest area	285 000	FIM/dwelling	(100)
–	most expensive area	758 000	”	(266)

– mean 449 000 ” (157).

Accordingly, the most expensive area costs some 2, 7 times more per dwelling than the cheapest one. The former contains solely small houses and the average size of dwellings is some 2.1 times that in the cheapest area (one with a majority of blocks of flats). The great increase in cost variation as compared with the previous results according to the FIM/floor sq.m criterion is due to the above mentioned differences in the size of dwellings. They considerably increase the costs per dwelling in small house areas because there the average size of dwellings is about 1, 7 times that in blocks of flats in all the areas studied.

2.2 Potential saving possibilities

The following cautious saving estimate was made on the basis of the total cost variations in the research (Appendix 2, figure 2):

It is possible to save at least 5% of the building costs in residential areas without lowering the standard of the environment. These savings can be achieved by planning and constructing the residential areas as economically as possible, taking the research results into account. The annual saving is over 1000 million FIM at the national level, calculated from the average figures of the research and related to the annual dwelling production in the planned areas. Dwellings and the total housing environment for more than 7,000 inhabitants could be built with this saving.

The estimated savings hardly require any saving investments at all. Such things as transfer of information to planners and decision makers, introduction of new planning and testing methods, development of relevant research and training are needed most. Their costs are only a fraction of the savings thus possible (Appendix 2, figure 2). For example, the planning costs of a residential area are at the most 0, 5% of the building costs. Considerable savings in the building costs can be achieved by an increase in planning resources and by more thorough planning. The quality of the housing environment can thus be improved by more effective planning.

2.3 Building costs and density

In the ASTA-research the variation in the relative building costs was analysed by five different density factors. The best indicators of the cost variation are the average size of buildings, average number of storeys and percentage of blocks of flats in the study areas. Each of these factors can statistically explain 75 to 80% of the cost variation. Consequently, choosing the average size of buildings, number of storeys and percentage of blocks of flats fixes the relative total costs of an area to a considerable extent. This is due to the influence of these highly interrelated factors on the building costs of both houses and networks. According to the study, the area building density and the average block building density do not account for the variation in relative costs nearly so well as the above mentioned factors.

The regression curve gets the following form (Appendix 2, figure 3):

C_{in} (A_b)=3928+224680: A_b, where C_{in} is the relative internal building costs of the study areas (FIM/floor sq. m).Ab is the average size of buildings (floor sq. m); the average size of buildings is given by the division of the total floor area by the number of buildings. It shows how great masses of floor area the buildings on an average contain.

When the average size of buildings grows, the relative total costs initially fall very sharply (Appendix 2, figure 3). In the “last part” of the mixed areas with a majority of small houses (the average size of buildings about 700 floor sq.m) the costs are comparatively low, below the average for the whole material gathered. For areas with a majority of blocks of flats (the average size of buildings over 1,000 floor sq.m) costs remain almost level. In other words, the growth in the average size of buildings from approx. 1,500 to over 3,000 floor sq.m no longer lowers costs to any great extent.

The results of the calculation based both on the town plan and on the actual structure of the study areas show that the areas of solely small houses are on an average clearly more expensive than the other areas.

It is possible, however, to plan mixed areas with a majority of small houses almost as enonomically as mixed areas with a majority of blocks of flats. Further the areas of solely blocks of flats are on an average not cheaper than the most economic mixed areas. The growth in the average size of buildings over 1,500 floor sq.m does not noticeably reduce total building costs.

2.4 Building costs and soil conditions

Soil conditions considerably affect the building costs of a residential area. Only a few municipalities had sufficient knowledge of the soil conditions in the study areas when drawing up the town plan, though a residential area of 100,000 floor sq.m located in the worst soil conditions may produce costs 47 million FIM greater than in the best soil conditions. This alone means roughly a 9 million FIM cost variation in the municipal accounts.

Additional costs from soil conditions were studied by calculating the building costs of the study areas separately according to the actual soil data and from the predetermined control soil in addition to calculating their differences. The percentage of the additional soil costs thus calculated of the total costs are at their most expensive +10, 2%, on an average +1, 5% and at their cheapest −1, 3% (i.e. cheaper than the control soil). According to previous reports, the costs from soil tests can be approx. 0,03 % of the building costs of an area in difficult and changeable soil conditions while the greatest additional soil costs can amount to 300 times this figure. The money spent on soil tests, especially in difficult and greatly changeable soil conditions, will easily be repaid many times over if the test results are taken into account during the planning phase.

The research also shows that when a plan is drawn up in soil conditions worse than usual, first the location and shaping of buildings and only second the location of networks and other structures has to be considered in order to reduce total costs. When soil conditions grow worse, the share of buildings in the additional costs noticeably increases. It may be over 70% in bad soil conditions. Therefore as little as possible of the floor area should be planned on bad soil. The best soil is even, frostresistant, easy to excavate, and of good bearing capacity. Most additional costs result from hilly and rocky ground or that of poor bearing capacity. Rocky ground with relatively small height differences can be a rather advantageous construction base for the buildings if these are located in suitable positions.

2.5 Building costs during implementation

The relative building costs vary during the implementation process of the study areas between 3916 to 12343 FIM/floor sq.m (Appendix 2, figure 6). This variation is dependent on the construction order of different structures. The maximum costs are caused in the cases, where the essential parts of the external and internal networks but only a little part of the floor space have been constructed. Then the costs are on a relative high level but the cost divisor (floor sq.m) is small.

Loss of interest due to wrong timing of construction (“frozen” capital investment) can amount to 5% of the building costs in an area according to calculations. An economic result is achieved, for instance, by building dwellings, networks and services in balance as much as possible, completing sections in stages, and timing expensive structures and possible investment thresholds so that they may be utilized immediately on completion. Naturally this does not imply, for example, lowering of standards of service.

A balanced timing of the construction of networks can be achieved, among other things, in the following ways (Appendix 2, figure 7). The building starts from the side where the linking of the area to external networks is situated. Then it systematically proceeds by constructing suitable units towards the other sides of the area and avoids unconstructed sections inside the area. Care must be taken so that the given service standard is realized in the construction phase, too. This may inevitably give rise to temporary spare capacity and loss of interest. However, these drawbacks can be reduced, for instance, by taking full advantage of construction in stages and of various temporary measures. The nature of many structures in a residential area is such that their construction in stages is often possible if this is noted at a sufficiently early time. For example, schools and heating plants are gradually extended with the growth of consumers or the streets are finally paved only after other construction in the area. The types of construction objects that are more excpensive than average may greatly vary in a residential area (e.g. structures to be constructed in bad soil conditions; overpassing or/and underpassing of rivers and other natural obstacles; construction of big service buildings).

3 Operating costs of residential areas

3.1 Operating and energy costs of the study areas

The operating costs of study areas average more than FIM 17 million per year or some FIM 5300 per inhabitant. The share of buildings in the operating costs is more than a half while the share of transportation is more than a third (Appendix 3, figure 1). The energy costs average 45 % of all operating costs. The relative annual operating costs vary in the study areas from 118 to 204 FIM /floor sq.m, the average being 152 FIM/floor sq.m. In the most expensive area the relative operating costs are also more than 70% greater than those in the least expensive area. The variation is directly or indirectly due to the town planning solutions alone. The most significant factor for the variation in relative operating costs is external traffic costs.

The energy costs in the study areas average slightly more than FIM 8 million per year, which means costs of nearly FIM 2600 per inhabitant. The share of heating of buildings in the energy costs is almost half. The share of external traffic is nearly a quarter. In the most expensive area the relative energy costs are more than 60 % greater than those in the least expensive area. This variation is due to the solutions made concerning the location, dimensioning, density and structure as well as other town planning factors of the study areas.

According to the ASTA II -research it is possible by means of the town planning to save at least 5% in the operating costs of residential areas without lowering the quality of the environment. This means for the annually implemented living environment of Finland approximately FIM 800 million savings at the current price level. This calculation includes the current value of savings in operating costs for 50 years.

3.2 Microclimate and energy consumption

In the study areas the microclimate (wind conditions, solar access, local temperatures) gives rise to at most a 10% variation in the heat consumption of single buildings. By taking the different climatic zones in Finland into consideration it can be calculated on the basis of the research data that the microclimate may increase the heat consumption of a building by 20% at most when compared with the minimum level.

In the average heat consumption of all buildings the microclimate creates in the study areas a 3% variation only. This results partly from the random location of buildings in the study areas in relation to microclimate factors. Thus the good and bad microclimatic conditions partly cancel each other’s effects. The small variation is partly due to the fact that the same meteorological data of Jyväskylä-city were used in the research in calculations for all areas and these data do not represent the greatest microclimatic variation in Finland. In the areas with great climatic variation a conscious and systematic consideration of microclimatic factors can bring about 5 to 10% savings in the heat consumption of the whole area as compared with the worst solution.

The ASTA II -research showed that the heat consumption of buildings is primarily affected by the conditions regarding the temperature and solar access and only secondarily by the wind conditions when microclimatic factors were analyzed. In extremely windy places such as coastal regions the situation may, however, be the opposite. For this reason, the analysis of microclimatic factors should always be made case by case in urban and town planning.

3.3 Operation costs, location and dimensioning

The location of residential area is usually chosen in connection with the master plan of the city. As factors affecting the operating costs it fixes the microclimate, location in relation to traffic, network linkings and accessibility of existing services. The share of these factors in the operating costs of an area is highly significant i.e. about 40%. Operating costs due to the location can be lowered by locating the planning areas near the existing community structure and, if possible, so that a centralized heat supply becomes feasible. If mere cost savings are attempted, it is not worth lengthening significantly the distance of an area from the existing structures even for a good microclimate. This is because an extra journey length of already 200 m will grow the traffic costs more than it is possible to save heating costs by this means.

The size of an area has a complex and partly contradictory impact on the operating costs. Accordingly, there was no unambiguous correlation found in the research between the size and relative operating costs in an area. In connection with dimensioning, the operating costs can be lowered e.g. by setting the internal service level and self-suffiency in workplaces in the area high enough, which decreases the external traffic costs. With dimensioning it is possible to get the services, networks, fields and other such structures exploited with their full capacity, thus cutting the relative operating costs to the minimum.

3.4 Operating costs, density and structure solutions

According to the research the internal operating costs of study areas bear no unambiguous correlation to any density variable (Appendix 3, figure 2). This is mainly because the subfactors of operating costs of buildings, which average about 80 % of the internal operating costs in an area, partly cancel each other's effects when the density changes. The most significant factor laying behind this is the assumption made in the research concerning different self-support levels of maintenance work in different housing types. According to this assumption the maintenance costs in blocks of flats become more expensive than in small houses, due to a smaller amount of self-made work.

On the other hand, the heating costs of blocks of flats are generally lower than in small houses owing to their more favourable envelope ratio and heat supply system. If the maintenance costs, heat supply system and heat-technical properties of buildings remain approximately constant, the operating costs will decrease slowingly as the building size grows. Town planning regulations and notations can cause as high as a 50% variation in the heat consumption of individual buildings as compared with the minimum. The density and structure solutions inside an area can produce a cost variation in the operating costs of networks and internal traffic costs, which equals 10% of the total operating costs of the area.

3.5 Building and operating costs

The annual operating costs examined in ASTA II are 4, 0% of the building costs studied in ASTA I on average (Appendix 3, figure 3). In other words, when calculated for 25 years they equal the building costs. The location of an area usually has a parallel impact on both building and operating costs. However, the soil conditions and microclimate resulting from the location may also be mutually contradictory.

Complementing an incomplete area is more economic than building a new area, both regarding the building and operating costs. The size of an area does not have any unambiguous effect on building nor on operating costs. The building density explains well the building costs but poorly the operating costs.

4 References

Kivistö, T., Rauhala, K., Koskikallio, J., **Town Planning and Building Costs of Residential Areas,** ASTA. Final Report. Helsinki 1979, Ministy of the Interior, Division for Planning and Building, Research 62/1979. 329 p.

Kivistö, T., Rauhala, K., Koskikallio, J., **Town Planning and Building Costs of Residential Areas,** ASTA. Appendix. Helsinki 1979, Ministry of the Interior, Division for Planning and Building, Research 63/1979. 151 p.

Kivistö, T., Rauhala, K., Koskikallio, J., **Town Planning and Building Costs of Residential Areas**. Espoo 1980, Technical Research Centre of Finland, Laboratory of Land Use, Reports 31. 52 p.+ app.8 p.

Town Planning and Building Costs of Residential Areas. Helsinki 1979, Ministry of the Interior, Division for Planning and Building, Information Report 2/1979. 51 p.

Kivistö, T., **The formation and amount of energy investments of residential areas,** 15th Sept. 1978. Copy. 55 p.

Kivistö, T., Wahlgren, I., **The impact of the order and speed of construction on the building costs ofresidential areas**. Espoo 1984, Technical Research Centre of Finland, Research Reports 269. 115 p.+ app. 141 p.

Kivistö, T., Koskikallio, J., Rauhala, K., **Town planning and operating costs of residential areas** (ASTA II). Report 1: Calculation principles and tentative results. Helsinki 1982, Ministy of the Interior, Division for Planning and Building, Research 7/1982. 162 p.+app. 162 p.

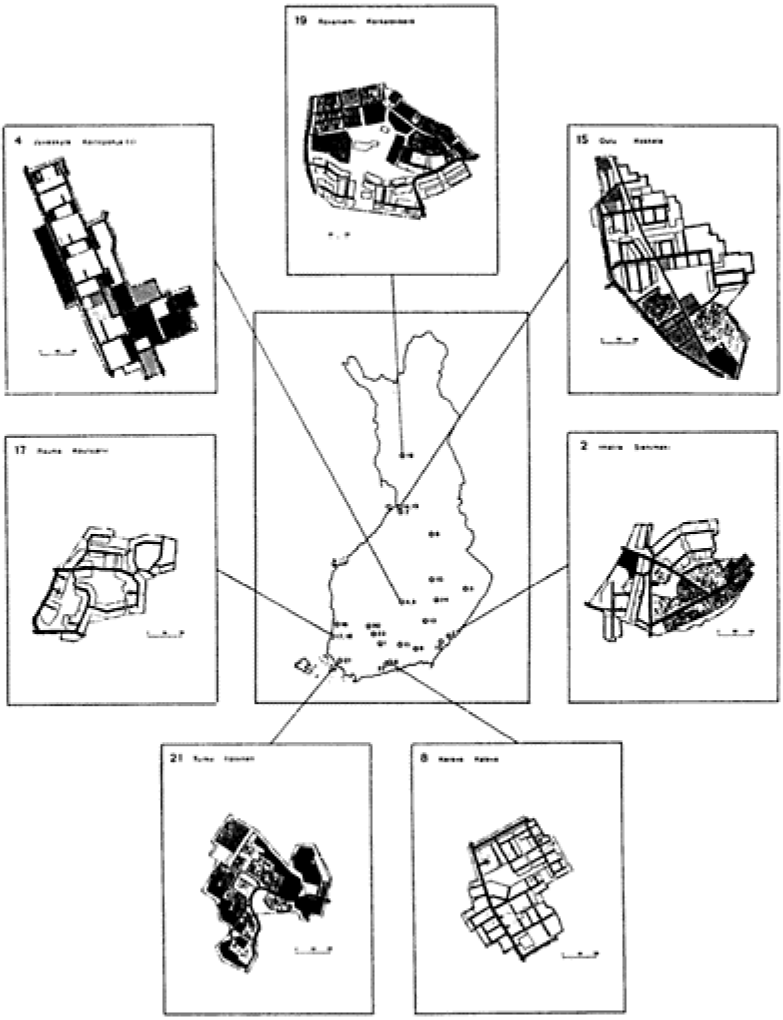
Kivistö, T., Rauhala, K., **Town planning and operating costs of residential areas,** Report 2: Results on area level and conclusions. Helsinki 1987, Ministry of the Environment, Division for Planning and Building, Research. To be published.

Kivistö, T., Rauhala, K., **Town planning and operating costs of residential areas** (ASTA II). Helsinki 1985, Ministry of the Environment, Division for Planning and Building, Information Report 2/1986.64 p.

Kivistö, T., **Town Planning and Building Costs of Residential Areas.** Hanko 1987, Doctor Thesis 137 p

Kivistö, T., Rauhala, K., **Town Planning and Operating Costs of Residential Areas** (ASTA II). Espoo 1989, VTT Research Notes 935, 61 p.

Appendix 1: Location of the study areas, examples of the area structures



Appendix 2: Building costs of study areas

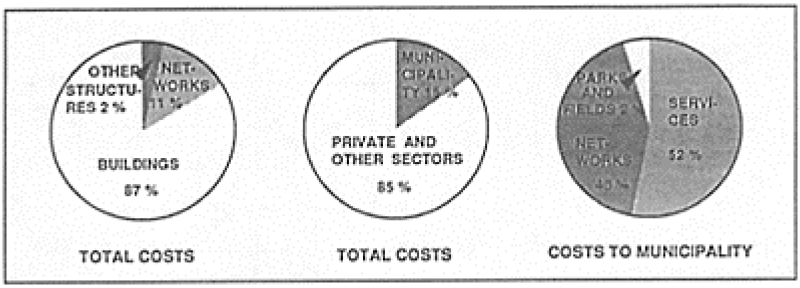


Figure 1. Average cost shares of the study areas

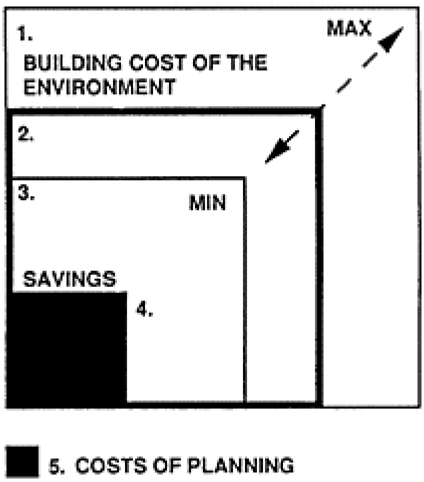


Figure 2. Costs of building, planning and, studying the residential areas.

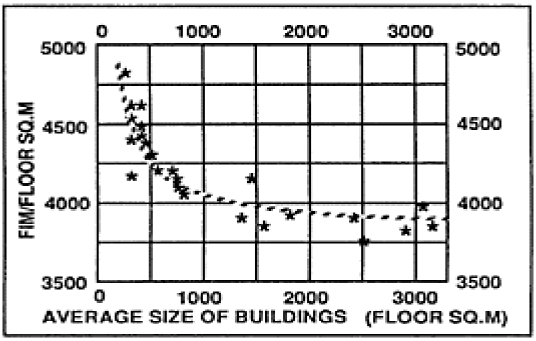


Figure 3. Correlation between relative total building costs and the average size of buildings

The building costs of the annual dwelling production (48,000 dwellings) and of the housing environment thus implied are 40, 24 and 16 milliard FIM (fields 1, 2 and 3) after the most expensive, mean and the cheapest area of the study. The potential savings (field 4) are over 5% and the costs of planning (field 5) about 0.5 % of the average building costs.

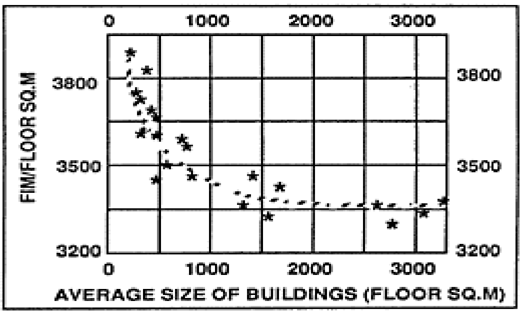


Figure 4. Correlation between relative costs of residential buildings and the size of buildings.

Appendix 2: Building costs of structures

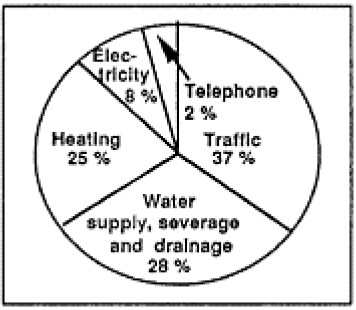


Figure 5. Cost shares of different networks from the total networks costs.

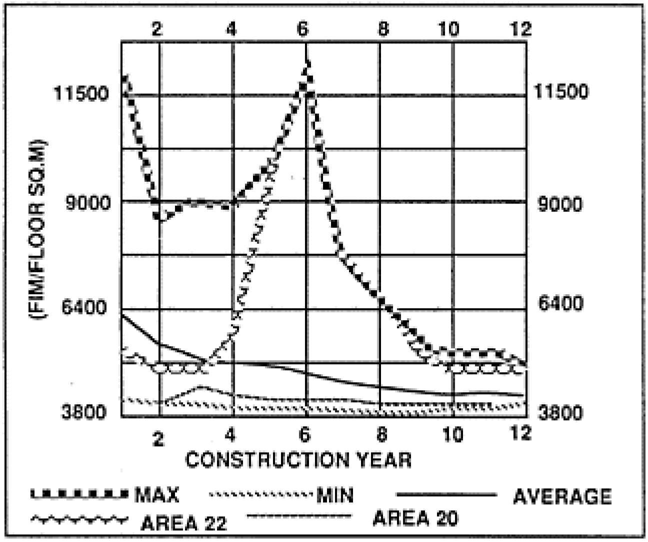


Figure 6: Relative building costs during the construction process.

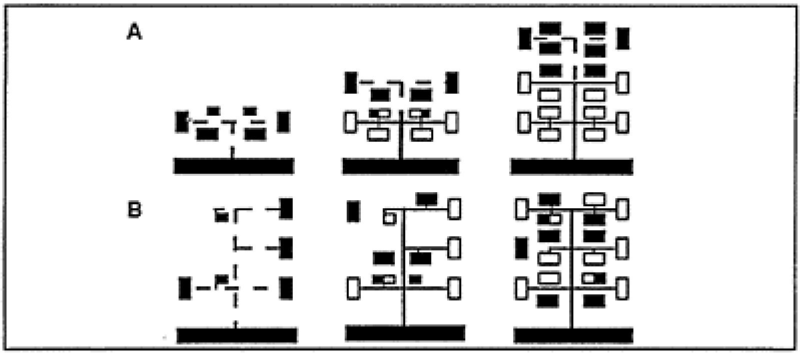


Figure 7. Examples of economical and uneconomical timing of construction in a residential area.

In case A, the construction systematically proceeds starting from the side where the linking to external networks is situated. The building of dwellings, networks and services proceeds in balance, and neither loss of interest nor shortage of services occurs. In case B, considerable losses of interest will result especially from the ineffective use of networks but also from that of services. The quantity of real losses of interest significantly depends not only on the extent of network and service investments but also on the duration of different phases. The longer the period between the construction phases in case B is, the greater the losses of interest.

Appendix 3 : Operating costs of study areas

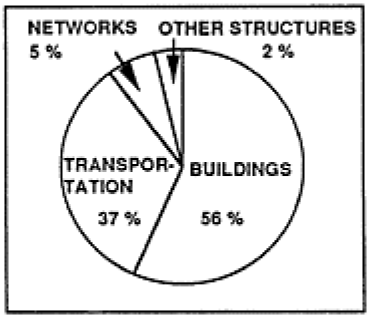


Figure 1. The percentages of different factors of the operation costs.

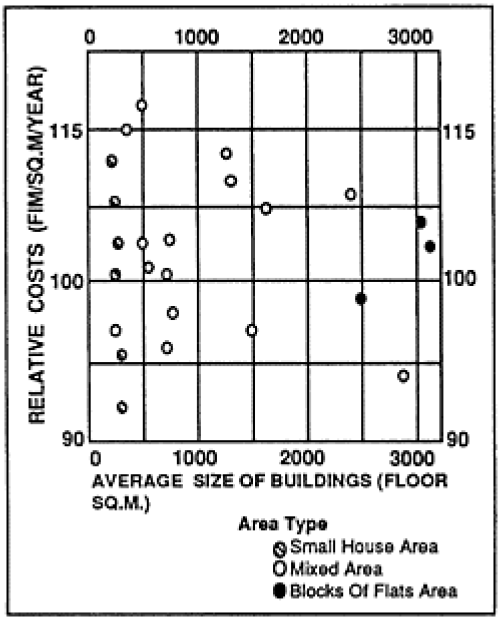


Figure 2. Correlation between relative operating costs and the average size of buildings.

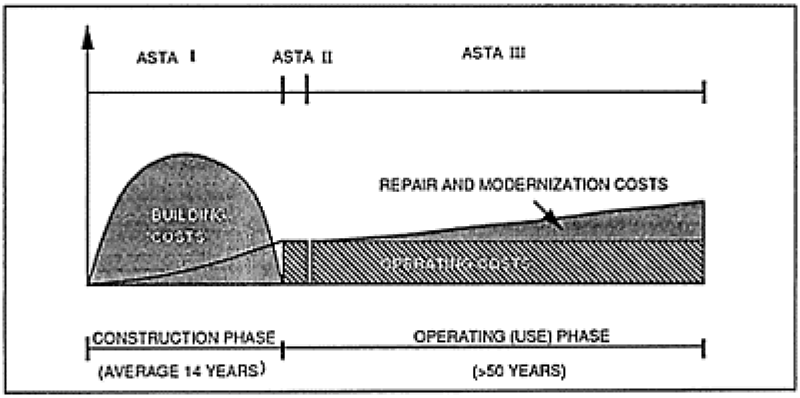


Figure 3. Total costs of the study areas

124
Reliability-based optimization of prefabricated concrete structures

O.J.KOSKISTO and B.R.ELLINGWOOD

Abstract
This paper presents a decision model for minimizing the life cycle cost of prefabricated concrete elements and structures, taking into account the building design-manufacturing-construction-maintenance process as a whole. The decision model utilizes principles of engineering economic analysis under uncertainty, considering costs and benefits of construction, maintenance, repair, and consequences of failure. The optimal solution is obtained by identifying those values of the decision variables that result in minimum expected total cost. Performance constraints are imposed on the optimization process by the need to ensure safety under extreme loads with a high level of reliability and serviceability under conditions of normal usage. The concepts are illustrated for precast concrete floor slabs. The constraint, in the form of a limit on the probability of flexural failure, is formulated using principles of structural reliability theory.

Keywords: Buildings, Concrete (precast), Concrete (prestressed), Life Cycle Cost, Limit State Design, Optimization, Probability, Reliability, Structural engineering.

1 Introduction

The building process consists of several stages: planning, design, manufacturing, construction, and maintenance. All stages must be considered in building design to obtain a result which is optimal for the entire process. The owner's interest is in obtaining a safe and serviceable building at a minimum overall cost during his period of ownership. The interests of other building project participants do not always coincide with that of the owner. For example, minimizing construction cost by choosing the lowest construction bid is unlikely to result in minimum overall costs for the life of the building.

The traditional role of structural design in this process is to identify the overall structural geometry and select member sizes so as to achieve near-minimum cost or weight and meet the performance objectives of the code, the architect and the owner/developer. The designed structure must have sufficient reliability against ultimate and serviceability limit states specified by the code. Structural failure, defined as the building's inability to sustain the loads for which it was designed, is considered to be the ultimate limit state of the building. Prior to ultimate failure, the building may reach various serviceability limit states that impair its usefulness under conditions of ordinary use.

There is an inherent tradeoff between safety and economy in structural design. Recent developments in structural codes make use of probabilistic methods in setting safety and serviceability criteria. The current load and resistance factor design codes (ACI, 1983; AISC, 1986; NKB, 1987) address mainly design of single structural members. The member target reliabilities in the first generation of probability-based codes (e.g., AISC, 1986) were arrived at through a calibration process which involved the assessment of reliabilities in existing codes. None of these codes have utilized methods that incorporate engineering economic analysis under uncertainty, and thus there is no assurance that the current design requirements are optimal from a minimum overall cost viewpoint.

An improved basis for structural design would be obtained by selecting safety and serviceability checking procedures and tailoring quality assurance programs so as to minimize the life cycle cost (LCC) of structural components or systems. Life cycle costs include investment cost (planning, manufacturing, construction, quality assurance and quality control costs), operation cost, and maintenance cost (preventive and corrective maintenance). A methodology has been proposed for aseismic design which takes into account the life cycle of the building (Rosenblueth, 1979, 1986). However, similar methodologies do not appear to exist for buildings in general. Among the barriers to the development and implementation of such methodologies are the lack of quantitative data and the difficulties in incorporating various intangible costs in the analysis.

2 Plant Precast Construction

There are certain systems or subclasses of building structures for which optimization methods appear feasible with presently available information. For example, in plant precast or industrialized building construction, the prefabricated structural elements are made in better controlled circumstances than in cast-in-situ construction. Quality assurance and quality control procedures are required of manufacturers of type-approved precast concrete elements, and so more quantitative data exist to describe the variability of structural properties and the costs that are needed for optimization analysis.

Prefabricated concrete structural elements typically are designed by the manufacturer. The structural engineer identifies dimensions and design loads which the elements have to sustain and then selects appropriate sections from tables provided by the manufacturer. Structural properties of the concrete elements are fixed by the manufacturing process. The manufacture of prestressed, precast hollow core slabs consists of the following operations: prestressing of strands; mixing, extrusion, and curing of concrete; release of prestress; and cutting the units. The cost of slabs depends on the following engineering and production parameters: cement content in, water-cement ratio, gravel-cement ratio, amount of steel, concrete batch size, mixing time, and time to achieve the concrete strength needed in order to release prestress. The manufacturer also is responsible for transportation and erection of the elements. Thus, the cost of a concrete slab associated with the manufacturing and construction phases is a function of weight, as would be expected, manufacturing and construction productivity, and other factors.

3 Minimum Cost Decision analysis

When the consequences associated with each alternative in decision analysis can be expressed in terms of monetary values, a widely used criterion for decision is the expected monetary value. If the benefit associated with each alternative can be regarded as a constant, one should minimize the total expected cost,

$$C_T=C_D+Cp+C_C+C_{QA}+C_M+p_fC_F \tag{1}$$

where C_T is the total cost of the project, C_D is the planning and design cost, Cp is the production cost, C_C is the construction cost, C_{QA} is the quality assurance cost, including cost of QA measures and cost of corrective actions in response to QA measures, C_M is the cost of maintenance and in-service inspections, p_f is the probability of failure, and C_F is the cost associated with failure. The term p_fC_F is the expected failure cost. All costs must be adjusted to present worth to allow for the effect of time. These costs are dependent on engineering and production variables, designated by the vector x. Constraints may be imposed on the minimum expected cost analysis by the need to maintain safety and serviceability, and by the ranges that can be assumed by specific decision variables. The latter may arise from the physical nature of the process, availability of raw materials, and operating characteristics of the machinery used in production.

Both p_f and C_F depend on the mode(s) of failure being considered (Melchers, 1987). C_F is assumed to be independent of the design, manufacturing and construction variables. The evaluation of C_F should take into account damage to the structure, the expected value of lives lost, injuries inflicted, social impacts, and loss of reputation of those involved in the building's design and construction (Rosenblueth, 1986). Different parties involved at various stages during the life cycle of the structure may evaluate C_F differently; in that case, a multiobjective optimization approach is required, with C_F varying for different interest groups (Melchers, 1987). In this paper, however, a single objective is considered from the design and manufacturing point of view, and it is assumed that the design task is to maximize the total expected monetary value or minimize the total expected cost.

Before the expected cost in Eqn. (1) can be carried out, the relationship between pf, the costs C_D(x), C_P(x), C_C(x), C_{QA}(x), and C_M(x) and the vector x must be established. Some components of x are common to more than one phase of the building process and can affect more than one of the cost components in Eqn. (1). The example provided subsequently deals with precast concrete structures. When building and construction companies have developed their quality assurance and quality control procedures more fully, cost data should be available from a wider variety of construction types.

4 Structural Reliability Theory

Minimum expected cost decision analysis utilizing Eqn. (1) requires that the limit state probability, p_f, be expressed in terms of the engineering variables identified as contributing to the cost functions in the previous section.

The resistance, *R*, of a reinforced concrete structure or component generally is a nonlinear function of the tensile strength of the reinforcement, compressive strength of concrete, dimensions of the members, and the location of the reinforcement, all of which are random in nature (MacGregor et al., 1983). The overall structural action due to the applied loads, *S*, is a linear function of those loads, provided that the structure behaves elastically. The limit state occurs when $R<S$. Accordingly, the limit state probability, $P(R<S)$, is

$$p_f = P(R < S) = \int_0^\infty F_R(s) f_S(s) ds \tag{2}$$

in which $F_R(s)$ is the cumulative distribution function of *R* and $f_s(s)$ is the probability density function of *S*. These probability distributions describing *R* and *S* can be determined (at least conceptually) from the probability distributions of the basic material strengths, dimensions and individual loads, which are included in the vector, x.

The integral in Eqn. (2) can be evaluated in closed form in a few special cases. If *R* and *S* both are lognormal random variables,

$$p_f \approx 1 - \Phi\left(\frac{ln(m_R/m_S)}{\sqrt{V_R^2 + V_S^2}}\right) \tag{3}$$

in which $\Phi(\cdot)$ is the standard normal cumulative distribution function, m_R and V_R are the mean and coefficient of variation in *R*, and similarly for *S*. In general, m_R and V_R can be expressed as functions of the basic variables, x= $(x_1, x_2,\ldots, x_k)$;

$$m_R=m_R(\mathrm{x}) \quad V_R=V_R(\mathrm{x}) \tag{4}$$

Thus, the limit state probability is a function of x as well;

$$p_f=p_f(\mathrm{x}) \tag{5}$$

The objective of probability-based design is a structure or component for which p_f is less than some target limiting value, p_{f_0},

$$p_f(\mathrm{x}) \le p_{f_0} \tag{6}$$

This requirement can be transformed into a constraint involving the variables, x, using Eqns. (3) and (4)

$$ln(m_R) - ln(m_S) - \Phi^{-1}(1 - p_{f_0})\sqrt{V_R^2 + V_S^2} \ge 0 \tag{7}$$

in which $\Phi^{-1}(\cdot)$ is the inverse of the standard normal distribution function.

5 Optimization Procedure

The building process can be described by the model presented in Fig. 1. The decision variables $x_d=(x_1,\ldots, x_j)^T$ can be varied through engineering or manufacturing process control to achieve an optimum minimum-cost solution. Examples of these variables for precast concrete construction are cement content, water-cement ratio, height of the slab, and amount of steel.

The vector $x_r=(x_{j+1},\ldots, x_k)^T$ consists of structural parameters which are not decision variables but which may influence the constraints on the process. The constituents of the vector x_r may be described by probability laws if they are random. This randomness may have to be considered while evaluating the values of the constraints. The width and the span of the slab, and the position of the steel strands are examples of these parameters. The vector $x_v=(x_{k+1},\ldots, x_n)^T$ includes parameters such as temperature, humidity, live load, wind load, and snow load which are not under the control of the designer or manufacturer. The noise vector, $n=(n_1,\ldots, n_l)^T$ represents uncontrollable parameters. Finally, $y=(y_1,\ldots, y_m)T$ is a vector of output variables which represent costs (objective function) and structural behavior limit states of the concrete elements (constraints).

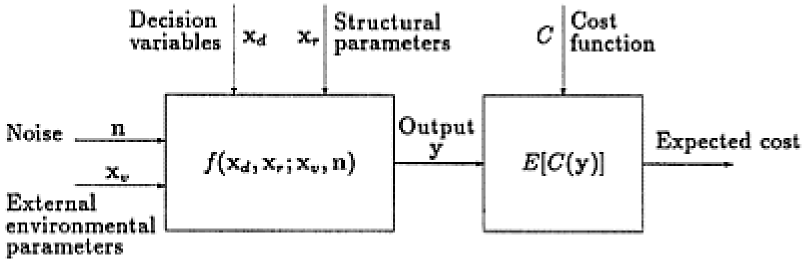


Fig. 1. Manufacturing process.

The output variables y can be evaluated in terms of decision variables x_d and structural parameters x_r, but the relation often is so complicated that the exact expression cannot be determined. An approximate substitute model of the process can be written in the form:

$$y_1=F_1(x_1,\ldots, xk)$$
$$y_2=F_2(x_1,\ldots, xk)$$
$$\vdots$$
$$y_m=F_m(x_1,\ldots, x_k)$$

The functions F_j describe approximately the dependence of the cost and constraints on x_d and x_r for a given set x_v. The choice of the functions F_j approximating the behavior of should be based on careful analysis of the process. In the absence of more precise information, second-order polynomial models often are used:

$$y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k} b_{ii} x_i^2 + \sum_{i=1_{i<l}}^{n-1} \sum_{l=2}^{n} b_{il} x_i x_l \qquad (8)$$

where b_i are first order coefficients, b_{ii} are second order coefficients, and b_{il} interaction coefficients.

The minimum cost optimization can be formulated as follows:

$$Min \qquad y(\mathbf{x}_d) = b_0 + \sum_{i=1}^{j} b_i x_i + \sum_{i=1}^{j} b_{ii} x_i^2 + \sum_{i=1_{i<l}}^{j-1} \sum_{l=2}^{j} b_{il} x_i x_l \qquad (9)$$

subject to *n* reliability or performance constraints, e.g.:

$$p_{f_n} = \int_{g_n(\mathbf{x}_r) \leq 0} \int f_{\mathbf{x}}(\mathbf{x}_r ; \mathbf{x}_v) d\mathbf{x} \leq (p_{f_0})_n \qquad (10)$$

and additional imposed limits on the decision variables:

$$x_i^l \leq x_i \leq x_i^u \qquad i = 1, \ldots, j \qquad (11)$$

6 Example

Consider a process involving the design and manufacture of precast concrete hollow core slabs. The quantities which influence the manufacturing cost include:

– cement content, in kg/m^3
– amount of steel, A_s
– water-cement ratio, *w/c*
– height of the slab, *h*

These quantities form the vector of design variables $\mathrm{x}_d=(x_1,\ldots, x_j)^T$.

The nature of the manufacturing process places practical limits on many of these variables. For example, the manufacturing process is very sensitive to variations in the fine aggregate grading and free *w/c*-ratio and uniformity in slab production is only possible if these two factors are controlled within very stringent limits in the production process (Lewitt, 1982). The strength of concrete is a function of cement content, water-cement ratio, the fine aggregate grading, and heat treatment during slab curing. In this example, the effect of these variables has been combined and represented by the compressive strength, which is treated as an independent decision variable.

The production cost *Cp* is approximated by the linear function:

$$y = b_0 + \sum_{i=1}^{j} b_i x_i \qquad (12)$$

where b_0 represents a fixed cost which would include investment and design cost and b_i indicate the relative importance (weights) of the decision variables. Because data are not available at this relatively early stage at the research, only equal weights were assigned in this example; additional data will permit these weights to be revised later. All cost values are assumed to have been converted to present worth.

Acceptable performance of concrete slabs depends on the following limit states:

– flexural cracking
– shear or diagonal tension failure
– flexural tensile failure
– excessive deflection

In this example we will limit our attention to slabs spanning between 6 *m* and 12 *m;* for such slabs, the flexural tensile failure limit state is the most significant. The controlling design load combination for the slabs is assumed to be dead plus occupancy live load.

The flexural strength for an underreinforced concrete slab element in one-way flexure is expressed as,

$$M = A_s f_y d\left(1 - 0.6\rho\frac{f_y}{f_c}\right) \tag{13}$$

where M is the moment capacity of the slab, A_s is the area of the reinforcement, f_y is the yield strength of steel, d is the depth to the centroid of tensile reinforcement, $\rho=A_s/bd$ is the reinforcement ratio, b is the slab width (nominally 1.2 *m*), and f_c is the compressive strength of concrete.

The design equation for precast prestressed concrete slabs in flexure is,

$$M_d \geq 1.2g_k + 1.6q_k \tag{14}$$

in which M_d is design flexural strength, and g_k and q_k are characteristic dead and occupancy live load. The flexure strength, M_d, is computed using the design values of steel tensile strength and concrete compressive strength, $f_{yd}=f_{yk}/1.15$ and $f_{cd}=f_{ck}/1.50$ in Eqn. (13). The characteristic strengths f_{yk} and f_{ck} of the steel and concrete are, in turn, related to the means and coefficients of variation of these strengths by,

$$f_k = m_f(1 - 1.65V_{f_k}) \tag{15}$$

in which the parameter 1.65 arises from the assumption that the characteristic strength, f_k is approximately the 5% exclusion limit of the random strength, f. Conversely, once f_k is specified, m_f can be estimated from Eqn. (15), and the mean resistance in Eqn. (4) can be determined. The coefficient of variation of the yield strength of steel, V_{f_y} is 0.08 and of the concrete strength, V_{f_c} equals 0.10. The mean dead load, m_g, is assumed to equal g_k, while V_g is 0.08. The mean annual extreme live load, m_q, is taken as 0.4 kN/m^2 for residences and 0.8 kN/m^2 for office buildings (CIB, 1989). These statistical data are sufficient to determine m_R, m_s, V_R and V_s in Eqn. (7) in terms of the decision variables, x_d, identified above. The desired limit state probability is also required to formulate the constraint: herein, it will be assumed that P_{f_0} is 10^{-5}/*year*.

Optimum values of slab height, h, area of steel, A_s, and compressive strength of the concrete, f_{ck} are summarized in Table 1. The characteristic concrete strength, f_{ck}, remains the same for all cases and is the lowest allowed strength of 35 *MPa*. This is due to the nature of the flexural limit state, which is insensitive to the compressive concrete strength. The height of the slab, *h*, and the amount of steel, *As*, are the most important variables for the flexural limit state. The moment capacity depends mostly on area of reinforcing steel and the depth to the centroid of the reinforcement, and the latter, in turn, is directly proportional to the height of the slab. The optimal values of h and A_s depends on the relative weights in the cost function. The height of the slab seems to depend more on the mean value of live load than the amount of prestressing steel. Selecting the nearest standard height of the slab after optimization (cases identified with an asterisk in Table 1) has only a slight effect on the relative cost.

Table 1. Results of the optimization.

m_q=0.4kN/m^2				
l[m]	*h[mm]*	$A_s[mm^2]$	$f_{ck}[MPa]$	*Relative Cost*
6	150	150 (3)	35	68.37
8	184	240 (4)	35	79.98
	150*	280 (5)	35	81.47
10	219	330 (5)	35	93.35
	200*	360 (6)	35	93.66
12	255	450 (7)	35	108.57
	265*	440 (7)	35	108.62
m_q=0.8kN/m^2				
6	187	180 (3)	35	74.72
	150*	230 (4)	35	76.40
8	231	270 (4)	35	88.30
	200*	310 (5)	35	88.83
10	276	370 (6)	35	102.87
	265*	380 (6)	35	102.95
12	321	420 (7)	35	112.00
	265*	570 (9)	35	121.39

( )=no. of strands, $\phi=9.3\ mm$
*=nearest standard height for precast slabs

7 Conclusion

The results of the optimization depend on the cost function under consideration. The cost function should be a function of the most important, independent decision variables and it should describe real costs as accurately as possible. Relative rather than absolute costs can be used. However, the decision variables and the relative weights of those variables must be selected carefully. The collection of cost data for the precast concrete building process and the creation of suitable cost models for design, manufacturing and construction phases currently is underway.. Additional data are needed to describe the random variables in the reliability constraints. The statistics used to describe these variables can be simulated if the basic nature of the process under consideration is known and can be modeled mathematically. The role of quality assurance programs and their impact on cost and on reliability constraints can be implemented as well if the effect of QA measures on the decision variables and the mean and dispersion of engineering and production parameters can be identified.

The optimization procedure presented in this paper provides a systematic approach to finding the most economical structure from the life cycle cost point of view. With the additional data being developed, it may lead to more balanced design of buildings and building products.

8 References

AISC (American Institute of Steel Construction) (1986) **Manual of Steel Construction, Load & Resistance Factor Design**. AISC, Chicago.

ACI (American Concrete Institute) (1983) **Building Code Requirements for Reinforced Concrete**. ACI 318–83, Detroit.

CIB Commission W81 (1989) Actions on Structures, Live Loads in Buildings. **CIB Report,** Tenth draft.

Lewitt, M. (1982) **Precast Concrete: Materials, Manufacture, Properties and Usage**. Applied Science Publishers Ltd., Essex, England.

MacGregor, J.M., Mirza, S.A., and Ellingwood, B. (1983) Statistical Analysis of Resistance of Reinforced and Prestressed Concrete Members. **ACI-Journal,** May-June, pp. 167–176.

Melchers, R.E. (1987) **Structural Reliability, Analysis and Prediction,** Ellis Horwood Ltd., West Sussex, England.

NKB (The Nordic Committee on Building Regulations) (1987) Guidelines for Loading and Safety Regulations for Structural Design. **NKB-Report,** No. 55E, Copenhagen.

Rosenblueth, E. (1979) Optimum Design to Resist Earthquakes. **Journal of Engineering Mechanics,** Vol. 105, No. EM1, February, pp. 177–187.

Rosenblueth, E. (1986) Optimum Reliabilities and Optimum Design. **Structural Safety,** Vol. 3., No. 2, pp. 69–83.

125
Housing rehabilitation projects: a simulation based approach to evaluating the cost and time implications of alternative strategies

V.K.MARSTON

Abstract
This paper considers the need for improved tools to assist in the cost/time evaluation of alternative design approaches and management strategies for multi-unit housing rehabilitation projects. It identifies probabilistic output and a production process basis as essential ingredients, and proposes what is termed an intelligent simulation approach. This approach is essentially a stochastically evaluated simulation of the production process, the formulation and operation of which is supported by knowledge based systems.
Keywords: Housing rehabilitation, Knowledge based systems, Simulation, Cost forecast, Duration forecast, Repetitive processes

1 Introduction

Multi-unit housing rehabilitation projects pose unique problems of operational planning. Clients and their advisors face policy and strategy decisions that affect the entire operational context of the project, and hence its cost and duration. Construction planners and managers face operational decisions within the context set by the client, against a background of poor information and extensive uncertainty. Conventionally there is no mechanism, other than the broad brush of experience, to inform the client and his advisors upon the implications of such strategic decisions, or to identify those requirements of the construction team that are critical to the successful completion of the project.

Characteristic of multi-unit housing rehabilitation projects are strategic client centred decisions such as:

– Policy regarding existing tenants. Choices may include decanting all occupants into alternative accommodation for the duration of the works, staged relocation of occupants or completion of the work with tenants in situ.
– The extent of renewal to be undertaken. For example, a given objective final condition for the property may be achieved by a patch and repair approach which seeks to minimise the quantity of building work undertaken, or by extensive gutting and renewal which involves greater nominal quantities of work but improved operational efficiency.
– A completion or hand over rate that is realistic and deliverable.

Contract planners and managers face various operational decisions including:

– Sequencing of work over the multiple housing units.
– Temporary works requirements.
– Timing of key materials supplies.
– Maintenance of essential services to occupants.
– The extent and breakdown of subcontracting.

Uncertainties pervade the context in which these decisions are made. In addition to those generally inherent in construction work, such as weather, productivity rates, compliance with delivery dates etc, multi-unit housing rehabilitation projects involve uncertainties concerning:

– The detailed condition of the existing buildings, which will affect both the extent of work and achievable productivity rates.
– The availability of workplaces where tenants are to be decanted.
– Access and conditions of working where tenants remain in occupation.
– Materials ordering where specifications of work have an element of tenant choice.

There is a clear need for tools to advise upon these decisions. Seeking optimum solutions to such wide ranging and complex problems is impracticable. It is feasible however, to provide decision support which gives significantly improved information to the decision maker and allows a degree of experimentation with alternatives. A model is required which is capable of both reflecting operational consequences and accounting for the uncertainties that are a key and integral part of the problem.

2 Simulation and knowledge based systems

2.1 Simulation of construction projects

Computer simulation offers a means of experimenting with representations of complex systems. The experimentation can be interactive gaming or classical experimentation designed to represent stochastic behaviour (Pidd 1989). There has been a lot of interest in computer simulation of construction projects, based on conventional planning models of the production process. Jackson (1983) advocates the use of stochastic simulation in the evaluation of conventional critical path network plans. CASPAR, developed at the University of Manchester Institute of Technology, (Thompson and Willmer 1985) is a project management tool aimed at risk assessment of strategic development decisions for major civil engineering projects, again employing stochastic evaluation of a network plan. The Construction Project Simulator (CPS), developed at Reading University (Bennett and Ormerod 1984), models building projects using Gantt charts and is particularly interesting because it invokes uncertainty in two forms, the 'normal' variability in the durations of activities, and interferences with (or disruptions to) the production process, such as the effects of weather, late instructions, subcontractor default etc.

Such systems give probabilistic output and, being based on planning models of the production process, are capable of representing operational consequences. However, they require extensive and skilled work to formulate the production plan. This mitigates against their being used to experiment in a gaming, interactive way. It also poses problems if the simulation is to be undertaken in the early stages of project development, because detailed information is not available and contract planners are not yet involved. There is a more fundamental problem however. These systems rely on the stochastic evaluation of a predetermined plan. The reality of construction projects is different. It involves extensive tactical planning by the site management during the production process together with management control action. In the real world the stochastic element is not allowed to run unchecked, but triggers responses from management. Actual project cost and time is a product, not just of planning and chance, but also real-time management control. Building interdependences into the model may deal with some aspects of this problem, but has a severe penalty in increased complexity, and demands considerable skill of the model builder. A different structure is necessary to tackle the problem at its root.

2.2 Intelligent simulation

Hybrids of simulation and knowledge based systems offer a potential solution to these problems. Adding intelligent components increases the capacity to simulate complex systems, particularly those with significant behaviourial components. (Paul 1989, Flitman and Hurrion 1987, O'Keefe and Roach 1987). A knowledge based approach can be used to support the formulation of the production plan upon which the simulation will be based. This will speed the process of setting up the simulation, and make it accessible to users with limited expertise in contract planning. The same knowledge based system can also be used to allow replanning to take place during the simulation, where events have caused unacceptable deviations from the original plan. This latter facility can be enhanced by the provision of a second knowledge based module representing the construction management domain, and enabling the tactical decision making and control actions of site management to be emulated within the system.

Construction contract planning is a very complex process, and the use of expert systems in plan formulation has been the subject of extensive work, particularly in the USA (see for example Hendrickson et al 1987, Ibbs and De La Garza 1988, Navinchandra et al 1988, Alshawi and Jagger 1989, Moselhi and Nicholas 1990). The greatest successes have been with constrained or simplified situations, such as oil platform construction (Levitt and Kunz 1985), where a limited set of activities occur with largely definite precedences. However, because of the high level and set pattern of repetition involved, relatively simple construction precedencing and a limited number of activity types on a given project, multiple unit housing rehabilitation appears to offer the potential for at least semi-automatic plan formulation.

Outside the construction field, work has taken place on the use of expert systems in the control of discrete event simulations (Flitman and Hurrion 1987), from which some lead may be taken in the emulation of management control in the simulation of construction projects.

The feasibility of developing an 'intelligent' simulation system for housing rehabilitation projects is the subject of a study currently under way at Salford. The work envisages a tool capable of offering the cost-time evaluation of strategies, and allowing both gaming style experimentation and the representation of stochastic behaviour. The aim is to support operationally significant decisions faced by both the client and contract planners/ managers, of the kind exemplified at the start of this paper.

3 Planning housing rehabilitation projects

3.1 Strategic planning

The early stages of the work at Salford have involved a preliminary knowledge elicitation process carried out with the assistance of collaborating surveying and contracting organisations. This has shown that the methods used in practice for overall project planning are both simple in principle and application. Extensive simplifying assumptions are used, and the major input is judgement from experience, rather than formal feedback or detailed analysis.

In practice the approach to overall project planning follows the general principles of the line of balance method, although formal application of the technique rarely takes place. The essential features of the planning process are as follows. A hand over rate is determined for each of the trades involved to match the time constraints imposed by the client, and an assessment of the resourcing required to meet these rates is made. The rates of unit completion for a trade gang are assessed from experience, there is little evidence of formal feedback mechanisms. These rates are quite general and appear to be widely accepted in the industry; typical examples are one week for internal painting and decoration in the case of tenanted 3 bedroom dwellings, one week for plastering of unoccupied 2 bedroom apartments. The quantities of work to be carried out by each trade in each dwelling are taken to be equal, and therefore the duration of each trade activity in each workplace is assumed to be the same. This simplification is made even in cases where there are known to be significant differences in work requirements from one workplace to another, as a result of differences in the size or initial condition of the housing units for example, or because of different tenant requirements. Considerable attention is paid to ensuring continuity of work, particularly for subcontractors, and this tends to be a major consideration in determining the sequencing of work.

Tenant related matters are critical to the overall planned duration of the works and the sequencing of operations within the housing unit. Where tenants remain in occupation the need to maintain essential services, the limited amount of demolition or concurrent work which can take place and the spacial restrictions, all contribute to an increase in the duration of the works. This increase may be of the order of 25% compared to unoccupied dwellings.

3.2 Tactical planning and control

Practitioners see project success as achieved at the tactical rather than overall planning level. The central issues in tactical planning are workplace availability, materials ordering and delivery (frequently critical because of limited on site storage and widely distributed workplaces), continuity of work for sub-contractors and the need to complete units for inspection or hand over continuously throughout the project. Control responses depend on the type of contractor. In this respect there is a significant difference between direct labour organisations[1] (DLO) and private sector contractors. DLO tend to minimise subcontracting, and are frequently able to employ resources flexibly across contracts, tending to shift labour freely to maintain hand over rates. They also show some success in developing multi-trade gangs and multi-skilled

[1] Until recently, in the UK direct labour organisations were contract works departments of local authorities and as such were employed extensively on local authority housing rehabilitation projects. Over the last few years, changes in legislation have forced these organisations into full competition with the private sector and have encouraged their privatisation. Therefore the differences in approach cited here are likely to be short lived.

labour, with resultant improvements in efficiency and an easing of continuity of work problems. Private sector contractors face different problems. Generally they subcontract heavily and lack the flexibility of labour allocation available to the DLOs. Although they pass the responsibility for achieving productivity targets to their subcontractors, the problem of ensuring the necessary continuity of work and availability of workplaces and materials becomes critical.

4 System development

4.1 Theoretical form

A theoretical schema for an intelligent simulation approach to construction cost-time forecasting is shown in Fig 1. The user inputs requirements for the project in terms of a description of the work *(design)* and the strategy that is to be employed in its

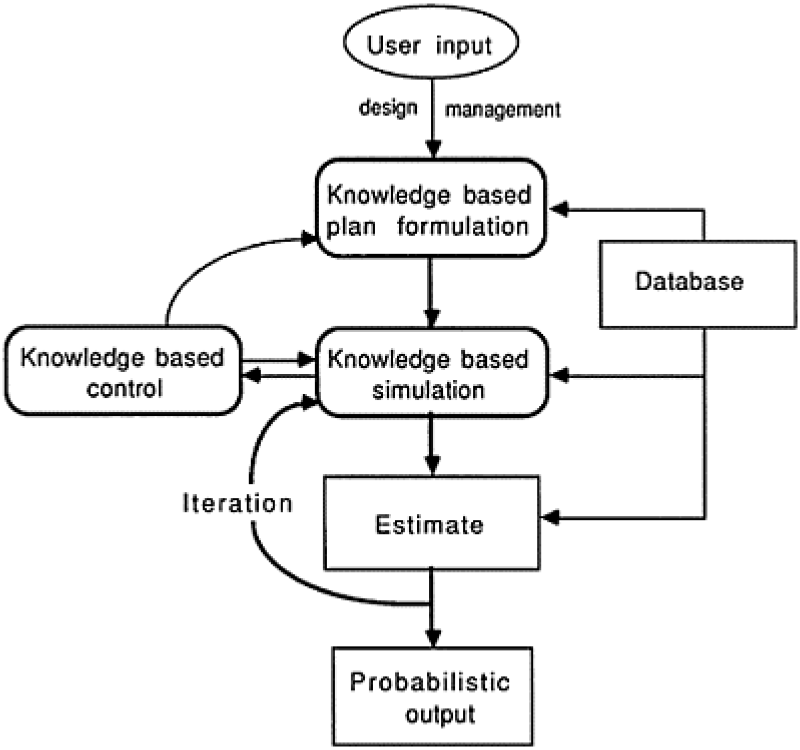


Fig.1. Theoretical system schema

execution *(management)*, including such matters as decanting of occupants, hand over rate required, subcontracting policy etc. A knowledge based module then formulates the plan which will act as the model of the production process during simulation, accessing data such as productivity rates from a database of technical information. The production process itself is then simulated, drawing productivity rates and occurrences randomly from appropriate probability distributions and again accessing information from the database. During simulated production the knowledge based control facility emulates management control by triggering and specifying action such as revision of the subsequent plan, resource level adjustments etc. The resources consumed are costed out to give a project total cost, and this value and the total project duration are recorded. The simulation iterates through the specified number of trials and the resultant probabilistic time and cost estimates provide the main system output.

Although not shown in the diagram, a visual interactive interface for the user is necessary to provide a measure of continuous validation in use. Graphical presentation would enable the plan generated by the system to be confirmed or altered. Visual run time monitoring of the simulations would also be useful, not only to improve the facility for gaming, but also as an aid to system development.

4.2 Working structure

For the purposes of the feasibility study it was decided to limit consideration to the modernisation of low rise housing of traditional (UK) construction. The total range of distinct activities to be encompassed is usefully limited by this decision to around 30. Furthermore, the number of critical activities encountered on an individual project is small, typically ten to fifteen.

The approach adopted is to represent activities within the system as objects, using a frame structure with the attributes of the activity defined in slots. Some attributes, such as information on the technical description of the activity, technologically determined precedences and certain default values, are predefined. The values of others are determined as instances during system operation. The attribute values necessary to specify each activity are determined by means of a rule based conversion of the user's description of the design requirements, supported by information held in the system technical database. The values of attributes such as duration, planned and actual start and finish times, and resource consumptions, are generated by the planning and simulation processes outlined below.

A plan is generated by the system to act much as it does in the real world, as an initial statement of intent and a notional set of targets against which actual progress can be checked. The difference is that the system plan is followed by simulated rather than actual production. It is not necessary for the plan to be optimal, just realistic. The system is intended to produce estimates of likely project cost and duration, not to seek optimal planning solutions. The plan developed by the system therefore should be neither better, nor worse than plans typically produced in practice. This important point derives directly from the objectives of the system; fortunately, it also greatly simplifies the problems of automatic plan formulation. Simple rules of technical precedence, standard productivity rates and line of balance principles can therefore be used to generate the planned start and finish times for the activities.

The site production process is simulated by assigning actual start and finish times to each activity in turn, following the precedences in the plan. Activity durations are determined by random selection of productivity rates from probability distributions; the distribution parameters are a function of key context variables, for example season of the year and position on the learning curve for repetitive operations. Start times are affected by completion dates of preceding activities where buffers have been absorbed.

In a similar way to the Construction Project Simulator mentioned earlier, interferences are also simulated, their occurrence and extent also the product of random selection from probability distributions. To illustrate the simulation action, Fig 2 shows a plan

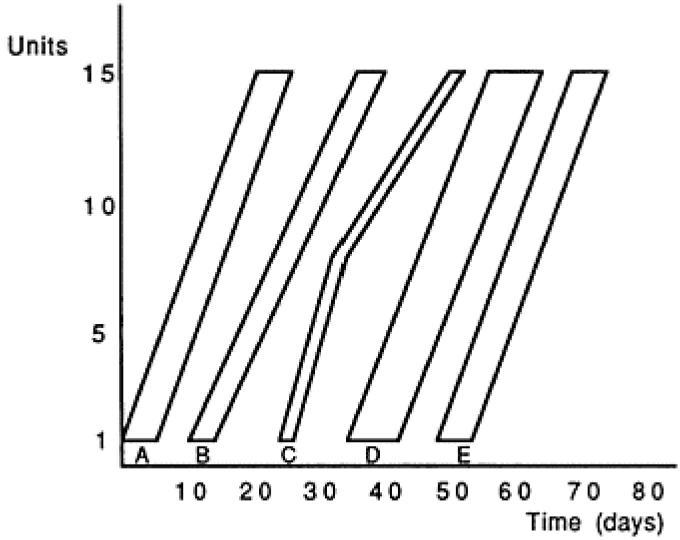


Fig. 2a. Overall project plan

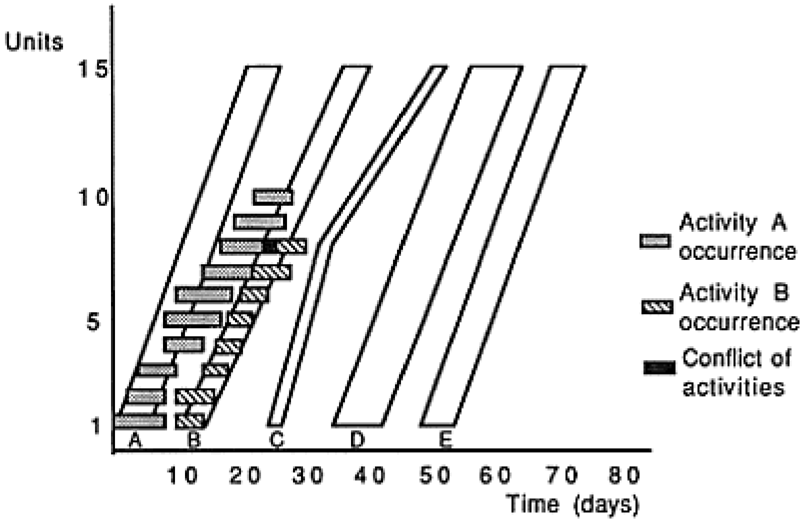


Fig. 2b. Simulated occurrence of activities

for a simple 5 activity (labelled A to E), 15 unit project in the form of a line of balance schedule. Fig 2b shows simulation of the production process under way, with simulated occurrence of the activities shown as hatched blocks superimposed on the plan. Activity A has a duration of 5 days per unit, with separate gangs working on 3 units concurrently;

activity B has a duration of 3 days per unit, with gangs working on two units concurrently. It can be seen that activity A has fallen behind schedule from the outset, with delayed starts and some occurrences taking 7 rather than 5 days . Activity B on the other hand has kept broadly to programme. Up to day 22 the buffer between A and B has been sufficient, now on unit 8 a conflict has arisen where activity A work has not been completed and will force a delayed start to activity B.

As the simulated production process progresses through the planned activities, at intervals the production state is referred to a rule based module which emulates production control. The management domain knowledge encapsulated in these rules determines whether action is taken and if so, its nature and extent. The action may involve adjustments to resource availability, higher cost production such as overtime, or possibly replanning subsequent activities. In the Fig 2 illustration, management may recognise the impending problem as activity A falls behind and take corrective action, or the situation may be left until delay to subsequent activities occurs. The rules in the management domain knowledge base determine the simulated response.

To represent stochastic behaviour, the system repeats the simulation of the process until a predetermined number of iterations has taken place. The initial plan is deterministic and remains the same through all iterations, only changing if the project details or constraints are altered.

At the time of writing the work is still in the early stages of both knowledge acquisition and system design, and much of the approach outlined above remains to be implemented. Many problems remain to be resolved, in particular considerable difficulties are apparent in the construction management control emulation; the rules for control action appear highly context sensitive and the resultant actions are wide ranging and difficult fully to accommodate within the system as currently perceived.

5 Conclusions

The power of experimentation offered by computer simulation has real potential as decision support within the construction industry. That potential is considerably advanced by the addition of knowledge based components, which can both assist in the formulation of the model and provide an effective means of representing behaviourial components within the system.

The development of hybrid systems of this kind for cost-time forecasting on multi-unit housing rehabilitation projects shows considerable promise. There is a clear need for forecasts which are based on an operational model and capable of reflecting the high levels of uncertainty inherent in this kind of project. Although the present feasibility study is still in the early stages, the indications are that in practice simple planning processes are used which are quite capable of being represented in the system. Because the objective is simulating realistic planning rather than seeking an optimal planning solution, automatic plan formulation is considerably simplified. The limited number of activities that need to be simulated for a useful system is also encouraging. However, the construction management knowledge necessary to emulate site management control action is proving more difficult to both capture and represent.

6 Acknowledgements

This paper is based on work supported by the Science and Engineering Research Council under grant GR/F 88117. The author also acknowledges the assistance given by colleagues Dr Arkady Retik and Constantinos Koudounas.

7 References

Alshawi, M. and Jagger, D. (1989) An Expert System to Assist in the Generation and Scheduling of Construction Activities. **Proceedings of AI Civil-Comp,** London.

Bennett, J. and Ormerod, R.N. (1984) Simulation Applied to Construction Projects. **Construction Management and Economics,** Vol 2 No 3, 225–263.

Flitman, A.M. and Hurrion, R.D. (1987) Linking Discrete Event Simulation Models with Expert Systems. **Journal of the Operational Research Society** Vol 38 No 8, 723–733.

Hendrickson, C. Zozaya-Gorostiza, C. Rehark and D. Barracco-Miller, E. (1987) Expert System for Construction Planning. **Journal of Computing in Civil Engineering,** ASCE, Vol1, No 4, 253–269.

Ibbs, C.W. and De La Garza, J.M. (1988) Knowledge Engineering for a Construction Scheduling and Analysis System, in **Expert Systems in Construction and Structural Engineering** (ed H Adeli), Chapman and Hall, 137–159.

Jackson, M.J. (1986) **Computers in Construction Planning and Control**. Allen &Unwin, 107–114.

Levitt, R.E and Kunz, J.C. (1985) Using Knowledge of Construction and Project Management for Automated Schedule Updating. **Project Management,** XVI(5), 57–76.

Moselhi, O. and Nicholas, M. (1990) Hybrid Expert System for Construction Planning and Scheduling. **Journal of Construction Engineering and Management,** ASCE, Vol1 16, No2, 221–238.

Navinchandra, D. Sriram and D. Logcher, R.D. (1988) GHOST: Project Network Generator. **Journal of Computing in Civil Engineering,** ASCE, Vol2, No 3, 239–254.

O'Keefe, R.M. and Roach, J.W. (1987) Artificial Intelligence Approaches to Simulation. **Journal of the Operational Research Society** Vol 38 No 8, 713–722.

Pidd, M. (1989) Developments in Discrete Simulation, in **Computer Modelling for Discrete Simulation** (ed M Pidd), John Wiley & Sons, 1–22.

Paul R.J. (1989) Artificial Intelligence and Simulation Modelling, in **Computer Modelling for Discrete Simulation** (ed M Pidd), John Wiley & Sons, 121–147.

Thompson, P.A. and Willmer, G. (1985) CASPAR—A Program for Engineering Project Appraisal and Management, **2nd International Conference on Civil and Structural Engineering Computing Vol 1,** London, 75–81.

126
Investment analysis in building projects—developers and financial institutions methodologies

V.M.MARTINS, A.A.BEZELGA and A.M.CUNHA

Abstract
This paper briefly presents research and development work carried out or in progress at the Technical University of Lisbon—Institute Superior Técnico, in the domain of Investment Analysis in building projects.

Thus: i) a general model of economic-financial analysis is presented; ii) a methodology of analysis is produced for the project developer; iii) the main aspects of the analysis are outlined, from the -point of view of financing institutions; iv) approaches are discussed regarding the analysis of the influence of the project in the economic-financial structure of the enterprise.

Keywords: Developer, Financing Institution, Profitability Analysis, Building Projects, Deterministic, Sensitivity and Risk Analysis.

1 Introduction

The present paper is mainly concerned with the analysis and control of investment profitability in building projects generally.

In Institute Superior Técnico a model of economic-financial analysis of building projects is being developed to be used from two points of view:

That of the project developer.
That of the financing institution.

The main activities from the client's point of view in an undertaking of this kind, are as follows:

Identification of the pattern of demand.
Acquisition of land.

Design contract.
General coordination and control of building design.
Negociation of external financing.
Awarding work contract or execution of work by self;
Marketing management.

From the point of view of the financing institutions, the main activities are as followws:

Identification of the pattern of demand.
Decision as to granting of loan.
Economic-financial control of project.
Management of debt servicing.

Usually the profitability analysis is made in a deterministic way and sometimes there may be some subsequent studies of sensitivity to the most significant investment variables.

This paper proposes an overall model for analysis and control of profitability, which includes initial control analyses and periodic control analyses.

Three levels are foreseen for each analysis—deterministic, sensitivity and probabilistic.

2 General Model

The model of economic-financial analysis proposed herein is similar for both types of analysis: i) from the developer's point of view; ii) from the financing institution's point of view. In both cases, deterministic and sensitivity analyses must be made, which may be complemented or not by probabilistic analyses, depending on the size and complexity of the projects.

Nevertheless, in analyses from the point of view of the financing institution, an evaluation of the financing profitability has also to be made, that institution being considered a project co-investor.

For both points of view—though obviously with different aims and degrees of detail—whenever justified there must be an evaluation of the project impact on the economic-financial structure of the developer.

Below are described:

The detailed development of the evaluation from the point of view of the project developer.

The main aspects of the evaluation from the point of view of the financing institutions.

The main aspects of complementary evaluation regarding the project influence on the structure of the enterprise.

3 Developer Model

3.1 —System

An overall model for analysis and control of the profitability of a project is proposed, which is to follow up progress of the undertaking and will be backed up by a computer-based system developed expressly on purpose. This model is such as is described hereinafter.

a) Initial analysis and control analyses

The model is based on: i) one or several initial analyses of profitability; ii) successive control analyses of profitability.

The initial analyses of profitability will lead to the decision of whether or not carrying out the project.

Control analyses of profitability are to be performed in the course of the different stages of execution of the project.

The most important stages to be considered in a project are the following: i) inception; ii) execution; iii) marketing; iv) end of project.

The initial analyses of profitability usually concern the inception stage.

Successive control analyses will in general be: i) punctual—at the beginning and at the end of all main stages; ii) periodic—monthly control analyses are proposed to begin immediately after the inception stage.

The following is noteworthy: although analyses might not being monthly carried out, the computer-based system developed requires that the cost/benefit information supplied should be prepared on a monthly basis.

According to other classification, control analyses may: i) not include re-evaluation of stocks; ii) include re-evaluation of stocks.

b) Types of analysis and their sequence

The initial analyses of profitability and the control analyses are exactly of the same kind as regards methods used or indicators obtained.

Thus depending on indicators obtained, both can be belong to one of the following types:

> "Economic profitability analysis"—it is independent of financing sources—in the cash-flow overheads do not comprise financing charges and investment values are not separated into internal financing and external financing.
>
> "Financial profitability analysis" or "analysis of internal financing profitability"—it is intended to evaluate consequences of financing on project profitability—overheads are to include external financing charges and investment is envisaged only in terms of internal financing.

On the other hand both can totally or partially include the three types of analysis already referred to:

1 – Deterministic analyses—leading to obtaining deterministic economic and financial indicators.

2 – Sensitivity analyses—leading to obtaining sensitivity diagrams.

3 – Probabilistic analyses—leading to obtaining probability distributions of indicators.

In principle the analyses will be made following the above indicated sequence, i.e., from 1 to 3. Sensitivity analyses will in fact permit to define the variables to be analysed in more detail through the probabilistic analysis.

These three types of analyses will be the subject of some later references in 3, 4 and 5.

c) Variables

The main economic and financial variables comprised in the model developed, in overall terms, are the following: cost of land (acquisition cost, urban infrastructures cost, and price adjustment rates), design cost, inspection cost, cost of permits and taxes, construction costs (lump sum, date of start, work time limit, monthly invoicing, payments deadlines, prices adjusment rates), financial costs (rate of interest, maturity dates), marketing costs, management costs, net receipts (total sale value, monthly value of contracts signed, contract terms, discount indexes), utility function and rates of discount to be used in the profitability analysis.

d) Computer-based system

The set of programmes developed forms an integrated system for assessment and control of profitability to be used in compatible personal microcomputers.

QuickBASIC was the language used. When developing the programmes due attention was paid to the characteristics required for systems of this type—simplicity, strengthness, easy control, flexibility, exhaustiveness and easy communication.

Time of utilization is acceptable, though it may be improved.

3.2 Deterministic analysis

Deterministic analysis calls for previous definition of cash-flow. There are two types of cash-flow depending on the analysis being economic or financial.

In the package developed cash-flows are defined on basis of previous definition of several documents, on basis of initial data, namely the plan of receipts and the plan of costs.

Table 1 shows the financial plan including a chart of costs and receipts, a chart of funds and charts for the owner’s capital cash-flow and the project cash-flow.

As intermediate outputs, we can also obtain the financing plan (monthly), current budget (monthly) and the trading account, in addition to some others, which however are not presented in this paper.

The final output consists of the values of all profitability indicators shown in Table 2, subdivided into two groups: financial indicators (cash-flow of owner’s capital), and economic indicators (cash-flow of projects).

For the definition of the indicators earlier works by HAROLD MARSHAL were closely followed. In fact in recent years most indicators, included in the computer system were subject to thorough analysis and systematization in works by that author and by the APPLIED ECONOMICS GROUP Of the NATIONAL INSTITUTE of STANDARDS AND TECHNOLOGY, USA. [4, 5, 6, 7,…].

It should be stressed that the experimental analysis carried out on the package developed make it possible to conclude that in the analysis of building developments such as those considered herein the most important indicators are PVNB, AIRR and IRR, following this order [8] .

3.3 Sensitivity analyses

It is known that sensitivity analyses are often carried out to complement deterministic analyses.

Actually interesting research has been developed in this area in recent years [1, 7].

In this computer system, all variables to be considered were previously defined, based on practical experience, namely:

Overall cost of land acquisition and construction of urban infrastructures.

Overall cost of planning and design, inspection, permits and taxes.

Overall cost of contract work and completion time. Price adjustment index and rates of interest.

Marketing and management percent rates.

Overall sale value, date of start, sales period and rate of discount.

Overall value of internal financing.

Discount rate of cash-flow.

Sensitivity analyses make it possible to draw sensitivity diagrams—either simple or with probability contours [1, 7, 8] .

Table 1—Financial plan

FINANTIAL PLAN:

DESCRIPTION	TRANSPORT Mar-1989	13 Apr	14 May	15 Jun	16 Jul	17 Aug	18 Sep	19 Oct	20 Nov	21 Dec	22 Jan	23 Feb	24 Mar	TOTAL
PRODUCTION COSTS														
LAND														
Aquisition	105500	0	0	0	0	0	0	0	0	0	0	0	0	105500
Infrastructures	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price adjustm.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DESIGN	13000	0	0	4000	0	a	0	0	0	0	0	0	0	17000
SURVEYING	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LICENCES, TAXES	1500	0	0	500	0	0	0	0	1000	0	0	0	0	3000
BUILDING														
Constr	0	0	0	0	0	0	0	4386	3650	4596	6670	9600	13117	42020

uction														
Price adjustm.	0	0	0	0	0	0	0	0	23	59	130	249	427	889
OTHER COSTS:														
Finantial C.	0	0	0	712	0	0	0	0	0	1709	0	0	0	2421
Commercial C.	0	0	0	0	0	0	0	0	0	0	0	845	1062	1907
Management C.	7200	0	0	313	0	0	0	263	280	382	408	642	876	10364
COSTS	127200	0	0	5525	0	0	0	4650	4954	6746	7207	11336	15413	183100
PROFITS														
Net Sales	0	0	0	0	0	0	0	0	0	0	0	2816	3540	6356
BALANCE	−127200	0	0	−5525	0	0	0	−4650	−4954	−6746	−7207	−8520	−11943	−176744
FINANTIAL COVERING:														
Own Capital	115000	0	0	0	0	0	0	0	0	0	0	0	0	115000
Bank Capital	12200	0	0	5525	0	0	0	4650	4954	6746	7207	8520	11943	61744
Self financement	0	0	0	0	0	0	0	0	0	0	0	2816	3540	6356
TOTAL	127200	0	0	5525	0	0	0	4650	4954	6746	7207	11336	15483	183100
ACUMULATED:														
Bank Capital	12200	12200	12200	17725	17725	17725	17725	22374	27329	34074	41282	49801	61744	61744
OWN CAPITAL:														
Costs	127200	0	0	5525	0	0	0	4650	4954	6746	7207	11336	15483	183100
Investment	0	0	0	0	0	0	0	0	0	0	0	0	0	115000
Cash-Flow	0	0	0	0	0	0	0	0	0	−0	0	0	0	187703
PV in period t	130440	131480	132528	133585	134650	135724	136806	137897	138997	140105	141223	142349	143484	143484
PROJECT:														
Costs	127200	0	0	4813	0	0	0	4650	4954	5037	7207	11336	15483	180680
Investment	1060	0	0	4813	0	0	0	4650	4954	5037	7207	8520	11943	20.716
Cash-Flow	−1060	0	0	−4813	0	0	0	−4650	−4954	−5037	−7207	−8520	−11943	200439
PV in period t	135400	136480	137568	138665	139771	140885	142009	143141	144283	145433	146593	147762	148940	148940

In the model developed, sensitivity analyses allow us to define to what variables indicators are more sensitive. Of course in probability analyses those variables are to be considered preferably.

3.4 - Probability analyses

It is known that the analysis of the risk factor based on probabilistic analyses can be made through the following methods: i) analytical method [3, 7, 10, 11]; ii) simulation method.

In this model the simulation method was used to generate the probability distribution of variables and, in the scope of this method, the inverse function method was chosen.

After a comparative analysis with other distributions, namely the BETA distribution, it was decided to estimate probabilities from a triangular distribution. It is assumed that the user will supply such data as the percentiles a and b (any) and the most probable value, m. These data were shown to permit a single-valued definition of the inverse function. On the other hand, there seems to be general agreement on that those data are appropriate to a subjective estimation process.

In the package developed, it was considered that the random variables would be all already mentioned in 3.3 as regards sensitivity analyses, excepting for the discount rate of cash-flow.

Some interesting points could be raised as concerns the development of the model for probability analyses. Only two will be mentioned here:

– Dependence of variables

The degree of dependence of the different variables had to be thoroughly analysed which led on one hand to a limitation of the level of disaggregation of the variables and, on the other hand, to the analytical definition of the dependence between variables. Of special importance are the relations between the variables “overall cost of contract work” and the variables “monthly invoicing” and also between “overall sale value” and “monthly value of contracts signed”.

– Number of iterations

It is known that the Monte Carlo method will permit satisfactory precision at the ends of the distributions if enough iterations are made. A first criterion for determining the minimum number of iterations will consist in securing that the simulation can lead to the probability distributions that were assigned to each generated variable. After some thinking about this theme, it was decided: i) to carry out in general 100 iterations in the model developed; ii) for each case to include the chi-square method in order to assess fitting of distributions.

Lastly it should be noted that the probability distributions of all indicators shown in Table 2 requested by the user can be obtained as output of the probability analysis, in addition to other results.

Table 2—Indicators included in the model

FINANCIAL AND ECONOMIC INDICATORS

1	–	PVNB	–	Present Value Net Benefits
2	–	AIRR	–	Adjusted Internal Rate of Return

3	–	IRR	–	Internal Rate of Return
4	–	DPB	–	Discounted Payback Period (month)
5	–	BCR	–	Benefit-to-Cost Ratio
6	–	MVNB	–	Monthly Value Net Benefits
7	–	MVR	–	Monthly Value Receipts

ACCOUNTANCY INDICATORS

1	–	SP	–	Sales Profitability
2	–	OCP	–	Overall Capital Profitability
3	–	BEP	–	Breack-Even Point (month)

Fig. 1 shows the probability distributions of IRR for a given hypothetical example of application.

3.5 —Evaluation and decision criteria

It is outside the scope of this paper to carry out an analysis of the different valuation and decision criteria that may be applied to select alternative solutions or to accept a given alternative, in the light of results from indicators (combination of statistical parameters, rule of Bayes, MAXIMIN, MINIMAX, MAXIMAX, utility function, etc.).

A reference should only be made to the fact that the package developed includes the option of supplying to the system the utility function of the firm, which would permit to obtain both the distribution functions of the indicators and their utility.

3.6 —Profitability control

The types of control—punctual and periodic, with and without re-evaluation of stocks—were already referred in 3.1.

In conceptual terms, control analyses are similar to initial analyses.

Nevertheless in some details a number of punctual procedures had to be introduced in the package, taking into account that at every control time the real past values are already known and future previsions must be changed (change of monthly invoicing prevision, sales prevision, financial charges, etc.).

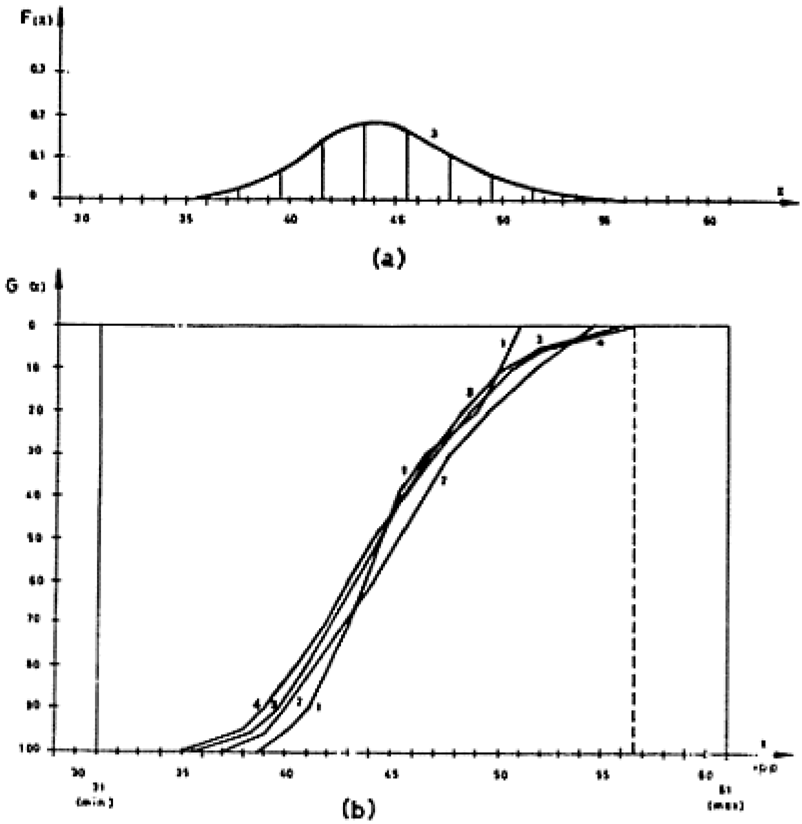


Fig. 1—IRR probability distribution

4 Model for financing institutions

The overall model for project profitability evaluations and control by financing institutions is being developed and will include:

> Establishment of economic-financial evaluation analogous to those intended for the developer, for ascertaining the economic profitability of the project, though in principle with more aggregated data as, for the majority of variables, less information will be included.
>
> Establishment of economic-financial evaluation for ascertaining the profitability of financing (including value of loan, interests and reimbursement).

The model will also allow to establish evaluations with different degrees of detail, according to the size of the projects.

Besides the profitability indicators used in the evaluation from the point of view of the project developer, some specific financial indicators will be applied.

The model will also include control analyses to permit appropriate debt servicing management, so that corrective measures may be taken in due time.

5 Influence on financial structure of developer

The evaluation of the project impact on the financial structure of the enterprise will be carried out through the following methodology:

1 – Analysis of the historical background of the enterprise

1.1 – Analysis of Balances and Profit and Loss Statements for the 5 recent years.

1.2 – Drawing up of the following maps, based on 1.1:

Map of annual operation cash-flows; Map of annual obligatory and eventual cash-flows.

Map of strategic decision cash-flows.

1.3 – Determination of economic-financial ratios based on cash-flow maps of 1.2, namely the following:

Profitability ratios—commercial profitability (gross surplus of operation/sales), economic profitability (gross surplus of operation/economic assets) and financial profitability (gross margin of self-financing/firm’s own capital).

Ratios of financing structure and liquidity—ratio of short-term analysis (financial charges/gross operation surplus) and ratio of medium-term analysis (medium-term liabilities/gross margin of self-financing).

Ratio of analysis of the indebtedness capacity (sustainable debt increase/ef-

fective debt increase). Ratio of investment policy analysis (investment value/net fixed assets).

2 – Prediction of future evolution

This analysis is made by considering several alternatives, namely:

Either including or not the execution of the building project under analysis.

Possibly, by considering several alternatives of future evolution strategies regarding the life of the enterprise during execution of the project. The analysis will be carried out by determining, on basis of the assumptions adopted, the maps of future cash-flows and the corresponding economic-financial ratios during the lifetime of the project.

3 – Comparative analysis of economic-financial ratios

The evaluation of the project impact on the financial structure of the enterprise will be based on the comparative analysis of the evolution of economic-financial ratios in the course of several years.

6 Conclusions

The analysis of building construction projects, particularly those above a certain size, requires a more detailed study of their profitability and the corresponding control both by developers and by financing institutions.

Insufficient analysis and control of profitability may lead to bankruptcy of developers and to the corresponding irrecuperable credits of the financing institutions, with all associated losses and drawbacks.

The model proposed is intended as a contribution to provide developers and financial institutions with a methodological tool in this field.

In more specific terms, the following should be stressed:

> Indicators PVNB, AIRR and IRR, following this order, seems the most interesting in this kind of project, either as concerns deterministic analysis or probability analysis.
>
> The model allows us to graduate the detail of analysis in accordance with the size and risk of the project.

The model allows us to graduate the detail of analysis in accordance with the size and risk of the project.

References

1—Flanagan, R., Norman, G., Meadows, J., Robinson, G., **Life Cycle Costing,** Oxford, BSP Professionel Books, 1989.

2—Francis, J.C.—**Investments—Analysis and Management,** Fourth Edition—McGraw-Hill International Editors, 1987.

3—Hillier, F., The derivation of Probabilistic Information for the Evaluation of Risk Investments, **Management Science,** No. 9, 1963.

4—Marshall, H., Ruegg, R., **Recommended Practice for Measuring Net Benefit/Cost and Savings-to-Investment Ratios for Buildings and Building**

5—Marshall, H., **Recommended Practice for Measuring Net Benefits and Internal Rates of Return for Investments in Buildings and Building Systems,** USA, NBS, 1983.

6—Marshall, H., **Survey of Selected Methods of Economic Evaluation for Building Decisions,** Proceedings of the 4th CIB W55 Symposium, Copenhagen, 1987.

7—Marshall, H., **Techniques for Treating Uncertainly and Risk in the Economic Evaluation of Building Investments,** USA **,** Department of Commerce, NIST, 1988.

8—Martins, V., **Rentabilidade de Empreendimentos Imobiliários—Avaliação, Tomada de Decisão e Controlo,** Porto, Faculdade de Engenharia, 1989.

9—Neves, João C.—**Análise Financeira—Métodos e Técnicas.** Lisboa, Texto Editora, 1990.

10—Ranasinghe, K.A.M.K., **Analytical Method for Quantification of Economic Risks during Feasibility Analysis for Large Engineering Projects,** Ph.D Thesis, The University of British Columbia, Canada, 1990.

11—Wagle, B., A Statistical Analysis of Risk Investment Projects, **Operational Research Quaterly,** Vol. 18, No.1, 1967.

127
Economic optimisation through improved use of indigenous building materials for low cost housing

G.C.MATHUR

Abstract
In developing countries the use of indigenous building materials is in vogue for housing at low cost. However, there is a great need to achieve economic optimisation through their improved use in construction by application of modern developments in Science and technology. This will ensure better performance, economic service life and durability of low cost houses; avoid wastage of building material resources and save labour cost required for frequent repairs and reconstruction of houses; and minimise large scale damage and destruction of houses in the event of the occurance of natural disasters. The innovative and appropriate indigenous building materials and construction technologies for lowcost housing have been briefly mentioned in the paper in the above context.

Keywords: Innovative, Appropriate, Indigenous Building Materials and Construction Technologies, Low cost Housing.

1. Introduction

Low cost housing has become one of the complex problems of our times, specially in the developing countries. As per the United Nations presently one billion people are homeless in the world. Unless urgent measures are taken to build more houses by the turn of the Century the number of homeless population may increase to two billion.

2. Economic Significance

The use of indigenous building materials has been made extensively for building houses at affordable cost.

These materials are easily available at locally little cost or no cost and local people are conversent with the technology of using these for construction of houses largely through self-helf.

The performance of the houses built with indigenous building materials is suited to the geo-climatic conditions. However, frequent repairs and reconstruction of houses are required. Moreover large scale damage and destruction of houses takes place due to natural disasters like heavy rainfall and floods, earthquakes and land slides, strong winds and cyclones fires etc.

It is therefore incumbent to achieve economic optimisation in the use of indigenous building materials by application of modern Science and technology, so that more durable and liveable houses could be constructed at lowest possible cost. This is also necessary to ensure sustainable development without causing environmental degradation and ecological imbalance which have become matters of over-riding significance. Also the availability of improved indigenous building materials at cheap cost is a matter of prime concern.

3. Indigenous Building Materials

For achieving economic optimisation, some notable progress which has been made in some developing countries in the improved use of indigenous building materials for low cost housing is briefly mentioned here, indicating their potential for tackling the massive problem of shelter for the people at affordable cost. Intensive research and development work also needs to be undertaken to upgrade the use of indigenous materials.

3.1 Inorganic Materials

These include commonly used materials like soils and laterite, burnt clay bricks and tiles, building lime and clay pozzolana, stones, and sands. As a result of research work done improved use of these materials for construction of low cost houses has been developed for achieving economic optimisation on the following lines:-

* Techniques of soil stabilization using materials like lime, cement and emulsified bitumen to make mud walls strong and durable.
* Water Resistant Mud Plaster using bitumen emulsion for application on soil-based walls and roofs to prevent erosion caused by rain fall.
* Good quality laterite and lime bricks for construction walls.
* Better quality of burnt clay bricks and tiles for construction of walls and roof.
* Good quality building lime and clay pzzolana and also ready-to-use lime and lime—pozzolana mixtures.
* Stone spalls with cement concrete to produce stone blocks used for masonry work at economical cost.
* Sand-lime bricks and blocks that are strong and durable.

3.2 Organic Materials

These include widely used materials such as grasses and leaves, husks and straws, reeds and bamboos and wood and wood products which are vulnerable to early decay and insect attack. Improved techniques of extending the service life of these materials have developed which will lead to economic optimisation in the use of organic materials in the following manner:-

* Application of chemical treatment for preservation for extending the service life of grass thatch and palm leaves etc.
* Use of rice husk with cement to form roofing sheets.
* Production of small roofing tiles using straw mixed with mud.
* Reed boards formed by compressing a small bunch of reeds together and wiring them tightly.
* Use of bamboo treated with preservatives and also bamboo reinforced cement concrete construction.
* Use of secondary species of timber after preservative treatment and solar kilns for seasoning of timber.

4. Appropriate Housing Technology

The ramifications of the choice of housing technology in the economic, social and environmental planning for development should be carefully considered. The following general guidelines for the selection of appropriate housing technology are relevent:

a) Make the maximum use of local resources, both material and human.
b) Expand the use of local skills and improve on existing methods.
c) Be capable of expansion and growth within the formal and informal sectors.
d) Encourage the incorporation of the informal sector into the formal sector and thus have a base on skills that are initially easy to acquire.
e) Avoid depending on complex infrastructure for implementation.
f) Be flexible enough to encompass as wide a sector of the population as possible;
g) Be capable of accepting production fluctuations without disastrous economic results.
h) Rely as little as possible on foreign skills and inputs.
i) Minimise the use of sophisticated imported technologies and minimise waste of resources.

5. Innovative Housing Technologies

During the International Year of Shelter for the Homeless, 1987, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Bangkok, had fielded a Mission of which the author was the leader to visit Asian Countries to identify innovative and appropriate technologies for lowest housing based on indigenous building materials. Based on this, the ESCAP have broughtout a series of leaflets providing working details for adoption of the following improved indigenous materials and construction technologies:-

A. SOIL TECHNOLOGIES

1. Rammed Soil Construction.

2. Compressed Earth Blocks

B. LIME AND POZZOLANA TECHNOLOGIES

3. Improved Lime Production
4. Some Artificial Pozzolana

C. BRICK CONSTRUCTIONS

5. Precast Brick Elements for Roofing
6. Improvements in Bricklaying

D. CONCRETE TECHNOLOGIES

7. Precast Concrete Elements
8. Fibre Reinforced Concrete Roofing

E. TIMBER AND FOREST PRODUCTS

9. Non-Poisonous Timber Protection
10. Improved Pole Timber Constructions
11. Curved Bamboo Roof structure

F. UTILIZATION OF WASTES

12. Use of Organic Wastes

6. Conclusion

The significance of economic optimisation through improved use of Indigenous Building Materials for low cost housing has been best summed up by S.A.M.S. Kibria, Executive Secretary of ESCAP as per the following :

"The building and construction activity we will witness in the coming decades is likely to be of a magnitude that will dictate reliance on ingidenous resources. It is therefore essential to widely disseminate among builders easily understood information about methods of making best use of materials and resources that are still affordable by the low income group. I am confident that once appropriate building materials and construction technologies are available to the people who have already demonstrated their commitment to help themselves, we will see dramatic improvements in the quality of shelter".

The author will be glad to provide technical advice and consultancy in adoption of innovative and appropriate housing technologies based on improved use of indigenous building materials to achieve economic optimisation in low cost housing.

7. References

Mathur G.C., 1976 Report on Survey of Rural Housing and Related Community Facilities in Developing Countries of ESCAP Region, United Nations Economic and Social Commission for Asia and the Pacific, Bangkok.

Mathur G.C., 1976 status Report on Rural Building Materials Department of Science and Technology, Government of India, New Delhi.

Mathur G.C., 1983, Development and Promotion of Appropriate Technologies in the field of Construction and Building Materials Industries in India, United Nations Industrial Development Organisation, Vienna.

Mathur G.C., 1984, Chapter on Indigenous Building Materials Encyclopedic, on Materials Science and Engineering, Pergamor Press, New York.

128
Quick assessment method 'MER': theories and applications

P.MERMINOD and M.KETATA

Abstract
The Quick Method for Assessment "Methode d'Evaluation Rapide: MER-60" [2] concerns itself with buildings of 1950's and 1960's. It divides the construction into several modules: façades, stairs, basements, terrace, housings,… related to common functions: structures, electricity supply, heating, water and sewer systems,….

The aim will be to give an assessment of the state of the building after a diagnosis which will lead to an estimate of the cost of repairs. Therefore, we consider the rehabilitation as a transformation related to specified parameters such as: Classification, Type, Size, Amount, Accessibility, Economic situation and Urgency. This model deals with the influence of those parameters and their reliability. Some testing works called pilot project "chantiers pilotes" have served for scaling and checking.

Keywords: Rehabilitation, Diagnosis, Standard state, Evaluation, Splitting-Unsplitting, Constructive system, Components chain, Building's model.

1 Introduction

As a response to new needs in the field of rehabilitation and the improvement of existing buildings in Switzerland and in Europe, many models have appeared and are still being developed [3] [5]. MER deals with housing in particular. Its aim is to maintain security, salubrity, and to improve the usual comfort. This is done, particularly by making an aid-decision-method based on the diagnosis of the building taking into account its state of disrepair which tells about degradations and lacks in order to select some appropriate, economical means of rehabilitation and then restore the use of collective housing building.

2 Notes about the MER-OFL Method

Faced with an increasing demand in the sphere of rehabilitation, various studies have demonstrated that the different types of work tend to be quite similar. Thus, at the beginning of the 1980's, the MER-OFL appeared. This consists of a rapid but detailed visit of the building which leads to an evaluation of the state of disrepair of three dwellings as well as the common areas. This method allows one to determine the cost of the work necessary in order to put the building back into a state known as **standard** starting with an analysis of the building, the MER-OFL considers 41 criteria: elements or functions classified following a diagnosis (which will be defined later). For the classified or diagnosed element, we link according to a calibration, a weight in points that indicates the expense necessary for rehabilitating a classified criterium. The assessment of actual building is given after a correction referring to the model of the building with the aid of weighting and correcting cefficients. These coefficients depend on the variation of considered elements as well as work conditions.

To terminate, MER-OFL considers all other expenses: the charges of rehousing during worktime, etc…, resulting in the total costs of rehabilitation and their effects on primary rent.

3 MER-60: An analytic method

3.1 Theorical bases

MER considers the following definitions:

Quick assessment: It's a budget forecast of rehabilitation made up from a diagnosis of disrepair and elements lacking.

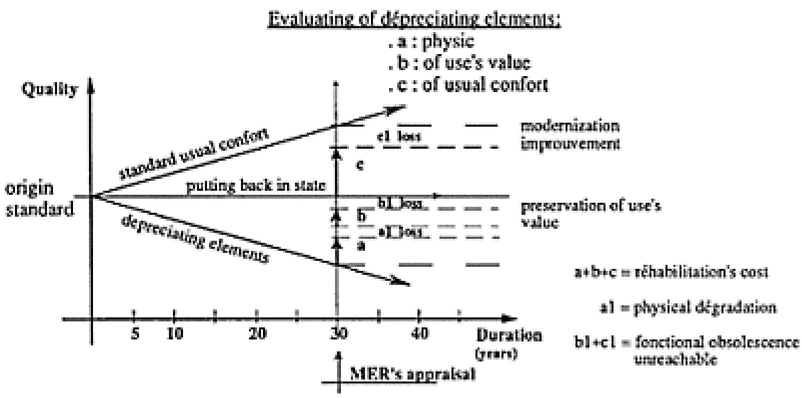


Fig.1. Diagram of putting back in state

Rehabilitation is a transformation after which, the building passes from a real state which is more or less deteriorated to a state of reference also called standard, defined by uses and actual norms. We give the following diagram to represent how MER considers this conversion.

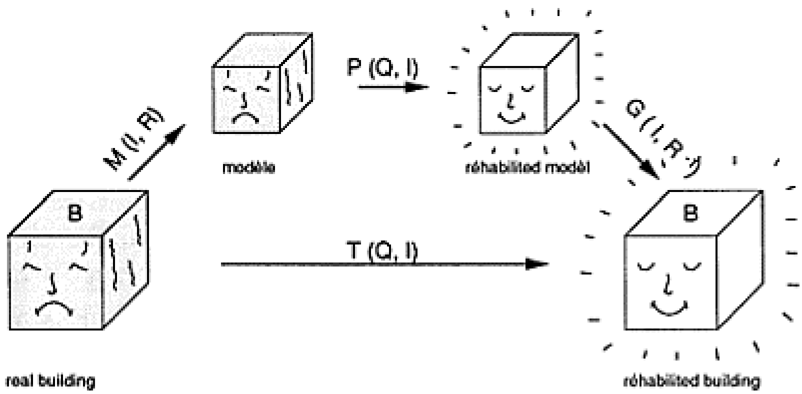


Fig.2. MER's process of rehabilitation

The nature of repetetive works as well as the great analogy of the buildings have led to a search for the standard building known as a model statistically representative in size and which presents the more common usual characteristics. With the aid of this, the transformation may primarily contain two components:

– Qualitative one or function Q
– Another Qualitative or function R

Where I represents the Identity function, R^{-1} the inverse of R. The functions above mean:

M(I, R): to keep the same Quality (Q=I) on the model which could have a different size, then R.

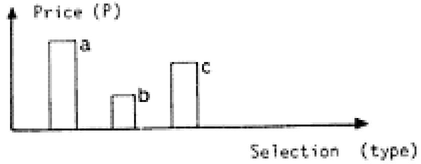
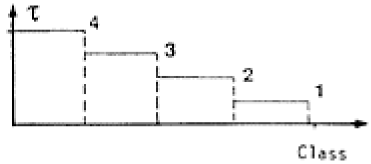
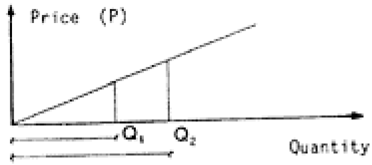
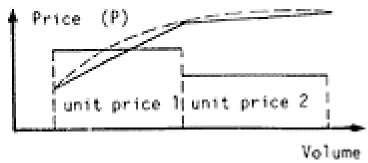
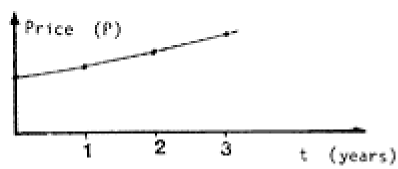
P(Q, I): To improve quality (Q=I) on the model (R=I)

G(I, R^{-1}): rehabilitated building's model (Q=I), transformed geometrically to actual one (R^{-1})

T(I.Q.I, R, I, R^{-1})=T(Q, I)

Thus, T is a transformation of quality for a quantity that remains unchangeable. T is a scheme of rehabilitation. MER-60 could then be defined as a quantization of expenses to pass from the actual state of the building to a standard one. This is made possible by using a set of simple transformations described by the following variables:

Tableau 1. Definitions and representations of variables

<table>
<tr><td>1—Type (of element or component)</td><td>
</td></tr>
<tr><td>2—Classification or Diagnosis
(|: as a recovering ratio)</td><td>
</td></tr>
<tr><td>3—size</td><td>
</td></tr>
<tr><td>4—size effect</td><td>
</td></tr>
<tr><td>5—Accessibility, importance stocking and manageability</td><td>(correction, weighting)</td></tr>
<tr><td>6—Awarding
7—Urgency
8—Economic situation</td><td>(correction, weighting)
(posponment)

</td></tr>
</table>

3.2 Bases of calculation

The apartment building is the place where individual and collective interests are blended to the highest degree. The property offers benefits which are specific to each apartment as well as being communal: the elevator, the laundry room,…items which are used by the occupants of the building.

MER introduces the notion of habitable area (Shab) that serves as a common denominator for sharing out the expenses of rehabilitation.

$$Shab = k_1(Sho-Spc) \quad (1)$$

Where,

Sho: is the external base area

Spc: the area of common spaces

k_1: a coefficient that depends on the importance of the area taken up by walls, partitions and interior distribution surfaces, k_1=0.8

Some variables of the transformation presented above affect the whole building. Others intervene in the description of one element in the rehabilitation process. If we take as an example the attempt to study the construction of the structural function, we may isolate the following elements: the facade, others vertical elements, the floors. Such a division permits us to sum up as concisely as possible the costs of rehabilitation.

$$P(S) = \sum_i P(e_i) \quad (2)$$

the same way, for element e_i

$$P(e_i) = \sum_j P(x_j) \quad (3)$$

Now the expense of reconstructing a component x_j, is dependent on its type, then on its selection according to the rule book, as well as its classification or diagnosis that could be understood as a level of recuperation of the component to the standard state.

$$P(xj)=c_j.t_j(E) \quad (4)$$

t_j is the cost of component x_j of a certain type in the standard state relative to the component or to the chain of components of a building's model (E).

c_j is the value of classification or diagnosis of component x_j

The building models mentioned below have served as a yardstick for calculating these coefficients as well as the coefficient of the shape of the facade etc…[2]

This last analysis, supported by a statistical study, permits a precise and rapid evaluation for the different scales of sharpness of the diagnosis.

3.3 Practical developments of the MER-60 method

3.3.1 Termionology and definitions

The analytical method MER of second generation functions in an analytical way: each part of the building has to be examined for disrepair and elements lacking in order to evaluate the state and the potentialities of repair, replacement, or necessary additions to maintain the use's value at a usual standard of comfort.

Diagnosis: It is regulated and uses a scale of 1 to 4:

4: in a good state
3: easily repairable
2: hardly repairable
1: to be replaced or added to

This diagnosis concerns about 400 elements of construction which are the result of an appropriate division of the building's model. A state of disrepair in one part may influence another in a different part. This correlation of diagnosis could be settled by the requirement code pattern.

requirement codes: to each state of diagnosis could correspond any kind of complimentary works that are necessary for repair, replacement or addition, relative to the concerned part of the building.

Kinds of works: The evaluation of these kinds of useful works, is based on searching for the techniques that are best-suited to building. These kinds of works also have to be the cheapest ones, with optimal durability, and in close accordance with the rule book.

Models: Evaluations of diagnosis and expenses relative to one kind of work are referred to a standard building known as a model. This presents the most frequently encountred characteristics. Varying of constructive types is also recognised.

Weighting coefficients: By using some weighting coefficients; geometrical, of density or shape's factor, and which express the conditions in the building site, the importance of the work; the values of the model could be adjusted to bring them more in line with the actual building, yet still within limits recognised as acceptable.

Points: HER also introduces a convention of measure in points that indicates a unit of expenses in (Fr.) for a unit of habitable area related to the building's model. This convention is applied to each group of diagnosis. The sum of points weighted with the model's own coefficients, expresses the investment needed to rehabilitate 1 m2 of the real building.

Total evaluation: It is sufficient to multiply this value of points number per m by the total habitable area (Shab) to obtain the total costs of rehabilitation. The value of a point expressed in Fr. and fixed at a time, is adjusted with relation to economic circumstances using the price index (in the absence of a rehabilitation index).

Inquiry's manual: The manual of diagnosis is well ordered in accordance with a mode of visiting of the property. It details the order of visit, its stages, groups, and separate units of diagnosis. A convenient choice of degradation's degree: 4, 3, 2 or 1 for each identified rubric is sufficient for the evaluation. All calculations can be done with the help of a simple computer program.

3.3.2 The method of analysing a building

The group of diagnosis constitutes a coherent set of localized objects that is subjected to a scrutiny of diagnosis and deficiencies established on the basis of reference criteria of disrepair, obsolescence, lack of usual comfort in accordance with the definitions in the inquiry's manual. The group is subdivided into modules which define the component chains of localized objects to be diagnosed. The degree of subdivision per modulus follows a suitable rule of dependency to the chain and to the rationality of diagnosis conditions: interdependence of the criteria, localisation. The modulus could also be subdivided into some submodules of diagnosis using the same logic.

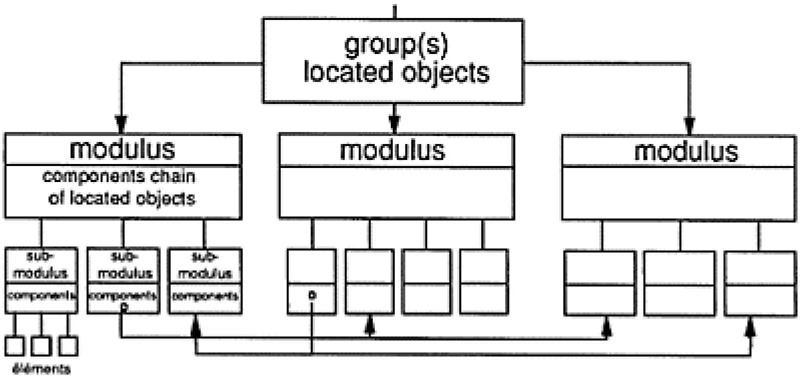


Fig.3. Splitting of the groups of localized objects

3.3.3 The modules of housing buildings

The concept of evaluating rehabilitation costs related to HER, is to bring the **base costs** of typical and usual works to a habitable area of reference which corresponds to the building's model. This model is represented by the build, the functional organisation, and the layout of the system of construction most frequently encountred in the inventory of building area.

The definition of a model is based on a study of representative samples of buildings, picked according to region, built-up areas and towns but also to period of construction so that it leads to a gauge, representative of geometrical, physical and functional properties of all buildings.

A general study of property stock, made up help of the federal investories data and other research, more specific to some Swiss towns (Aarau, Zurich, Bern, Geneva) [4] had made it possible to release the characteristics of buildings useful for the definition of the two models.

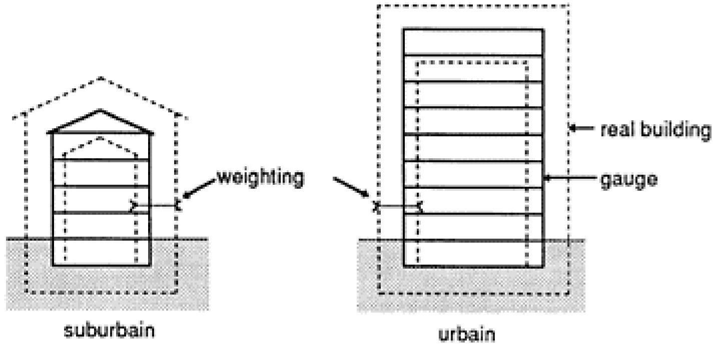


Fig.4. Models and their gauges

3.3.4 The actual building

When the actual building corresponds to the model's characteristics and its gauge, no weighting is necessary. On the other hand, as it becomes more distant in dimensions but also remains yet acceptable, some weighting coefficients of geometrical and functional characteristics are needed, these coefficients serve to act on volume, surface, density of equipment and then to adjust the standard value to the model and to its gauge.

The introduction of two models: urbain and suburbain has become necessary in order to avoid weighting that is too important distorting the greatness order of quantities, functionality and kinds of works, and then affecting accuracy of the cost evaluation.

3.3.5 Constructive types

Every building's model could contain one or more constructive types characterised by the specific reference constructive system.

For a base constructive system, we could make out some components lists, their interdependence by chains and then define the probable medium quantities of each component, referring to building's model and constructive type.

3.3.6 Groups and stages of diagnosis: The course of a visit

The MER method is made up of ten groups of diagnosis, classed in three categories: method and registrations; data, identification and diagnosis; transference and grouping of specific diagnoses.

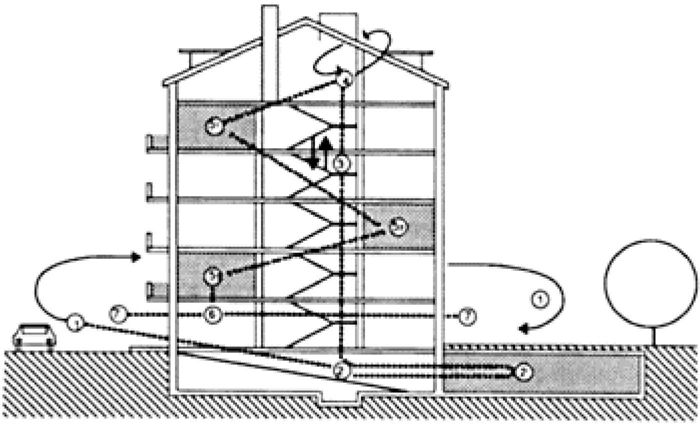


Fig.5. Stages of diagnosis: The building round

The groups of diagnosis are made up and organised in relation to the course of the visit to the building that happens in 7 stages:

stage 1: recognising the outside-building's type. Diagnosis of the facade

stage 2: visiting the basements: premises and technical equipment, installations, network and garage.

stage 3: common areas, hall, existing elevator, new elevator, stairs, structures, corridor, skylight.

stage 4: roofing, roof trussing, lodgings in roof trussing, installations in roof trussing

stage 5: visiting 3 selected lodgings, installations, holding structures.

stage 6: visiting of professional premises

stage 7: visiting the outsides

3.3.7 Diagnosis of disrepair and deficiencies

The diagnoses which refer to the definition of criteria already explained are made up of a coded scale of disrepair and deficiency, consisting of 5 degrees:

code 4: good state, evaluation of ordinary provision, servicing and corresponding kinds of works.

code 3: reparable degradation and wear, evaluation of ordinary and periodical upkeep provisions.

code 2: wear, degradation and deficiency, more difficult to repair or correct

code 1: important irrepairable deterioration, standard exchange, one or more components of a chain reaching the limit of service, amelioration of the usual standard, interdependence of requirement codes.

code 0: This code indicates the possibility of differing momentaneously or for a short time, some of the usual repair works. This notion of keeping in state needs further interventions that are more

important for a components chain untill a complete repairing.

Diagnoses are done following identification, classification and the mode of analysis of a building adopted by the HER method.

– Identification and geometrical classification: the model and its gauge
– Identification and constructive system classification: the constructive type.
– Visiting and classification of functional objects: groups, diagnosis of localized objects
– Splitting up into sets: chains of components, modules
– Splitting up into subsets: submodules of partial chains of components
– Splitting up into unities: components and elements

Table 2: Tree classification: groups, modules, submodules,

Groups	of identifications and figures	o					classification
	of diagnosis	x					visit classification
	of translation's translation	1 to 9					grouping of parcial diagnosis
Modules *B*	of componment's chain of constructive types		1 to 9				global diagnosis first degree rehabilitation
Sub-modules	of parcial componment's chains			01 to 99			detailed diagnosis 2nd degree rehabilitation
Componments of a chain					a to Z		servicing diagnosis first degree
Componment's elements						a1 to a9	servicing diagnosis 2nd degree

3.3.8 Diagnosis and points grid

the investigator starts by choosing the appropriate building's model and constructive types relative to the actual building. This is done by means of:

– general identification sheets
– identification grids of constructive types

The diagnosis process follows, by stages, the order of groups, modules and submodules, etc... diagnoses are done at two speeds:

– faster one made of modules and submodules
– slower one made of components and elements

In the actual stage of experimentation, rehabilitation assessment may be restricted to modules and submodules diagnoses.

3.3.9 Evaluation by points

A model's point is a simplification of the measure of these base cost values related to a unit of habitable area for chain components of building's model and that corresponds to the order of size of the expense of rehabilitation linked to diagnosis.

The quality of points is constant for a components chain of given model, but may vary from one model to another. The real point is obtained after the application of weighting coefficients that tend to reduce the differences between the model's values and those of the actual building

3.3.10 Diagnosis recapitulatory's grids

These grids are organised following the stage of the visit and the order of diagnosis groups. They gather all diagnoses by modules and submodules in the strict directives of the inquiry's manual .

The investigator selects the model visually, does his round proceeding with diagnosis in the same way as it appears in the manual. All reports, all calculations would be done in a further computated phase. A statistical study [1] on the margin of error would permit the definition of the validity margin of results in relation to the splitting of the diagnosis.

3.3.11 Evaluation of rehabilitation

The definition of the kinds of works depends on the selection of architectonic disposals considered the more efficient and rational in the best quality-price ratio, in a close application of the rule book, on one hand and the choice of an economic result on the other hand. The selection of minimal controlled interventions is designed to lay down a probable level of investment, compatible with the state of building to be rehabilitated.

the knowledge of this minimal reference value authorizes a good administration of the rehabilitation project.

3.3.12 Weighting and correcting coefficients

– weighting coefficient of size

. coeff. a (α) : horizontal components chains

. coeff. b (β) : vertical components chains

– weighting coefficient of plan’s density

. coeff. c (γ) : components chain of apartments in relation to their size

– weighting coefficient of shape

· coeff. f : (Φ) components chain of outwards

– surface’s weighting coefficient

. coeff. m (μ) : of habitable area

m (μ’) : of habitable area and loggias

– correcting coefficient of kinds of works

. coeff. r (ρ) : for building-site’s implementation access, stocking, handling, scaffoldings

– overvaluation constant acting on base costs to bring closer to real costs

1+0.2 in Geneva 1+0.4 in France

– The economic correcting coefficient of the model’s point value (i) in Fr. per m^2 of habitable surface.

3.3.13 The group of translations

The organisation of groups of diagnosis that follows is founded on a manner of visiting the localized objects as the set of elements and components belonging to an apartment that can easily collected into dry and humid functional premises.

The diagnosis evaluation of structures, for example, and that conserns the whole building can only be carried out after a succession of fragmented visits stages. Only a subsequent grouping of These independant sequences allows a global evaluation of the modulus (general holding structures of the building) and then constituting a transfer modulus.

This recapitulation is representative of the global state of the building’s holding structures for which have to be added all others estimations that depend on inquiries codes. This way of tranferring could also be usefull for global assessment of other modules: Water systems, thermal insulation,….

4 Conclusion

The fundamental basis of MER’s method is a general diagnosis made up of sharpened diagnosis of the state of disrepair related to components and components chains of the considered apartments building. These diagnoses have to be the basis of the constitution of the global rehabilitation service. MER’s approach proposes then, a rehabilitating project which aims for a true service according to the rule book and at a lower cost. This has required the definition of a threshold, i.e. a bench mark of a standard of reference to be attained without submitting the building to heavy modifications. This room to manoeuvre would be as much profitable to the investigator who finds a direction to estimate the assessment in its own conception and then suggests solutions that he feels appropriate. Therefore, the MER method could be considered as an instrument for help to a project of rehabilitation.

5 Acknowledgement

Authors of this paper would like to thank the "Office Federal de Logements (OFL)", The "Département des Travaux Publics (DTP)" of Geneva for all their help and confidence. As well as all collaborators of "Centre d'ETude pour l'Amélioration de l'Habitat (CETAH)" namely of Miss Mc GOWAN for her help in translation, Miss F.PASCHE secretary and Messrs: L.COTTON, Professor, D.MARCO, J.L.GENRE, F. GRAF, A.CAPONNETTO, D.HAAS, C.WILLEMIN, Architekts, R. CAMPONOVO, J.PERRETEN, Engineers, for their participation in the development of this work.

6 References

Marietan, S., Kohler, N. (1990) **'Méthode d'estimation rapide du coût de renovation des bâtiments anciens.'** Une étude statistique. Projet LESO/EPF Lausanne, Suisse.

Merminod, P. and al. (1991) **'MER-60'** (to be edited at the end of 91)

Merminod, P. and Vicari, J. (1983) **'Manuel MER, Methods d'évaluation rapide des coûts de remise en état de l'habitat'** Bulletin de Logements, volume 28, Suisse

Merminod, P. and al.(1989) **'Modèle MER-60, Etude statistique'** OFL- CETAH et Etat de Genève

Monneau, M. (1990) **'Maintenance du patrimoine**. **Le nouveau logiociel entropi.'** Bureau véritas (France)

129
Management of housing maintenance in a major public housing authority—a case study

P.J.MINOGUE

Abstract
This paper is based on a comprehensive study of housing maintenance management carried out for Dublin Corporation, Ireland's largest Housing Authority. The study/ which was carried out by the author, was completed in 1989. The paper outlines the main features of the housing maintenance operation of the authority, identifies some of the key areas dealt with by the study and summarises the main findings and recommendations of the study in these areas. These include the objectives of housing maintenance, maintenance planning, organisation structure, cost control, quality control, performance of the maintenance system and maintenance information system requirements.

Keywords: Maintenance Management, Objective, Planning, Organisation, Control, Information System.

1 Introduction

Dublin Corporation is the major public housing authority in Ireland with some 38,215 dwellings rented in February 1988. Total expenditure on the maintenance of this stock in 1987 was some £17.3m. There was considerable pressure to reduce maintenance expenditure in the context of a general policy of reducing public expenditure. In addition serious concern had been expressed regarding the level of service being provided to tenants and the impact of an increasing backlog of maintenance work on the condition of the housing stock. Against this background, An Foras Forbartha (reorganised as the Environmental Research Unit during the course of the study) was asked to carry out a comprehensive review of existing procedures and to recommend improvement of existing systems and the introduction of new systems where appropriate.

2 Background

2.1 Housing Maintenance in Context

Within a large public housing authority, the housing maintenance system is a relatively complex one. It involves a variety of maintenance work ranging from relatively minor repairs and replacements, generally carried out in response to tenant requests, to significant programmes of work, some programmes being planned on a cyclical basis while others are developed in response to identified needs. It involves a multiplicity of individual customers, dwellings, trades and jobs. In particular, it is an open system subject to a variety of economic, political, social and organisational pressures.

Maintenance is but one element of overall housing management, albeit an important element in terms of annual expenditure, quality of housing and service to tenants. The management and organisation of maintenance, must be seen in the context of overall housing management. This study was undertaken in the context of the existing organisational structure of Dublin Corporation and of the housing management function, in particular. The housing management function was highly centralised, apart from one or two experiments with decentralised administration and the existing degree of decentralisation of maintenance through the use of local depots. It became clear during the course of the study that, in line with trends internationally, active consideration was being given to some form of housing management decentralisation, e.g. provision of a local housing office and decentralisation of certain administrative functions, at least in areas of severe social deprivation with a high density of Local Authority housing.

However a more radical approach to the devolution of housing management such as, for example, appointment of local housing managers with full management authority and control of the necessary resources, or, the establishment of area-based tenant self-management systems, did not appear to be contemplated.

This is the context in which the study was carried out and to which the proposals made apply.

2.2 Housing Stock

No comprehensive housing data base was maintained by Dublin Corporation. Such data as existed were retained by different operational areas and related to different bases. Considerable time and effort were spent in the early part of the project attempting to improve the data base and the following were some of the main features identified.

(a) The total stock of dwellings at February 1988 was 38,215–15,840 flats and 22,375 houses. For response maintenance purposes these were serviced by 10 maintenance depots—each of which (with one exception) serviced between 3,000 and 5,500 units.

(b) The total number of units remained relatively static during the 1980s. The number of units becoming vacant annually for reletting varied considerably from some 5% of stock in the early 80’s to over 10% in 1985–87.

(c) Overall, some 50% of the stock was constructed prior to 1971. However, some 75% of flats and only 27% of houses were in this category. The average age of flats was some 32 years while that of houses was only 17 years.

(d) In location terms the stock can be considered to fall into 3 broad categories.

(i) The inner city. Within this area there were some 12,000 units, of which approximately, 9,500 were flats,

(ii) The inner suburbs. Within this broad area, the authority owned some 11,000 units, of which only some 2,000 were flats. In these areas over 70% of Corporation provided dwellings had been sold. This means that much of the remaining stock was scattered,

(iii) The outer suburbs. Much of the stock provided was relatively new and still in Corporation ownership. Overall it comprised some 15,000 units (including some 3,000 high rise flats).

(e) Some 73% of all tenants were wholly or mainly dependent on social welfare payments. Average rental income per unit was only £8 per week and total annual rental income at £15.75m was less than maintenance expenditure of some £17m per annum.

(f) Some 5,750 dwellings had been identified by Dublin Corporation as possibly requiring refurbishment work. This was estimated to cost approximately £90m (based on estimates provided by Dublin Corporation). As part of the study, a sample condition survey of the remaining pre-1981 stock (some 12,961 houses and 10,328 flats) was carried out. This provided an estimated cost of £44m for the maintenance works required in order to upgrade the stock to a predetermined standard. This estimate did not include necessary work to external structural elements, nor external facilities of flat blocks. The condition and maintenance requirements of the 9,175 units of post 1981 stock had not been assessed, but were assumed to be satisfactory.

2.3 Maintenance of Stock

Annual maintenance expenditure per unit rose from £395 in 1983 to £451 in 1985 and had been relatively static since that date. The actual number of repair requests dealt with per annum was not known, but was estimated to be about 60,000. In 1986 some 50% of dwellings had no repair request and some 78% of total maintenance requests related to 26% of dwellings. During the period 1983 to 1987, less than 2,000 dwellings per annum were painted externally on the cyclical maintenance programme. The current painting cycle was 12 years for flats and 41 years for houses. This compares with a generally recommended target of 5–6 years. To meet this target the number of dwellings completed would have to be increased by a factor of 3.

Maintenance work was heavily biased towards response maintenance. This tendency had been aggravated by the high incidence of dwellings for relet in recent years. Overall maintenance expenditure (1987) could be summarised as follows:

	£m	%
Response Maintenance	12.0	69
(of which work in relation to relet or sale)	(3.0	17)
Planned cyclical maintenance	3.0	17
Planned programmed maintenance	2.3	14
Total maintenance expenditure	17.3	100

The planning horizon adopted by the Authority was, basically, one year i.e. the Annual Budget Cycle.

2.4 Maintenance Organisation

Housing maintenance was the responsibility of the Housing Maintenance Section within the Housing Management Department. The Housing Maintenance Officer was the Head of this Section which was responsible for all aspects of maintenance from acceptance of repair request and planning of work programmes through to completing work by direct labour or supervising contractors, when used.

Maintenance work generally was carried out by direct labour, except for a number of specialist areas which were carried out on a contract basis—usually by other departments within the Authority. Occasionally, some specific urgent projects have been carried out by contract, when the authority's own staff was unable to carry out the work. The contracting out of such work had generally been objected to by the Trade Unions representing the direct labour staff. Although some 20% of maintenance work was done by contract, only 5% approximately was carried out by private contractors working directly for the Maintenance Section.

Response maintenance was organised from 10 depots located throughout the city and county. Each depot was managed by a Maintenance Inspector (who may be more correctly called a Depot Manager) and, with one exception, serviced between 3,000 and 5,500 dwellings. Some 3–6 foremen reported to the Inspector at each depot and were each responsible for the maintenance of a sub-area within the depot area. The only local facility for receipt of requests was the local maintenance depot.

As regards planned maintenance, the direct labour forces engaged in such works, whether cyclical or programmed, operated in squads of appropriate size and skills from a central base, but with operatives reporting directly to their current work site.

Involvement of tenants in the maintenance process was limited. The maintenance system did not formally allow for tenant involvement except in making repair requests. No formal mechanism existed for the involvement of tenants in planned or programmed maintenance and no self-help schemes were operated by the Authority. Some experimentation has been carried out, e.g. in Shangan and Fatima Mansions, both of which have been considered successful. Some tenants carry out maintenance work which, strictly speaking, is the responsibility of the authority.

3 Findings and Recommendations

The study which took some 18 months to complete was comprehensive in nature dealing with all aspects of the system and leading to a major report containing detailed findings and recommendations for action (Minogue, 1989). In this paper it is only possible to highlight some of key areas identified and the recommendations arising therefrom.

3.1 Maintenance Objectives

In general, the main justifications for a strong emphasis on maintenance are preservation of the housing asset including extension of its useful life, commitment and responsibility to tenants and reduction of social problems. In framing objectives for housing maintenance, a balance must be struck between these. The objectives must be explicit and promulgated to all, so that misunderstandings are avoided and morale maintained at a high level among both workforce and tenants.

Dublin Corporation, in common with most housing authorities, had not provided an explicit objective for housing maintenance in the past. The primary objective perceived by those responsible for the maintenance function is the economic one of preserving the housing asset and sustaining its utility, although the need for a satisfactory service to tenants and the special role of maintenance in “problem” housing areas were also acknowledged. The actual objectives pursued in the ‘70s and ‘80s appear to have been based on social criteria related to satisfaction of tenant’s short-term needs and utilisation of the existing work force, rather than criteria based on the value and utility of the stock. This was not explicit policy but was manifest in the shift of resources from cyclical to response maintenance.

The study concluded that the primary objective for Dublin Corporation should be preservation of the housing asset, with service to tenants as a secondary objective. However, it acknowledged that in certain identified areas, special maintenance inputs, as part of an overall housing management initiative, may also be required.

3.2 Maintenance Planning

An increased emphasis on planned maintenance was recommended, involving a three-fold increase in output of cyclical maintenance and a selective approach, based on condition surveys, to programmed maintenance. The extent and details of such programmed work could only be determined on the basis of a detailed analysis of the stock characteristics, area by area and specific condition surveys.

In broad terms, three levels in the maintenance planning process were identified viz.

(a) Strategic—dealing with the broad approach to maintenance based on estimates of the overall demand,

(b) Medium term—specific programme of work to be tackled in the medium term, viz 5 years,

(c) Short term—specific work packages to be completed in the short term, viz 1–2 years.

Recommendations were given on the development of plans for each of the three levels identified. The following estimate of annual maintenance expenditure and balance between types of maintenance work was developed:

	£m	%
Response Maintenance	8,6	46
Planned Cyclical Maintenance	5.0	27

Planned Programmed Maintenance	5.0	27
Total Maintenance Expenditure	18.6	100

This suggested that current maintenance expenditure was not excessive but that the balance between types of maintenance work should be significantly altered.

3.3 Organisation for Maintenance

A central focus of the study was the establishment of the appropriate organisational form for the management and implementation of the maintenance function. This was seen as being, to a significant degree, unique to the particular authority, as, in addition to the maintenance strategy adopted, it would also be influenced by a number of other factors e.g. the size, nature and distribution of the housing stock, the authority's corporate culture, objectives and policies in areas such as housing and personnel, the management structure within the organisation as a whole and within the Housing Department in particular and the existing maintenance organisation. The following were some of the main issues addressed.

3.3.1. Separation of Roles

The maintenance function within a housing authority can be considered to involve two seperate elements. On the one hand, there is the role of developing maintenance policies and budgets, balancing priorities, setting standards, deciding on the work to be done and monitoring performance. On the other hand, there is the carrying out of this work effectively and efficiently. In Dublin Corporation, these were carried out in a closely integrated manner, particularly at the operational level. In both response and cyclical maintenance work, the primary responsibility for deciding on the work to be carried out, ensuring that it was carried out and monitoring performance lay with the same foreman and inspector.

The study concluded that a separation of roles is desirable with a "client-contractor" type relationship being created between the two elements. This was considered to allow for more objective control and performance assessment, greater flexibility in terms of carrying out work and more valid comparisons between the performance of direct labour and private contractors. In seeking this ideal, caution was advised so as to avoid duplication of work on the one hand and to ensure that the important input to programmes, policy and strategy, which can be made by the operational arm, was not lost.

To this end a reorganisation of administration and management involving, in particular, the appointment of a Direct Labour Manager responsible for the performance of the direct labour workforce, clarification of lines of responsibility and the strengthening of the cost planning and control functions, was recommended. However, to avoid duplication and to ensure no reduction of service to tenants, it was accepted that certain "client" functions may continue to be carried out by the operational arm e.g. acceptance of repair requests at local depots, pre-inspection of response maintenance work.

3.3.2. Direct Labour Operations

The study identified definite advantages in using a well-managed efficient direct labour force for certain types of maintenance work, characterised by a need for flexibility and fast response, difficulty in supervision and quality control and a need for rapport with and trust of the tenants. The critical difficulty is ensuring that it is well managed and efficient in the absence of direct competition.

From an examination of practice elsewhere it was concluded that a better service is provided by those housing authorities operating a mixture of direct labour and private contracting, compared with authorities employing one or other method exclusively. It was therefore recommended that Dublin Corporation should adopt a strategy of increasing the proportion of work done by external contractors. On the assumption that identified efficiency improvements would be achieved by the direct labour operation the use of contract work should initially be confined to the increased workload recommended in the planned maintenance area, with a pilot project on the use of contractors for response maintenance. It was also proposed that the existing accounting system be reviewed in the context of the proposed organisational changes, so that the true cost of carrying out the "contractor" function by direct labour could be established.

3.3.3 Organisation of Response Maintenance

Because of the amount of lost time associated with the present system, where individual depots served relatively large areas, the introduction of a zoning and "tradesman reporting at maintenance point (TRAMP)" system was recommended for response maintenance. This system is based on the division of the depots' housing stock into areas and organising the workforce into multi-trade teams to deal with non-urgent maintenance in each zone in turn. The work is pre-inspected if necessary and a specially fitted caravan is used to carry the required materials (including an imprest store of regularly used materials). This caravan also acts as a reporting point and base for the operatives. It was recommended that the system be tried on a pilot basis at first, as some experimentation would be required in relation to team size and composition, size of zone and length of cycle. In order to deal with urgent and emergency work, a system of mobile tradesmen operating individually, but with radio contact, or, using a paging system should be introduced.

The use of permanent estate-based depots serving smaller areas of dense housing (up to 1,000 units) was considered but it was recommended that this approach should be limited to where required as part of a broader housing management initiative and preferably, with a local housing office to deal with repair requests and other aspects of tenant contact. In this context it was also recommended that, if housing management policy developments involved a devolved housing management function with local decision making (rather than simply a decentralised office), then consideration should be given to the creation of local direct labour squads dealing with response repairs and directly answerable to the local housing manager.

3.3.4 Tenant Involvement

While the involvement of tenant associations in maintenance work was considered to be very desirable, it was concluded that such involvement should ideally be part of tenant involvement in overall housing management. This in turn would involve a firm commitment from housing management, as a significant staff input in winning confidence and commitment is required for tenant involvement to be real and effective. Decentralisation of housing management is generally found to be a key element. In its absence, it was recommended that tenant involvement in maintenance should be limited to specific maintenance issues, which can be clearly defined and separated from other aspects of housing management, e.g. specific planned cyclic or programmed maintenance proposals. A role in dealing with dwellings becoming vacant and in countering vandalism and destructive behaviour was also identified. Experimental self-help schemes, in the areas of both dwelling maintenance and environmental works were also recommended.

3.4 Cost Control, Quality and Performance

Detailed proposals were put forward for the improvement of cost control procedures for all aspects of maintenance, including the identification of expenditure by cost centre, e.g. housing area or housing estate. Similarily, detailed proposals were made aimed at the creation of an efficient and cost-effective direct labour unit. These proposals involved changes in accounting procedures, organisation and working practices and included the introduction of a revised comprehensive set of standard job times.

It was recommended that the maintenance department should exercise supervision and quality control on all work, whether contract or direct labour and not rely on the operatives or foremen directly involved for this aspect of control as heretofore. For work carried out by direct labour within the Maintenance Section, there should be selective quality assessment by personnel other than those involved in carrying out the work. This was seen to assume greater important in conditions where there would be pressure for improved efficiency.

An important measure of service to tenants is the response time for repair requests. Requests can be categorised in accordance with intended maximum response times. However Dublin Corporation did not categorise maintenance requests in this way. Certain types of work were considered to be emergencies and every effort was made to deal with these as soon as possible—definitely within 48 hours. Otherwise, priority was assigned by the foreman dealing with the requests. All requests outstanding more than 10 weeks were brought to his attention for immediate completion, if possible.

The implementation of a more formal response time system, involving the categorisation of maintenance jobs, e.g. emergency, urgent, normal and deferred to planned maintenance, was recommended. The appropriate response times was seen as a matter of policy for Housing Management, bearing in mind the level of resources available at any time.

The backlog of work on hand is a further measure of service. The existing work scheduling system measured backlog, but because of deficiencies in the system it was considerably understated. A level of 3–4 weeks work inhand is normally considered necessary for work scheduling and satisfactory in terms of service. The provision of accurate information on this aspect of performance was identified as an important function of an improved information system.

Measures of overall performance of the maintenance system include tenant satisfaction and overall stock condition. The measurement of tenant satisfaction through sample consumer-type surveys was proposed. The condition survey carried out during the study was the first structured attempt to establish the condition and maintenance need of the existing stock. The results of this survey gave some guide to the existing condition and provided a benchmark against which future performance can be measured. Proposals made regarding maintenance planning include the carrying out of condition surveys. The results of such surveys can also be used to assess the overall success of maintenance policy.

Analyses carried out during the course of this study showed that the maintenance service, measured in terms of requests serviced, varied considerably between tenants. The perception that the maintenance service is availed of disproportionately by a limited number of tenants was widespread among maintenance personnel. On the other hand, it must be accepted that apparently similar properties have different maintenance needs. No generally applicable rules can be applied in this area, but at a minimum, recent maintenance history should be available when a repair request is being considered, so that tenants making heavy demands on the system can be identified at the point of making a request and the validity of such requests verified.

3.5 Information System and Computerisation

An effective maintenance management system requires the handling and processing of a considerable amount of data. As well as recording the wide range of transactions involved in the housing maintenance system, the information requirements for planning and control at the operational, management and strategic levels must bé met.

The overall information requirements for maintenance management were considered in some detail during the study. In particular, the need for information by individual property, for repair request processing (including immediate access to the status of any particular job), for cost control and scheduling purposes and for materials handling was identified. The particular needs for management summary and exception reports were also considered.

In the context of the existing management information system, and the proposals for maintenance in the report, it was recommended that priority for development should be assigned to:

(a) repair request processing;

(b) information requirements for cost control purposes;

(c) planned maintenance information for planning and control purposes in the context of increased planned maintenance work ;

(d) the property data-base. This may be developed as part of developments in the overall housing information system, but development of the condition information in particular, will have to be undertaken by maintenance management.

A key recommendation was that the implementation of a computerised response maintenance system (dealing with both request processing and work scheduling and control) based on a property data base, should be investigated in detail by the Authority. An outline specification for such a system was given in the report.

The stages envisaged towards the implementation of this proposal

(a) the development of a detailed system specification based on the outline given and taking account of decisions on the other relevant recommendations. This would require considerable involvement of Corporation maintenance personnel;

(b) the seeking of tenders on the basis of this specification from a selected short-list of possible suppliers. Maximum hardware and software flexibility should be allowed to tenderers, provided they meet the performance requirements of the specification;

(c) tenders to be assessed on the basis of first cost, running cost, flexibility of the system, staff (in particular computer staff) requirements and possibilities for future development;

(d) the chosen system to be pilot tested in one area prior to full scale implementation. The final decision on acceptance must await satisfactory pilot testing.

It was also recommended that, in choosing a system consideration be given to any developments with regard to the computerisation of other Housing Management functions within the Authority. It was felt that a modern integrated system dealing with all aspects of housing management may provide the best overall solution provided the system chosen dealt adequately with the identified maintenance management requirements.

4. Implementation

The main recommendations of the report are currently in the course of implementation. The total annual budget for housing maintenance in 1991, at £19.2m, shows a slight increase in real terms compared with 1990. The maintenance management function has been strengthened particularly in the area of work planning and the proportion of planned programmed and cyclical work has been significantly increased so that such planned work is now approaching 50% of the total. Together with this change in work pattern there has been some further reduction in the direct labour workforce and a noteworthy increase in the use of contractors particularly in the area of cyclical maintenance. Greater flexibility has been introduced in the implementation of response maintenance. The introduction of a system of radio controlled vans for emergency maintenance and of the principle of “main tradesman makes good” are under active negotiation. A scheme of separate random post-inspection of a proportion of jobs has also been introduced. The pilot schemes of housing management decentralisation have been extended. These include for maintenance request reporting to a local housing office and a system of local estate based response maintenance has been developed in support of such schemes. A comprehensive housing information system is being planned by the authority. This will incorporate the housing maintenance system recommended in the study report. Implementation of this system is expected to commence later this year. The implementation of this system is a key element of planned improvements in cost-control procedures. It will also provide necessary data for the assessment of the performance of the overall maintenance system and a solid basis for the further improvement of that system. Current indications are that the changes made to date have improved the efficiency and effectiveness of the system and are clearly to the benefit of both authority and tenants.

Reference

Minogue. P. (1989) Maintenance of Local Authority Dwellings—Dublin Corporation. Environmental Research Unit, Dublin.

130
The role and performance of housing in an investment portfolio

G.J.NEWELL

Abstract
Asset allocation is the process of determining the proportion of financial resources available to institutional or corporate funds managers that is to be invested in specific asset classes such as equities, bonds and real estate. Fundamental to any major investor is the need to develop a diversified investment portfolio in an attempt to reduce risk exposure. The purpose of this paper is to examine the role, contribution and recent performance of housing as an asset class in an investment portfolio. The role of housing in an investment portfolio is illustrated using housing performance in Australia over 1985–90.

Keywords: Asset Allocation, Investment Portfolio, Risk, Return, Risk-Adjusted Returns, Diversification, Co-variability, Risk Reduction Investment Strategies.

1 Introduction

Asset allocation is the process of determining the proportion of financial resources available to institutional or corporate funds managers that is to be invested in specific asset classes such as equities, bonds and property. Up to 80% of portfolio results are attributable to asset allocation, as opposed to the specific stock selection process. Given the highly competitive and sophisticated nature of investment management, asset allocation investment strategies by fund managers have become particularly important in recent years. The October 1987 stock market crash emphasized the importance of investment portfolio diversification.

Most fund managers now follow the "golden rule" of investment and develop diversified investment portfolios in an attempt to reduce risk exposure. Using modern portfolio theory and risk-management techniques, sophisticated asset allocation computer packages such as the Cadence Asset Mix Optimiser System and the BARRA Risk Model software are available for use in asset management to determine optimum asset class combinations for specified risk levels.

2 Real estate as an asset class

It is universally recognised that diversification across asset classes and within asset classes is fundamental to developing a risk averse investment portfolio, where the addition of property to an institutional investment portfolio provides additional diversification and lowers portfolio risk.

As such, there is strong evidence of the need to include real estate in an investment portfolio, as it possesses the following desirable attributes (Jones Lang Wootton, 1990):

* good hedge against inflation
* good income and capital returns
* low variability in returns (low risk)
* low co-variability with equities and bonds.

In particular, earlier studies have highlighted the diversification benefits of residential real estate in an investment portfolio. For example, Goetzmann and Ibbotson (1988) used the Case-Shiller residential real estate return series (based on over 40,000 homes in four major USA cities) to show that residential real estate outperformed a range of alternative institutional investment options over 1970–86. The risk levels for residential real estate were also found to be low, with these risk levels only marginally above those of treasury bills.

Goetzmann and Ibbotson (1988) also illustrated the portfolio interaction benefits of residential real estate with other asset classes. Over 1970–86, residential real estate exhibited low co-variability with the movements in returns in the other major asset classes. The correlation coefficients of residential real estate relative to the other major asset classes were:

* equities (r=−.20)
* 20-year bonds (r=−.54)
* 1-year bonds (r=−.56),

with this illustrating the counter-cyclical nature of residential real estate compared to equities and bonds. The impact of this interaction for residential real estate is to provide an effective hedge against changes in the equities and bond markets, and reduce the level of risk exposure for the investment portfolio. A correlation coefficient of .56 with the CPI also showed that residential real estate returns fluctuated with the CPI to provide a good hedge against inflation.

Goetzmann and Ibbotson (1988) provided further evidence of the investment portfolio risk-reduction benefits of geographic diversification for residential real estate. Residential real estate return correlations between the four major USA cities studied (ie Chicago, Atlanta, Dallas and San Francisco) ranged from—.05 to .25. These low correlations across the different cities lead to a significantly reduced portfolio risk level, with a balanced portfolio of residential real estate across those four major cities having a risk level approximately 50% of the level of the lowest-risk city.

The risk-reduction benefits of geographic diversification in residential real estate have also been shown by Locke (1987) in a study of residential real estate performance for six major Australian cities over 1980–84. Inter-city return correlations ranging from—.27 to

.45 were obtained in this study, further highlighting the risk-reduction role of geographic diversification in an investment portfolio.

3 Investing in housing

Given the strong evidence of risk-reduction benefits from having residential real estate as an asset class in an investment portfolio, why has residential real estate traditionally been ignored or given a low priority by investment fund managers? For example, property trusts have been a major force in property investment-in Australia throughout the 1980's, with total assets in 1989 in excess of AUS $17 billion. Yet only 2% of this total property portfolio is residential real estate (predominantly executive residential), compared to commercial property (51% of total portfolio), retail property (28%) and industrial property (5%).

The main factors that have limited the role of institutional investors in investing in residential real estate are (Etter, 1989; Goetzmann and Ibbotson, 1988; Whipple, 1990):

* project specific risk, with each piece of real estate being unique and requiring individual evaluation with respect to investment opportunity
* high management costs, with active and skilled property management required; with this being outside the normal activities associated with managing an equities/bond investment portfolio
* funds managers are usually trained in securities analysis and lack experience in real estate investment
* current legislation restricts owner's rights and favours tenant's rights
* real estate market information for investment decision-making is less reliable, not readily available and more expensive to acquire than equity/bond market information
* real estate investment involves large economic units, with potential illiquidity and divisibility problems
* real estate investments normally use financial leverage, but generally investment funds prefer not to use this investment option
* cyclic nature of the real estate market
* limited tax benefit
* extra charges involved (eg: land tax, council charges and outgoings)
* quality residential real estate is often in short supply
* real estate investment decisions are long-term commitments
* lack of effective control over external forces which affect value
* improvements may become functionally or economically obsolete
* general reputation of real estate "entrepreneurs"
* real estate investments are often considered "risky".

However, an interesting recent trend in Australia is that residential real estate investment is now being reconsidered by institutional investors. For example, AMP, one of Australia's largest institutional investors has recently invested AUS $145M in Sydney residential property; this being AMP's first such investment in residential real estate. With the level of home ownership in Australia being 69%, considerable scope exists for quality residential real estate investment.

4 Housing performance :1985–90

To examine the role, contribution and recent performance of housing as an asset class in an investment portfolio, the analysis of housing performance in Australia over 1985–90 was carried out and compared with the performance of a range of alternative institutional investment options, including equities, bonds, bills and commercial property.

Representative investment performance indicators for each of these asset classes were utilised. These indicators were obtained from the corresponding stock market or financial indices, including:

* Australian equities: accumulation indices for six major equity market sectors (eg All Ordinaries, All Industrials)
* Australian bonds: 10-year Commonwealth Government bonds
* Australian bills: Reserve Bank 90-day Treasury bills
* commercial property: Jones Lang Wootton commercial property accumulation index for Sydney CBD (Jones Lang Wootton, 1989, 1990)
* CPI: Australian Bureau of Statistics Consumer Price Index.

Housing performance was assessed using the Residential Investment Property Index developed by the author for the Real Estate Institute of Australia, involving the investment performance of 3-bedroom houses in each of the six major Australian state capital cities.

A risk-adjusted performance analysis (Baum and Crosby, 1988; Locke, 1987, 1990) was carried out for each of the above asset classes over 1985–90, incorporating the calculation of:

* average annual total returns, accounting for both income (eg rentals) and capital growth
* risk, accounting for investment volatility
* risk/return ratio
* Sharpe index, accounting for risk-adjusted returns.

Table 1 presents the risk-adjusted performance analysis for housing and the alternative asset class investment options over 1985–90. The performance analysis of housing provides some interesting insights into its performance relative to the other investment options. In most instances, the average annual total returns for

Table 1. Performance analysis of asset classes : 1985–90

Asset class	Annual return (%)	Risk (%)	Risk/return ratio	Sharpe index	Rank
Housing					
Sydney	21.6	26.2	1.21	0.25	5
Melbourne	18.5	11.3	0.61	0.31	4
Brisbane	20.6	10.3	0.50	0.55	1
Adelaide	12.4	11.2	0.90	–0.23	12

Perth	22.1	14.9	0.68	0.48	2
Canberra	12.9	4.6	0.36	−0.44	13
Commercial property	20.3	15.9	0.78	0.34	3
Equities					
All Ordinaries	19.1	27.4	1.43	0.15	8
All Industrials	21.6	27.2	1.26	0.24	6
Property Trusts	15.3	18.7	1.22	0.02	9
Developers	15.3	35.9	2.34	0.01	10
Gold	33.8	103.9	3.07	0.18	7
10-year bonds	13.0	0.6	0.05	−3.05	14
90-day bills	15.0	1.9	0.12	0.00	11
CPI	8.3	0.8	0.09	−8.66	15

Table 2. Asset class correlation matrix : 1985–90

	SYD	MEL	BRI	ADE	PER	CAN	CP	AO	AI	PT	D	G	10YB	90DB
MEL	.58													
BRI	−.16	.20												
ADE	−.27	−.35	.68											
PER	.68	.60	.57	.39										
CAN	.67	.48	.21	−.31	.48									
CP	.94	.63	.17	−.08	.83	.79								
AO	−.04	−.61	−.86	−.22	−.56	−.46	−.33							
AI	−.04	−.39	−.84	−.23	−.48	−.62	−.35	.92						
PT	−.11	−.66	−.85	−.40	−.72	−.24	−.36	.92	.74					
D	.02	−.48	.95	−.45	−.63	−.33	−.29	.97	.89	.95				
G	.21	−.60	−.68	−.23	−.37	.07	.02	.82	.57	.89	.81			
10YB	−.85	−.76	.39	.67	−.37	−.53	−.71	.02	−.09	.04	−.14	−.05		
90DB	−.55	−.33	.72	.93	.19	−.47	−.35	−.32	−.27	−.47	−.53	−.45	.79	
CPI	−.23	−.78	−.75	−.11	−.66	−.49	−.46	.97	.84	.94	.92	.83	.24	−.18

housing outperformed the other asset classes, with risk levels considerably below those of the equity sectors and below that of commercial property. In all cases, housing returns easily outstripped the effect of inflation; as reflected in the CPI benchmark. While gold showed the highest returns over this 5-year period, this was accompanied by high volatility or investment risk, reflected in the highest risk/return ratio of 3.07; thus providing an excellent example of the investment risk-return trade-off paradigm.

While individual housing markets showed a range of returns from 12.4% to 22.1%, the volatility or risk of these housing markets were reasonably consistent, with the exception of the “traditionally” more volatile Sydney housing market. The only investment options with lower risk were the standard “low risk” or “risk-free” options of 10-year bonds and 90-day bills.

An examination of the individual Sharpe indices clearly illustrates the strong risk-adjusted return performance of the housing sectors over 1985–90 compared to other investment options. Of the 15 investment options considered in this study, the best risk-adjusted performances were achieved by housing in Brisbane and Perth. Importantly, housing accounted for four of the top five risk-adjusted investment options and clearly outperformed the risk-adjusted performance of the equities, bonds and bill asset classes.

Table 2 presents the correlation matrix for the range of investment option asset classes and further highlights the portfolio interaction benefits of housing and the risk-reduction benefits of geographic diversification. This is reflected in:

* all cities generally having a strong negative correlation with the equities options and 10-year bonds
* correlations between the six major city housing returns ranged from −.35 to .68, giving rise to a significantly reduced portfolio risk level for a balanced housing portfolio across these major cities.

5 Conclusion

The results of this study clearly illustrate the strong performance of housing compared to a range of alternative investment options over 1985–90. While housing possesses several important limitations that has traditionally seen housing ignored or given a low priority by institutional funds managers, these results clearly show the important role that housing could play in an investment portfolio in terms of providing substantive risk-reduction and diversification benefits. If funds managers are able to develop the level of unique skills necessarily needed for property investment and management, housing could be an important element of an institutional investment portfolio.

References

Baum, A. and Crosby, N. (1988) **Property Investment Appraisal**. Routledge, London.

Etter, W. (1989) A comparison of US and UK pension fund activities. **Land Economics Review,** 1, 28–36.

Goetzmann, W. and Ibbotson, R. (1988) The performance of real estate as an asset class. **Journal of Applied Corporate Finance,** 3, 65–76.

Jones Lang Wootton (1989) **Asset Allocation From a Property Perspective**. JLW Property Research, Sydney.

Jones Lang Wootton (1990) **Property Portfolio and Investment Management**. JLW Property Research, Sydney.

Locke, S. (1987) Performance assessment indexes and capital asset pricing models. **Journal of Valuation,** 5, 230–249.
Locke, S. (1990) Comparing property portfolio performance. **New Zealand Valuers Journal,** 12, 29–31.
Newell, G. and Barrett, V. (1990) **The role of property in optimal investment portfolio analysis**. CIB90 Building Economics and Construction Management, 3, 144–148.
Whipple, T. (1990) Property as an investment : some strategic considerations. **The Valuer,** 31, 256–260.

131
Optimization of a national public housing programme—a case history

C.O'ROURKE

Abstract
In the late 1970's, the Department of the Environment (DOE) in Ireland was concerned that the right balance was not being achieved in the trade-off between quality and cost in the National Public Housing Programme. Although design guidelines had been issued to the 87 separate local authorities in the country, there was a wide disparity in unit costs for a standard local authority house and the annual average increase in cost per unit for each of the previous five years had been significantly more than the rate of inflation.

Following approaches from the DOE on the need for formal procedures for the analysis and control of local authority house construction costs, An Foras Forbartha (The National Institute for Physical Planning and Construction Research) developed Cost Planning and Control Procedures based on building elements as agreed by CIB (The International Council for Building Research and Documentation) and which formed Table 1 of the revised (1973) SfB system. These procedures were submitted for consideration and following an application study on fourteen housebuilding contracts, they were adopted by the DOE and made mandatory for all Local Authority Housing Schemes.

The issues raised are discussed, the procedures are described, the implementation programme is outlined and the results are assessed.

1 Introduction

In Ireland, the Department of the Environment (DOE) is charged with the primary responsibility for human settlement. In exercising its responsibility, the DOE formulates policy and prepares legislation on housing, physical planning, the main infrastructural services (roads and sanitary services) and environmental protection. It also oversees the construction industry. In addition, it guides and co-ordinates the activities of 87 local authorities, who are delegated responsibility for the implementation of policy in relation to human settlement and who form the main subordinate tier of government.

The basic aim of housing policy is to ensure that, as far as the resources of the economy will permit, every household can obtain a house of good standard/located in an acceptable environment, at a price or rent it can afford. A secondary aim is the promotion of home ownership. An important principle in the operation of the policy is that those who can afford it are expected to house themselves. The local authorities accordingly provide houses for persons who cannot afford to provide adequate accommodation for themselves, including persons living in unfit or overcrowded conditions, as well as special categories of need, such as aged or disabled persons.

The State provides the capital for the local authority housing programme and also meets in full the loan charges on the local authority borrowings for the programme. More than one third of the total housing stock in the State has been built by local authorities. Most of these have been sold on discounted terms to tenants, so that about 90,000 dwellings, or just less than 10 per cent of the national stock, now remain in the ownership of local authorities.

2 Background to the development of Design Cost Control Procedures

During the 1970's and 1980's the State was the largest client in Ireland's construction industry, consistently accounting for more than two third's of total output. There had been much discussion during the late 1960's on the need for a more formalised approach to project management and control from the point of view of the client. Arising from these discussions the National Building Elements Committee (NBEC) was established in 1970. The NBEC's remit was to establish a common approach to design procedures and cost control across the whole range of new building projects.

3 The Requirements of a Cost Control System

The design cost control techniques briefly described below were evolved on the basis that the system must fulfil the following requirements:

(i) provide a reliable cost target for a building at an early stage in the design process;

(ii) provide a system whereby the cost of the building would be spent in a balanced way on the different parts of the building;

(iii) provide for corrective action to be taken by the design team during the evolution of the design to ensure that the cost target would not be exceeded;

(iv) provide quick and reliable cost guidance to the design team on alternative solutions for each part of the building as the design developed.

4 Cost Control Procedures for General Building Projects

The initial work of the NBEC was concentrated on building work other than housing. This was because the Committee considered that in view of the repetitive nature of housing, a somewhat different and indeed simpler approach than that for general building would be more appropriate. Work on housing was accordingly deferred at that time and the initial work of the NBEC was embodied in an AFF publication "National Standard Building Elements and Design Cost Control Prodedures" (1973). This publication was a milestone in project management for general building in Ireland and it provided the basis for cost planning and control for the great majority of medium and large sized building projects that have been undertaken subsequently.

5 Cost Control Procedures for Low Rise Housing

In the mid-seventies, at the request of the DOE, the NBEC turned its attention to low rise housing and by 1977 had developed a system specifically tailored for the planning and control of housing costs. The system was tested by AFF in an application study on fourteen housebuilding contracts involving approximately one thousand houses. The study confirmed that the system worked in practice. The results of the application study suggested improvements which were incorporated and the procedures were published by AFF as the "National Standard Control Procedures for House Construction Costs" (1979).

As with the procedures for general building work, this system was devised around the concept of National Standard Building Elements. An element may be defined as "that part of a building which always fulfils the same function irrespective of design or specification".

In order to put the role of the building elements into context, it is necessary to consider the manner in which building work is organised in Ireland. A breakdown of total building costs is contained in the priced Bill of Quantities $(BOQ)_3$. The BOQ lists, in great detail, the various items of work (e.g., m of concrete in foundations, m^2 of wall plastering, etc.,) that together constitute the complete building. The BOQ may contain many hundreds or even thousands of such items, but because of this degree of detail, it is not suitable as a basis for cost control during the design stage, nor is it suitable for comparative cost guidance on alternative solutions. The BOQ items do not reflect the manner in which the design of a building develops. In designing, the architect is not thinking in terms of quantities of concrete or brickwork, but rather in terms of how to enclose his building shape, the roof and floors that are necessary, the type of lighting and the type of finishing etc., and it is these design elements that have been adopted as the cost centres for cost control purposes.

The national standard building elements are based on those agreed by CIB (The International Council for Building Research and Documentation) and which formed Table 1 of the revised (1973) SfB system. A condensed list of Element Definitions is given in Appendix A.

The links between the design stages and the cost control procedures are shown diagramatically in Figure 1.

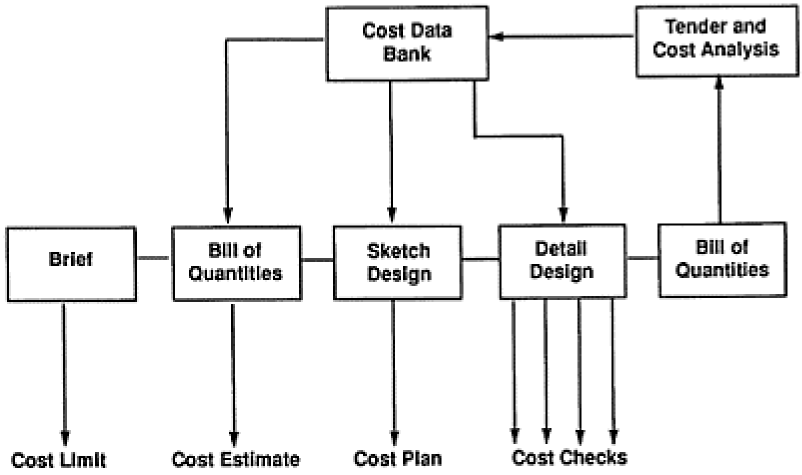


Fig. 1 Cost Control Procedures at Design Stages

The cost terms used may be briefly explained as follows

(i) Cost Limit

Cost limits apply where the amount of money available, or, which the client is prepared to pay, is limited. Such a limit is normally stated at the time the brief is given to the design team.

(ii) Cost Estimate

This is a broad estimate of the cost which is made at the stage when draft proposals are being considered. The site has normally been choosen before this stage and general proposals as to the number of houses, types of accomodation and forms of construction are being considered.

(iii) The cost plan is a calculated prediction of the tender price and is set out in sufficient detail to allow the cost implications of design decisions to be assessed. The cost plan cannot be prepared until the sketch layout and the outline specification have been agreed.

(iv) Cost Checks

Cost checks take place as the detail design is developed and they compare the cost of each element when fully designed with the allowance for that element in the cost plan. When the cost of the designed element exceeds the planned cost, other elements may be examined in a search for compensating savings, or else, the prediction of final cost is altered.

(v) Cost Analysis

The cost analysis of the successful tender allows for detailed comparision with the cost plan, with other tenders and with the information available in the data bank relating to similar contracts. The analysis of the tender is then added to the information in the cost data bank.

(vi) Cost Data Bank

The cost data bank is formed from the cost analysis of tenders and of final accounts. The information stored is retrieved, when necessary, in order to assist in preparing other cost estimates and cost plans, or, for cost checking and comparison purposes.

The system is fully explained in the publication "National Standard Control Procedures for House Construction Costs" referred to above. Copies of the standard forms required are included and guidance notes for their completion are provided. The contents of the building elements are defined and technical terms are clarified

The cost plan and the cost analysis are organised under five main headings

(i) General Project and Cost Information;
(ii) House Substructure and Superstructure Costs;
(iii) External Works and Site Development Works;
(iv) Special Works;
(v) Indirect Project Costs.

The principal unit for expressing cost is the house. In the general and siteworks comparisons, the costs of projects are compared on the basis of cost per house. However in the case of superstructure, detailed comparison is made on the basis of cost per particular house type. Thus, for example you might have:

Overall Cost	£A per house
Element (40) .13 Roads	£B per house

In the case of a two storey, 3 bedroom, 5 person house, you would have for that specific house type

Element (21) External Walls	£C per house

The system also provides the cost per square metre of floor area. This allows cost comparisons between house and general building construction and with costs of housebuilding in other countries.

When cost planning is used in housebuilding, the greatest benefits are frequently in the area of siteworks. In the application study that tested the suitability of the system, the average cost of siteworks in the ten projects examined was 32 per cent, ranging from 27 per cent for the lowest to 47 per cent for the highest.

The quantities of construction work per house under siteworks can vary considerably from project to project. This makes the cost analysis of siteworks as a total sum per house, or even further divided into elemental cost per house, inadequate. Many of the elements require a statement of quantity of construction. The system provides for this measure, in both the cost plan and the cost analysis. In considering the economic efficiency of alternative site layouts for example, a statement of square metres of road and of paths, or metres of walls or services can be of assistance to the design team, even before the elements are costed. When costed, the quantatative information will assist in separating the cost implications of the layout design from those of the construction specification.

6 Implementation of the Procedures

The procedures were introduced, on a gradual basis, starting in 1981 and were supported by a series of two-day workshops that took place around the country in the period 1981–1983, in order to provide the training which was necessary to acquire familiarity with the system. In 1983, the procedures were made mandatory for all local authority low rise housing schemes of six or more units.

There was a body of opinion opposed to the introduction of the procedures for two main reasons:

(i) Some designers considered that the procedures would interfere with the process of developing unique design solutions appropriate to the environment of the particular housing project. They viewed the procedures as a means of producing buildings at the cheapest possible capital cost, without any regard to how the development would blend with its surroundings.

(ii) Some quantity surveyors considered that the filling out of the cost plan and cost analysis forms would be tedious and time consuming. This would add substantially to the design cost and would delay the overall design process.

Both of these aspects provoked lively debate at the workshop sessions, but this debate was healthy and useful, since it contributed to put at rest two misconceptions regarding the procedures.

In the first instance, the system does provide very considerable flexibility in compensating costs as between elements and there had never been any intention of inhibiting creative design solutions for individual housing projects. Indeed the system demanded that local authority housing would continue to be constructed to standards that were higher than those obtaining for the average house in the private sector. The essential issue that had to be faced, was that the State must satisfy itself that value for money, in terms of both cost and performance, was being achieved in its housing programme.

With regard to the amount of time it would take to complete the cost plan and cost analysis forms, the workshops themselves demonstrated, that even for complex projects and allowing for an initial unfamiliarity with the system, the documentation could be completed by one person within three days. With familiarity, this time period would be reduced. There could be further reductions too, if the BOQ was organised on an elemental rather than a work category basis. The time input involved was more than compensated for by the quality and usefulness of the data base that was generated.

During the course of the workshops, many designers expressed surprise at the importance of siteworks in the context of overall total cost (See Section 5 above, where on average it amounted to 32 per cent). There was, moreover, general agreement that the cost and potential savings implications for siteworks had perhaps not been fully appreciated in the past.

7 Results

The local authority housing programme is dominated by a single house type—the two storey, terraced, 5 person, 3 bedroom house—such that on a year to year basis, the mix of housing in the programme does not vary significantly. Accordingly, assuming that performance criteria remain constant, the average cost per unit, on a year to year basis, provides a useful guide in assessing the value for money which is being achieved.

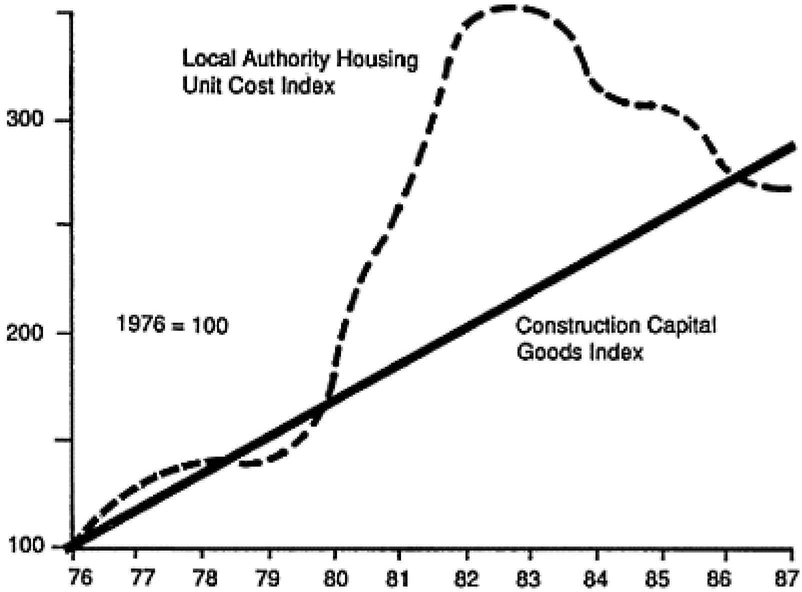


Fig. 2 Local Authority Housing Unit Costs 1976–1987

Figure 2 compares an index of unit cost with an index of construction capital goods in the period 1976 to 1987, both to base 1976=100. It is evident from the Figure that while unit costs performed unfavourably in the period 1980–1986, this circumstance was rectified and indeed it is scarcely coincidental that the recovery started around 1983.

Although there were other factors contributing to this recovery, the DOE is convinced that the Control Procedures were primarily responsible for putting the local authority housing programme back on a sound financial basis. In particular the procedures have enabled managers to pinpoint elements with large variances at an early stage in the design process and to take such corrective measures as would be necessary. These variances have frequently identified embellishments which were out of context with the concept of a balanced approach to expenditure on the various parts of a building. The more commonly occurring problem areas were found to be windows, external walls, heating centres and siteworks.

Far from slowing down the design process, the ability to be able to pinpoint problem areas at an early stage and to ask pertinent questions has streamlined the whole system and has resulted in a more efficient and effective design service.

With regard to the quality of local authority housing since the introduction of the system, there is no evidence to suggest that performance has in any way suffered. Indeed the programme continues to provide imaginative and commendable developments, particularly in inner city areas.

It is fair to say that the procedures have achieved widespread acceptance and are viewed as a progressive measure for managing the overall local authority housing programme. While the effectiveness of the procedures has not been quantified, it could be conservatively estimated that as a consequence of the implementation of the Control Procedures an additional 500 houses were provided by the programme out of the same capital allocation, in the period 1983–1987.

Apendix A DEFINITION OF ELEMENTS

Substructure	
(19).1	General
(19).2	General floor insulation
Superstructure	
(21).1	External walls structure
(21).2	External walls insulation
(22)	Internal walls
(23)	Upper floors
(24)	Stairs
(27)	Roof structure
Building Structure Completion	
(31)	External walls
(32)	Internal walls
(37)	Roof
Building Finishes	
(41)	External wall
(42)	Internal wall
(43)	Floor
(45)	Ceiling
(47).1	Roof finishes
(47).2	Roof insulation
Building Services (Piped and Ducted)	
(51)	Heating Centre
(52)	Internal waste and roof drainage
(53)	Hot and cold water services

(54)	Gas supplies
(56)	Space heating
Building Services (Electrical)	
(69)	Electrical Installation
Building Fittings and Furniture	
(73)	Kitchen Fittings
(74)	Sanitary Fittings
(76)	Cupboards, Wardrobes
External Works	
(10).01	Prepared site
(20).01	Ancillary site structures
(30).01	Site enclosures
(40)	Pavings
(50)	Site Services (Piped and ducted)
(60)	Site Services (Electrical)
(80)	Landscaping
Site Development Works	
(10).01	Prepared site
(20).01	Ancillary site structures
(30).01	Site enclosures
(40).11	Paths
(40).12	Kerbs
(40).13	Roads
(40).14	Parking
(50).12	Surface water drains
(50).13	Watermains
(50).14	Oil distribution
(50).15	District heating
(60). 11	Electrical
(60).12	Telephone
(60).13	Television
(70)	Site fittings

(80).11	Seeded areas
(80).12	Planting
(80).13	Paved areas
Project Indirect	
(06)	Preliminaries
(07)	Insurance
(08)	Contingencies

132
Cost information system for building projects: state of the art in Turkey

İ.ORHON, H.GİRİTLİ, E. TAŞ and H.YAMAN

Abstract
The growing size and complexity of projects has generated a need for increasing volumes of information in the construction industry. Extensive developments in computer technology and database techniques facilitate information transfer between participants within the building process. This study aims to develop a computer system which will allow the transfer of cost information with consequent benefits to cost modelling. Its ultimate purpose is to take step of establishing a cost data bank which will operate in the Turkish Construction Industry. This paper will report on the characteristics of the principal cost information sources in the industry, which will form the first part of the study.

Keywords: Cost Modelling, Cost Information, Data Bank.

1 Introduction

We live in an age of information. The establishment of adequate information sources and channels is seen as a “necessary precondition” for rational decision making. As is known well, rational decision are usually made in the light of the information available at the time of the decision. The increasingly important role of information in decision making is a growing area of concern in management theory and practice. The rapid developments in telecommunication and computer technology have greatly increased the potential for the storage, processing and distribution of information gained all over the world.

The reflection of the industrial development followed in other fields of production on the construction industry and the growing size and complexity of construction projects have generated a need for increasing volumes of information. It is true to say that the building process is information intensive. Each stage of the process requires the continues collection, updating and exchange of information by, and between the various parties responsible for the production of building, The processing and communication of this information is vital for achieving success in the construction industry. The availability of information of the correct quantity, quality and type, the suitable formulation of that information and its subsequent application and use are key elements in increasing efficiency of construction management.

There is a mounting awareness of the significance of modelling effective information systems as an important area of building research worthy of commanding funding support. For this reason, a number of attempts have been made to improve data co-ordination between the users of data in the building process.

Rising prices, restrictions on the use of capital and high interest rates have led increasingly to the need for reliable and useful cost data in the management of design and construction process as well as maintenance. In the construction industry, an effective cost information service is vital to ensure that resources are used to the best advantage. It was for this reason that banks of cost data were established in several countries (BCIS and BMCIS in the UK, UNTEC in France)

Turning now to what currently exists in Turkey, the construction industry is in lack of a standard for the description and structuring of information exchance between the various parties involved in the act of construction. The major problem faced by the industry is the absence of communication media between the users of data.

This paper describes a research project which aims to develop a computer-based cost information system for building projects. The ultimate purpose of the research is to take step of establishing a cost-data bank to be operated in the Turkish Construction Industry. The research will give emphasis to the need of harmonisation of national practices in the construction sector so as to allow cost information to be exchanged between countries.

The paper has been prepared at the commencement of the research cited and has attempted to review the major sources of cost information available to the Turkish Construction Industry, by indicating their shortcomings.

2 Sources of cost information

It is generally recognised that the act of cost estimating and control is dependent upon the availability of cost information sources to the industry. As mentioned previously, the first step of the research project described in this paper is to review the major published sources of cost information in Turkey.

Although the preliminary phase of the study will end up in December 1991, it is intended, in this paper, to draw general conclusions about the published cost information and the cost studies prepared by the industry.

The main sources of published cost information may be reported under five headings.

Input prices
  Unit prices
  Building cost
  Cost indices
  Cost studies

2.1 Input prices

One of the published information on wage rates, material prices and plant rates is supplied by the Ministry of Public Works and Resettle-ment. In this publication, wage rates are based on different skill levels, and material prices are provided for different material ranges. Supplementary information is also supplied on delivery place of material. As for plant rates, they are priced in terms of different tasks (Table 1).

In public sector projects the pricing of work items are subject to the afore said list which appears once a year. In addition, it is possible to find this type of information in the journals concerned with design and construction. Due to the rapid increase in input prices, these journals provide information about the current state of the tendering climate.

2.2 Unit prices

Apart from the list of unit prices, the Ministry of Public Works and Resettlement also supplies a list of unit prices for measured work items which is published annually. In this list, work items are broken down into 30 categories. Unit prices for each element of work include a profit margin of 25 per cent, excluding transportation expenditure.

Table 2 shows breakdown of unit prices for typical work items.

Since the major cost significant factors such as location, size of contract, type and form of construction, and market conditions are not reflected in the prices, it is necessary to make adjustments in case of tendering for private sector projects.

2.3 Building cost

Building prices per m^2 for various types of building have been published annually by several public or private organizations for different purposes.

Rates per m^2 are adopted in the calculation of professional fees for building work. For public sector services the calculation is based on the list which is disseminated annually by the Ministry of Public Works and Resettlement. Another list that is produced by the Chamber of Architects exhibits some differences when compared to the former. It makes allowance for regional variations. Table 3 and Table 4 show the format of each.

Apart from these two lists, the Ministry of Finance and Costoms prepares a list of building prices per m^2 to be used in the calculation of property tax.

2.4 Cost indices

One of the real weaknesses of the Turkish Construction Industry is the inadequacy of published cost indices which will provide an empirical guide to changes in building costs. It stems from the lack of consistency between various published indices. For this reason, there is a clear need for development of reliable building price indices. This is on issue which requires action by both the government and industry.

In Turkey, the index data is compiled by the Business Research and Publication Department of the Ministry of Commerce, the Istanbul Chamber of Commerce and the Price and Trade Statistics Division of State Institute of Statistics. The most commonly used indicator of changes in the general price level is wholesale price index. Two types of wholesale price indices have been developed in the country.

Table 1. Input Prices (1000 TL=0,339 US & at the end of December, 1990)

ITEM	DESCRIPTION OF ITEMS	UNIT	UNIT PRICE (TL)	DELIVERY PLACE
	CONSTRUCTION MATERIALS:			
4.0070	Fine sand for plastering, sieved and washed	m3	8,418	at quarry
4.0081	Normal Portland cement, as bulk	ton	89,000	”
4.0180	Factory manufactured bricks;			
	A) Facade clay bricks (190*90*50 mm.)	each	160	at factory
	B) Horizontal holed (190*190*85 mm.)	each	130	”
	C) Vertical holed (190*190*135 mm.)	each	175	”
	†) Light bricks (190*390*135 mm.)	each	770	”
4.1510	Sawn pine wood, 1.st quality	m3	1,225,000	at site
4.1610	Wooden parquet, 1.st quality	m2	65,000	”
4.2510	Reinforcing steel rods, ST 1, 8–12 mm.	kg	753	at factory
4.2560	Steel sections	kg	1,075	”
4.4070	White glazed wall tiles, 150*150*6 mm.	each	410	at side
4.6532	Normal glass, 6 mm thick	m2	19,972	”
	LABOR			
1.0020	Skilled worker for floor tiling	hour	2,145	
1.0030	Skilled worker for glazed wall tiling	hour	2,145	
1.0080	Skilled worker for wooden joinery works	hour	2,145	
1.0120	Plasterer	hour	2,145	
1.0130	Wall builder	hour	2,145	
1.0190	Steel bender	hour	2,145	
1.0230	Painter	hour	2,145	
1.4011	Heavy truck driver	hour	2,442	

1.4090	Formen	hour	3,077
1.5010	Unskilled worker	hour	1,403

Source: Ministry of Public Works and Resettlement (Extact from the list of Input Prices, 1990)

Table 2. Unit Prices for Measured Works of Construction (1000 TL=0,339 US & at the end of December, 1990)

ITEM	DESCRIPTION OF ITEMS	UNIT	UNIT PRICE (TL)
	MASONRY WORKS:		
18.0010	Red clay brick wall with 200 kg cement mortar	m3	142,479
18.0110	Red clay brick half -wall with 250 kg cement mortar	m2	15,664
18.0112	Halw-wall with facade clay bricks	m2	24,504
18.0311	Load bearing wall with 200 kg cement mortar and factory manufactured clay bricks (block or vertical holed)	m3	187,957
18.0312	Wall building with light-weight, vertical holed bricks sized as 390*135*190 mms.	m3	98,549
18.0313	Ditto, brick sizes are 240*115*235 mm.	m3	100,016
18.0314	Ditto, brick sizes are 240*145*235 mm.	m3	94,827
18.0315	Ditto, brick sizes are 240*175*235 mm.	m3	93,620
18.0316	Ditto, brick sizes are 290*190*235 mm.	m3	87,393
18.0317	Ditto, brick sizes are 240*240*235 mm.	m3	86,145
18.0318	Ditto, brick sizes are 240*300*235 mm.	m3	83,473
18.0319	Ditto, brick sizes are 240*365*235 mm.	m3	113,902
18.0710	Wall building with 200 kg cement mortar and factory manufactured, horizontal holed clay bricks, all sizes	m3	73,021
18.0711	Half-wall building with 250 kg cement mortar and ditto	m2	8,095
18.0810	Load bearing wall with 200 kg cement mortar and factory manufactured clay bricks (block or vertical holed), all sizes	m3	82,912
18.0811	Halw-wall building with 250 kg cement mortar and factory bricks, vertical holed, all sizes, modular	m2	13.783

Source: Ministry of Public Works and Resettlement (Extract from the list of Unitprices, 1990)

Table 3. Building Cost Per Square Meter (1000 TL=0,339 US & at the end of December, 1990)

CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5

140.000TL/m²	200.000TL/m²	400.000TL/m²	600.000TL/m²	840.000TL/m²
-Workshops, studios 100m² -Sheds, barns -Open sport places	-One storey workshops -One storey garages -Open swimming pools -Two story house buildings -Simple factory buildings	-Multi storey workshops -Dormitories -Multi storey garages -Dispensaries -Primary schools -Gas stations -Houses (no elevator and no central heating)	-Simple office buildings -Malls, stores -Swimming pools -Hospitals -Simple religional buildings -Appartment with elevator and central heating -Factory buildings -Administrative buildings -Social and sport buildings -Hotels (one or two stars)	-Banks -Hospitals (more than 100 beds) -Cultural buildings -Holiday villages -Cinema and theatre buildings -Department stores -High quality houses -Religious building -Hotels (three, four and five stars) -All type restorations

Source: The Istanbul Chamber of Architects.

Table 4. Building Cost Per Square Meter (1000 TL=0,339 US & at the end of December, 1990)

CLASS 1 112.000TL/m²	CLASS 2 220.523TL/m²	CLASS 3	CLASS 4	CLASS 5
		GROUP A 371.621TL/m²	GROUP A 477.799TL/m²	GROUP A 796.331TL/m²
-Huts -Retaining walls	-Towers -Small houses	-Simple industrial buildings -Simple holiday villages Social houses -Simple sport facilities -Simple office buildings Group B 424.710TL/m² -Industrial buildings -Simple libraries -Office building -Social houses (with central heating) -Multi storey	GROUP A 477.799TL/m² -Complex school building -Saunas -Administrative buildings GROUP B 530.888TL/m² -High quality houses -Office buildings -Stadiums and sport facilities -Campus buildings -Office buildings (banks) GROUP C	-Embassy -Administrator houses GROUP B 955 598TL/m² -Congress centers -Concert hales -Museums GROUP C 1.114.864TLm² -High quality hotels -Big radio and television buildings GROUP D 1.306.800TL/m² -Theatre and opera houses -All type

		garage -Dormitories	637.065TL/m^2 -Hotels (3 or 4 stars) -Hospitals -Cultural building -Swimming pools -Hostels	restorations

Source: Ministry of Public Works and Resettlement.

2.5 Cost studies

Since the 1970s, a number of building cost studies have been undertaken and supported by the National Research Organizations and the universities. In recent years, private construction firms and institutions have found it profitable to give attention to the research and development of cost forecasting and control.

Among the national research organizations, the Scientific and Technical Research Council of Turkey combines the work of several organizations. The Government finances the work undertaken by the organizations affiliated to the Council. Regarding these organizations, the Building Research Institute has been conducting extensive research programmes into various aspects of building cost since it was formed in the late 60s.

Further research has been carried out at the universities into building cost studies. The results usually obtained during these studies are often published to contribute to the developments which take place within the construction industry.

3 The research project

As has been mentioned earlier, this paper is concerned with a research project which intends to develop a computerized cost data base and information service. The research will be conducted by the writers to do the following.

To foster the use of life-cycle costing methods in investment appraisal

To provide relevant data to developers or financial institutions for evaluating competing proposals

To enable contractors to make better contract pricing decisions

To provide architects with up to date and reliable information needed for making rational decisions at design stage

To assist property managers in the establishment of a maintenance policy for the building.

The study will be carried out in the following steps:

1. The development of a theoretical model of cost information system
2. The translation of the above model into a. computer model

3. The application of the computer model designed
4. The establishment of the Turkish Cost Data Bank

The collection of information of the correct quantity, quality and type, the suitable formulation of that information and the application of suitable interpretive techniques will form the basis of modelling the system.

Validity of the computer model to be proposed will be tested through a pilot study. It is intended that the pilot study will be conducted on sample of projects from tourism sector.

The starting point of the work is to treat the present cost information sources and cost studies available to the industry. In the

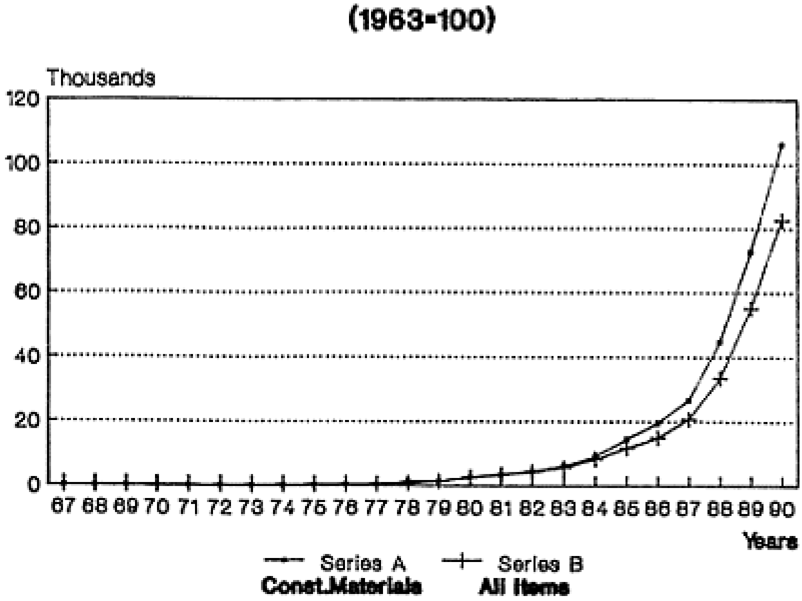


Fig.1. Wholesale price index of the Istanbul Chamber of Commerce

The whole sale price index of the Istanbul Chamber of Commerce has been published in the Price Indices Journal of the aforementioned organization since 1951. No coefficients are used for the items included in the index which is calculated by the unweighted geometrical mean. Since the beginning of 1965, the index numbers have been adjusted to different base years; 1958=100, 1963=100 and 1968.100. As for the indices prepared by the Business Research and Publications Department of the Ministry of Commerce, total production values are taken as indicators both in the selection of items and grouping. Originally 1938 was taken as the base year for the index numbers calculated using the Laspeyres formula and later the base year was shifted several times to 1953, 1958 and 1963.

Each of these wholesale price indices covers prices of construction materials. But the main shortcoming of these indices is that they take no account of the implications of differential price movements in construction materials. However, within construction materials as a group, prices of some materials may change faster than others.

Figure 1 shows in graph form the wholesale price index of the Istanbul Chamber of Commerce over the period 1967–90.

course of this phase, a data base will be compiled to provide the relevant data.

4 Conclusion

For some years, there has been a growing concern with regard to the availability of reliable building cost information. It has been proved that the successful management of the building process is based upon the sound cost information. Though the importance of cost information is well understood by the protagonists of construction, one of the primary weaknesses in the Turkish Construction Industry is the lack of an effective cost information system.

Hence, the research project described herein was commenced with the aim of developing a computerized cost data base and information service. It is hoped that if such a system can be established, it will stimulate the exchange of cost data between countries.

Acknowledgments

The work described in this paper is funded by the State Planning Organization. The reference data on the cost information sources will be available from the writers after December 1991.

133
Maintenance management—the benefits of a planned maintenance programme

J.PELLING

Maintenance has a particular problem insofar as it does not produce a new or extended facility, and in many cases, if not carried out, the adverse effects may not become apparent for a long period. In this area planned maintenance reports (PMR's) can be an effective tool in demonstrating to the decision makers the economies which can be gained by structured maintenance of buildings and, equally as important, highlighting the losses which can result from failure to do so.

Changes in U.K. local and central government organisations have also increased the demand for PMR's where the re-organisation has involved the transfer of large portfolios of property from one authority to another. In such circumstances the receiving party needs to know the liabilities it is undertaking, and conversely the donating authority also requires such knowledge to assess claims or demands it may receive regarding funds necessary to off-set or cushion the burden of the repairing liability on those properties being transferred.

This situation is of course paralleled in the commercial sector, e.g., in the event that one company merges with or takes over another.

PMR's are an efficient way to highlight backlog maintenance together with present and future repair/renewal works required to a building or group of buildings. Over the last 20 years in the United Kingdom there has been a growing demand for PMR's on all types of buildings both in the public and private sectors.

One of the main reasons has been the increasing demands on both public and private finances, and the increasing call for accountability of individuals charged with expenditure in these areas. In consequence, greater stress has been placed in respect of planning, controlling and monitoring budgets in such organisations. Property is no exception to such controls and has had to compete for funding with other departments within both the public and private sectors.

In the U.K., Building Surveyors in particular have demonstrated that their traditional skills are particularly relevant when undertaking such inspections. Their undoubted skill in understanding how buildings are constructed, their experience of where failures are most likely to happen, and how they will happen, their ability to forecast when remedial works will be necessary, and of equal importance, their knowledge in formulating repair proposals appropriate to the circumstances makes them ideally suited to this task. In the building surveyors work very few of the required repair techniques are contained within standard text books, and are normally evolved through experience of encountering such problems on actual buildings. This expertise, together with the building surveyors skill in organising and controlling the resources and logistics of carrying out large portfolio surveys, clearly highlights them as the appropriate expert in this field.

What is a planned maintenance programme? Firstly, it must be appreciated that it is not a detailed document specifying exactly what works need to be carried out, i.e. it is not a Bill of Quantities, nor is it a job specification.

It is a “working tool”, particularly in the area of financial planning, but also forming the strategic plan for the repairing, maintaining and improving of a building or group of buildings over a period up to 50 years or more.

In order to be an effective tool it must be prepared in a concise form so that it can easily be referred to and used. Also, as the programme represents, in effect, an on-going diary or calendar of what works need to be carried out and when it is necessary that the document can be readily updated to take account of repair works as they are carried out and also to reflect changing conditions within the building, i.e. anticipated rates of deterioration in roof covers may be greater than that originally envisaged.

It will be understood therefore that the traditional structural survey report, commonly prepared in the U.K. when buildings are being purchased, is totally inappropriate because of its “prose” format. This type of report presentation results in a bulky document which is inflexible to easy updating and as such only represents a “snapshot” of the building at the time the report was prepared and can easily be out of date within six months.

Unlike the survey, the PMR does not seek to identify or analyse why the fault or disrepair occurred. Although the surveyor when carrying out his inspection has to consider these aspects, he only records on the PMR the fact that the fault exists, the appropriate remedial solution, and an indication of the year in which works will be required, together with the costs.

The scope of the PMR is dictated by the Client and his budget. It can range from considering the day to day cleaning costs through to assessment of when major refurbishment will be necessary. Indeed it is possible that such analysis will also identify the time when demolition will need to be considered. The wide range in the scope of PMR’s is illustrated by two examples of inspections carried out by John Pelling & Partners. On the one hand we have carried out surveys of office buildings where the PMR was limited to approximately 10 pages long and, in contrast, on another more complex building the information was entered into a computer and never reproduced in hard copy because of the length of time it would have taken to print.

Why prepare a PMR? It is a sophisticated exercise and consequently expensive to carry out. Also to be of value it needs to be regularly updated on an annual basis, and arguably totally reviewed every 4–5 years.

The reason is that the benefits of a PMR are such that the financial savings and economies that can be achieved will outweigh the initial expense.

Firstly, and in my view most importantly, the PMR allows for financial planning to be correctly structured. It will identify the annual resource necessary to maintain a building, or portfolio of buildings, over a given period of time. That time can be and should be related to the normal financial projections of the company or authority commissioning the PMR. The cost projections will aid in demonstrating the need for such resources especially when competing with other departments for funding. Accordingly, financial resources can be allocated in the future and contingency plans, such as sinking funds, can be considered and established if necessary. Often when the PMR is initially produced it will indicate a heavy requirement for investment in the initial years, generally as a result of backlog maintenance.

It should be noted that accrued or backlog maintenance should not occur if PMR were instituted from the day the building was completed. However, it is necessary to be realistic, and if this situation occurs, i.e. a large financial commitment is required in the early years, then it is possible in most cases to review the PMR and to spread the costs over a longer period compatible with the financial capabilities of the building owner.

Whilst planned maintenance programmes can be, and are often, priced at present day costs, it is of more use and increasingly more common to cost them taking into account life cycle costs, allowing for inflation and discounting for present value of the currency. This will enable evaluation of repair or renewal proposals on the basis of their cost over their total operating life, rather than on their initial capital costs which can be seriously misleading. For example, the initial cost of a felt flat roof will be significantly cheaper than that of a tiled pitched roof over a period of say, 60 years. However, if the material used requires renewal of the flat roof four times within that period, then together with the associated disruption costs it could prove more expensive than providing a pitched roof construction which would last for this period, and longer, without any of the associated repair and disturbance.

The tabulated form in which PMR's are normally presented enables an easier appraisal to ensure that the programming of works is structured to avoid any abortive or duplication of work. For example, it ensures you do not paint the windows of a building one year and then renew them two years later. Another example is that you avoid erecting scaffolding one year to renew roof coverings and then a year later you re-erect scaffolding to carry out external redecoration. In other words, PMR's enable various repair works to be properly combined together into sensible work packages.

The benefit from the implementation of PMR's is that there are no nasty surprises. You are able to plan and repair on a proactive basis, and as such, minimise or eliminate disturbance of the building use or occupancy, a circumstance almost impossible to avoid on a building where maintenance is on a reactive basis only.

How is a PMR prepared? Firstly, you must establish in your own mind what you are seeking to achieve. If, for example, you are an owner of a large portfolio of warehouses or offices which are tenanted and you are only concerned with the maintenance of the external structure, then the inspections should be structured accordingly. On the other hand, if you are concerned with the total maintenance of the building then you may wish to address all costs, internal and external, together with the running costs of the heating and even the cleaning costs. In the latter case, the PMR could, if you wish, even address the matter of floor finishes and the speed and ease with which they can or cannot be cleaned, and the resultant effect on daily cleaning charges. You can also include, if you wish, information which will enable you to establish when areas would need to be refurbished, or whether heating systems are the most efficient in life cycle cost terms, i.e. it may prove cheaper in the long run to replace a heating system with high running costs with a totally new system which has lower running costs and will achieve a payback within a reasonable period. You will appreciate this can extend to other areas such as energy conservation, etc.

With the advent of information technology it is more common for PMR's to be input into computers. Because of the capabilities of modern computers there is a great temptation to ask for a greater amount of detail than can economically be gathered or put to use. For example, why pay for experienced experts such as building surveyors to collect minor data on buildings, e.g. ceiling heights, which can be more economically gathered by possibly your own non-expert staff. More importantly, of course, is the more data required the more expensive the exercise, and as explained before it is our opinion that the primary aim of the PMR is to produce a financial planning tool.

Although many organisations have the in-house capability to carry out these PMR's, it is certainly the case in the United Kingdom for such exercises to be carried out by consultant organisations such as ours. As such, it would be normal to hold discussions with your consultant in the early stages to discuss the type of survey required and the extent of detail they consider necessary to meet your requirements, and also to agree the format in which the information will be presented.

Having established in effect the brief, the inspections will almost certainly, in the case of large portfolios, be carried out by a team of surveyors. It is important that these surveyors are all briefed together and that during their inspections their reports are monitored to ensure there is a consistency in the extent of their inspection and their interpretation. As mentioned before, with the advent of information technology it is more usual for such programmes to be input into computers. Accordingly, the data collection is often input into small hand held computers or on to Data Forms using light pens which are subsequently 'read' by optical or bar code readers. These are down-loaded onto the computer back at the office onto a computer programme which, more often than not, is a standard programme which has been adapted to a particular Client's needs. We have carried out surveys ourselves on such a basis and, in one case, a local authority provided a terminal in our offices enabling us to directly input the information into that terminal which was, in turn, connected direct to the main computer of the Client's offices.

To summarise, it is our view that planned maintenance programme is an essential tool in calculating and allocating adequate financial funds to the proper maintenance of a building or group of buildings, for the formulation using life cycle costs of appropriate remedial/renewal works, both of which when implemented will ensure sensible economic proactive maintenance of buildings, of any type, to ensure minimal disturbance or interruption of the function or occupancy of a building emanating from lack of maintenance. The costs of such inspections are minimal compared with the benefits, and are certainly insignificant when compared to the potential losses which can accrue through poor or bad maintenance. They must be regularly updated in order to retain their value as an operating tool, and must be fully and properly costed.

Finally, maintenance is often viewed as low priority and low skilled areas of the construction industry. This is an outmoded view and the current demands on resources means that all aspects of life, including buildings, must be viewed with the object of conserving such resources as far as possible. Maintenance is an important aspect of this and demands the involvement of experts such as building surveyors in advising on all aspects of building care, including not least of all planned maintenance programmes.

18 February 1991

134
Cost-optimal flexibility of housing supply

H.T.PLAT

Abstract
The use of a house in the long run depends on market demand and on the total supply of housing services. Changes in the population and in the economy are the decisive factors in the demand for housing services: in quantity and in quality. Depending on the circumstances, either a house has to be adjusted to changing demand (active flexibility), or a change in the total stock of houses (giving rise to passive flexibility) will result in adequate supply.

Since a house will supply a heterogeneous flow of building services over a very long period, we have to distinguish components with different economical lifes. As a consequence a distinction can be made between maintenance (to maintain the flow of equal services) and adjustment activities (to change the flow of services). For cost calculation depreciation and maintenance cost are the basis. Average cost should be minimized in the long run.

Maximal flexibility of an individual house will never be optimal. In an increasing demand situation a heterogeneous stock of houses will be efficient, while in a stable situation some flexibility of an individual dwelling will be useful.

Developed countries face a rather stable stock with some need for adjustable houses. East-European countries have to deal with a quantitative and qualitative demand with less need for flexibility. Developing countries will for a long period just add to the stock in quantitative sence. Qualitative demand on small scale will be fulfilled by addition to the stock. Growing houses will be part of the solution.

In all circumstances modular coordination has advantages.

Keywords: Flexibility, Cost Calculation, Economical Development, Modular Coordination.

1. Introduction

A stock of houses should be able to meet the demand in a region in the long run. According to changing demand the stock may have to be adjusted by adding houses to the stock or by rehabilitation of existing houses. There will be no general answer to this question, since for different circumstances different scenarios will be possible.

In Western developed countries the existing stock will have to be adjusted depending on fashion, new materials and only a moderate increase in population. In some countries the sharp increase in income since World war II has more than proportionally be used for subsidization in the social housing sector, which has resulted in a less heterogeneous supply than would have been the case when the individual could have chosen freely. In Eastern Europe the stock will have to be enlarged at least in urban areas, while the existing stock has to rise in quality. Developing countries have to face a fast increasing population in urban areas, while the increase in imcome is lagging behind.

The different scenarios demand for different types of building activities: new-building and rehabilitations. Consequently the cost calculation should be adequate, depending on the different lifes of the building components. Based on this cost calculation a choice about optimal flexibility can be made.

2 A house as one element out of the stock

2.1 A building as a durable production good

Over a long period a building will supply services, which do’nt have to be equal. Because of this characteristic a building differs from most of other durable production goods. Similarity only exists with ships and planes.

A building however usually has a much longer than the life.

Above that, a building can in fact only be used on the place where it has been constructed. Consequently a building has to be adjusted to changing demand on the place where it exists. A building should be the most flexible durable production good we can imagine.

Buildings have a long life and sometimes a large sequence of families which use the building. A house will be used by the same family for five, ten or thirty years. As a consequence up to fifteen families will use the same building. But they will in fact use different buildings, since buildings will at least two or three times during their life be adjusted for changing demand.

Adjustment is something else than maintenance: cars will maintained, but not adjusted to changing demand. A car which cannot fulfil the wishes of the owner will be sold. A building which cannot fulfil the wishes of the present owner usually will be adjusted marginally.

However, one cannot state that a building should be kept in the same condition as being built originally. The frequency of adjustments depends on the structural change in demand. One should try to adjust a building only when demand is lacking in the market.

2.2 Which economical life?

The economical life is the period over which the building or the building component will be used as the best option. Other options are more expensive at equal quality, while the demand is actual.

It is hardly a problem to find the cheapest option out of the possibilities. The problem however is how to define demand. Should the building fulfil market demand in competition with other buildings, or should the building follow changing demand of the casual user of the building (figure 1). The shorter the economical life, the more expensive the services. It is pure luxury to adjust a building to the changing demand of the individual user. The advantages of the environment of the building should be much higher than the disadvantages of high adjustment costs. This choice is realistic as long as the user realises the cost consequences of his choice.

In general we can state that for the social sector—rental sector which in principal can be subsidized—market demand is decisive. In the not-subsidized rental sector the owner would like to maximize his return on investment, so he will try to meet market demand as well. Only in the buying sector short economical lifes dictated by the present owner/user can be realistic.

For nearly the whole market in most countries we have to calculate on the basis of economical lifes dependent on market demand. We have to focus now on the problem of flexibility of the stock.

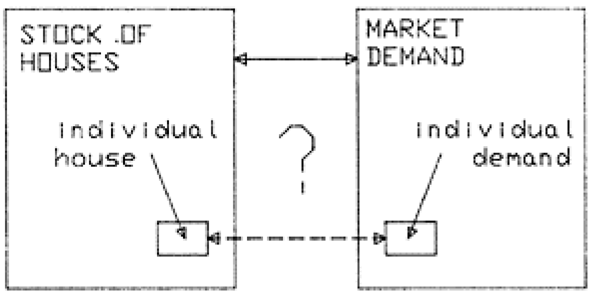


Fig. 1. Balance of market or individual supply and demand?

2.3 Economical life versus flexibility

Maximization of the life of a building component means an economical life equal to the technical life. Even when the demand is defined by market demand the economical life usually will be shorter than the technical life. The choice of materials depends on construction and different types of insulation which results in a long technical life. This is, however, an economical choice.

Constructive support components usually will have a long technical life. When the support components and the infil components can be disconnected easily, the economical life of the support components can be long as well. Dressing (infil and shell) components usually will have an economical life much shorter than the technical life. But the economical life still is optimal as long as market demand is taken into account. Now flexibility is an economical problem looking for technical solutions.

Maximized economical lifes of infill components means minimized flexibility of the individual building (active flexibility). But we know, that services have to be supplied to the market by the total stock of buildings, within a region like an urban area. Flexibility of the stock is maximized when the stock is heterogeneous to such an extent that all segments of market demand find adequate supply (passive flexibility). The remaining question now is how to create and maintain the heterogeneous stock in various circumstances.

3 Housing cost calculation

3.1 Expenditures and periodical cost

Expenditures are responsable for costs. But the importance of different expenditures depends on the moment of payment and on the useful period. The first point is financial in character, while the second point depends on the use of the building. The difference in the moments of payment can be solved by the process of discounting: most interesting will be the moment of decision making (fig. 2).

When all expenditures have been made comparable we have not yet got a basis for decision making. Because of the long useful life of the building it is difficult to predict all expenditures, e.g. concerning maintenance and rehabilitation activities. Relevant expenditures have to be predicted and translated into costs.

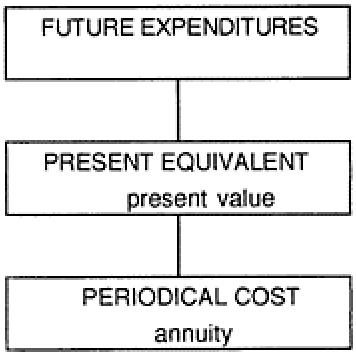


Fig. 2. In two phases from expenditure to cost.

Most processes need information about expenditures and receipts (or costs and income) within a planning period. Usually several planning periods will be used: at least one for the short run (one year) and one for the long run (five years or more). A yearly report will be made to see whether the process has to be continued on the same basis or not. The cost of the building used in a process should be calculated for a relevant period of one year. Since interest expenditures are a factor as well, the only useful solution is to calculate on the basis of average anual cost.

3.2 Maintenance and adaption activities

A building only has value when it is useful. Activities to keep the building usable are needed over the total life of the building. They generate costs, but not all of these expenditures should influence the present periodical cost. On the one hand the expenditures should be forseeable and on the other hand the costs should only be payed for by the user of the facilities. Most of the future expenditures have no relation with the present user of the building. The character of an activity depends on its goal.

Maintenance activities are necessary to keep the building “in the orinal shape as long as possible on a realistic financial basis”. As a consequence the maintenance expenditures can be predicted. A fund has to be created. Realistic dotations to the maintenance fund have to be considered as costs of the component (fig.3).

The situation is entirely different in the case of not-necessarily identical replacement of components. When at the end of the technical life of a component a choice can be made out of several components with different services, the expenditures cannot be considered as maintenance any more. A new investment decision needs a new financing decision. This means that the investor should be free when it has to be decided about (not)identical replacements. The old component has lost its value, which in economical terms means that it has been depreciated totally. A depreciation fund just covers the past investment, but not the future adaptation expenditure.

Not-identical replacements generate only costs in the following period, while maintenance generates costs in the proceeding period. Keeping buildings usable needs two kinds of activities: maintenance activities with a static goal (maintain a flow of constant services) and the renovation activities with a dynamic goal (adapting the flow of services to changing demand).

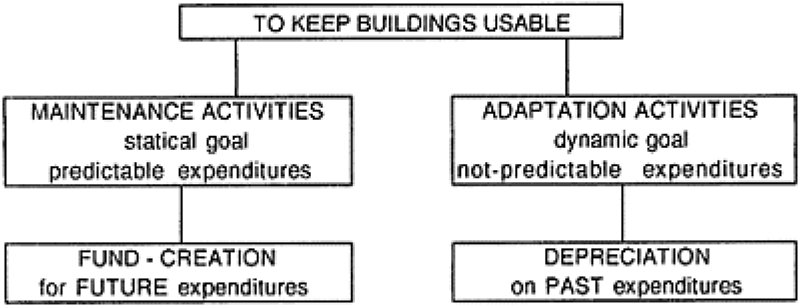


Fig. 3. Predictable and not-predictable activities to keep buildings usable.

3.3 Various depreciation periods

The adjustment of a building to changing circumstances should be based on adequate depreciation. All parts of the building should have been depreciated totally on the moment of replacement. Some parts (group of components) will have a long life, others a short one. The support structure can have a life of 30 or more years. Specific infill, depending on the using process, can have a life of only 5 or 10 years.

The investor should have the possibility to remove the parts without any loss. In financial terms it means, that the investment which has to be removed has been payed back totally. At that moment a free choice has to be made: identical or not-identical replacement.

After replacement the annual cost will be changed. As a consequence the annual cost can only be predicted over the period during the life of the components with a short life. For a longer period only a part of the costs can be predicted (fig. 4).

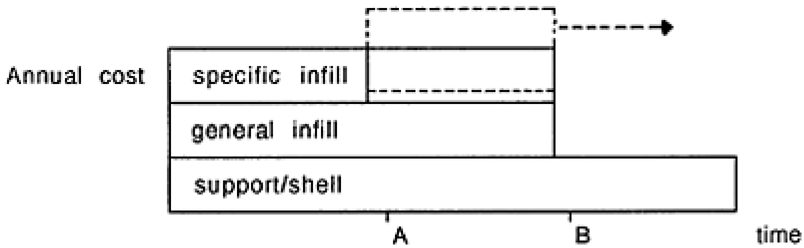


Fig. 4. Annual cost by addition.

This way of cost calculation gives us the opportunity to adjust buildings to changing demand at realistic prices. The user only pays for building parts he is using over the most probable period.

3.4 Modular coordination and long run decision making

In fact we now have created a foundation for modular coordiantion in financial sence. One of the advatages of modular cordination is that assembling in new construction and in rehabilitations is much more simpel. But to know the consequences of different options during the same using period or subsequent using periods the periodical cost of the individual (or groups of) components should be calculated.

Modular coordination does not mean that we have to try to reach maximum flexibility in new building and in rehabilitation. A balance between initial investment and rehabilitation expenditures should be reached. The balance can only be found on the basis of the most probable scenario of future developments in demand. These scenarios depend on the present situation and on growth of the economy and of the population.

The central government or the local authorities should be aware of the long term effect of decisions concerning new building. Flexibility should be used to get adequate supply in the long run, but on the other hand the investor should have a reasonable return on his investment. Maximum flexibility does not automatically mean that the return on the investment has been maximized as well. Actors and activities in the long run have been visualized in figure 5.

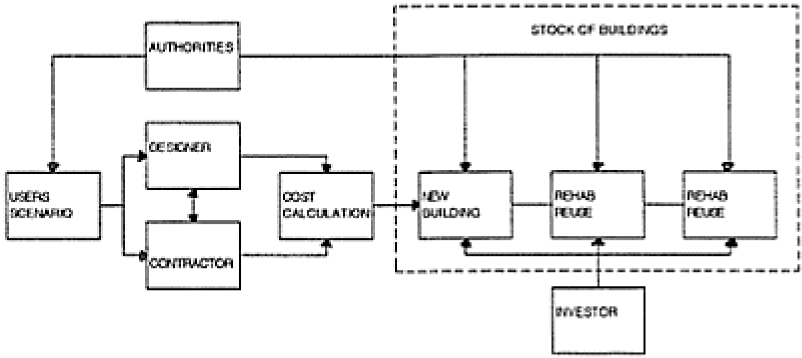


Fig. 5. Decision making about buildings in the long run.

4 Long term policy: east-west, north-south

4.1 Factors influencing demand

Demand for buildings is constantly changing because of three reasons:

– change in the population;
– change in the income per capita;
– change in the process of use.

A growing population results in demand for an enlarged stock. Larger families demand for larger houses. An increase in the family income can result in a qualitatively changing demand.

In a country which is stable as far as the size of the population and the income per capita are concerned we have to face a qualitative change in demand in a different sense. The distribution of age will not be constant, which will result in a changing use of the available space.

Even more important is the fact, that an individual family will change several times during its life. The size of the family will grow as well as its income. After some time the size will become smaller and possibly its income as well. So, a 'stable country' will face a changing process of use of the individual buildings, at least to some extent.

4.2 Three situations: east, west and south

We have to distinct at least three situations with different present circumstances and probable futures:

– the industrialized, developed countries, with a rather stable population and only marginally increasing spendings on housing;

– the countries of Eastern-Europe, with a rather stable population, but probably increasing spendings on housing;
– the developing countries, with a sharp growth of the population, but a very low and constant income per capita.

Depending on the situation, the attention has to be focussed on an increase in quality of the existing stock, an increase in quantity of the stock or a constantly changing stock at stable spendings. In a situation of growth it is questionable whether a future increase in demand for quantity or quality should be met by existing buildings or realised in new buildings. Do we have to build growing houses or not.

		family income	
		growing	stable
po- pu- la- tion	growing	enlarging houses/stock I	enlarging stock II
	stable	III quant./qual. increase each house	IV adjustment within stock

Fig. 6. Building policy in various situations

Western-Europe and other industrialized countries deal with a rather stable population and a moderate increase in the family income. We have to doubt whether an increase in income will substantially influence the demand for housing. Probably people in those countries have reached a level of housing which will not rise. In some countries it is even possible (like in the Netherlands) that the level has become too high because of a not realised increase in national income expected by the government. The responsability will to a large extent be given back to the individual, which means that families will even spend less on housing.

In figure 6 this means, that the housing stock will not change quantitatively (IV). Within the stock will be adjusted at the moment when the economical life of some infill components will have expired. Until that moment the passive flixibility of the stock will be used.

The countries in Eastern Europe have a lack of adequate housing supply. The amount of houses is not enough and are in a bad shape of maintenance, while the quality of newly built houses is low. The supply is lagging behind demand, which means that at first (II) the stock has to be enlarged at rather low quality after which the quantity and quality per house (III) will have to be increased. After disappearance of the lag Eastern-Europe will stay in area III. Because of the expected increase in quality demanded for in the future, the houses have to be built in such a way that quantitative changes can be adapted easily.

Developing countries face a fast growing population in urban areas, with a stable or even deminishing family income. The housing stock to be created will be of minimal standard, but the amount of dwellings has to grow fast. When in the future—at least for a part of the population—the family income will rise, either existing houses should be adjusted for increasing qualitative demand (a growing house) or qualitative better houses should be added to the stock. From II (constant family income, enlarging stock at constant quality) we will move to I (enlarging individual houses and/or the stock). Because of inferior infill materials there lifes will be short, giving rise to flexibility in the short run.

4.3 A growing house or a growing stock

In the situations I, II and III either the stock or the houses will have to be enlarged in quantitative and qualitative sense. Since the population and/or the family incomes rise it is possible to incorporate a flexibility in houses to enlarge the space and other facilities after some time. This flexibility will be used by one family with changing desires or subsequent families. We have to be sure that it is a one way change. We will not let shrink the house after some time, but some steps back on the way of luxury will be possible.

In the case of industrialized countries we see, that most of the people have reasonable housing conditions. One can doubt whether people will spend a substantial part of additional income for housing services. As a consequence one can state, that the present stock has to fulfil demand. Within the financial possibilities, however, the character of the demand will change. The size of the families can change, the way of living and the average age of the population. In this case we have to choose between adjusting individual buildings to changing demand of the present user (e.g. a growing house for an individual family) or to change the supply only by replacement of building components with expired lifes. In a stable situation growing houses implicitely demand for addition to the stock ofnew small/simple houses to grow afterwards. On the average the quality will increase, while average demand is not increasing. Growing houses are no solution; the stock should change at low speed while moving actions will make use of passive flexibility.

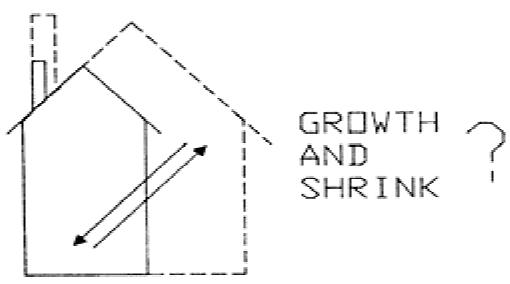


Fig. 7. A growing and shrinking house?

Developing countries and East-European countries face an enlargement of the stock of houses. It will always be possible to add simple/small houses to the stock to get on the average the quantity and quality demanded for.

5 Conclusions and lessons from the past

5.1 Cost-optimal flexibility

Not one-family-demand and one-house-supply should be in equilibrium over their lifes, but market demand and supply by the total stock of houses in a region. Long lifes, however, do not indicate that flexibility of an individual house is not needed. On the contrary, demand for housing services will change fast compared with the technical life of building components. Based on market demand the shortest economical lifes of building components will be between ten and twenty years.

Adjustment of a building to changing market demand means that building components with short lifes should be removed and replaced easily: in technical and in financial sense. Modular coordination facilitates replacement activities, while adequate cost calculation has to be based on realistic depreciation periods.

In most circumstances replacements based on changing market demand will be enough to meet changes in individual demand as long as moving actions are accepted and are cheaper than adjustment of buildings.

5.2 Lessons from some wealthy nations

In some way supply is dictated by demand, either individual demand in a totally free market or aggregated demand as it is the basis for government decisions. Housing services at least to some extent have to be considered as a merit good. Unfortunately in a situation of low income per capita, government influence is needed but the financial possibilities are only marginally. On the other hand we see that in some very wealthy countries the housing supply is still considered as a merit good: a substantial part of the stock is heavily subsidized because of reasons of income redistribution.

In wealthy nations, because of the long expected lifes of buildings, replacements and adjustments will be financed out of future, increased income; real economical growth. Since economical growth has slowed down, some countries added too many and to luxury houses to the stock than they can really afford. By giving back responsibility to the individual, governments try to solve their budget problems. People now realise that—all together—they have been spending more on housing than they realised and really wanted to. To get a good allocation of scarce resources in the long run government influence should be just complementary.

Contrary to what would be expected, government influence in housing is less in Eastern-Europe than in Western industrialized countries. People invest in a house and usually will use it the rest of their life. But in urban area the stock is far from appropriate, while government influence is substantial. These countries have to realise that governmental decision making and subsidizing should be temporary and exceptional to avoid future problems when going back on the way to individual responsibility.

In developing countries the lack of adequate housing is striking at least in urban areas. The first goal is to create space at minimal quality. Since the population will grow fast during the next decennia, demand will exeed supply for many years. Government can hardly do anything. They have to concentrate on the stimulation of self-help building and the subsidization of support structures. In this way some influence will be possible on the allocation of scarce space in urban areas, while individual influence on the level in the infill will not be lost.

135
Assuring the economy of residential building projects

M.PŠUNDER

Abstract
The economy of residental building projects is decided already in the phase of the project life cycle inception during the elaboration of the general (major) design. In our contribution, first the theorethical background for economical housing construction is given, and then the way in which it is possible to control the economy of the general design during its elaboration is presented. Two exemples of economic evaluation of location conditions for housing construction are given together with the evaluation of the projects technical requirements. In both cases the economical evaluation is based on technical parameters

Keywords; Housing Construction, Residental Buildings, Economy, Projects, General Design, Economic Evaluation.

1. Introduction

The need to have an apartment or a house is a fundamental human need. Therefore, social concern in housing construction is of paramount importance and the focus of attention in all social systems. Everywhere there is the tendency toward economical housing construction: so that the means available would suffice for the construction of a maximum number of apartments and so that selling prices would be as close to the purchasing power as possible.

This necessitates a broad range of measures and actions in different socio-economic systems they are carried out differently, but everywhere the economic aspects (for short, the economy of the housing construction) are of central importance.

The present contribution first deals with the theoretical points of departure and, following these, with the practical application of how to determine and to influence the economy of housing construction in the phase of preparing the documentation.

2 Theoretical Aspects

The economic factors of a residential building or of an apartment, which represent the relation between the amount of size of production and the costs, can be defined in terms of the theory of value and prices.

The social costs accrued along with those of the construction work are the costs of ongoing work and of the expenditures for past work for: preparation of the land register documentation; purchasing and preparing construction sites: construction of public utilities, and various other costs not directly included in the costs of the construction of the residential building.

It is because of these particular social expenditures that the value of a residential building has to be explained more fully. What is necessary in an explanation from three angles: in other words, the sum total of the value of residential buildings is made up of: work in the phase of preparation; socially needed ongoing work of construction workers, and past labour, invested in the socially needed use of construction material and machinery, which is represented in the material costs. Such an explanation of the value of a residential building helps in principle to determine the range of prices, which can not be determined simply by the mechanism of supply and demand (operative mechanism of the law of value).

In follows from the principled orientation, in accordance with the above three angles pointed to, that we have to distinguish between the full social price of an apartment, and the actual selling price of an apartment, which may for social and political reasons be lower from the full one (lower for the part of the social labour in the preparation phase).

In this paper we are limiting our attention to just the actual selling price of the apartment, which means that we shall discuss the economy of housing construction only with reference to elements making up the structure of the selling price of residential buildings.

The principles briefly outlined determine the structure of the selling price as follows: The selling price is made up of the following three elements—(a) construction costs of the residential building, (b) costs of furnishing the site with public utilities, and (c) other accrued costs. The awareness of such a tripartite structure of the selling price of residential buildings is important in order to see that the economy in the house construction is to be sought on a large scale in the costs of present and past labour in these three complexes of costs. In our continuation, however, attention will be restricted to the economy in construction works—i.e. to the economy in the first complex of the selling price of a residential building.

The economy of the construction work depends on numerous factors representing the costs of construction works. From the structure of the selling price and from related calculations it is generally known that the expenses are represented by: material costs; amortization of basic production means; ongoing labour.

3. Economy of Housing Construction

The costs of the construction of residential building (and indirectly the construction costs of apartments) can already be to a significant degree shaped in the initial phase when urban and construction documentation is being prepared. On the basis of experience, practical insights have been gained into how the costs of construction are affected by variables as regards conditions for location and the requirements of the project. In practice these variables have led to the emergence of numerous parameters by means of which it is possible to indicate the differences from the starting “normal” standards.

The economy of housing construction as regards conditions of location depends on the following parameters: location of residential building as determined by conditions of development, location of residential building as regards distance from urban centre, bearing capacity, possible degree of earthquake, climatic conditions, height of buildings in relation to residential units.

The values for the individual alternatives of these parameters, presented in percentage in relation to the “starting normal” values, are shown in Table I.

A knowledge of the values of these parameters is necessary in order to assess the economical aspects of the location of a residential building. Some of them are determined by the macro-location of the building (possible degree of earthquake, climatic conditions) and these can not be subject to alteration in different proposals. More important are the remaining parameters, where designers and city planners can exert their influence—to mention just the bearing capacity of the ground, the height of buildings and the size of building according to the number of residential units.

Let us by way of an example look at what economic effects are achieved by comparing an adequately chosen location and an inadequately chosen one:

Reference	Building A (good location)	Building B (bad location)
101/1,101/3	0.0000	0.0712
102/1,102/2	0.0000	0.0528
201/1,201/4	0.0000	0.1116
301/5,301/6	0.0000	0.1752
302/3,302/1	0.0000	0.4467
Total	f_A=0.0000	f_B=0.4467

This imaginary example of the differences in the location parameters of residential buildings shows that there may be indeed very high differences in the expenses and costs of apartments between an adequately and an inadequately chosen location of the residential building (in the above case 44, 67%).

The value of the individual alternatives of these parameters are shown in Table II. These parameters are important for the evaluatin of the economy of the project as regards its requirements. Such an evaluation ought to be made in the initial phase of design. A residential building is economically designed if the sum total of all the parameters is 0.000 or near to 0.000 if this is due to objective circumstances. The following imaginary example illustrates what differences in the costs and prices of one square meter of floor space come up when the building is adequately, and when inadequately, designed.

Reference	Building A (adequate)	Building B (inadequate design)
401/3,401/1	0.0000	0.1111

501/1,501/3	0.0000	0.0645
502/2,502/3	0.0000	0.0574
503/2,503/3	0.0000	0.0254
504/1,504/3	0.0000	0.0702
505/1,505/3	0.0000	0.0418
506/1,506/2	0.0000	0.0980
601/1,601/2	0.0000	0.0570
Total	f_A=0.0000	f_B =0.5254

This imaginary extreme example of the differences in the design parameters of residential objects shows that there are truly big differences in the costs and prices of apartments when designed economically and when not (in our case 52, 54 %).

4. References

M.Jamnik, “Reasonable Price, System and Policy of Prices”, Centre for Economy Research (Belgrade, 1976) 6, pp. 76–126.

M.Plunder, “Problem of Selling Price, Price Policy in Social Oriented Housing Construction”, Association of Housing Construction of Slovenia (Ljubljana, 1983) 10, pp. 136–149.

M.Plunder, “Some Possibilities of Increasing Economy and Productivity in Construction”, Gradbeni Vestnik (Construction Gazette), 7, pp, 162–167 (1984).

Table I. Values of location parameters[1]

Reference	Parameter	Factor (f)
101	Location Determined By Condition of Development	
	1. Free ground	0.0000
	2. Partly developed area (one-layer base concrete)	0.0356
	3. Developed area (two-layer base concrete)	
102	Location As Regards Distance from Urban Center	
	1. Construction in communal centres	0.0000
	2. Construction outside communal centres (over 20 km)	0.0528
201	Bearing Capacity of Ground	
	1. Bearing capacity of ground over 300 kPa	0.0000
	2. Bearing capacity of ground from 200 to incl. 300 kPa	0.0341
	3. Bearing capacity of ground from 100 to incl. 200 kPa	0.0806
	4. Bearing capacity of ground from 50 to incl. 100 kPa	0.1116

202	Possible Earthquake Degree		
	1.	VIth to VIIth degree MCS	−0.0112
	2.	VIIth degree MCS	0.0000
	3.	IXth degree MCS	0.0356
301	Altitude of Building		
	1.	One storey building	0.2844
	2.	Ground floor plus one storey	0.0864
	3.	Ground floor plus two stories	0.0744
	4.	Ground floor plus three stories	0.0278
	5.	Ground floor plus four stories	0.0000
	6.	Ground floor plus five to first floor plus nine stories	0.1725
	7.	Ground floor plus over nine stories	0.1530
302	Size of Building According to Residential Units		
	1.	Building with up to 10 residential units	0.0386
	2.	Building with up to 20 residential units	0.0321
	3.	Building with up to 35 residential units	0.0257
	4.	Building with up to 50 residential units	0.0000

[1]M.Pšunder, “Problem of Selling Price”, “Price Policy in Social Oriented Housing Construction”, Association of Housing Construction of slovenia, (Ljubljana, 1983), 10, pp. 138–142

Table II. Values of Design—Technical Parameters[1].

Reference	Parameter		Factor (f)
401	Technology of Construction		
	1.	Classic system, construction with bricks and blocks	0.1111
	2.	Special system of full-wall steel frameworks	0.0278
	3.	Special system of room frameworks	0.0000
501	Economy of Project and Functional Concept (relation between the building surface and the floor space)		
	1.	Relation up to 1:55	0.0000
	2.	Relation up to 1:65	0.0322
	3.	Relation up to 1:75	0.0645
502	Use of ferro-concrete per Sq.Meter of Floor Space		
	1.	Ferro-concrete up to incl.24 kg/m2	−0.0431

	2. Ferro-concrete from 24 kg/m2 to incl. 36 kg/m2	0.0000
	3. Ferro-concrete from 36 kg/m2 to incl. 48 kg/m2	0.0574
503	Use of Concrete per Sq.Metre of Floor Space	
	1. Concrete from 0.25 m3/m2 to incl. 0.45 m3/m2	−0.0254
	2. Concrete from 0.45 m3/m2 to incl. 0.65 m3/m2	0.0000
	3. Concrete from 0.65 m3/m2 to incl. 0.85 m3/m2	0.0254
504	Development of Facade (relation between developed facade surface and smooth facades)	
	1. Relation 1:1—smooth facade	0.0000
	2. Relation up to 1:20-developed facade	0.0393
	3. Relation up to 1:40-developed facade	0.0702
505	Construction of the Roof	
	1. Wooden roof construction, standard tile material	0.0000
	2. Wooden roof construction, sheet zinc	0.0224
	3. Even roof, walkable	0.0418
506	Facade Walls, Inner Walls, Ceilings	
	1. Building with massive girders (concrete)	0.0000
	2. Buildings with wooden construction beams	0.0980
601	Inner Surfaces	
	1. Normal standards	0.0000
	2. Higher standards	0.0570

136
The comparative economics of rehabilitation and redevelopment in housing and construction

C.PUGH

Abstract
Decisions and policies on housing improvement (and on other building types) are often taken without systematic appraisal of the alternatives in redevelopment and rehabilitation. In this piece of writing it will be revealed how technical analyses and evaluations can be used to demonstrate the economically valid ways of determining the best ways to achieve improvement in housing and construction. Its scope will include the results of computer simulations and empirical research in the period 1974–1990.

1 Introduction

Methodologies and techniques of economic appraisal of whether to rehabilitate/refurbish or redevelop have been refined since the early 1960s. These economic appraisals come within the field of cost-benefit and cost-effectiveness analyses. Cost-benefit and cost-effectiveness analyses were developed for application to a variety of spheres, usually in public sector investment in the 1960s. One of the first applications was to housing, particularly in urban renewal policies. In the 1960s historical context, cost-effectiveness analyses were used as a means of determining whether to conserve low-income housing stocks in a situation of chronic housing shortages. As we shall presently see, cost-effectiveness analysis can be broadened into a more comprehensive cost-benefit analysis, with versatile application to wider fields of urban investment, including commercial offices, shopping centres, and others. Cost-effectiveness analysis gives focus to only comparative capital and recurrent costs, whereas cost-benefit analysis includes social and revenue benefits as well as the costs.

2 Housing Appraisal

The early literature on housing appraisal was contentious among authors who gave differing emphases to the purposes of rehabilitation and the significance of various terms in their equations and formulations (Pugh 1990). For example, Needleman (1965) regarded rehabilitation as a useful option to redevelopment, allowing a temporary stay of execution from the bulldozer blades and redevelopment. It contributed to "the most urgent need…to improve the accommodation of the families who are worst housed at present" (Needleman 1965:196). At the first stage in the economics of rehabilitation and redevelopment, Needleman restricted his approach to one where the formulation for appraisal was essentially one based upon comparative timestream costs, omitting any consideration of comparative revenues and benefits. Needleman's original criterion is:

Rehabilitate if:

$$C > R + M\left(\frac{1-(1+i)^{-n}}{i}\right) + \frac{C}{(1+i)^n} \qquad (1)$$

where

C is the cost of constructing a new house

R is the cost of rehabilitation of the old house

M is the annual savings in maintenance costs with a new structure rather than a rehabilitated one

n is the life of the present structure following rehabilitation

i is the interest rate, or the rate of discount

Although accepting the basis of this appraisal, with its focus that the prospects for rehabilitation depended upon the influence of the rate of interest, the future life of the rehabilitated building, and the difference in running costs compared with redeveloped buildings, Sigsworth and Wilkinson (1967) disputed some aspects of Needleman's formulation. They suggested that Needleman had ignored the capital value of the building before improvement, placing it in their alternative formulation as a cost against rehabilitation. In addition, they argued that rising building costs should be incorporated into the appraisal. Accordingly their modifications gave a reformulation:

Rehabilitate if:

$$C > R + B + M\left(\frac{1-(1-i)^{-n}}{i}\right) + \frac{C(i+z)}{(1+i)^n} \qquad (2)$$

where, for the new terms:

B is the capital value of the house before improvement

z is the annual rate of increase in replacement costs

The subsequent exchanges in the literature (Needleman 1988, and Sigsworth and Wilkinson 1967) revealed the contentions and issues.—For Needleman, "once the decision has been taken to improve the house…the unimproved house will have ceased to exist" (1968:88). On this basis he excluded the capital value of the house before improvement. But Sigsworth and Wilkinson had argued that where rehabilitation extended the life of a dwelling it represented two elements, one being the cost of rehabilitation, and the other "the existing investment of capital which that house represents" (1967:112). Further aspects of the contentions and issues can be ascertained from my earlier writing (Pugh 1976) and from Merrett (1979). Both Merrett and I have indicated that redevelopment involves the destruction of an asset, and can be regarded as a cost of redevelopment rather than as a cost against rehabilitation. Authors in the United States proceeded on the basis of this understanding (see below). Merrett additionally indicated that the Sigsworth and Wilkinson formulation leads to earlier rather than later demolition. Or, put in other words, in using the Needleman and the Sigsworth/Wilkinson formulations in empirical computer applications, the Needleman formulation has a bias towards rehabilitation and the Sigsworth/Wilkinson formulation has its bias towards redevelopment.

In the United States, urban renewal economists such as Mao (1966) and Rothenburg (1967) had developed formulations which charged the value of a demolished property as a cost of redevelopment. Shaaf (1969) went further, adding sophistication and new terms to Needleman's original 1965 formulation. Shaaf's formulation is:

Rehabilitate if:

$$C > R + M\left(\frac{1-(1+i)^{-n}}{(1+i)^{n}}\right) + \frac{C(1+nr)}{(1+i)^{n}} + \frac{D\,1-(1+i)^{-n}}{i}$$

where, for the new terms and amendments:

C now includes the value of the demolished building, where appropriate

D represents the differences in annual rental values of the new and the rehabilitated dwellings

r is the annual rate of depreciation of the new structure

Schaaf's approach opened up new possibilities in the application of property appraisal to urban renewal. A renewal authority had a choice in assuming a variety of possible values for 'C' (the standard of the new dwelling), and for 'R' (the expenditure level on rehabilitation). The level of 'R' selected would also determine both 'M' (the annual difference in maintenance expense) and 'n' (the future life of the rehabilitated dwelling). In the implications of all this, Schaaf proposed a new term 'D' (annual differences in rental income) in order to reflect the different standards of amenity and convenience between new and rehabilitated dwellings. Furthermore, Schaaf suggested that rather than regarding rehabilitation in the base year as simply a means of postponing redevelopment, conceivably the future options could include both various standards of additional rehabilitation or redevelopment. This means that futures beyond year 'n' could be considered, with possibilities for optimisation in the sense that it would, in principle, be possible to maximise the differences between current redevelopment and various future recurring options in rehabilitation and redevelopment. But for practical and professional purposes, enough good information and analysis for a period of up to 50 years can be obtained from Schaaf's basic criterion (equation 3). Also, versatility is added once it is acknowledged that the basic principles of all the formulations from the various authors can be applied to mixed rehabilitation-redevelopment schemes, and to whole projects. They are not limited to appraisals of single buildings. As revealed below, the Schaaf criterion has good versatility and feasibility in empirical and applied research.

3 Applied and Empirical Research

In the period 1974–90 I have used the inherent versatility of the Schaaf formulation to appraise rehabilitation/refurbishment and their redevelopment alternatives in housing and in commercial offices. Current work includes the extension of applications to refurbishment in shopping centres. The research is published elsewhere in its elaborated detail (Pugh 1976 and Pugh 1990). What follows is a summarised version of the main principles, procedures, results, and interpretations.

In 1974 I used the Schaaf criterion to assess the comparative economics of housing rehabilitation and redevelopment in an urban renewal project in the Adelaide suburb of Hackney in Australia (Pugh 1976). For convenience the format of the Schaaf criterion ws amended:

$$Y = C_1 + C_2 - \left[R + \frac{C_2(1-nr)}{(1+i)^n} + \frac{M(1-(1+i)^{-n})}{i} + \frac{D(1-(1+i)^{-n})}{i}\right] \qquad (4)$$

where:

Y is the maximand (ie, the end result)

C_1 is the value of the existing dwelling

C_2 is the cost of the new dwelling

R is the cost of rehabilitation

M is the annual saving in maintenance costs with a new structure, compared with a rehabilitated one

D is the difference in the annual rental value of the new structure and the rehabilitated one (ie, the difference in dwelling amenity)

n is the life of the present structure, following rehabilitation

i is the discount rate

r is the annual rate of depreciation of the new structure.

In the interpretation of the results, a positive value for Y indicates the superiority of rehabilitation, and a negative value indicates the superiority of redevelopment. The formulation was programmed for simulation tests, using various chosen values which had realism in the context of the prevailing building costs, rates of interest and other economic conditions at the relevant time in Australia. Variations were used for C_2, i, and D. A least squares regression analysis of statistical records was used to establish M, it being: M=11.9+1.7x, where x is the age of the dwelling. The value selected for ‘r’ was 1.5%, reflecting the usual estimates in the literature. It should be borne in mind that for nonhousing buildings such as offices or shops, it is frequently appropriate to adjust the rate of depreciation upwards. The standards for R were obtained from experienced professionals and builders in the housing industry.

The empirical results and the simulations for testing the sensitivity of the key variables followed the inherent logic of the Shaaf-Needleman formulations, and the general pattern of the results are reported as follows:

Rehabilitation is relatively advantaged when:

1 The standards of rehabilitation are sufficient to extend the life of the older dwelling in the range of 30 to 50 years.
2 The value of the existing structure is comparatively high.
3 The differences in the rental values between the new and old, rehabilitated, dwellings are small.
4 The rate of interest is comparatively high.
5 The cost of the new dwellings is comparatively high.

In fact these general principles suggest some useful alternative ways of presenting the empirical results. As the formulation stands (ie, equation 4), the results reveal the net present value of benefits in excess of costs. Other ways of revealing the results include: (a) specifying the higher or lower rental values which would extinguish the difference between redevelopment and rehabilitation, and (b) indicating the change in interest rates which, likewise, would eliminate the differences. Rental differences and interest rates are, of course, the key things which interest investors, property developers, and financiers.

The end results of my 1974 research in Australia was that housing rehabilitation had comparative economic (and social) advantage compared with redevelopment. Redevelopment would have required an intensification of land use and densities which were unjustified on social or economic grounds.

As was mentioned, the Schaaf formulation has the potential for application to commercial offices, and with research assistance I pursued this in 1989 (Pugh 1990). By the mid-1980s it became relevant to consider the comparative economics of rehabilitation and redevelopment for commercial offices. A large proportion of the stock built in the 1960s was variously obsolescent, nearing its re-investment cycle, and at a stage when the changing needs of client users had to be considered. For example, the prescriptive ideal for modern office investment and development is towards flexibility, versatility, and adaptability to rapidly changing economic and technological conditions. Technological and management conditions have created demands for offices to accommodate new information technology, and to use office space in a new management idiom where the emphasis is upon professional networking and closer management-staff consultation, compared with earlier more hierarchical ways of operating largely routine, clerical, functions. All of this imposes new demands for spatial arrangements and partitioning in offices. The modern demands favour client-specific requirements, large floor areas, floor-to-ceiling heights which can accommodate cable systems. Modern demands also give greater consideration to attractive environments, security and safety (especially for women), and flexibility to change circulation arrangements, and internal 'fixtures' within a durable framed building.

The inherited 1960s office stock is frequently obsolescent in terms of the foregoing modern demands. But, in some circumstances, and for some of the stock refurbishment is feasible and sometimes competitive with redevelopment and new building. Increasingly the new build and the refurbishment options are competitive with each other. For rehabilitation, rents can sometimes be increased by some 60%, attaining levels at 80% of those in new buildings. Refurbishment can be undertaken at lower risk in volatile markets, with possibilities for progressive adaptation and change in spreading cost over time. For its part, new building and redevelopment offer opportunities to use modern ‘fast track’ methods of construction, to design clearly in terms of modern demands, and to readily achieve any relevant changes in the intensity of land use.

In what sort of economic and situational circumstances might rehabilitation be appropriate? First, as a general principle, it can be acknowledged that frequently buildings with low existing values will need high refurbishment costs to bring them into competition with new building or redevelopment. Buildings with high values would in comparison require lower refurbishment costs, and accordingly we can imagine that the ‘required’ rehabilitation costs will fall in per unit terms as the value of existing building (hypothetically) increases. Redevelopment or new building costs are independent of the value of existing buildings. Hence, with required rehabilitation costs which potentially fall when we (hypothetically) increase the value of the existing building, there will be a range of values among existing buildings where refurbishment is competitive with new building and redevelopment. In short, the costs are lower in these cases because the resource addition by way of rehabilitation will readily bring the existing building up to higher market values (at comparatively low expenditures) which then competes with higher cost redevelopment and new construction.

A second reason for some competitive advantage for rehabilitation arises from considerations of submarket differentiation in commercial offices. At the top end of the market firms may seek expensive (conservation) rehabilitation in historically significant buildings. Lower down the market, as argued in the previous paragraph, some ranges of values in existing buildings bring refurbishment into account as a cheaper means of raising the value of the building than by creating a similar value by new building or redevelopment. Finally, in some low-value submarkets, refurbishment can be used modestly to create small additions to value, staying within the limited affordability to pay higher rents among clients who use downmarket offices.

Empirical studies and sensitivity simulations to key variables were conducted in 1989, selecting an office complex in Leeds, a northern regional city-region in England. The office complex selected fell within the submarket range where refurbishment and redevelopment were potentially competitive. But rather than relying upon entrepreneurial hunches, the use of technical analyses and appraisals would illuminate the costs and benefits of making good rather than bad investment decisions. The full results are reported elsewhere (Pugh 1990), and in this particular instance tests were run using each of the Needleman (equation 1), Sigsworth and Wilkinson (equation 2) and Schaaf (equation 3) formulations. The values for new construction costs, property acquisition costs, rental values, maintenance costs, rates of interest, and assumed extended life of the building (from refurbishment) were varied within realistic ranges for the period of analysis in 1989 in England. The calculations were worked from a ‘Super Calc 3’ spreadsheet.

In consistency with the earlier discussions on application to housing projects, the advantage to refurbishment is greater when refurbishment standards extend the range of the economic life of the building substantially, when the value of the existing structure is relatively high, when the rental differences between the new and the refurbished offices are narrow, when the rate of interest is high, and when new development costs are relatively high. Also, as would be expected from the earlier discussions of the formulations, the Needleman test is biased towards refurbishment, the Sigsworth/Wilkinson test to redevelopment, and the Schaaf test characterised with less bias in either the one direction or its alternative. Overall, the empirical study demonstrated the technical and economic feasibility of refurbishment, and its comparative advantage under some conditions prevailing on costs and rates of interest in Britain in the years 1988–89.

Some further comment can appropriately be made for commercial office appraisal.—First, compared with housing, technological obsolescence is likely to be more rapid, leading to tendencies towards high cost in refurbishment and to caution on the duration of the 'life' of refurbished or the new office. 'Life' in commercial offices will tend to be shorter than for housing, and more is said about 'economic life' in the next (and concluding) section. Second, commercial offices lie within some particularly volatile sectors of the modern economy. They are subject to building cycle variability which tends to periodically under- and over-supply the market. Also, in the economic conditions prevailing since the first OPEC crisis in 1973–74, general fluctuations in rates of inflation, rates of interest, exchange rates, and in boom and recession add to volatility in office yields and prospects. The refurbishment and the redevelopment decisions need to be well timed in relation to building cycles and general economic fluctuations in order to fulfil (optimistic) expectations. Finally, city-regions are experiencing greater economic inequalities, which influences relative costs and inflationary tendencies in labour, land, and other markets. This means that appraisals have to be tailor-made to their specific conditions and locations, consequently avoiding over-generalisation of the results of any single appraisal or set of empirical studies.

4 Evaluation

This piece of writing has established the theoretical principles and usefulness of operational methods in appraising the relative economic merits of refurbishment/rehabilitation and redevelopment. Economic appraisals are important for various social and economic objectives, including considerations of efficiency, conservation, improving decisions on urban property development, and bringing formal rationality into decision making. However, this is not all that is relevant to the topic: further understanding can be obtained by revealing additional opportunities and by discussing some contingent conditions.

One important contingent condition concerns the nature of the Needlman, the Sigsworth/Wilkinson, and the Schaaf formulations. They do not, in themselves account social costs and benefits, being largely confined to private costs and returns. In urbanisation such social costs as environmental conditions, pollution, traffic congestion, and inconvenient results will often have to be considered. It is possible, with suitable adjustments to the specification of the costs and benefits in the formulations, to include analyses of the social costs and benefits. In addition urban change usually has impacts upon the distribution of income, upon the functioning of urban social networks, and other factors. Although it is seldom easy to provide exact measures of such impacts, methodologies are available, and these can be used in conjunction with the formulations used in the research studies reported in this piece of writing.

Another contingency relates to the nature of urban processes and urban change. It amounts to bad judgement to use the technical formulations in routine and unthoughtful ways. Urbanisation is by its very nature dynamic, whereas the methods of appraising refurbishment and redevelopment are biased toward static conditions, reflecting a particular point in time and some time-based attitudes to future uncertainties. Also, as was mentioned earlier, construction and property markets have cyclical elements, both from within their internal economic functioning and from relationships with the wider (fluctuating) economy. All of this means that wider context evaluations have to be made to supplement and to interpret the results of the technical formulations and appraisals.

The appraisal methods and formulations have possibilities for widening their potential. For example, rehabilitation or refurbishment effectively reduces future maintenance costs and increases future rental potential of buildings. In other words it extends the ‘economic life’ of buildings. Analyses and theories of the ‘economic life’ of buildings (as distinct from their possible physical life) have been well developed by Harvey (1987) and Evans (1985). These can be developed further by virtue of considering the impacts of rehabilitation or refurbishment, and in another piece of writing I have elaborated the relevant principles and the extension to the work done by Harvey and Evans (Pugh 1990). But, the potential can be widened and deepened in other directions. For example, there is an increasing interest in the notion of ‘life cycle’ building costs. ‘Life cycle’ costs of buildings contain a variety of considerations. These include trade-offs between development and maintenance costs, conflicts between user efficiencies and environmental considerations, pre-planning for future adaptable changes, and so on. The formulations presented in this piece of writing are characterised with the principles of the capitalisation of costs, and the Schaaf approach gives information on ‘net present value’ or ‘internal rates of return’. In principle, the formulations and their characteristics can be adapted to extend technical appraisals into the notion of ‘life cycle’ costs.

Another opportunity to widen the use of the formulations used in this study piece lies in the sphere of retailing. Modern retailing is characterised with frequent refurbishment and alteration of buildings and their spatial arrangement. This reflects rapidly changing consumer preferences, the progress of new ideas in the management of shopping centres, and the dynamics of market change. Entrepreneurs and developers or refurbishers in retailing can appropriately take the following perspective.—They can ascertain which market growth spheres in retailing will propel property values and rentals upwards, and which will grow less rapidly. Then they can discern the competition and determine the links between the redesign of shops, the variations in costs and standards, and the ‘niche’ or market pitch with its associated rental potential. All of this is possible in the use -and adaptation of the Schaaf formulation which emphasises possibilities for varying the standards of refurbishment, their associated costs, and their linked implications in future rental income. Retailing is a sphere which is ready for these sorts of appraisals.

Clearly in the 1990s and beyond, the professional application of economic appraisals will increase in decisions relating to redevelopment, refurbishment/rehabilitation, and life cycle building costs. Those who are interested in good theory and operational feasibility to achieve 'best practice' can use (and adapt) the Schaaf and other formulations which have been reviewed in this study piece. The formulations can readily be applied to computer simulations to ascertain the sensitivity of investment decision to changes in the values of relevant variables of cost, rate of interest, and potential rental income. They can be used in applications made to financiers for borrowing or for their participation in the equity of development and refurbishment projects.

5 References

Evans, A.W. (1985) **Urban Economics: An Introduction,** Oxford, Blackwell.

Harvey, J. (1987) **Urban Land Economics,** London, MacMillan.

Hornby, S. (1989) **The Future for the 1960s Office Building,** an honours dissertation for the degree of BA Urban Land Economics, Department of Urban and Regional Studies, Sheffield City Polytechnic.

Mao, J.T. 'Efficiency in Public Urban Renewal Expenditure Through Benefits and Cost-Analysis', **Journal of the American Institute of Planners,** Vol 32, No 2, March 1966, pp 95–107.

Merrett, S. (1979) **State Housing in Britain,** London, Routledge and Kegan Paul.

Needleman, L. (1965) **The Economics of Housing,** London, Staples.

Needleman, L. (1988) 'Building or Renovation: A Reply', **Urban Studies,** Vol 5, No 1, February p.86–90.

Pugh, C. (1976) 'Older Residential Areas and the Development of Economic Analysis', in J C McMaster and G R Webb (eds), **Australian Urban and Regional Economics: A Reader,** Sydney, Australian and New Zealand Book Co.

Pugh, C. (1991) 'The Costs and Benefits of Rehabilitation and Refurbishment' **Property Management,** May 1991 (forthcoming).

Rothenberg, J. (1966) **Economic Evaluation of Urban Renewal,** Washington DC Bookings.

Schaaf, A.H. (1969) 'Economic Feasibility Analysis for Urban Renewal' **Journal of the American Institute of Planners,** Vol 35, No 4, November 1969, pp 399–404.

Sigsworth, E.M. and Wilkinson R.K. (1967) 'Rebuilding or Renovation', **Urban Studies,** Vol 4, No 2, June 1967, pp 109–21.

137
Analytical method for quantification of economic risks during feasibility analysis

M.RANASINGHE and A.D.RUSSELL

Abstract
This paper generalises the theoretical developments of the risk measurement framework, which is the foundation of the proposed analytical method. The framework is a consistent, moment based approach for quantifying uncertainty of a derived variable ***Y*** described by an arbitrary function *g*(**X**). It utilises Pearson distributions, a four moment approach and robust treatment of correlations between variables. A numerical example is used throughout to illustrate the concepts. The application of the framework to the project economic structure for the development of the analytical method is briefly described.
Keywords : Risk Quantification, Moment Analysis, Correlations, Probability, Analytical Method.

1 Introduction

The method often proposed for the quantification of economic risks is Monte Carlo simulation (Diekmann, 1983; Jaafari, 1988; Martins and Bezelga, 1990; Perry and Hayes, 1985; Thompson and Wilmer 1985). Simulation's strength lies in its ability to focus on the real characteristics of the problem as opposed to simplifications required to make it analytically tractable. However, when the number of variables required for a detailed feasibility analysis is large and they are correlated, simulation is both time consuming and computationally expensive, precluding exploration of a wide range of alternatives prior to selecting the best strategy.

This paper generalises theoretical developments of the analytical method proposed by Russell and Ranasinghe (1991) for economic risk quantification of large engineering projects. The method was developed by applying a risk measurement framework based on moment analysis to the project economic structure. The validation of the analytical method and its computational economy was demonstrated using Monte Carlo simulation in Ranasinghe and Russell (1991 a).

This paper is structured as follows. The analytical structure of the problem and how it was exploited to develop a process for risk quantification is described briefly in the next section. A numerical example for a construction activity of a high-rise building is introduced in the third section. Generalised risk measurement framework to quantify the uncertainty of a derived variable is developed in the fourth section. It provides the foundation for the analytical method. The numerical example is used to illustrate the concepts being discussed. The special case of a linear function for the derived variable is also explored. We conclude with an assessment of the analytical method.

2 Analytical Structure

The project economic structure was described in terms of a hierarchy containing all of the derived economic variables of an engineering project (see Russell and Ranasinghe, 1991). For discussion purposes three levels of description, namely, project decision, project performance and work package/revenue stream were assumed. Work package and revenue streams were linked together by way of a precedence network. The work package/revenue stream level was considered the lowest level at which meaningful information can be obtained during feasibility analysis.

Performance variables at every level of the project economic structure can be described by an arbitrary function $Y=g(\mathbf{X})$ where Y is defined as the derived variable and $\mathbf{X}$ is the vector of it's primary variables, some or all of which may be correlated. The derived variables of the lower levels of the project economic structure are the primary variables for the higher levels. At the work package/revenue stream level the derived variables are work package duration, start time, cost and net revenue streams. At the project performance level the derived variables are project duration, cost, revenue and cash flow profile while the primary variables are the derived variables at the work package/revenue stream level. At the project decision level the derived variables are project net present value and internal rate of return while the primary variables are discounted project cost and revenue.

3 Numerical Example

The duration to fly form a typical slab of 3000 ft^2 in a single suite per floor highrise building is considered as the derived variable for the numerical example to demonstrate the analytical derivations. The duration can be estimated from the decomposed relationship given by,

$$T = U + \frac{Q}{P\,L} \qquad (1)$$

in which T is the duration to fly form a typical slab in *days*, Q is the estimated quantity in ft^2, P is the estimated labour productivity in ft^2*/manhour* once the fly forms are placed, L is the estimated labour usage in *manhours/day* and U is the time required to fly the forms in *days*. While the quantity is deterministic, the other variables are considered as random. Then, equation (1) re-written as,

$$T = X_1 + \frac{3000}{X_2\, X_3} = g(\mathbf{X}) \qquad (2)$$

is used for the numerical illustrations. Other authors (Jaafari, 1984; Hendrickson et al., 1987) have used decomposed relations to compute activity duration.

4 Risk Measurement Framework

In this section, using five assumptions, we generalise the framework to quantify the uncertainty of a derived variable *Y* expressed in terms of an arbitrary function ***g*(X)**. See Russell and Ranasinghe (1991) for an elaboration of the first four assumptions and steps of this framework. The numerical example is used to illustrate the concepts being discussed. The special case of a linear function for *Y* is included.

4.1 General Case : Arbitrary Function for *Y=g(X)*

Assumption 1 : The derived and primary variables are continuous and their probability distributions are approximated by the Pearson family of distributions.

The uncertainty of a derived variable *Y* can be quantified using its first four moments (ffm) with the first assumption. The ffm of a variable are it's expected value and second to fourth central moments which describe the standard deviation, skewness and kurtosis.

Assumption 2: An expert can provide estimates for the percentiles of his subjective prior probability distribution for a primary variable at the input level.

The ffm of the derived variable are evaluated from moment analysis using the ffm of the primary variables. The step by step process for approximating the ffm of a primary variable is given in Russell and Ranasinghe (1991). The starting point of this process follows from the first two assumptions.

The first assumption permits us to use the table for percentage points of standardised Pearson distributions (Amos et al., 1971; Johnson et al., 1963). The table defines cumulative distribution functions (cdfs) for the standardised Pearson variable with zero mean and unit variance for each pair of $(\sqrt{\beta_1}, \beta_2)$; where $\sqrt{\beta_1}$ and β_2 are the skewness and kurtosis of the standardised variable. From the second assumption we elicit estimates for the 5, 25, 50, 75, and 95 percentiles of an expert's subjective prior probability distribution for a primary variable (Ranasinghe and Russell, 1990).

The subjective percentile estimates for the primary variables elicited from an experienced engineer who was considered as our expert are given in Table 1. The ffm and shape characteristics for primary variables approximated from these subjective percentile estimates are given in Table 2.

Table 1: Subjective Percentile Estimates for *U*, *P* and *L*

Variable	5%	25%	50%	75%	95%
U(days)	0.25	0.33	0.375	0.42	0.5
P(ft^2/*mh)*	17.0	19.0	20.0	21.0	22.0
L(mh/day)	75.0	83.0	88.0	92.0	96.0

Table 2: First Four Moments and Shape Characteristics for Primary Variables

X_i	$E[X_i]$	$\mu_2(X_i)$	$\mu_3(X_i)$	$\mu_4(X_i)$	$\sqrt{\beta_1}$	β_2
U	0.375	0.0064	0.0	0.00037	0.0	9.0
P	19.815	2.37	−2.9189	23.0304	−0.8	4.1
L	87.075	42.248	−192.23	5890.29	−0.7	3.3

Assumption 3 : A derived variable can be more accurately estimated from a set of primary variables that are functionally related to it than by direct estimation.

Assumption 4: ‘The correlations between primary variables are linear.

The approximations for the ffm of the derived variable are based on the third and fourth assumptions. To obtain an accurate estimate of the ffm for the derived variable, correlations between primary variables have to be treated. The standard approach to treat correlations between primary variables **(X)** in the moment analysis of a derived variable *Y* is by expanding the equations defining the moments (Ang and Tang, 1975; Bury, 1975). This approach can include the linear correlations easily only in the approximations for the first two moments. A variable transformation approach that includes the linear correlations in the higher order moments is used in the development of our framework.

This development requires the elicitation of a positive definite correlation matrix **(R)** for the primary variables from the expert. The theoretical requirements and a process for eliciting such a correlation matrix is discussed in Ranasinghe and Russell (1991b).

The positive definite correlation matrix for the numerical example elicited from the experienced engineer using the suggested method is as follows.

$$\mathbf{R} = \begin{bmatrix} 1.0 & -0.5 & 0 \\ -0.5 & 1.0 & -0.4 \\ 0 & -0.4 & 1.0 \end{bmatrix}$$

The negative correlation between $U(X_1)$ and $P(X_2)$ suggests the greater the productivity, probably the greater the efficiency of flying the forms and vice versa. The negative correlation between $P(X_2)$ and $L(X_3)$ implies that the smaller the crew the greater the productivity (minimum congestion, all crew members visible and not able to hide).

4.2 Variable Transformation Approach

A set of correlated variables can be transformed to a set of uncorrelated variables having mean values and unit variances by (for proof see Ranasinghe, 1990),

$$\mathbf{Z}=\mathbf{L}^{-1}\,\mathbf{D}^{-1}\,\mathbf{X}. \tag{3}$$

X is the vector of correlated primary variables, $\mathbf{X}=[X_1,\ldots, X_n]^T$; **Z** is the vector of transformed variables with unit covariance matrix; $\mathbf{L}^{-1}$ is the inverse of the lower triangular matrix obtained from the Cholesky decomposition of the correlation matrix $\mathbf{R}(=\mathbf{LL}^\mathbf{T})$; and $\mathbf{D}^{-1}$ is the inverse of the diagonal matrix of standard deviations of the **X** vector ($\mathbf{D}$=diag $[\sigma^i]$).

The diagonal matrix of standard deviations **(D)** and lower triangular matrix **(L)** of the correlation matrix for the numerical example are,

$$\mathbf{D}=\begin{bmatrix}0.08 & 0.0 & 0.0\\ 0.0 & 1.54 & 0.0\\ 0.0 & 0.0 & 6.5\end{bmatrix} \;;\; \mathbf{L}=\begin{bmatrix}1.0 & 0.0 & 0.0\\ -0.5 & 0.866 & 0.0\\ 0.0 & -0.462 & 0.887\end{bmatrix}$$

and the inversions of these matrices are,

$$\mathbf{D}^{-1}=\begin{bmatrix}12.5 & 0.0 & 0.0\\ 0.0 & 0.649 & 0.0\\ 0.0 & 0.0 & 0.154\end{bmatrix} \;;\; \mathbf{L}^{-1}=\begin{bmatrix}1.0 & 0.0 & 0.0\\ 0.577 & 1.155 & 0.0\\ 0.301 & 0.601 & 1.127\end{bmatrix}$$

The vector of transformed variables can be evaluated from equation (3) using these matrices.

4.3 Moments of the Uncorrelated Variables

Since the transformation given by equation (3) is linear the ffm of the transformed uncorrelated variables can be evaluated directly from the ffm of the correlated primary variables. Then, the ffm of a transformed uncorrelated primary variable are,

$$E[Z_i] = \sum_{j=1}^{n} A_{ij}\, E[X_j] \tag{4}$$

$$\mu_2(Z_i) = \sum_{j=1}^{n} A_{ij}^2\, \mu_2(X_j) \tag{5}$$

$$+ 2 \sum_{j=1}^{n} \sum_{k=j+1}^{n} A_{ij}\, A_{ik}\, cov(X_j, X_k) = 1$$

$$\mu_3(Z_i) \approx \sum_{j=1}^{n} A_{ij}^3\, \mu_3(X_j) \tag{6}$$

$$\mu_4(Z_i) \approx \sum_{j=1}^{n} A_{ij}^4\, \mu_4(X_j) \tag{7}$$

where $\mathbf{A}=\mathbf{L}^{-1}\mathbf{D}^{-1}$ and $E[X_j]$, $\mu_2(X_j)$, $\mu_3(X_j)$, $\mu_4(X_j)$ are the ffm of the j^{th} correlated primary variable in the **X** vector.

The matrix **A** for the numerical example is,

$$\mathbf{A} = \begin{bmatrix} 12.485 & 0.0 & 0.0 \\ 7.208 & 0.75 & 0.0 \\ 3.754 & 0.391 & 0.173 \end{bmatrix}$$

Hence,

$$Z_1=12.485X_1 \tag{8}$$

$$Z_2=7.208X_1+0.75X_2 \tag{9}$$

$$Z_3=3.754X_1+0.391X_2+0.173X_3 \tag{10}$$

and the ffm of the transformed uncorrelated variables evaluated from equations (4) to (7) are given in Table 3.

Table 3: First Four Moments of the Transformed Variables

Variable	$E[Z_i]$	$\mu_2(Z_i)$	$\mu_3(Z_i)$	$\mu_4(Z_i)$
Z_1	4.682	1.0	0.0	9.0
Z_2	17.565	1.0	−1.232	8.289
Z_3	24.251	1.0	−1.177	5.942

4.4 The Function

To use moments of the transformed uncorrelated primary variables to evaluate the ffm of the derived variable Y, the function $g(\mathbf{X})$ has to be transformed to the uncorrelated space. This transformation is done from,

$$\mathbf{X}=\mathbf{DLZ}=\mathbf{BZ} \tag{11}$$

Then the transformed function is $Y=G(\mathbf{Z})$. If the original function $g(\mathbf{X})$ was complicated, this transformation increases the complexity as each variable in the **X** vector is replaced by a linear combination of variables from the **Z** vector. However, since this transformation is linear and in practice the replacement will be done by the computer, the increased complexity of the transformed function is not apparent to the user. (In fact, as described briefly later, it is not necessary to ever write $G(\mathbf{Z})$ explicitly. Instead, one works with the transformed variables **Z,** converts them to **X** using equation (11), and then evaluates Y using $g(\mathbf{X})$).

Then the transformed function for the numerical example is given by

$$T = \sum_{j=1}^{3} B_{1j} Z_j + \frac{3000}{\sum_{j=1}^{3} B_{2j} Z_j \sum_{j=1}^{3} B_{3j} Z_j} = G(\mathbf{Z}) \tag{12}$$

The **B** matrix for the numerical example is

$$\mathbf{B} = \begin{bmatrix} 0.08 & 0.0 & 0.0 \\ -0.769 & 1.333 & 0.0 \\ 0.0 & -3.002 & 5.765 \end{bmatrix}$$

Hence,

$$X_1 = 0.08Z_1 \tag{13}$$

$$X_2 = -0.769Z_1 + 1.333Z_2 \tag{14}$$

$$X_3 = -3.002Z_2 + 5.765Z_3 \tag{15}$$

and using these values $G(\mathbf{Z})$ for the numerical example can be written as.

$$T = 0.08Z_1 + \frac{3000}{(-0.769Z_1 + 1.333Z_2)(-3.002Z_2 + 5.765Z_3)} \tag{16}$$

4.5 The First Four Moments of *Y*

If all the correlated primary variables are normally distributed then there are no non-linear correlations between the transformed variables. Even though the variable transformation ensures that there are no linear correlations it is not possible to prove that it precludes the existence of non-linear correlations amongst the transformed variables. Thus, we invoke our fifth assumption.

Assumption 5: There are no non-linear correlations between the transformed variables.

This assumption permits the treatment of higher order cross product terms (boxed in equations 18 to 20) because their components can be broken out. Without this assumption, estimates of cross product terms would be required, a difficult if not impossible task. Hence, in practice they would be ignored, leading to a loss of accuracy in estimating moments of the derived variable.

The ffm of the derived variable are evaluated using the transformed function, $G(\mathbf{Z})$, as the new function for the derived variable. Our moment analysis approach considers terms involving up to the fourth order. Then, the approximation for the expected value is,

$$E[Y] \approx G(\bar{\mathbf{Z}}) + \frac{1}{2} \sum_{i=1}^{n} \frac{\partial^2 G}{\partial Z_i^2} \mu_2(Z_i) \tag{17}$$

the approximation for the second central moment is,

$$\mu_2(Y) \approx \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i}\right]^2 \mu_2(Z_i) + \sum_{i=1}^{n} \frac{\partial G}{\partial Z_i}\frac{\partial^2 G}{\partial Z_i^2}\mu_3(Z_i) + \frac{1}{4}\sum_{i=1}^{n}\left[\frac{\partial^2 G}{\partial Z_i^2}\right]^2 \left[\mu_4(Z_i) - [\mu_2(Z_i)]^2\right] + \boxed{\sum_{i=1}^{n}\sum_{j=i+1}^{n}\left[\frac{\partial^2 G}{\partial Z_i \partial Z_j}\right]^2 \mu_2(Z_i)\,\mu_2(Z_j)} \tag{18}$$

the approximation for the third central moment is,

$$\mu_3(Y) \approx \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i}\right]^3 \mu_3(Z_i) + \frac{3}{2}\sum_{i=1}^{n}\left[\frac{\partial G}{\partial Z_i}\right]^2 \frac{\partial^2 G}{\partial Z_i^2}\left[\mu_4(Z_i) - [\mu_2(Z_i)]^2\right] + \boxed{6\sum_{i=1}^{n}\sum_{j=i+1}^{n}\frac{\partial G}{\partial Z_i}\frac{\partial G}{\partial Z_j}\frac{\partial^2 G}{\partial Z_i \partial Z_j}\mu_2(Z_i)\,\mu_2(Z_j)} \tag{19}$$

and the approximation for the fourth central moment is,

$$\mu_4(Y) \approx \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i}\right]^4 \mu_4(Z_i) + \boxed{6\sum_{i=1}^{n}\sum_{j=i+1}^{n}\left[\frac{\partial G}{\partial Z_i}\right]^2\left[\frac{\partial G}{\partial Z_j}\right]^2 \mu_2(Z_i)\,\mu_2(Z_j)} \tag{20}$$

$\bar{\mathbf{Z}}$ is the vector of expected values for the transformed variables **Z,** $G(\mathbf{Z})$ is the transformed function for Y and $E[Z_i]$ $\mu_2(Z_i)$, $\mu_3(Z_i)$, $\mu_4(Z_i)$ are the ffm of the i^{th} transformed variable.

The first $(\frac{\partial G}{\partial Z_i})$ and second $(\frac{\partial^2 G}{\partial Z_i^2}, \frac{\partial^2 G}{\partial Z_i \partial Z_j})$ partial derivatives with respect to the transformed variables are evaluated at $\bar{\mathbf{Z}}$. In the automated process the derivatives are evaluated numerically. This process consists of incrementing and decrementing each Z_i in turn by 1% about its expected value $(e.g.\ \Delta Z_i = \pm 0.01\bar{Z}_i)$, finding the corresponding revised **X** vectors using equation (11), evaluating the function $Y=g(\mathbf{X})$ for the revised **X** vectors and then computing the values of the derivatives using standard numerical techniques (Howard, 1971). Thus, $G(\mathbf{Z})$ never has to be written explicitly.

The first and second partial derivatives with respect to the transformed variables evaluated at $\bar{\mathbf{Z}}$ for the numerical example are given in Table 4.

Table 4: First and Second Partial Derivatives evaluated at $\bar{\mathbf{Z}}$

Variable	$\frac{\partial G}{\partial Z_i}$	$\left(\frac{\partial^2 G}{\partial Z_i \partial Z_j}\right)$		
		Z_1	Z_2	Z_3
Z_1	0.14764	0.00525	−0.00675	−0.00447
Z_2	−0.05705	−0.00675	0.01181	−0.00019
Z_3	−0.11515	−0.00447	−0.00019	0.01525

The ffm for duration to fly form a typical slab approximated from equations (17) to (20) respectively are 2.13 *days*, 0.042 $days^2$, 0.0061 $days^3$ and 0.0078 $days^4$.

4.6 Special Case : *g*(X) is linear

When $g(\mathbf{X})$ is linear, i.e $Y = \sum_{i=1}^{n} a_i X_i,$ the transformed function $G(\mathbf{Z})$ from equation (11) is,

$$Y = G(\mathbf{Z}) = \sum_{i=1}^{n} \left[\sum_{j=1}^{n} a_j B_{ji} \right] Z_i \tag{21}$$

The expected value of the derived variable *Y* is,

$$E[Y] = \sum_{i=1}^{n} \left[\sum_{j=1}^{n} a_j B_{ji} \right] E[Z_i] \tag{22}$$

the second central moment of *Y* is,

$$\mu_2(Y) = \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i} \right]^2 \mu_2(Z_i) \tag{23}$$

the third central moment of *Y* is,

$$\mu_3(Y) = \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i} \right]^3 \mu_3(Z_i) \tag{24}$$

and the fourth central moment of *Y* is,

$$\mu_4(Y) = \sum_{i=1}^{n} \left[\frac{\partial G}{\partial Z_i}\right]^4 \mu_4(Z_i) + 6 \sum_{i=1}^{n} \sum_{j=i+1}^{n} \left[\frac{\partial G}{\partial Z_i}\right]^2 \left[\frac{\partial G}{\partial Z_j}\right]^2 \mu_2(Z_i)\, \mu_2(Z_j) \tag{25}$$

Note that for this special case $\left[\frac{\partial G}{\partial Z_i}\right] = \sum_{j=1}^{n} a_j B_{ji}$.

For this special case the first two moments of the derived variable are exact with or without assumption (5) because *G*(**Z**) is also linear. With assumption (5), the third and fourth moments are also exact. The assumption will be in error only if non-linear correlations develop between the transformed variables.

4.7 Cumulative Distribution Function

The approximated central moments are used to evaluate the shape characteristics, skewness $(\sqrt{\beta_1})$ and kurtosis (β_2) for the derived variable from,

$$\sqrt{\beta_1} = \frac{\mu_3(Y)}{\mu_2(Y)^{1.5}} \tag{26}$$

$$\beta_2 = \frac{\mu_4(Y)}{\mu_2(Y)^2} \tag{27}$$

in which $\mu_2(Y)$, $\mu_3(Y)$ and $\mu_4(Y)$ are the approximated central moments for the derived variable *Y*. A cdf for *Y* is selected from the Pearson family of distributions from the method suggested by Johnson et al.(1963). The Pearson distribution is the one which corresponds most closely to the shape characteristics of *Y*. The cdf is the quantification of the uncertainty associated with the derived variable.

The skewness and kurtosis for the duration to fly form a typical slab computed using equations (26) and (27) are 0.713 and 4.47 respectively.

5 CONCLUSIONS

In this paper, we have generalised the theoretical foundation of the proposed analytical method for quantification of economic risks in building and engineering projects. It involves the application of a risk measurement framework based on the four moment approach, Pearson family of distributions and robust treatment of correlations between variables, to the analytical structure underlying the time and economic analysis of a project. The flowchart of the analytical method is given in Fig. 1. The validation of the process (Ranasinghe and Russell, 1991a) shows that the method is computationally economical, allowing for the exploration of a wide range of alternative strategies prior to executing a project.

REFERENCES

Amos, D.E., & Daniel, S.L. (1971), Tables of Percentage Points of Standardised Pearson Distributions, **Research Report # SC—RR—710348,** NTIS, Virginia, U.S.A.

Ang, A.H-S., & Tang, W.H. (1975) **Probability Concepts in Engineering Planning and Design,** John Wiley & Sons, New York.

Bury, K.V. (1975), **Statistical Models in Applied Science,** John Wiley & Sons, New York.

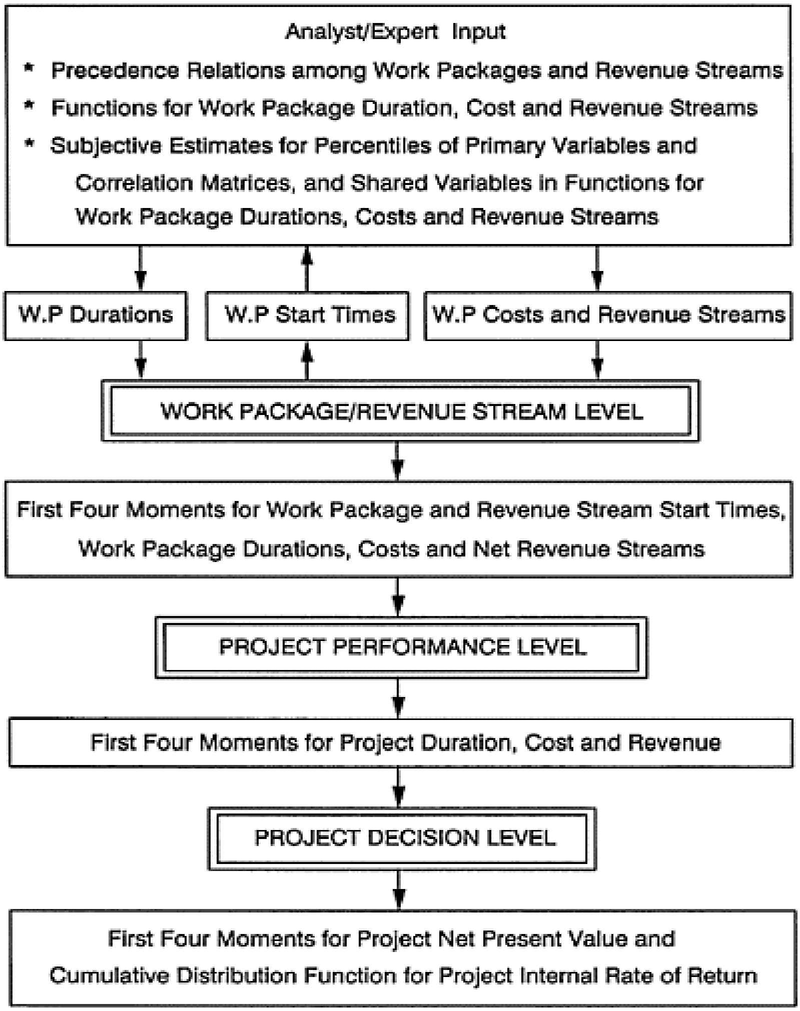


Fig.1. Flowchart for the Analytical Method

Diekmann, J.E. (1983), Probabilistic Estimating: Mathematics and Applications, **J. Const. Èngrg. & Mgmt.,** 109(3), 297–307.
Hendrickson, C., Martinelli, D., and Rehak, D. (1987), Hierarchical Rule-Based Activity Duration Estimation, **J. Const. Engrg. & Mgmt.,** 113(2), 288–301.
Howard, R.A. (1971), Proximal Decision Analysis, **Mgmt. Sci.,** 17(9), 507–541.
Jaafari, A. (1984), Criticism of CPM for Project Planning Analysis, **J. Const. Engrg. & Mgmt,** 110(2), 222−233.
Jaafari, A. (1988), Project Viability and Economic Risk Analysis, **J. Mgmt. Engrg,** 4(1), 29−45.
Johnson, N.L., Nixon, E., and Amos, D.E. (1963), Table of Percentage Points of Pearson Curves, for Given $\sqrt{\beta_1}$ and β_2, Expressed in Standard Measure, **Biometrika,** 50(3&4), 459–498.
Martins, V., & Bezelga, A., (1990), Profitability of investment in building projects—valuation, decision-making and control, in **Managing Projects** (eds V. Ireland & T.Uher), CIB 90(4), Sydney, Australia, 315–326.
Perry, J.G., and Hayes, R.W. (1985), Risk and its Management in Construction Projects, **Procd., Inst. of Civ. Engr., U.K,** 78(1), 499–521.
Ranasinghe, K.A.M.K. (1990), Analytical Method for Quantification of Economic Risks during Feasibility Analysis for Large Engineering Projects, **Ph.D Thesis,** The University of British Columbia, Canada.
Ranasinghe, M., & Russell, A.D. (1990), Elicitation of Subjective Probabilities for Risk Analysis in Engineering Construction, in **Managing Projects** (eds V.Ireland and T.Uher), CIB 90(4), Sydney, Australia, 376–387.
Ranasinghe, M. &; Russell, A.D. (1991a), Analytical Approach for Economic Risk Quantification of Large Engineering Projects: Validation, Submitted to the **J Const. Mgmt. & Econ.,** U.K.
Ranasinghe, M. & Russell, A.D. (1991b), Treatment of Correlation for Risk Analysis of Engineering Projects, Submitted to the **J Comput. Civ. Engrg,** ASCE.
Russell, A.D., and Ranasinghe, M. (1991), Analytical Approach for Economic Risk Quantification of Large Engineering Projects, **J Const. Mgmt. &: Econ.,** U.K (to appear).
Thompson, P.A. and Wilmer, G. (1985), CASPAR—A Program for Engineering Project Appraisal and Management, **2nd Int. Conf. Civ. &: Struct. Engrg Comput.,** 1, 75–81.

138
Quality of office building rehabilitation: a feasibility study

J.ROBINSON

Abstract
An outmoded multi-storey office building, losing its occupiers in a highly competitive market, is required by law to improve certain systems to enhance fire safety. As a result of obsolescence, it is unlikely to attract new occupiers without a substantial upgrading of finishes and services. The purpose of this study is to assess the costs and benefits of minimum, medium and complete rehabilitation. The study emphasises that building quality cannot be analysed by costs alone because all costs generate a value effect. Financial modelling is used to establish the feasibility of the proposals taking into account variations in timing, costs and benefits as measured by the market in which the building is placed.

Keywords: Quality, Costs, Benefits, Lift Cycle Costing, Feasibility Study.

1. Introduction

Quality in the building context has been defined as "the totality of attributes of a building which enable it to satisfy needs" (Burt, 1978). However, this and most other definitions of quality, is inadequate for practical use. In order to facilitate discussion, reference is made to a case study of a commercial office building and, in this case, those features which constitute building quality may be established by observing the reaction of the real estate market.

Quality has been discussed by several authors in a number of different ways. For example, quality has been discussed in terms of mean initial building costs over time for a range of building types. From this it can be established that some building types are increasing in quality (and some decreasing or remaining static) which reflect the degree of importance which society places on these building types (Powell, 1986). It has been argued that quality is not necessarily directly related to cost and the effect of certain design choices may be measured by considering them on a ceteris paribus basis (Brandon, 1984). A third approach involves the relationship between construction or project management and quality. With the use of proper systems, the quality control of a building under construction may lead to higher quality of finish as a result of enhanced workmanship (Ireland, 1985).

The main purpose of this paper is to postulate that building quality is reflected in market prices, i.e., in rental values in the office building case study context, and that this factor provides the benefit component of a cost-benefit analysis where the well known life cycle cost analysis procedure provides the cost component. However, care must be taken to avoid assuming an unrealistic degree of sophistication in the commercial office property market. Although quality is recognised in the price and value of accommodation as a result of initial capital expenditure, it tends not be recognised in terms of future capital expenditure and revenue expenses or outgoings such as maintenance and energy costs.

The three approaches to cost-benefit analysis in buildings, namely, the experiential, the feasible and the technical, have been classified (Robinson 1986). In this paper, the feasible or feasibility approach is tied to standard techniques which produce the well-known measures of residual property value (RV) and internal rate of return (IRR). The level of sophistication of data inputs obtained by reference to market analysis is used to model the effect of quality by observing changes in RV and IRR. The paper is an expansion of earlier work (Robinson, 1989).

2. Aspects of quality in the commercial office market

2.1 Location

A primary market feature affecting the quality of a building is location. Location dictates many other building features. For example, it is unlikely that a prestige quality building will be developed in a fringe location and, conversely, an investment quality building in a prime location. Note that all of these descriptions: prestige, fringe, investment quality, prime, are subjective (qualitative) but the market which forms the context of this paper ascribes to them a highly objective meaning. However, features forming the basis of building quality may be isolated if location is taken to be fixed and these are now discussed.

2.2 Planning

A number of planning aspects are considered by the market to contribute to building quality:

the net rentable (or usable) area of the typical floor,
floor plan shape,
service core layout,
dimension from service core to external wall,
availability of natural light and view, and
availability of car parking space.

All of these together affect the efficiency of the layout. Efficiency may be adversely affected by, for example, small floor areas, poor natural light, off-centre service core, excessively elongated plan shape or insufficient car spaces.

2.3 Flexibility and adaptability

The accelerating cost of obsolescence is causing optimum building life to be radically reduced. It has been shown that the average commercial building requires major refurbishment only 17 years after completion (Randall, 1988) in order to maintain market position. To assist in facilitating such refurbishment, and to allow for rapid technological and social change, office buildings require such features as column free floors, adequate storey height (optimum now around 4.00 m) and adequate vertical service ducts with access thereto.

2.4 Materials

The selection of materials should reflect market preferences, for example, natural stone is considered to enhance building prestige whereas reconstructed stone, precast concrete and other applied finishes are not so prestigious. Factors which contribute to quality include workmanship, durability, maintainability, redecoration and service life.

2.5 Services

The concept of the intelligent building is based upon the availability of services, in particular power and communications, together with allowances for expansion. Air conditioning installations need to be able cope with a constantly increasing heat rejection load resulting from office equipment. Wiring for power and communications needs to have adequate space capacity. Flexibility is assisted by the provision of riser rooms and access floors although these diminish rentable area and increase initial cost respectively.

2.6 Aesthetics

The aesthetics of the building design is a highly qualitative factor. The market is particularly interested in the external envelope and in the entry foyer. Office buildings in Melbourne generally comprise two major elements. The first is a low rise podium covering the whole site and reflecting the character of the surrounding streetscape in parapet height and in materials and proportion. The second element is a multi-storey tower set well back from the street frontage which has an image of international style and maximum building height.

2.7 The property market

In general terms, the quality of a building is reflected in the rentals charge, the time taken to lease the building after completion and the leasing incentives offered by landlords to tenants. Location, discussed above, affects rentals per se and the supply/demand balance affects rentals in terms of leasing time and incentives offered.

However, there are cases of high quality and low quality buildings achieving apparently equivalent rentals, but, over time, it has been shown that the higher quality building will maintain a satisfactory rental whilst the lower quality building will show a falling rent and/or an increasing proportion of vacancies. Furthermore, the higher quality building will maintain its value and sell at a lower capitalisation rate than a lower quality building (see equation (2) below). Moreover, the lower quality building will generally take longer to lease (i.e., higher vacancies) and/or require greater incentives such as rent free periods (two or three years rent free equivalent in a 10 year lease is common) or contributes to tenant's fit out and removal expenses (quite often provided free to landlords).

3. Feasibility concept

The feasible approach forms part of the determination of the viability of a project (Robinson 1984). It may be defined as the outcome of cost and value analysis procedures built into an economic or financial viability study. These studies are often based upon the simplified developer's equation, viz:

$$V=C \quad (1)$$

where V=the total benefit created which is taken to be the capitalised (discounted) net future income called the income approach, and C=the total cost incurred which is usually conveniently sectionalised into the costs of land, buildings, finance and management (called the cost approach). Thus:

$$V=Yn\times 1/i \quad (2)$$

where Yn=net annual income, and i=the overall capitalisation rate (which is a rate of return calculated by reference to market evidence, e.g.:

$$i=Yn/Vs \quad (3)$$

where Vs=sale price), but:

$$Yn=Yg-x \quad (4)$$

where Yg=gross income, and x=outgoings (which are the costs of operating the building such as repairs and cleaning, energy, insurance, rates and so on).

On the cost side of the equation:

$$C=L+B+F+P \quad (5)$$

Where0:

L=land costs and expenses,
B=building costs and expenses
F=finance costs, i.e., interest, and
P=management costs, i.e., profit

Two items in the above equation, B (from 5) and x (from 4), are usually considered as part of life cycle costing. Initial viability studies generally use average values for building cost (e.g. \$ per m^2 for prestige quality high rise commercial buildings) and outgoings (e.g. % of gross income).

The decision on whether or not to proceed with a development is almost always based on this simplified typical data. The more sophisticated discounted cash flow techniques are then employed as controls during the detailed design and development.

The cost consequences of design decisions may be reflected in either or both of the relevant sections: initial capital cost consequences in building (B in equation 5) and recurring cost consequences in outgoings (x in equation 4). This is because life cycle cost analysis is almost universally a trade off between a choice, in relative terms, having a high initial cost with low recurring costs and a choice having a low initial cost with high recurring costs. Although the minimisation of initial cost is the most commonly employed strategy on the cost side of the developer's equation, the commensurate probable increase of recurring costs (outgoings) represents a quite sensitive item on the value side of the equation.

Even though some outgoings are often passed on to tenants, the more informed tenants will consider outgoings as part of the total rental package and will make their accommodation decisions accordingly. Added to this, the high proportion of owner/occupiers, including the entire public sector, will be directly concerned with outgoings in relations to their imputed rent.

If the minimum initial cost strategy results in the cost of buildings (B in equation 5) being decreased by an amount b', the cost of outgoings (x in equation 4) may well be increased by an amount a' based upon the trade-off situation mentioned above, thus:

$$V=[Yg-(x+a')]\times 1/i \tag{2a}$$

and:

$$C=L+(B-b')+F+P \tag{5a}$$

The apparent saving in initial cost, b', may well be offset by capitalised increased recurring costs, $a'\times 1/i$, i.e., $a'/i>b'$. Thus the saving in initial cost is false in optimum life cycle cost terms.

Conversely, if the cost of outgoings can be decreased (by a") by the expenditure of further initial capital funds on buildings (b") thus:

$$V=[Yg-(x-a'')]\times 1/i \tag{2b}$$

and:

$$C=L+(B+b'')+F+P \tag{5b}$$

then the increase in initial cost, b”, may well be offset by savings in recurring costs, and a higher quality building will be achieved resulting in the possibility of a higher income and therefore value.

But this approach should be about costs <u>and</u> benefits. From an inspection of the developer’s equation, it should be noted that value (V) and cost (C) are not independent. A change in one may lead to a change in the other. If the higher quality building achieved above results in a higher income of c, equation 2b may be rewritten as follows:

$$V=[Yg+c)-(x-a'')]\times 1/i \tag{2c}$$

The increase in initial building cost, b” will almost certainly be offset by an increase in value as a result of capitalising the greater income (c/i) as well as the savings in recurring costs (a”/i), i.e., (a”+c)/i may well be greater than b” (from 5b). Thus the postulation of this paper is formulated.

4. Case study

4.1 The building

The building was constructed over 20 years ago and was considered to be a high quality office building at that time. It is now outmoded due to its configuration, the condition of its services and finishes, and changed office space standards. A statutory report require the upgrading of fire safety systems has been served as the owner; time is of the essence. Moreover, the building contains a quantity of asbestos despite an earlier contract which was supposed to have removed all of this material. Furthermore, the external precast concrete facade panels exhibit significant spalling damage.

The building comprises a basement, lower ground and ground floors, six large podium floors and 16 small tower floors. The gross building area is about 30,000 m^2 and the net lettable (useable) area is about 20,000 m^2. The front of the building is set back some 15m from the street alignment to form a paved courtyard. The building structure is a concrete encased steel frame with internal columns at 7m spacings and a floor to floor height of 3.6m.

The services and finishes are dilapidated and obsolescent and require substantial replacement.

The building has been occupied by tenants on leaseholds of various terms and, until fairly recently, has enjoyed close to full occupancy. Most of the tenants have been attracted to newer developments which have been recently completed, or are nearing completion, as a result of unprecedented property development activity. All existing leases will be determined in the next year or two and very few of the sitting tenants are likely to renew their leases.

Accordingly, the owner seeks to regain the market position once held by the property and there are several options open:

Do nothing.
Demolish and redevelop.
Refurbish.
Sell.

4.2 Options

The 'do nothing' option is short term due to the legal requirement to carry out fire safety works failing which the building will be closed.

The redevelopment option is rejected due to the substantial expense together with the loss of development density due to the enforcement of more stringent controls.

Sale of the property has been rejected due to the poor price likely to be obtained in a severely depressed market.

It has been decided that refurbishment is the preferred option and several alternatives have been investigated:

(a) minimum refurbishment work to satisfy the legal requirement and to provide some cosmetic details.

(b) medium refurbishment consisting of a high quality development providing an upgraded appearance and image.

(c) complete refurbishment containing premium quality features, increased floor area and a new prime image.

(d) major refurbishment including the high quality works as well as increased floor area. This was a series of compromises between the medium and complete developments and were attempts to reduce costs.

(e) optimum refurbishment brought about by the need to further reduce costs without reducing income.

4.3 Costs and benefits

Indicative cost estimates have been prepared for each of the options. Market research was undertaken to assess the benefits which would be likely to accrue to the various options as a result of their quality. The evidence obtained demonstrated that there was sufficient sophistication in the market to be able to differentiate the benefits of quality, but it was not possible to differentiate revenue expenses in any useful way.

Table 1. Costs and benefits

Option	Cost ($AUD millions)	Rent (per m^2 per annum)	Area (m^2)	Capitalisation Rate	Value on Completion
Minimum	$9.0	$240	20,000	8.50%	$56.5
Medium	$37.0	$340	20,500	7.50%	$93.0

Complete	$53.0	$385	22,750	7.00%	$125.0
Optimum	$32.0	$320	21,000	7.25%	$93.0

4.4 Timing

Due to the depressed state of the office market, a number of timing options were considered for both single stage and multi-stage development programmes. Assessments and forecasts of present and future demand were made and this affected:

rental levels due to growth resulting from inflation,
time taken to let up the building,
level of incentives paid to attract tenants,
capitalisation rates.

There were three main timing options in which construction was to commence in one, two and five years in order to bring the refurbished building to fruition in a forecast improved market. The programmes were further affected by varying construction terms. Results were obtained using residual analysis and discounted cast flow analysis.

4.5 Residual analysis

A residual analysis comprises the calculation of development benefits (see equation 2 above) from which is deducted all known development costs including letting up allowances, profit and risk margin, construction costs, finance charges and holding charges and the residue is a measure of property value.

In conceptual terms, equations (1) and (5) above may be re-arranged thus:

$$L=V-(B+F+P) \tag{6}$$

Comparative results can be calculated taking into account the varying costs and benefits; these results demonstrate that an optimum expenditure, and therefore quality, can be formulated.

Table 2. Example of residual study

OPTIMUM REFURBISHMENT; TIMING 1 YEAR		
Timing	Planning	12 months
	Building	24 months
Interest		18.00% per annum
Development Returns		
Office		
	Net lettable	21000

Rental p m2	$320			
Net rental		6,720,000		
Carparking				
No of spaces	60			
Rental p space	$6,046			
Net rental		362,760		
Net Income			7,082,760	
Capitalisation rate			8.00%	
GROSS RETURNS			88,534,500	
		say	88,500,000	
Less selling costs		2.00%	1,770,000	
			86,730,000	
Less letting up allowance				
incentive		21,248,280		
vacancies		6,905,691	28,153,971	
			58,576,029	
less letting costs		10.00%	708,276	
			57,867,753	
Add rent during development			3,500,000	
NET RETURNS				61,367,753
Development Costs				
Allowance for Profit & Risk		15.00%		8,004,490
				53,363,263
Building costs & expenses			32,200,000	
Interest		18.00%	5,796,000	
Total				37,996,000
				15,367,263
Less outgoings			3,600,000	
Interest		18.00%	648,000	
				4,248,000
				11, 119, 263
Less holding charges		36.00%		2,943,334

			8,175,929
Less land purchase expenses	6.00%		462,788
RESIDUAL PROPERTY VALUE			7,713,141
		say	7,700,000

Table 3. Residual values ($AUD million)

	Timing		
	1 year	2 years	5 years
Minimum	18.5	26.3	–
Medium	2.3	17.1	30.6
Complete	nil	13.8	24.7
Optimum	7.7	24.2	32.1

4.6 Discounted cash flow analysis

Discounted cash flows were also carried out in order to more accurately model the highly variable cash flows during the shortly after the construction programme.

Table 4. Internal rates of return

	Timing		
	1 year	2 years	5 years
Minimum	13.37	16.82	–
Medium	13.72	15.90	13.50
Complete	13.31	13.09	12.46
Optimum	14.82	23.26	19.67

Studies were carried out based on both market value and book value and both before and after tax, but the relativities are similar to those illustrated above.

4.7 Detailed quality studies

Several design features were investigated in isolation in order to establish their individual returns. Space prevents their discussion in any detail, but all features were considered in their capacity of improve quality by a commensurate improvement in RV and IRR. They include:

(a) Two-storey retail arcade in the lower ground and ground floors with sections of the ground floor slab removed to create a space two floors in height. In any event, the cost of this feature was not matched by the benefits and it was discarded.

(b) Extension of the ground floor and podium floors to the street frontage in order to increase the lettable area and create a new image. This proved to be a net benefit and has been incorporated into the refurbishment.

(c) Extension of car parking facilities in the basement and lower ground floors. It was decided that the marketability of the whole development would be enhanced by substantial car parking and this feature was incorporated.

5. Conclusion

The quality of a building may be measured, at least in part, by its performance in the rental market where appropriate. It is rather more difficult to measure quality in buildings such as public buildings for which there is no market.

Performance in the rental market may be quantified as a value effect or benefit. The benefits may be compared with the costs by using the developer's equation approach discussed above or cash flow analysis.

In the final analysis, each case must be considered on its merit although the experiential approach is sometimes able to assist. Empirical analysis is required to produce useful market based data. However, the establishment of large life cycle cost and benefit data banks may be of doubtful use since such data show actual expenditures, possibly resulting in false economies, and not normative expenditure (Robinson, 1987).

A consideration of both costs and benefits is the correct procedure for assisting in the optimum use of resources in buildings as the above results clearly demonstrate.

6. References

Brandon, P.S. (1984) Cost versus quality: a zero sum game. **Construction Management and Economics.** 2, 111–126.

Burt, M.A. (1978) **A survey of quality and value in building**. Building Research Establishment, Watford, 1978.

Ireland, V. (1985) The role of managerial actions in the cost, time and quality performance of high rise commercial building projects. **Construction Management and Economics.** 3, 59–87.

Powell, C. (1986) Some trends in relative costs of building types: description and interpretation. **Construction Management and Economics.** 4, 201–212.

Randall, K. (1988) Building owners go for "economic life". **Business Review Weekly.** 29 April, 43–44.

Robinson, J. (1984) Economic feasibility analysis, in **Real Estate Valuation Reports and Appraisal** (ed. R.T.M Whipple), Law Book Co. Sydney, pp. 65–101.

Robinson, J. (1986) Life cycle costing in buildings: a practical approach. **Australian Institute of Building Papers.** 1, 13–28

Robinson, J. (1987) The incident and rectification of faults in residential buildings in Melbourne **Australian Institute of Building Papers**. 2, 31–48.

Robinson, J. (1989) Economic and Financial Measurement of Quality. **Proceedings CIB XIth International Congress, Paris.** 8 pp.

139
Energy efficiency and affordable housing in the USA

R.T.RUEGG

Abstract
It is estimated that cost-effective energy conservation measures could cut the amount spent in the U.S. on housing by as much as $25 billion a year. Yet, there are indications that housing continues to be built with lower than optimal energy conservation. Furthermore, much of the existing housing stock has not been retrofitted to reflect higher energy prices. This paper explores several potential causes of underinvestment in energy conservation in U.S. housing. These include a lack of knowledge about the energy costs of houses and the impact of various energy conserving features on costs; barriers to financing energy conservation investments; and differences in the investment time horizons and discount rates of builders, developers, homeowners, and the building community as a whole. Partial remedies to the problem of underinvestment include improved and practical energy and economic evaluation tools for designers and builders; home energy rating systems; new mortgage policies and innovative financing plans; and codes and standards that are based on appropriate economic methods, investment time horizons, and discount rates. The paper touches on each of these, with an emphasis on the role of investment time horizons and discount rates in encouraging socially optimal levels of energy conservation.

Keywords: Affordable Housing, Building Economics, Discount Rates, Economic Efficiency, Energy Conservation, Time Horizons.

1 Underinvestment in energy conservation makes houses less affordable

The annual expenditure on residential energy by U.S. households with family income under $5,000 averages $818, more than half the average for households with family incomes ten times greater. With about 6 million (6%) of U.S. households having incomes less than $5,000, and about 25 million (27%) having incomes below $15,000 a year, it is not surprising that today's high energy costs are an important obstacle to affordable housing (Statistical Abstract of the United States, 1990). According to U.S. Senator Timothy Wirth, Chairman of the Alliance to Save Energy (1989), energy bills account for about a fifth of the typical monthly housing expense in the U.S., but more than a third of the housing cost of low-income families. After rent or mortgage payments, energy is the largest cost of housing.

Lowering residential energy costs is an important way to increase the affordability of housing. The Alliance (1989) estimates that implementation of cost-effective energy efficiency measures could cut the nation's housing bill by about $25 billion a year, enabling many families to afford to become homeowners and others better to meet their housing costs.

For the average household, a potent opportunity for energy savings lies in the use of energy efficient water heaters and appliances (including lighting), as these are the largest energy users (Statistical Abstract, 1990, table no. 951). The American Council for an Energy-Efficient Economy (1989) estimates that households could reduce their energy bills an average of $150 a year by using energy-efficient water heaters and appliances. This estimated savings would comprise 24% of the $627 average annual household expenditure for water heating and other appliance usage (1987 costs). If all existing households used energy-efficient appliances, the annual savings nationwide would be about $13.5 billion (1987 costs, derived from data in the Statistical Abstract, 1990, table no. 951).

Another major opportunity for energy savings is in space heating. Recent field tests conducted by the Alliance (1990) indicate that cost-effective energy retrofits could save an average of 25% of the energy for space heating in single-family homes. Applying this estimate to the $350 average annual household expenditure in 1987 for space heating (Statistical Abstract, 1990, table no. 951) yields average annual savings of $88 per household, and nearly $8 billion a year nationwide.

Adding to the potential energy savings from appliances and space heating, a 25% reduction in the $109 average annual cost of air conditioning per household (Statistical Abstract, 1990, table no. 951) raises the potential average annual savings to $265. If the 93 million households in the U.S. were on the average to realize annual net savings of $265, the national net savings would amount to $25 billion annually, the Alliance's estimated cut in the nation's housing bill achievable by cost-effective energy conservation investments.

2 Why is there underinvestment in energy conservation?

If residential energy conservation offers lower housing costs to consumers, why would there be underinvestment in it? In an efficient market, without economic externalities, underinvestment should not occur. If, however, there are externalities and market barriers that hold the level of investment in energy conservation below the socially efficient level, underinvestment may occur. There is underinvestment if the marginal cost to society of additional expenditure on energy conservation would be more than offset by the resulting marginal benefit to society, such that societal net benefits are foregone by failing to increase the level of energy conservation.

An economic externality exists when an activity by one or more parties affects one or more parties who are external to the activity. To the extent that the costs associated with energy consumption extend beyond the direct purchaser/consumer of energy, there are external costs that are not taken into account in decisions to invest in energy conservation. The result is underinvestment in conservation. Examples of economic externalities that may arise from energy consumption and contribute to underinvestment in conservation are uncompensated pollution effects and national defense-related costs associated with using imported oil that are not reflected in its price.

Market barriers—the focus of this paper—may also cause underinvestment in residential energy conservation. Potential market barriers include the following: a lack of knowledge on the part of consumers and professionals about the energy costs of houses; a lack of consumer and professional knowledge about the impact of various energy conserving features on energy costs; unavailability of financing for energy improvements; and a divergence among builders/developers and individual homeowners in their time horizons and discount rates. These market barriers result in a series of individual decisions that fail to serve the best interest collectively of all those who own and live in a house over its life-cycle from inception to demolition. Each of these market barriers is discussed in turn, with an emphasis on the impact of time horizons and discount rates.

2.1 Lack of knowledge

A lack of knowledge by buyers and sellers means market inefficiency both in the demand for and supply of energy efficient housing. Many builders/developers are unsure which energy conservation features are marketable. To avoid the risk of providing a feature that may not yield the desired rate of return, they may simply omit it or make it optional.

Many consumers are unsure what features to ask for, how much they are worth, and how to compare houses in terms of their energy efficiencies. This may lead them to take a passive role in determining the energy attributes of housing and to rely on the builder/developer to make the decisions.

2.2 Lack of financing

A serious and widely recognized barrier to investment in energy conservation is a lack of financing. Only a tiny fraction of lenders in the U.S. now take into account the energy efficiency of a house in deciding the size of the loan they will approve. This severely constrains the level of energy conservation that most consumers are able to obtain, regardless of the intensity of their desire for it.

The constraint occurs in several ways. First, independent appraisers tend to underestimate the value of energy conservation features, thereby reducing the size of the loan the lender is willing to make to below justifiable levels. Second, the lender's assessment of the homebuyer's ability to meet monthly mortgage payments usually does not take into account the increased ability to pay as a result of reduced energy payments.

2.3 Time horizons that are too short

Basing investment decisions on time horizons that are too short is an additional factor that can cause the level of investment in energy conservation to fall below what is optimal for the building community. Time horizons can affect the level of investment by influencing decisions that are based on analyses performed directly in support of the decision, as well as through building codes or other specifications that have been based on a particular time horizon.

Builders, developers, homeowners, and society in general have different time perspectives for taking into account the benefits and costs of energy decisions. On whose time horizons is investment in residential energy conservation based? And, on whose time horizons and discount rates should it be based?

Apart from codes that set mandatory types and levels of conservation, the level of investment in houses is the net result of a series of individual decisions aimed at maximizing net returns to each decision maker in the process. The result is often less than optimal from a collective point of view, even if each decision maker correctly optimizes the decision from his or her perspective.

A speculative builder/developer is often at the beginning of the decision process. This decision maker typically holds houses for immediate sale and has an exceedingly short time perspective. Energy costs for maintaining and operating houses in short-term inventory are relatively small. In order to maximize profits from sales; i.e., sales revenue over production and selling costs, it may pay to skimp on energy conservation for non-custom housing even if some buyers would be willing to pay for it. More important is keeping costs within an acceptable range for the targeted market. There may be other, more "visible" housing features which cost about the same as energy conservation features but which are more marketable and return a higher profit margin.

Next in line in the decision process is usually the potential homebuyer. Typically in the U.S. this decision maker also has a limited time perspective due to the high turnover rate of housing. On the average, houses in the U.S. are held only about seven years before being resold, and in most major metropolitan areas, the turnover rate is even higher. Thus, though the homeowner is typically concerned about the level of fuel bills, the time perspective for evaluating energy conservation investments is only about seven years. This is the correct study period for estimating the cost-effective package of energy conserving features for this "typical homeowner." Any residual value expected to remain at the end of the homeowner's expected holding period should be recaptured as resale value.

In theory, this typical homeowner should be willing to pay for additional energy conservation as long as each additional dollar of expenditure results in more than a present-value equivalent dollar of combined savings and resale. But if the homeowner expects, say, only seven years of savings and little resale, he or she will correctly demand little energy conservation. And if the size of the loan for which the homeowner qualifies is fixed, regardless of the size of energy bills, he or she may prefer to use the limited line of mortgage credit to buy more of other building attributes, such as additional space or higher quality finishing and fixtures, instead of energy conserving features.

What about the subsequent buyer of the house? Again, this buyer also typically will hold the house for only about seven years, and therefore will have about a seven-year time horizon for evaluating (a) the value of existing energy conservation features and (b) the cost-effectiveness of retrofitting the house with additional energy conservation features. Prospects for recapturing investment costs through future resale may be no better than initially.

The subsequent buyer faces an additional barrier: the costs of buying and installing most energy conservation systems is higher for retrofits than for systems incorporated into houses when they are built—higher apart from general price inflation. Steps that can be taken easily during construction become more intrusive and expensive after construction. Increasing the level of insulation, making windows double glazed instead of single glazed, and raising the efficiency of appliances and heating and cooling equipment tend to be much more costly to do later than initially when they would have added little extra to baseline costs. Another factor that may raise the cost of retrofits is that financing costs for home improvement loans tend to be higher than for first mortgages.

The following example demonstrates how a series of individual decisions—each based on the time horizon of the individual decision maker—can result in underinvestment in energy conservation from a collective standpoint. Suppose the problem is to choose a system for domestic hot water for a new development of houses. A natural gas-fired boiler will be used for space heating. In the U.S., the prevalent choice for residential water heating is an electric water heater. An alternative choice, which takes advantage of the fact that a gas-fired boiler is to be used for space heating, is to provide an integrated space heating/domestic hot water system.

Table 1 summarizes the data for the example. The integrated system adds $500 to first costs of the boiler, but eliminates the need for the $300 electric water heater, resulting in a differential investment cost for integrated water heating of $200. The integrated system saves about $40 each month in electricity for water heating, or $480 per year, based on initial electricity prices. In all except about four months each year, the integrated system can meet the domestic hot water load at no additional fuel costs. Additional costs of natural gas for water heating over the four months are estimated at about $20 per month, or $80 per year, based on initial natural gas prices.

Table 1. Case Illustration: Assumptions

<u>Energy Conserving Choice</u>	
Package Boiler/Water Heater (purchase and installation)	$3,000
Additional Yearly Fuel Cost for Water Heating Only	$80
<u>Conventional Choice</u>	
Boiler (purchase and installation)	$2,500
Electric Water Heater (purchase and installation)	$300
Yearly Electricity for Water Heating Only	$480
<u>Other Assumptions</u>	
Maintenance and replacement costs	Unaffected[a]
System Lives	25 years
Mortgage Loan Rate (before taxes)	10.0%
Mortgage Loan Rate (after taxes @ 28%)	7.2%

Consumer Loan Rate (not tax deductible)	13.0%
Social Discount Rate (above inflation)	4.7%[b]
Time Horizon of Developer	1–6 months
Time Horizon of Initial Homeowner	7 years
Time Horizon of Resale Buyer	7 years
Collective Time Horizon	5 years
U.S. DOE Energy Price Projections	1991 U.S. Average

[a] For simplicity of exposition, maintenance costs and replacement costs are assumed to be the same for the integrated boiler/water heater and the boiler and electric water heater combination. In fact, the electric water heater would likely require replacement within the 25 year period, thereby increasing the cost effectiveness of the integrated system.
[b] The rate of 4.7% is used for purpose of illustration only. It is based on the market interest rate on long-term U.S. Government securities adjusted for the rate of general price inflation as projected by the U.S. Council of Economic Advisors. For further explanation, see the Federal Register (1990).

As a point of reference, consider first the cost-effective selection from the collective standpoint. Table 2 shows life-cycle costs (LCC) of the house with the conventional water heater and with the alternative integrated system. The calculations show that the integrated system has a much lower LCC and results in net savings of more than $5,000 in present value terms.

Table 2. Life-Cycle Cost (LCC) Comparison from the Collective Viewpointa

LCC=PV Investment Costs+PV Additional Energy Costs
Conventional Water Heating: LCC Calculation
LCC=[$2,500+$300]+[$480×14.76]=$9,885
Integrated System: LCC Calculation
LCC=[$3,000]+[$80×18.61]=$4,489
Net Savings (NS) from Integrated System
NS=$9,885−$4,489=$5,396

[a] Present value calculations are based on the assumptions in Table 1. Only the additional energy costs for water heating are included in energy costs. The factors 14.76 and 18.61, used to calculate present value of electricity costs and natural gas costs, respectively, account for projected real price escalation and discounting over 25 years. They are taken from Lippiatt and Ruegg (1990).

Choosing the energy conserving integrated system would add less than $1.50 a month to the homeowner's mortgage payment (i.e., an additional loan amount of $200 to be financed over 25 years at an after-tax mortgage rate of 7.2%). This cost would be much more than covered by the monthly energy savings which would start at close to $33.50.

The homeowner would be better off by about $32 an month from the start. From the collective perspective, the energy conserving system is the economically efficient choice.

Now consider the decision from the builder/developer's perspective. The builder/developer sees a higher production cost of $200, but probably not a higher appraised value. Fewer prospective homebuyers may qualify. Many may not understand the integrated system, being more familiar with a conventional water heater. The builder/developer may reason that this will mean more time and effort for marketers to explain the system, and hence an even higher cost to pass on to the buyer. The builder also may see other ways to spend $200 which will result in a more visible housing product that is easier to market and will generate a higher profit margin. If the builder/developer does not provide the integrated system, the new homebuyer does not get it. Is it then economical for the first, or subsequent, homebuyer to add the system as a retrofit? Remember, the initial calculations suggested more than $5,000 in potential net savings.

The problem is that the differential investment cost is no longer $200. Obtaining an integrated hot water/space heating system no longer can be accomplished at a cost of $500; now the cost is $1,500 for customized system modification. The $300 cost of the electric water heater is sunk; there is little market for used water heaters. Furthermore, the homeowner may have to get consumer financing under less favorable terms than the typical mortgage loan. For example, a consumer loan at 13% (non tax deductible) over 4 years will require a monthly payment of about $40, about $6.50 more per month than the estimated energy savings. Furthermore, the owner has little confidence of recouping costs at the time of resale, for the same reasons as for the builder/developer. Hence, the homeowner is unlikely to retrofit.

Now we see how the decisions of individuals may be efficient for them from their limited perspectives, but not necessarily for the collective group from its perspective. The example also illustrates that once a lower than socially optimal level of energy conservation has been provided, it is not easy to rectify the problem. The outcome is that the series of individuals who own a house over time will each pay more for energy than is economically efficient.

2.4 Discount rates that are too high[1]

Basing investment decisions on discount rates that are too high will also result in a level of investment in energy conservation below the level that is optimal from the standpoint of society. Like time horizons, discount rates feed into economic analyses and affect which and how much energy conservation will be estimated to be cost effective. The analysis may influence conservation decisions directly or indirectly through building codes.

Builders/developers are likely to have relatively high opportunity costs of capital, and, hence, high discount rates. They can, for instance, use their investment funds for housing features that have high market appeal and a high return. Even if their time horizons were long, a high discount rate would lead them to place little value on energy savings to be realized far in the

[1] For an indepth treatment of discount rates—what they are and how they are used in economic analysis—see Ruegg and Marshall (1990)

future. Hence the discount rates of builders/developers intensify an existing bias away from energy conservation.

What is the appropriate discount rate for deciding the level of investment in energy conservation for residences? In a landmark article, Hausman (1979) developed a model of household energy use and presented results suggesting that consumers characteristically use a high discount rate—he estimated it at 20%—in making tradeoffs between capital costs for energy-using durables and operating costs for those durables. He also concluded that the discount rate varies inversely with income, and that the high rate does not appear to be adequately explained by uncertainties.

Findings such as Hausman's are sometimes used to support the argument that the level of residential energy conservation should be based on high consumer discount rates- -the lower the income level, the higher the discount rate. (Setting a short maximum acceptable payback period (MAPP) is tantamount to using a very high discount rate.) Using a high discount rate drastically curtails the amount of energy conservation that will pass a cost-effectiveness test. If the rate is higher than is appropriate, underinvestment will result.

Although he points to high credit card rates and revolving credit card balances as a potential rationale for high consumer rates, Hausman comes down on the side of the argument that consumer discount rates are typically higher than they should be. "A simple fact emerges that in making decisions which involve discounting over time, individuals behave in a manner which implies a much higher discount rate than can be explained in terms of the opportunity cost of funds available in credit markets." (Hausman, 1979, p.51). He points out that rates on the order of 20% are much higher than the opportunity cost of funds available in credit markets would explain, and noted that economists since Pigou have commented on the prevalence of high individual discount rates in terms of the "defective telescopic faculty" of consumers.

3 How public policy can help

Public policy can help mesh interests of builders, individual homeowners, and society, bringing the series of private decisions about residential energy conservation in line with what is economically efficient for society. Partial remedies to the problem of underinvestment include improved and practical energy and economic evaluation tools for designers and builders; home energy rating systems; new mortgage policies and innovative financing plans; and codes and standards that are based on appropriate economic methods, investment time horizons, and discount rates.

Improving tools to perform energy and economic analysis of houses is a way to overcome the market barrier of lack of knowledge. One example of a computer analysis tool that is currently being improved and extended for use by engineers, architects, and officials to estimate the energy efficiency of heating, cooling, lighting, and other energy consumption patterns of residential and commercial buildings is the U.S. Department of Energy's ASEAM, A Simplified Energy Analysis Method (1991). Another computer analysis tool that has recently been improved for estimating and comparing the economic efficiency of alternative energy conservation packages is the National Institute of Standards and Technology's BLCC, Building Life-Cycle Cost Program (1991).

A computer analysis tool for determining the economically efficient level of residential insulation is the National Institute of Standards and Technology's ZIP (1990). Homeowners, builders, utilities, manufacturers, building researchers, and state energy offices can use this program to calculate economic levels of insulation for attics, walls, floors, basements, ductwork, and water heaters for houses in any location in the United States (at the three-digit zip code level). Climate and default energy and insulation costs are retrieved from the disk for that location. The user can enter actual insulation and energy cost as well as approximate heating and cooling system efficiencies to customize the calculations for a specific building.

Development of Home Energy Rating Systems (HERS) is another promising approach to help consumers and the rest of the building community better assess and compare the energy efficiency of houses. HERS attempts to quantify the energy efficiency of a house in a simple way—the simplest being a scalar designation, such as a score from 1–100 or a number of stars in a one-to-five star system. The objective is to increase the visibility of the energy-consumption feature of a house, a feature that is often given too little weight in decisions. Increasing consumer awareness could be expected to increase the level of demand for energy conservation. Although there are an estimated 150 systems that may be called HERS currently in use in the U.S., most are pass-fail type systems based on a checklist (Alliance, 1989, pp. 11–13). Further development, refinement, and implementation of HERS could help consumers become better informed, provided, of course, that HERS are based on valid analysis.

Encouraging lenders to take into account lower operating costs when computing loan eligibility is another policy action. According to one estimate (Alliance, 1989, p. 13), only about 18,000 loans that have closed have provided higher loan amounts to reflect energy conservation. Furthermore, efforts to implement uniform energy efficient mortgage practices among mortgage underwriters such as Fannie Mae, Freddie Mac, VA, and FHA are slow in coming (Alliance, 1989, p. 14). Overcoming this problem is closely tied to overcoming the problem of a lack of knowledge. Implementation requires that lenders and appraisers have reliable means of assessing when a house is energy efficient and how much they should extend their mortgage payment-to-income ratio to reflect homeowner energy savings.

Strengthening building codes and standards is another way to overcome underinvestment in energy conservation. It is critical that codes and standards for residential energy conservation be based on sound economic analysis. By taking a longer time perspective than that of the developer or typical homeowner, and by incorporating a social rate of discount, economics-based codes and standards will encourage optimal levels of investment in energy conservation.

There are other potential ways to overcome consumer resistance to the higher upfront costs of energy conservation. One is to provide tax subsidies to lower the initial capital cost. The U.S. at one time had this type of tax credit policy for home energy conservation, but the enabling legislation has lapsed. Another way is to shift the capital investment decision from the homeowner to the local utility which could perform analyses to determine what and how much should be done. The utility could borrow at relatively low rates to finance the capital purchases and could pass the charge to households in the form of a monthly rental rate folded into the utility bill. The combined bill with the rental of energy conserving features would be expected to be lower than the energy bill without the conservation features. A number of utilities are using this method to a limited extent.

When market barriers to economically efficient solutions exist, definite actions are needed to achieve optimal investment. This appears to be the case with residential energy conservation. Appropriate public policy actions are needed to make housing more affordable.

4 Acknowledgments

The author wishes to thank Dr. Harold Marshall, Mr. Stephen Petersen, Ms. Sieglinde Fuller, and Dr. Robert Chapman, all economists at the National Institute of Standards and Technology, for their helpful comments.

5 References

Alliance to Save Energy (1989) **Making Housing More Affordable through Energy Efficiency: Summary of Proceedings,** Policy Forum and Conference held in Washington, D.C., USA, October 1989.

American Consulting Engineers Council (1991) **ASEAM User's Guide,** 1015 15th Street, NW, Suite 802, Washington, D.C. 20005

Hausman, Jerry A. (1979) Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables. **Bell Journal of Economics,** 10:1, 33–54.

Lippiatt, Barbara C. and Ruegg, Rosalie T. (1990) **Energy Prices and Discount Factors for Life-Cycle Cost Analysis, 1990**. National Institute of Standards and Technology, NIST 85–3273–5.

Petersen, Stephen R. (1991) **The NIST "Building Life-Cycle Cost" (BLCC) Program (Version 3.0); User's Guide and Reference Manual,** National Institute of Standards and Technology, NISTIR 4481.

Petersen, Stephen R. (1991) **Zip—The Zip-Code Insulation Program, Version 2.0,** National Institute of Standards and Technology, NISTIR 88–3801–1.

Ruegg, Rosalie T. and Marshall, Harold E. (1990) **Building Economics: Theory and Practice**. New York, New York: Van Nostrand Reinhold Publishing Company.

U.S. Department of Commerce, Bureau of the Census (1990) **Statistical Abstract of the United States,** 1990.

Washington Post (Oct. 14, 1989) "Top-Rated Appliances Shave $150 from Yearly Electric Bill," p. E3.

Federal Register (1990) "Federal Energy Management and Planning Programs; Life Cycle Cost Methodology and Procedures; Proposed Rules," 10 CFR 436, Part V, 2590–2599, January 25, 1990.

140
State and outlook of the development of housing construction in the USSR

O.V.SEROV

The solving of the housing problem is conferred the same status as food problem by the public. It has every reason to think so.

By 1991 according to the data presented by the Central Statistical Board the population will be 289, 8 mln people or 90, 1 mln families and single men.

Over this period of time the housing resources with regard to the decrease of them will be 4, 7 milliards of square metres of the total dwelling place or 83, 1 millions of flats (houses).

The number of flats (houses) comes to 92, 2% of the number of families and single men.

The average providing of the population with housing which is equal to 15, 4 square metres of the total dwelling place per man ranges from 21, 2 sq.m per man (Estonian SSR) to 6, 9 sq.m per man (Tajik SSR).

By 2000 the population will be 331 mln people or 97 mln families and single men according to the data presented by the Central Statistical Board,

The required number of flats in the housing resources will run as high as 102–103 mln flats.

Such are the initial positions from which the construction complex must begin the realization of the provisions of the Decree of the President of May 19, 1990. “On the new approaches to the solution of the housing problem in the country and measures for their practical realization.”

The principal trends of the solution of the housing problem are given in the Decree.

In 1991–2000 we are to put into service not less than 2 milliards square metres of the total dwelling place or of about 30 million flats which is 1, 5 times increase of the housing resources of the, country.

In accordance with the 13th Five-Year Plan there should be put into service 890 mln sq, m of new dwelling place and reconstructed 60 mln sq.m of existing dwelling place. Throughout the 14th Five-Year Plan the new dwelling place put into service must constitute 1095 mln sq. m as the reconstruction of the existing dwelling place must constitute 105 mln sq. m. As a result by 2000 the number of flats (houses) in the country will be in accordance with the number of the families and single men, while the providing of people with dwelling place will be increased up to 19, 4 sq. m per man.

An essential feature of this work is the orientation of the investment structure of the housing construction with regard to the outlooks of the economics development and the transition to a market.

Unlike the structure of the housing construction on the financing source principle which provided the housing construction at the cost of the centralized investments and acted until recently it seemed to us that it will be correct to transit to the variety of investment policy.

Except for the centralized capital investments the means of social organizations, the funds of the social development of the enterprises and institutions, collective farms, housing cooperatives and the means deposited by the population into the individual urban and rural housing building must become the sources of financing.

The State will place a rent-free dwelling in the form of flats or houses at the disposal of families with material well-being below socially garanteed dwelling standard, those who reside in communal flats, ramshackle houses, building without necessary engineering equipment, war-disabled persons, disabled workers and large families.

A garanteed standard must be accepted by each republic at the average standard for each region but not less than 9 sq. m of dwelling place per man (in accordance with the housing laws of the USSR) and 13–15 sq. m of total place.

The dwelling given in accordance with this standard should be built at the expense of state means and the means of enterprises and organizations.

Acquisition of the dwelling exceeding the above-mentioned standard is to be carried out provided it is poid by a consumer.

The part of the individual housing construction in accordance with the 13th and 14th Five-Year Plans must account for in the average 35%. The State must favour this method of housing building by placing plots of land at a builder's disposal, by the development of the industry of building materials and the goods necessary for a house, by the satiation of the consumer market and wholesale trade with these goods, by stimulating of personal and social initiative in housing industry at the expense of the work by small contract, leasing, building at the expense of organizations and the enlargement of the solvency of the USSR Savings Bank.

The provision of individual building by the engineering and transport infrastructure and various facilities must be carried out at the expense of the State.

The share of housing co-operatives has to increase up to 16% and in accordance with the 14-th five-year plan-up to 20% of the whole housing construction.

According to the 13th five-year plan the housing construction at the expense of the state capital investment by which is meant the total dwelling place pu into service minus the housing construction at the cost of co-operatives and individual building accounts for about 50% and in accordance with the 14th five-year plan—about 40%.

The proposed investmentpolicy will allow to include the housing economy in commodity production when the principle of social justice is taken into account: so that the part of the population with the least material security and the families with a low duelling standard will receive the dwelling from the state.

Along with the putting into operation of new housing it is necessary to make a great amount of reconstruction and repairs. According to the 13th and the 14th five-year plans we have to make a capital repair in communal housing fund 114 mln sq. m of total dwelling place.

The investment policy must be closely related with the social effectivness. It is necessary to transfer from the equal dwelling security principle to the principle of the earning of dwelling, to connect the dwelling security with social productive, material-financial contribution of a citizen to the society life, economics of the country and housing construction. As mentioned above the only exception is weakly protected groups of population which are provided by the state in accordance with a guaranteed minimum.

It is necessary to improve the programs of housing construction according to the number of storeys, decreasing of the part of multistoreyed buildings on account of increasing of low buildings construction which does not only diminish the required amount of heavy construction equipment and some types of deficite engineering equipment (elevators, pumps etc), but will give substanti al acchitectural effect: will allow to form the silhouette of the building, create closed and half-closed yard spaces, help the advent of the more humane scale of the housing formations.

The structure of the housing construction must be perfected in the construction types of the dwelling--house. One-sided orientation for developing of large--panel construction must be refused. It is necessary to widen the volume of housing construction with the alternative methods in reference to large-panel construction. The housing construction from mass concrete, small-piece constructions, compound constructions, local materials must be speeded up. This well allow to dicrease the ex-penditure of steel by 10–15% and cement—by 20–25% in comparison to today's level of their expenditure.

The constituent of the housing programme is the social reconstruction of a village. The variety of the forms of property, economic independence of the users of land dictate the necessity of the social revival of rural settlements, housing constructions and that is of particular value the development of their engineer infrastructure.

The system of every day repairs and other services must be based on the concentration of all services in the basic centres of settlings or on delivery service by the means of conveyance to small settlements.

In the republics the work is carrying on order to specify the housing programmes for the conditions of action of the USSR President Decree.

The sum of republican and local programmes till 2000 will form the state programme for provision of each family and single citizens with a personal flat or an individual house when increasing the dwelling security on average to 19, 5 sq. m of total dwelling place per man.

One of the main reasons keeping back the development of the housing construction in general and individual construction at the cost of population especially is the increasing deficiency of building materials, construction and elements of housing.

The amount of the building materials which is given to the market funds offered for sale for population does not cover 30% of the demand for them in individual building construction.

The target figures for 1991 envisaged to widen in comparison with the plan of 1990 the output of designed capacity. If the use of the capacity at the rest of enter prises will be the same as in Belorussia and Lithuania one can increase the putting the housing into service by around 10% without additional expenditures.

In this case one must decrease the expenditure for the widening of large-panel housing construction base, using the remaining means for modernization and re-equip ment of operating plants.

The programme of mass concrete housing construction is carried out. The targets for the project institutes and the most important themes of the scientific investigations in this subject are worked out.

The perspective trend of the housing construction has to be the housing construction with the use of small blocks on the basis of local raw materials, primarily of cellular concrete which allow to build not only individual buildings but to provide the construction of the external walls of multistoreyed buildings of compound constructions.

The putting into operation of the plants for the production articles from cellular concrete of total capacity of (in 1995) 30 mln cub. m is envisaged.

For the providing of demands for individual housing construction it is necessary to increase the rate of growth in setting up small enterprises on the “basis of various forms of property for the production of building materials and articles. In connection with it the target of production on an enlarged scale at the plants of the country low capacity process equipment for the production of bricks, ceramic multy-cavity stones, cellular concrete, small blocks from industrial waste is envisaged.

The lagging in supplies of articles, elements, materials for the urban and rural engineering infrastructure, engineering equipment of domestic and administrative buildings, including autonomous systems for individual housing building continues to increase.

In these conditions it is advissable to begin the production of the various types of the engineering equipment including autonomous one at small enterprises attached to large machine-building plants or special assembling organization with the use of economy of resources and main production waste.

The elaborated conceptions of the USSR housing politics until 2000 and the integral system of measures for the realization of the President Decree of May 19, 1990 envisage the increase of architectural qualities of domestic and administrative buildings, building as a whole, generation of human habitat.

This must have legislative and legal base.

The elaboration of the USSR Foundations of town--building legislation must be completed. The USSR and the republican Foundations of civil laws must be added to a architectural creative work, a copy-right of an architector and the whole set of legislative, normative and lawful provision of town-building, architectural and building activities.

It is necessary to work out the proposals for economical stimulation of town-building, architectural and building activity, to organise the control of the housing and civil project provision, to begin the practice of the discussion of projects (before their approval) with public at large.

For confinement of the development of large cities, assistance the development of middle and small cities, increasing of the intensity of the usage of urban territories and the growth of the financial base of local councils it is necessary to make suggestions on differential payments and taxes upon the use of urban lands. It is essential to prevent growndless demolishing of domestic buildings by economical-legislative means.

Extensive use should be made of the possibilities of head architectors of territories, regions, cities on the choice of the types of the buildings, the number of storeys, individual projects.

It is necessary to promote address projecting of domestic buildings based on the local natural and town--building constructions, to carry out the individualization of the projecting of a dwelling in accordance with the distinguishing features of historical town medium, to achieve delicate incorporation of new buildings into historically established environment, to retain a local colour of town-building.

The structure of housing construction on the number of storeys developed by the State Committee in Architecture must assist to the generation of expressive silhouette of a town-building. This structure envisages the de cline of average height of buildings under construction, assists to form closed and half-closed yard spaces of middle and small dimensions, that will allow to refuse from hypertrophic inside-yard territories.

The use of combined construction solutions—e.g. internal panel carrying construction and external walls from the brick, local materials, mass concrete—must help in variety of outward appearance of buildings.

The promotion of an adaptable system of panel construction which allows to vary volume-spatial design of buildings serves the same purposes.

It should be noted that high-aesthetical qualities of a town-building are constituent of the comfort of a habitat and from this point of view play an important social role.

One of the principal objects confronting our society is the solution of the housing problem, the development of the economic basis of social sphere, the protection of the quality of a habitat of the Soviet people.

141
Resource utilization in housing production

Y.SEY and Ö.ÖZÇELİKEL

Abstract
The paper presents the results of a research which aims to determine the amounts of materials used in dwelling construction and their effect on building costs. Also the amount of building elements per sq.m. The study belongs to the first stage of the research. Results about resource amounts per sq.m. flat area, element costs per sq.m. flat area are found and correlations are searched in order to find the effect of various elements on total cost,
Keywords; Morphologic Analysis, Building Costs, Building Resources.

1 Introduction

Turkey needs approximately 450000 new dwelling units to be built every year. Due to the costs of building materials, high land prices and high inflation rate building costs increase at a rate higher then general price index. Due to this fact, the purchase power of users are decreasing gradually. In order to increase the level of production, it is obvious that to minimize resource utilization is the most important issue.

Relying upon the above mentioned considerations a research has been started. The aim of the research is to find out the effect of amounts of resources on the cost of building.

2 Method

The research has been designed in two stages. The first stage is a pilot study which will be used as a basis for a more comprehensive research.

2.1 Sample selection

The investigation is carried on a housing project of 4500 units in Istanbul. The technology used is a tunnel mould system which is mostly favoured for housing construction in Turkey. Dwelling units with two and three bedrooms are choosen.

Table 1. Gross floor area of flats (sq.m.)

				Percentage difference	
	Min.	Ave.	Max.	Negative	Positive
2.BR.Flat	68.57	85.09	112.36	–19.41	32.04
3.BR.Flat	96.61	101.56	117.20	–4.87	15.40

The below mentioned assumptions are made for the analysis.

– All blocks are five storey height.
– Building elements' materials and composition are the same in all types.
– Services such as sewage, clean water, gas, electricity and telephone outside the blocks are not included.
– Common spaces are included in the amount of flat elements.

2.2 Analysis procedure

The below mentioned steps are followed during the analysis.

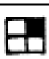
– Amount of building elements per sq.m. of gross floor area of dwelling units are calculated. The results are shown in Table 2 and Table 3.

The figures in Table 2 and Table 3 exhibits great variances for the amounts of elements per sq.m. which indicates the changes in the configuration of the flat. These differences are shown in Table 4 and Table 5.

– Amount of inputs which is required to produce 1 sq.m. of gross floor area are calculated.

This is realized by a computer program which is prepared according to the data of standard bill of quantity. Firstly the amount of construction operations are calculated and then the input amounts are found. The values of the main operations and inputs are given in Table 6 and 7.

Table 2. Amount of building elements per sq.m. of gross floor area in two bedroom flats

TYPE	PLAN	SQ.M.	TID /M2	TDD /M2	BID /M2	BDD /M2	ID /M2	DD /M2	ZA /M2	CAT I/M2
MA1		81.52	0.7679	0.2622	0.4181	0.3426	0.8618	0.0383	2.0600	1.1530

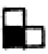
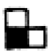
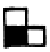
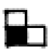
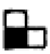
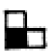
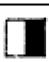
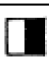
MA2		84.10	0.6983	0.4797	0.4272	0.2927	0.8695	0.0371	2.0600	1.1641
KA1		1100.92	0.7065	0.2206	0.3616	0.3229	0.7898	0.0644	1.9380	1.3476
KA2		70.52	0.7205	0.4129	0.4304	0.2627	0.7941	0.0490	2.0498	1.1470
KAb		68.57	0.7633	0.4199	0.4753	0.2938	0.9856	–	2.0840	1.1700
KAc		94.78	0.6209	0.2285	0.3993	0.3607	0.8598	–	1.8200	1.1500
KAf		84.58	0.6069	0.4022	0.3620	0.3073	0.9013	0.0768	2.0300	1.1620
SA1		112.36	0.5444	0.2581	0.3506	0.2526	0.6484	0.0266	1.8930	1.1170
SA2		99.64	0.5900	0.4213	0.4158	0.2503	0.6833	0.0313	1.9940	1.1410
MC3		69.52	0.5240	0.0632	0.4079	0.7978	0.8556	0.0667	2.1300	1.1820
MC5		83.16	0.7353	0.2416	0.6704	0.1688	0.9965	0.0749	1.8800	1.1210
MC5A		78.66	0.5949	0.2456	0.5836	0.1785	0.9739	–	1.8360	1.1280
MC6		91.58	0.2337	0.3049	0.5856	0.2059	0.8703	0.0715	1.9770	1.1433
MC6A		87.03	0.4537	0.2734	0.5979	0.2166	0.8677	–	1.9400	1.1290
KAC2		83.35	0.8657	0.2837	0.2043	0.4212	0.9537	–	2.1300	0.9570
KAC2A		89.20	0.7843	–	0.5550	0.5421	0.9668	–	2.2600	1.1990
KAC3		77.28	0.4960	0.3060	0.5467	0.3811	0.8026	–	2.0800	1.1660
KAC5		78.64	0.8655	0.2305	0.7749	0.1421	0.9965	0.7030	1.9800	1.1211
KAC6		81.28	0.6828	0.1480	0.6185	0.1421	0.8322	–	1.9000	1.1060

Table 3. Amount of building elements per sq.m. of gross floor area of three bedroom flats.

TYPE	PLAN	SQ.M.	TID /M2	TDD /M2	BID /M2	BDD /M2	ID /M2	DD /M2	ZA /M2	CATI /M2
MB3		105.05	0.3776	0.1906	0.7110	0.7482	0.9328	0.0666	1.8474	1.1130
KA3		147.91	0.5025	0.2702	0.5003	0.3003	0.7724	0.3003	1.8930	1.1139
KA4		117.47	0.6057	0.2754	0.5367	0.3054	0.9380	0.0595	1.9250	1.1250

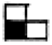
SB2		110.10	0.4526	0.1589	0.6168	0.1766	0.7964	0.1289	1.7970	1.1020
SB3		117.20	0.4189	0.2229	0.7043	0.1674	0.7253	0.1203	1.8000	1.1040
MC1		100.56	0.8090	0.0382	0.5631	0.4185	0.8944	0.0487	1.9890	1.1210
MC2		105.85	0.7713	0.0987	0.5229	0.4168	0.8535	0.1200	1.9920	1.1073
MC2A		86.09	0.5297	0.2445	0.6597	0.5670	0.9477	0.0906	2.0920	1.1500
KAC1		110.78	0.5700	0.4240	0.5380	0.2582	0.9066	–	2.0025	1.1340
KAC7		96.61	0.8426	–	0.4172	0.4362	0.8550	0.0681	1.9843	1.1180
KAC7A		98–14	0.5510	–	0.4584	0.4593	0.6128	0.4774	2.0717	1.1160
KAC8		107.11	0.7239	0.1013	0.5965	0.4028	0.9059	0.3022	1.9595	1.1160

Table 4. Variations in two bedroom flats

				Percentage difference	
	Min.	Max.	Av.	–	+
TID	0.2337	0.7679	0.6452	63.77	19.32
TDD	0.1480	0.4797	0.2888	48.75	66.10
BİD	0.2043	0.7749	0.4847	57.85	59.87
BDD	0.1421	0.7978	0.3089	53.99	158.27
ID	0.6484	0.9965	0.8689	25.37	14.68
DD	0.0313	0.7030	0.1127	72.22	523.77
ZA	1.8360	2.2600	2.0015	8.26	12.91
CA	0.9570	1.1990	1.1478	16.62	4.46

Table 5. Variations in three bedroom flats

				Percentage difference	
	Min.	Max.	Av.	–	+
TİD	0.3776	0.8426	0.5958	36.62	41.42
TDD	0.1013	0.4240	0.2020	49.85	109.90
BİD	0.4172	0.7110	0.5691	26.69	24.93
BDD	0.6174	0.7482	0.3900	57.07	91.84
İD	0.6128	0.9477	0.8458	27.54	12.04
DD	0.0487	0.4774	0.1636	70.23	191.80

ZA	1.7970	2.0920	1.9458	7.64	7.51
CA	1.1020	1.1500	1.1166	1.30	2.99

Table 6. Average amounts of construction operations

Operation	Unit	Ave. amount per sq.m. 2 Bedroom flat	floor area of 3 Bedroom flat
Excavation	m^3	0.79	0.76
Concreting	m^3	0.58	0.41
Masonry with gasbeton			
wall blocks	m^2	0.95	0.96
Roof tiling	m^2	0.20	0.20
Steel reinforcing	t	0.06	0.05
Wooden roof framing	m^2	0.20	0.20
Ceramic wall til ing	m^2	0.46	0.45

Table 7. Average amounts of input

Input	Unit	Ave. amount per sq.m. 2 Bedroom flat	floor area of 3 Bedroom flat
Portland cement	t	0.242	0.174
Roof tile	per	3.4	3.4
Ceramic wall tile	per	21.46	21.0
Wood	m^3	0.021	0.020
Steel ber	t	0.065	0.043
Excavator	h	0.014	0.014

– Building costs are calculated

Building costs are calculated for each type of flat are shown in Table 8.

Table 8. Cost of per sq.m. floor area

2 Bedroom flat		3 Bedroom flat	
Type	Cost TL/sq.m,	Type	Cost TL/sq.m,
MA1	599084.80	MB3	589856.74

MA2	658348.72	KA3	629869.80
KA1	635693.02	KA4	617658.10
KA2	648435.24	SB2	566308.00
KAb	679180.24	SB3	568609.50
KAc	598773.30	MC1	627480.60
KAf	644853.00	MC2	631607.80
SA1	569825.00	MC2A	679878.60
SA2	618588.60	KAC1	621016.20
MC3	677258.20	KAC7	604650.60
MC5	638216.80	KAC7A	656576.12
MC5A	599713.24	KAC8	611465.41
MC6	595399.70		
MC6A	592813.80		
KAC2	614576.00		
KAC2A	661055.90		
KAC3	623891.70		
KAC5	641720.50		
KAC6	573701.00		

As it is seen the minimum cost of two bedroom flats is 569825 TL and maximum is 679780 TL. The difference between minimum and average is 54971 TL. The value of maximum is 54384 TL. The minimum cost for 3 three bedroom flats is 566308 TL and the maximum is 679878 TL. Differences of the minimum and the maximum from the average is 50773 TL and 62797 TL.

– Share of input costs in unit building costs are calculated

The percent share of the cost of all inputs are listed from maximum to minimum. The highest eight materials are given below.

Table 9. Materials' with highest costs.

Material	Percentage of cost/sq.m. in 3 Bedroom flat
Wood	8.314
Gasbeton wall block	7.333
Reinforcement steel	7.081
Portland cement	4.565
Carpet	2.924

Ceramic tile	2.983
Window glass	1.716
Wall paper	1.288

– Share of element costs in unit building cost is calculated

Relying upon elemental analysis in Table 3 and Table 4, the share of element costs in unit building cost are calculated.

Table 10. Element costs as percentage of sq.m. building cost in three bedroom flats.

TYPE	TID/TL	TDD/TL	BID/TL	BDD/TL	ID/TL	DD/TL	ZA/TL	CATI/TL
MB3	4.75	4.04	8.79	4.24	15.52	1.68	30.53	30.42
KA3	6.74	5.29	6.69	4.80	12.30	6.30	29.29	28.50
KA4	8.20	5.48	6.80	4.98	14.74	–	30.38	29.30
SB2	5.98	3.44	8.26	3.14	13.40	3.40	30.93	31.37
SB3	5.21	4.80	9.69	2.96	12.12	3.02	30.86	31.30
MC1	10.50	0.90	5.83	7.68	14.19	1.60	30.90	28.80
MC2	9.40	2.31	5.39	7.55	13.40	2.83	30.74	28.26
MC2A	6.60	4.55	6.18	10.17	13.20	1.99	30.00	27.27
KAC1	7.80	8.29	4.77	4.66	13.50	–	31.43	29.44
KAC7	11.09	–	4.59	8.30	12.47	1.71	31.90	29.81
KAC7A	9.77	–	4.65	7.93	8.72	10.89	30.76	27.25
KAC8	9.19	2.37	6.40	6.64	14.48	6.86	31.24	29.42

Table 11. Element costs as percentage of sq.m. building cost in two bedroom flats.

TYPE	TID/TL	TDD/TL	BID/TL	BDD/TL	ID/TL	DD/TL	ZA/TL	CATI/TL
MA1	9.75	5.29	5.60	6.42	7.40	0.95	33.52	31.03
MA2	8.37	8.81	4.93	5.07	12.94	0.84	30.50	28.50
KA1	8.61	4.30	5.35	5.48	12.33	1.34	29.72	34.18
KA2	8.90	7.75	6.15	4.58	12.24	1.01	30.81	28.52
KAb	9.25	7.56	6.40	4.85	14.22	–	29.91	27.77
KAc	7.60	4.73	6.31	6.48	14.21	–	29.60	30.96
KAf	7.27	7.67	5.23	4.80	13.69	1.57	30.68	29.05
SA1	7.48	5.48	5.94	4.99	11.39	0.69	32.38	31.60

SA2	7.96	8.25	6.33	4.62	10.89	0.75	31.42	29.74
MC3	7.00	1.12	4.16	15.12	12.30	1.47	30.60	28.10
MC5	8.06	4.97	9.41	2.66	16.05	1.75	28.71	28.34
MC5A	7.08	5.13	8.24	3.00	16.36	–	29.84	30.32
MC6	2.73	6.57	7.34	3.48	14.72	1.79	32.37	30.96
MC6A	6.12	5.76	7.93	3.68	13.88	–	31.90	30.70
KAC2	10.26	5.58	2.62	7.90	14.70	–	33.78	25.10
KAC2A	8.45	–	5.18	10.00	13.78	–	33.30	29.54
KAC3	7.07	5.93	4.61	7.51	12.22	–	32.50	30.13
KAC5	10.20	4.40	7.76	2.23	2.65	14.48	30.08	28.16
KAC6	10.18	3.12	7.75	2.49	13.60	–	32.28	31.08

2.3 Correlations

The correlation between cost indicators and costs are searched and shown in Table 12 and Table 13.

Table 12. Correlation analysis (2 BR.flat)

	SQ.M.	TID	TDD	BID	BDD	ID	DD	ZA	CATI	U.COST
SQ.M.	1.0000	−0.2092	0.0047	−0.2321	−0.2797	−0.5456	−0.1197	−0.3843	0.1332	−0.5554
TID	−0.2092	1.0000	−0.0582	−0.0918	0.0110	0.4024	0.3009	0.2627	−0.1348	0.3589
TDD	0.0047	−0.0582	1.0000	−0.2420	−0.4497	−0.1913	−0.0580	−0.1071	−0.1175	0.0768
BID	−0.2321	−0.0918	−0.2420	1.0000	−0.4501	0.4065	0.4958	−0.2417	0.0563	−0.0369
BDD	−0.2797	0.0110	−0.4497	−0.4501	1.0000	−0.0094	−0.2439	0.6467	0.1701	0.4889
ID	−0.5456	0.4024	−0.1913	0.4065	−0.0094	1.0000	0.2866	0.1793	−0.2007	0.3984
DD	−0.1197	0.3009	−0.0580	0.4958	−0.2439	0.2866	1.0000	−0.0517	−0.0247	0.1757
ZA	−0.3843	0.2627	−0.1071	−0.2417	0.6467	0.1793	−0.0517	1.0000	0.0057	0.6233
CATI	0.1332	−0.1348	−0.1175	0.0563	0.1701	−0.2007	−0.0247	0.0057	1.0000	0.3401
U.COST	−0.5554	0.3589	0.0768	−0.0369	0.4889	0.3984	0.1757	0.6233	0.3401	1.0000

Table 13. Correlation analysis (3 BR.flat)

	SQ.M.	TID	TDD	BID	BDD	ID	DD	ZA	CATI	U.COST
SQ.M.	1.0000	−0.3050	0.4340	−0.0811	−0.4970	−0.2252	0.1865	−0.5461	−0.3614	−0.1108
TID	−0.3050	1.0000	−0.5271	−0.6244	0.0416	0.2353	−0.9560	0.5129	0.1138	−0.0424
TDD	0.4340	−0.5271	1.0000	0.3460	−0.2883	0.3394	−0.3924	−0.2076	0.4192	0.1811

BID	−0.0811	−0.6244	0.3460	1.0000	0.1431	0.2767	−0.3012	−0.4771	0.0289	−0.0026
BDD	−0.4970	0.0416	−0.2883	0.1431	1.0000	0.3499	0.0072	0.3850	0.2985	0.2727
ID	−0.2252	0.2353	0.3394	0.2767	0.3499	1.0000	−0.7104	0.1020	0.5987	0.0421
DD	0.1865	−0.9560	−0.3924	−0.3012	0.0072	−0.7104	1.0000	0.1815	−0.3517	0.3147
ZA	−0.5461	0.5129	−0,2076	−0.4771	0.3850	0.1020	0.5987	1.0000	0.6386	0.6510
CATI	−0.3614	0.1138	0.4192	0.0289	0.2985	0.5987	−0.3517	0.6386	1.0000	0.5198
U.COST	−0.1108	−0.0424	0.1811	−0.0026	0.2727	0.0421	0.3147	0.6510	0.5198	1.0000

3 Results

Table 12 and Table 13 indicates the below mentioned relations:

–Floor area, substructure and roof are the elements which have highest correlation with unit housing cost. External wall seems to be effective in the second order.
–Regarding the correlation of values which show the amounts of elements per sq.m. flat area to relation is found between total floor area/external wall and load bearing external wall/load bearing internal wall.
–Considering the minimum, average and maximum values of the amount of elements per sq.m. (Table 4 and Table 5) external walls and external floors are found to be most affected by configuration of the building.

It must be expressed that the number of samples are not sufficient enough to arrive accurate conclusions. But the results are clear enough to show the usefulness of the second step of the research. Also results seem to be useful to focus designers' attention to the most expensive elements.

4 Abbreviations

TID:	Load bearing internal wall
TDD:	Load bearing external wall
BID:	Internal partitions
BDD:	External partitions
ID:	Internal floor
DD:	External floor
ZA:	Substructure
CATI:	Roof
M2:	Sq.m.
TL:	Turkish Lira

142
Building and civil engineering construction projects—a specific analysis?

J.M.A.da SILVA

Summary
With the objective of identifying future specific features of building construction and civil engineering projects and their implication in forming methodologies suitable for their analysis, there follows a short presentation of the concept of the investment project, of the various types of appreciation and of the different criteria and levels of overall evaluation available. From this and by comparing typical industrial projects, we hope to adapt the traditional building construction project methodologies, and conclude that analysis is superior to evaluation and that there is need for a much tighter schedule. It should be noted that these leads are only preliminary and are pointers to further investigation.

1. Introduction

The challenge which was presented to us to compare the evaluation of a building construction or civil engineering project with the traditional evaluation of industrial projects, following on from a discussion of a Master's thesis concerning the evaluation of construction projects, has proved to be stimulating, complicated and is still to be finished.

On the one hand, it has made us bring together various levels of project appreciation, taken as a whole, as well as relevant criteria for project evaluation so that we can then try to fit in the specific features and the varieties of building construction projects.

The task is not easy and we only intend to begin with this short essay. The limitation of pages, which restricts it, does not allow for a full development and the phase in which the investigations of the problem place us does not permit a conciseness typical of finished studies.

2. What is an Investment Project?

If the fundamental objective of this short essay is the search for specific features of building construction projects so as to consider the need for a particular approach for their evaluation, a suitable typology is being searched for to characterize different investment projects. In all, the summary of this typology will not be possible without a careful characterization of its object: the investment project.

As a starting point, we opted for the definition by Price Gittinger (*) for whom a project "is an activity on which we will spend money in expectation of returns and which logically seems to lead to planning, financing and implementation as a unit. It is a specific ending point intended to accomplish a specific objective". This definition is, in a certain way, "downstream" from what we presented some years ago, concerning the selection of industrial projects (**): a project will be defined as a resource investment, with a specific dimension in terms of schedule, scale, localization, technology and structure of factors of production and of products. This means to say that we have tried to answer the following questions, with a given number of resources:

i) When is the investment made?

ii) What is the size, or the sizes of the undertaking?

iii) Where is it to be carried out?

iv) What technology or technologies will be used, among those available?

v) What are the production factors and in what proportions will they be used?

vi) What is the composition of the final product?

This signifies that, from this point of view, two projects will be different if they have anything divergent in any of the previous points.

This last criterion, which we consider to be relevant for an efficient characterization of building construction projects, illustrates clearly some inefficiency in our previous definition that, on another plane, J.Hirshleifer (***) noted in his seminal work on project evaluation: an explicit reference to the decisions of future consumption in proportion to the receipts of the project (or of the alternative applications to its non-realization) and an explicit reference to these same receipts and to their expected schedule.

* J.Price Gittinger, "Economic Analysis of Agricultural Projects", IED, IBRD, The John Hopkins University Press, Baltimore (1972)
** Amado de Silva and Anibal Santos, "Planeamento Industrial e Decisões de Investimento—Aplicação ao sector petroquimica; GEBEI, Lisbon (1979)
*** J Hirschleifer, "On the Theory of Optical Investment Decisions", Journal of Political Economy", Oct. 1958

This insufficiency of definition is basically rooted in the preferential perspective to which it directs itself—the selection of projects which require, by nature, a careful and prior identification of all the alternatives at stake and not, specifically, an exhaustive description of the project already chosen for analysis.

3. Selection, Analysis and Evaluation of Projects

This necessary distinction demands, before a project typology, vocationed for its appreciation in terms of the consumer-producer of resources in unphased schedules, a precision of different concepts which give form to that same appreciation. These are, fundamentally, three:

i) Selection—a process which consists of choosing, within the potential projects and noting their inter-specific relationship (independent, complementary, mutually exclusive projects), those which, with the available resources, can be carried out efficiently.

ii) Analysis—a process which consists of the complete appreciation of a given project, trying to identify its suitability and its fulfillment in such a way that it is economically profitable. It is a complex process which accompanies the selection, namely in the initial phase identification of investment opportunities—and which incorporates intransferable phases of the development cycle of the project(*), such as the pre-viablity study, the technical and economical viability study, the evaluation of its profitability, its negotiation, its construction and its launching.

This wide vision of the analysis of projects is consistent (and thus justifies our choice) with the definition of Gittinger, namely when he considers that part of it consists of "planning, financing and implementation as a unit".

iii) Evaluation—appreciation of the economical and financial profitability of a project being appreciated and which is often confused with others, or rather, is considered, wrongly, as being similar to others. That is what happens, for example, when one reduces the analysis of a given project to its Internal Rate of Return (IRR) or to its Net Present Value (NPV), as so often happens.

4. Criteria for Decision and Levels of Evaluation

The three concepts of appreciation of the projects referred to above present various points of agreement and also noticeable differences, but they all indisputably require a common instrument: a criterion for appreciation.

The search for this criterion has to overcome a series of anmbiguities which can not be shown, or one will not be able to establish an operational and credible criterion.

These ambiguities, namely in that concerning the search for a criterion of profitability, with those which allow judgments of technical and legal operationability and of access to material resources necessary for the fulfillment of the project considered to be out of date, reside in the difficulty of the exact definition of objectives for each project. One project can be good from the social point of view, but may not be efficient in the drawing

* United Nations, "Manual of Preparation of Industrial Feasibility Studies"

of resources nor in the generating of appropriate receipts. The awareness of these differences makes us identify beforehand the objectives of the project and judge it according to a criterion consistent with that objective. Because the objectives can be varied, so can the criteria, on the strict condition that for each objective there is one and only one criterion.

Thus were born the project appreciations within the viewpoint of the company and within the viewpoint of society. Still within the viewpoint of the company can be identified, for example, criteria of profitability from the overall investment viewpoint (for which the project financing conditions are irrelevant) and from the viewpoint of its own capital, which imposes, on the other hand, careful attention in how it is financed.

From the society viewpoint, there can still be distinguished the appreciation of price efficiency and the appreciation which takes into account the distribution of earnings generated by the projects.

5. Varieties and specific features of building construction projects

By nature, building construction projects should fit into different levels of appreciation and be judged by criteria which the different viewpoints impose, as, in principle, nothing is against that projects of this nature try to answer the various objectives underlying the different criteria. Meanwhile, the fundamental question which it places is that of knowing if the building construction projects will fit in better than others and above all, evaluation expressions which are more suitable to them, by the convenient adaptation of the general judgment criteria which, obviously, are not at issue.

5.1 Building Construction Project versus Industrial Project.

An investment project, looked at in a very aggregated way, consists in the application of resources which are saved (that is, that are not already consumed), to generate future resources, at a rhythm and intensity which compensates (note the compensation criterion) the abdications to consumption made in the present.

In this perspective, a typical industrial project consists of the application of a group of resources which are materialized in buildings, equipment, laboratories and other means of production, allowing the transformation of raw material and intermediary products, through the use of suitable labour—which will generate, for various periods, net receipts which are expected to compensate, with more or less “generosity”, the fixed resources (investment).

And here appears the first big difference in relation to a building construction project. This is that, normally, in an industrial project there is a period beforehand given over to investment (additional investments are of course, not excluded throughout the period) and another one given over to production and obtaining receipts which will have to make the project profitable, with the essential characteristic that the production period has a duration which is frankly longer than that of the investment period.

On the other hand, in a building construction project, the investment phase is almost confused with the production phase, for the simple reason that, in most cases, the building construction project is totally incorporated in the investment phase of agricultural and industrial projects, which are its “clients”, with the worsening factor that, frequently it does not correspond to any receipt which will be collected once only at the single act of the sale of the complete construction. This means to say that, generally, the life of a building construction project is much less than the cycle of an industrial project and, besides that, the schedules of receipts and expenses, even within periods of time of different lengths, are very asymetrical.

Such striking differences are only not felt so sharply when one does not analyse a building construction project, but a building construction firm, over a sufficiently long period of time in its life, as, in this case, each of its individual projects can be considered as one of its products which, during the time of evaluation, start appearing and are sold with regular cadences as happens, for example, with the equipment-producing industries.

5.2 The analysis of the project as a relevant concept of appreciation

Returning to the level of the building construction project there can be no doubts that the different characteristics and the different schedules which it presents compared to industrial projects makes one rethink the most suitable methodologies for their appreciation.

Reduced to this mere evaluation, through the traditional criteria of IRR and of NPV, if this is already bad for industrial projects, for civil construction projects they are a veritable fraud: it is that these indicators cannot encapsulate, in themselves, all the values of a project and, much less, give reasonable indications about the level of risk involved in it. In a normal building construction project these criteria, not being impossible to calculate, have an adulterated meaning, above all when one does not foresee a continuous flow of receipts but payment only once per act of sale. Thus, although less so in industrial projects, if the tendency has been increasing for evaluation to be only one of the steps in judging the whole process of the analysis of the project, it is crucial that this be, definitively, assumed as the relevant methodology for building construction. Nor can it be any other way if we look at what from the industrial project analysis process is part of a construction and implementation phase, that is, is part of the whole building construction project, while a supplier of industry.

Consequently, more relevant than the profitability indicators, with some interpretation difficulties as, like we have stated, the “investment” and “production” periods are here confused, is the control and the evaluation of the costs of its confrontation with the possible configuration of the receipts. They are much more in the hands of the investor than those who will decide in the end the level of risk which the project incorporates.

We cannot therefore accept, with an open mind, that as is stated in the thesis which served as a basis for this short essay* and that exemplifies building construction, that relevant costs for the analysis of construction costs (this is the aggregation) are considered at the same level as those of the project, control, licences, financing and others. One has to “discount” the construction costs in their various components and to schedule them adequately, as they constitute, in reality, the heart of the “productive process” of building construction. Without its disaggregation there is no analysis of the project.

5.3 The relevance of schedules in the analysis

This need to open the "black box" of the construction costs connected to the relatively small time duration of the project cycle (which we consider closed at the act of sale) imposes a scheduling which is sharper in these projects than in that which is used for industrial projects. And if for basically financial reasons, the use of term as a unit of time already begins to seem common, in substitution of the traditional annual period, in building construction the assumption of this period of time is vital, if not an even sharper period, such as a month, with the successive reinterpretation of the meanings of IRR and NPV.

It is only with this level of time disaggregation that it is possible to control and specify adequately the various items of construction, as well as the financial responsibilities, always present in this activity (which makes the viewpoint of one's own capital the most relevant in this type of evaluation) and also, above all, the receipts offered when the work is being paid, part by part, according to what has been constructed, which happens when the client has already been found and the uncertainty was reduced drastically. When this does not happen, this scheduling is fundamental for the analysis of the sensibility to the taking of receipts not assured, the only way of putting together a perspective of risk, admitting the tight and careful control of costs and of financial responsibilities of the construction.

Naturally, various types of construction are shown which appeal to analyses of different types, according to different perspectives of receipts and uncertainties which surround them. These are, for example, the cases of public works which can raise the problem of evaluation from a social point of view, at the same time having a certain schedule of receipts, if these were duly budgeted and the budgets were applied on time. Meanwhile there is some confusion in this application. Thus, let us imagine a construction of a new motorway. This is a work which can be evaluated from the social point of view. Only that fundamentally the exploitation of the motorway and not its construction is applied, as the construction project is considered completed with the handing over to the concessionary. But, from the country's or the community's point of view, the motorway construction project and its exploitation are not separate. The first is the investment phase and the second is the exploitation phase of an overall project which has to be evaluated, as a whole, from the society's point of view.

6. Final Conclusions

This last example, one of many which we can call on in the great variety which building construction and civil engineering offers, tries to leave open, if possible, the need to look further into the methodologies suitable for selecting and analysing (the evaluation will be the least relevant) each one of the projects, noting its specific features concerning its purpose, type of construction, type of client and schedule for execution. The considerations which we have covered are only a starting point for further deeper investigation into the economic needs the sector naturally requires.

* V.Garcia Martins, "Rentabilidade de Investimentos Imobiliarios, Avaliação, Tomada de Decisão e Controlo", Faculty of Engineering, University of Oporto, 1989.

143
Economic evaluation of structures in high rise commercial buildings

S.SINGH

Abstract
Charts, giving relationships between the quantities of various constituents of construction and the number of storeys, have been developed for commercial buildings in reinforced and prestressed concrete up to fifty storeys high. Column grids of varying sizes have been considered and the structural floor systems comprise of beam and slab, flat slab and waffle slab for reinforced concrete, and beam and slab for prestressed concrete construction. The quantities of concrete, steel and formwork derived are based on actual analysis and design which make the use of charts more realistic for cost estimates compared with the prevailing approximate methods. The charts presented are useful for comparative economic evaluation of structural schemes, preparation of cost estimates, budgeting for materials and checking of estimates.

Keywords: Structural Systems, Economic Evaluation, High Rise Buildings, Commercial Buildings.

1 Introduction

Cost estimates for economic evaluation are often made by assuming approximate quantities of concrete, reinforcement and formwork. In the absence of realistic information relating to variations quantities of materials with changes in sizes of column grids, structural schemes and number of storeys, the quantities assumed tend to be very approximate and the percentage error could be very large. Where more realistic comparison is required, engineer works out alternative structural schemes and the most economical scheme is selected after the quantity surveyor has worked out the quantities and costs for the various schemes. It is extremely unsystematic and wasteful if structural schemes are to be worked out and cost estimated every time a new building project comes up. It is the object of this paper to present charts which help to estimate quantities realistically and quickly in the reinforced and prestressed concrete structures. The charts are based on quantities derived through actual analysis and design of structures for varying column grids and structural systems.

2 Structural systems, analysis and design

Figure 1 shows the structural systems considered in this study. The sizes of the square column grids considered were 6, 8 and 10 metres for beam and slab as well as flat slab construction in reinforced concrete. Prestressed concrete beam and slab systems had grids of 10, 12 and 14 metres. In order to accommodate the sizes of standard moulds available locally, the column grid sizes used for waffle slab construction in reinforced concrete were fixed at 6.4, 8 and 10.4 metres.

The analysis and design were in accordance with the limit state design proposed in the British Code of Practice CP 110: Part 1: 1985, the service loads being taken from the British Code of Practice CP 3: Chapter V: Parts I and II: 1972. Generally, the first five floors of many commercial building are built for shopping and the remaining for office blocks. This trend has been taken into account in the various structures of different numbers of storeys. Dead loads of 1.2 kN/m^2 for finishes, 0.25 kN/m^2 for ceiling and 1.0 kN/m^2 for lightweight partitions have been considered in the analysis. The assessment of wind load was made for a basic wind speed of 31 m/second in the Singapore context. An ultimate horizontal load equivalent to 1.5 per cent of the total characteristic dead load was considered in place of wind load from stability considerations where the effects of these loads were found to be more severe than those of wind loads. A floor to floor height of 3.5 metres was assumed. Some adjustment in quantities given by the charts presented in this paper would be necessary where deviations occur from the assumptions stated above.

Frame-shear wall interaction was considered in the analysis for lateral loads, sub-frame, grid beam and continuous beam analyses being carried out for gravity load analysis depending on appropriateness. Flat and waffle slabs were designed using the empirical methods given in the British Code of Practice CP 8110:1985.

3 Quantities of constituents

The total quantities of constituents for the interior grid of different structural schemes for beam and slab system are shown in Figs. 2 to 4, for flat slab system in Figs. 5 to 7, for waffle slab system in Figs. 8 to 10 and for prestressed beam and slab system in Figs. 11 to 14.

Over 250 charts for quantities in individual elements for different grid locations, grid sizes, number of storeys, grades of concrete etc. have been developed and presented elsewhere by Singh and Murthy (1980, 81, 83).

4 Interactive computer model

Regression analysis was carried out to establish statistical relationships between quantities of each of the constituents of construction, in the different structural components as well as in the total structure, and the number of storeys of construction. The relationships were established for all the structural systems studied for the different structural schemes, grades of concrete, types of reinforcement and sizes of column grids. Interactive computer models have been developed by Singh (1987, 89, 90, 91) incorporating these statistical relationships which will facilitate rapid evaluation of the effects of various design variables on the quantities of constituents of construction and in turn the structural cost.

5 Application

At the architectural design stage, besides considering other factors, cost is one of the important criteria in deciding about the structural scheme and the grid size. The results of this investiga-

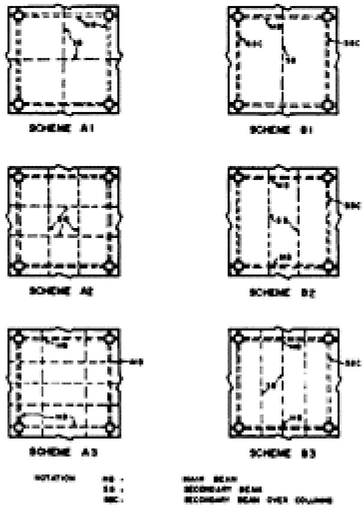


FIGURE 1: DESIGNATION OF STRUCTURAL SCHEMES AND COMPONENTS

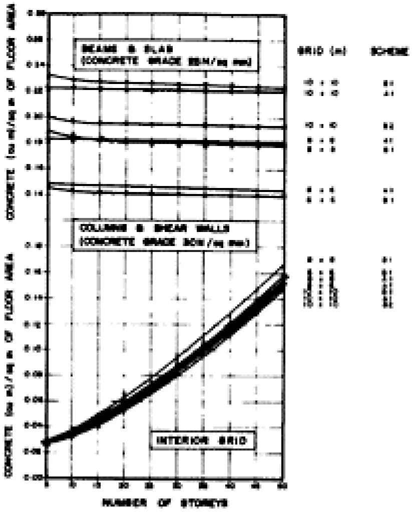


FIGURE 2: QUANTITES OF CONCRETE IN DIFFERENT ELEMENTS OF TOTAL STRUCTURE FOR REINFORCED CONCRETE BEAM AND SLAB CONSTRUCTION

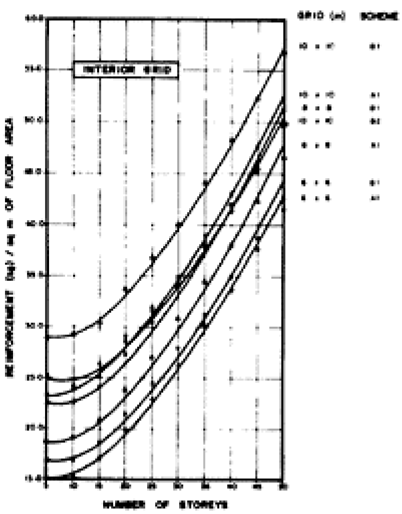


FIGURE 3: QUANTITIES OF REINFORCEMENT IN TOTAL

STRUCTURE FOR REINFORCED CONCRETE BEAM AND SLAB CONSTRUCTION

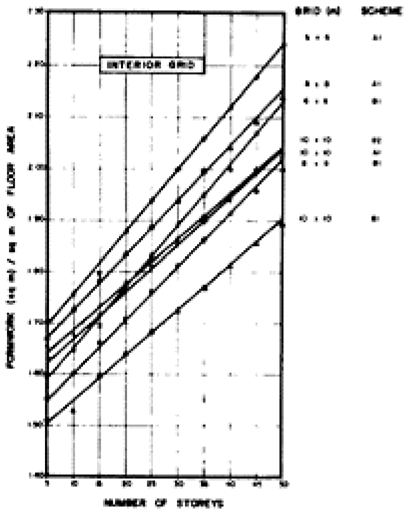


FIGURE 4: QUANTITIES OF FORMWORK IN TOTAL STRUCTURE FOR REINFORCED CONCRETE BEAM AND SLAB CONSTRUCTION

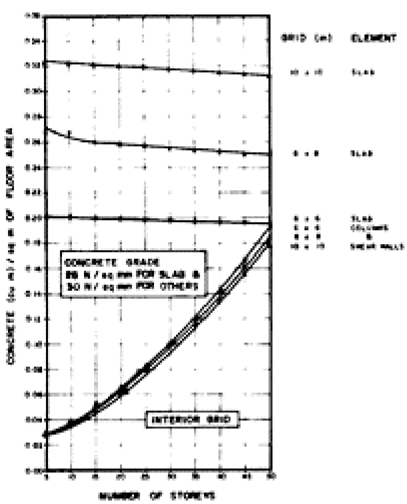


FIGURE 5: QUANTITIES OF CONCRETE IN TOTAL STRUCTURE FOR REINFORCED CONCRETE FLAT SLAB CONSTRUCTION WITHOUT COLUMN HEADS

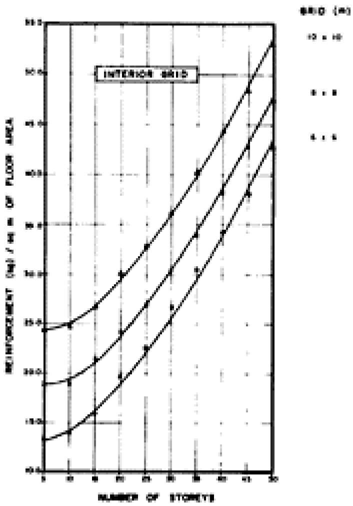


FIGURE 6: QUANTITIES OF REINFORCEMENT IN TOTAL STRUCTURE FOR REINFORCED CONCRETE FLAT SLAB CONSTRUCTION WITHOUT COLUMN HEADS

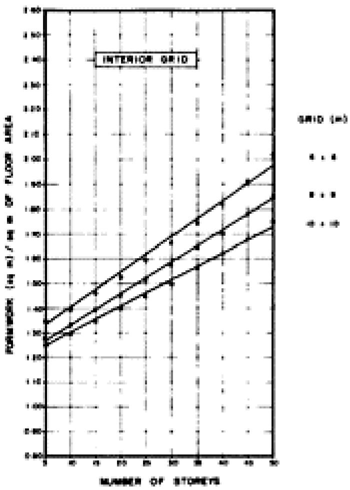


FIGURE 7: QUANTITIES OF FORMWORK IN TOTAL STRUCTURE FOR REINFORCED CONCRETE FLAT SLAB CONSTRUCTION WITHOUT COLUMN HEADS

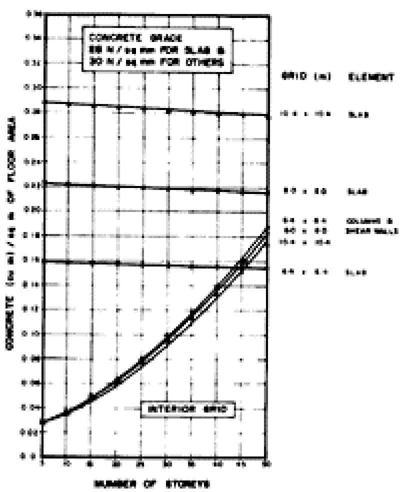


FIGURE 8: QUANTITIES OF CONCRETE IN TOTAL STRUCTURE FOR REINFORCED

CONCRETE WAFFLE SLAB CONSTRUCTION WITHOUT COLUMN HEADS

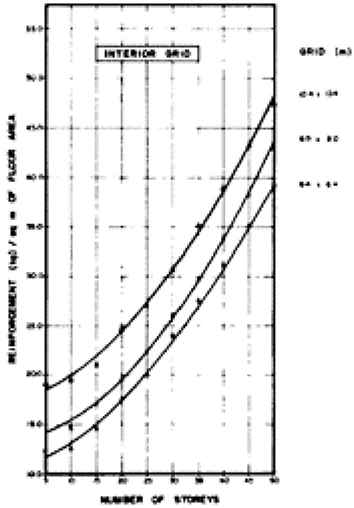


FIGURE 9: QUANTITIES OF REINFORCEMENT IN TOTAL STRUCTURE FOR REINFORCED CONCRETE WAFFLE SLAB CONSTRUCTION WITHOUT COLUMN HEADS

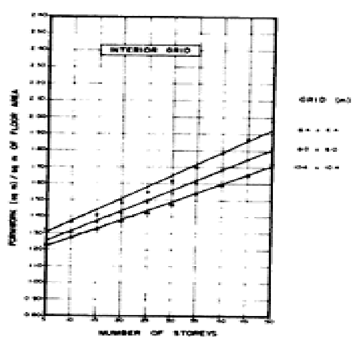


FIGURE 10: QUANTITIES OF FORMWORK IN TOTAL STRUCTURE FOR REINFORCED

CONCRETE WAFFLE SLAB CONSTRUCTION WITHOUT COLUMN HEADS

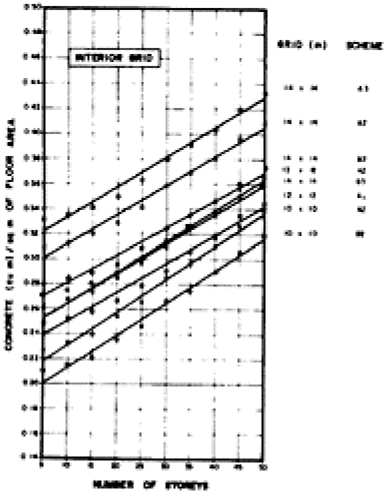


FIGURE 11: QUANTITES OF CONCRETE IN TOTAL STRUCTURE FOR PRESTRESSED CONCRETE BEAM AND R.C. SLAB CONSTRUCTION

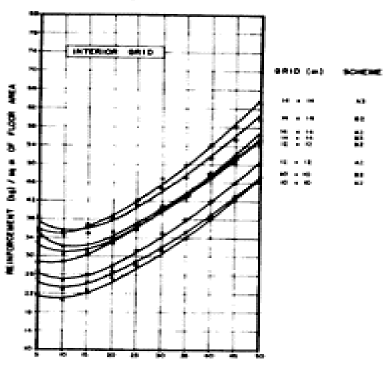


FIGURE 12: QUANTITIES OF REINFORCEMENT IN TOTAL STRUCTURE FOR PRESTRESSED

CONCRETE BEAM AND R. C SLAB CONSTRUCTION

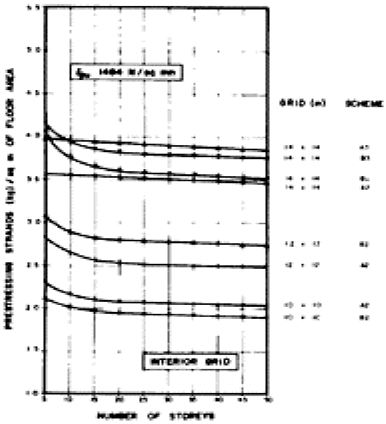


FIGURE 13: QUANTITIES OF PRESTRESSING STRANDS IN TOTAL STRUCTURE FOR PRESTRESSED CONCRETE BEAM AND SLAB CONSTRUCTION

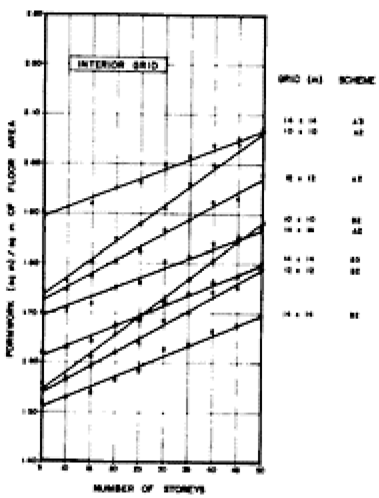


FIGURE 14: QUANTITIES OF FORM WORK IN TOTAL STRUCTURE FOR PRESTRESSED

CONCRETE BEAM AND R.C. SLAB CONSTRUCTION

tion can be utilized to compute the cost of alternative structural schemes and a proper decision can then be taken. Approximate cost estimation, budgeting of materials, approximate checking of design and estimates are some of the other areas for which the results of this investigation can be usefully employed. These are illustrated by Singh elsewhere (1987).

6 Conclusion

Appropriateness of a structural system for a building from the point of view of cost depends on the relative prices of materials of construction which vary disproportionately from time to time. The charts for the quantities of materials presented in this paper form a convenient tool in estimating structural costs for new projects and for selection of suitable structural systems.

7 References

Singh, S. and Murthy, C.K. (1980) Charts for quantities of materials in reinforced concrete structures for buildings. 5th Our World in Concrete & Structures Proceedings, Singapore, pp. F1/01–19.

Singh, S. and Murthy, C.K. (1981) Charts for quantities of materials—flat and waffle slab construction. 6th Our World in Concrete & Structures Proceedings, Singapore, pp. E3/01–19.

Singh, S. and Murthy, C.K. (1983) Economics of structural floor systems. Structural Systems for High-Rise Buildings Seminar Proceedings, Singapore, pp. 01–40.

Singh, S. (1987) Application of computer based cost models for building structures in concrete. Proceedings of the Second International Conference on Computer Applications in Concrete, Singapore, pp. 201–219.

Singh, S. (1987) Cost model for approximate cost estimation of structural systems in high rise commercial buildings. Proceedings of CIB W-55 Symposium on Building Economics, Copenhagen (Denmark), pp. 121–132.

Singh, S. (1989) Computer model for cost estimation of structures in high rise commercial buildings. Proceedings of the Annual Conference of Associated Schools of Construction, Nebraska (USA), pp. 18–27.

Singh, S. (1990) Cost database for structural systems in high rise commercial buildings. Proceedings of International Symposium on Value in Building Economics and Construction Management, Sydney (Australia), pp. 625–635.

Singh, S. (1990) Cost model for reinforced concrete beam and slab structures in buildings. ASCE Journal of Construction Engineering and Management, 116, pp. 54–67.

Singh, S. (1991) Cost estimation of prestressed concrete beam and reinforced concrete slab construction. International Journal of Construction Management and Economics. Accepted for publication.

Singh, S. (1991) Computer based cost model for reinforced concrete flat slab and waffle slab structural systems. International Journal of Project Management. Submitted for publication.

144
Computerised co-ordinated data bases in the management of large stocks

A.SPEDDING

Abstract
Data bases used in the management of large stocks of buildings have often grown up as a result of the gradual accumulation of systems and where these have been computerised this has often been done incrementally, starting off with computerisation of those data required by a Finance Department. Frequently, coding structures relate to previous manual bookkeeping systems or, in some cases, off the peg or slightly modified commercial accounting systems. With the increase in computing power many operational departments in large organisations have invested in mini computers, and micro computers have been bought for use by other operational staff who have devised programs to suit the information which they wish to hold in order to monitor their own work. Such systems have seldom been compatible with either the mini computer based system or the main frame system. This paper examines some of the problems related to such systems, the need for co-ordination of data bases throughout the organisation, and suggests that management should clearly define the purposes for which data are to be used. The author is conducting two research projects on the management and budgetary factors related to large stocks of buildings, one funded by the Hong Kong Housing Authority and the other by the Science and Engineering Research Council, and wishes to acknowledge with thanks the support of both these organisations.

Keywords: Data bases, Computerisation, Property Management, Maintenance, Built Assets.

1 Introduction

Housing by its very nature tends to be provided in many countries by municipal authorities and also by non government organisations. As housing frequently involves large numbers of units, many of which are built to relatively standardised space norms and quality standards, there tends to be an element of repetition even where the units are not completely standardised. Usually there is some repetition of specifications in respect of construction, finishes and fittings. Therefore housing lends itself to data collection and co-ordination in respect of the maintenance of quality at a more detailed level than is likely with large stocks of rather more disparate buildings. Where there is considerable repetition there is obviously scope for statistical and other means of forecasting of failure and there is opportunity for feedback into the system to improve specifications so that the overall quality and economics of housing may be improved over periods of time.

It is also the case that housing authorities will be significant buyers in the market place and therefore can apply pressure to manufacturers to modify their products if they can collect adequate information on failures. In the European context this is extremely important as the development of the single market will mean that the market potential for manufacturing firms is immense. Although supply and demand overall in some countries is roughly in balance, in some cases the housing is not in the appropriate place, and possible effects of demographic change and the movement of population could be considerable. There is of course a continuing debate on the role of the public versus the-private sector but it is likely that in most countries the public sector will have to take the initiative in commissioning housing even if they don't actually build and manage a lot of it themselves.

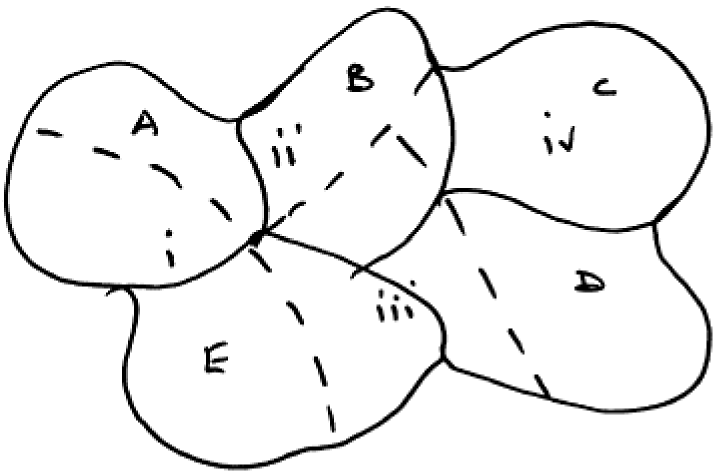
The relationship of supply and demand of course is important in respect of the amount of new build versus the need to maintain and manage existing stock. In the United Kingdom the tendency over the last ten years has been for the proportion of building maintenance to rise relative to the total output of the construction industry, whilst cyclical change in new build demands upon the Industry has affected the economics of maintenance. As has been seen in recent years in the United Kingdom the prices for maintenance work have escalated rapidly in times of boom, thus upsetting the budgets of many large housing authorities. The considerable rises in wage payments to specialist tradesmen in times of boom is exacerbated by the fact that the proportion of labour in maintenance and refurbishment is higher than new build. Additionally, the relative rise of maintenance work inevitably affects the organisations which are managing the stock. Many of these have been built up over a period of years, in response to a demand for new build, and have gradually been making the transition towards maintenance management. Thus the organisation, its staffing and its method of data collection and recording may have been devised for purposes which don't entirely pertain now.

The problems of co-ordination of data bases and the management of large stocks of buildings where quality and economics and the consumer are also to be considered, suggests that the concept of Facilities Management is appropriate in this field. The author has written an introductory paper on this topic 1 and suggests that quality in housing has to be established not only from the point of view of the owner/landlord as in the case of a municipal authority or housing association but also from the point of view of the user/tenant of the property.

2 Organisational Considerations and Data

In a large housing authority there may be two interlocking organisational groupings, one relating to housing management areas, and the other to maintenance and construction work teams. **Figure 1** illustrates the problem where the area is split into five housing management areas (A)–(E) but four maintenance areas (i)–(iv).

Figure 1



Of course it may seem sensible to make these areas coincide, particularly as the total will be subject to Finance Department control overall. In practice the different needs of the organisation and the need to ensure that workloads can be efficiently dealt with mean that apparent tidiness has to give way to practical considerations. Having said that, there are clearly areas of data which are of equal interest to the different management groups. As an example, changing perceptions of environmental quality will probably first be signalled to housing management due to the dissatisfaction of tenants and users of the building stock. They may find for instance that they are not able to keep the buildings completely free of damp and condensation because the cost of heating systems is high. Thus housing management will have to look to the maintenance and construction division of the organisation to try to improve the insulation or heating and ventilation of the properties. Tenants' organisations will tend to contrast good estates with estates which they feel are deficient in some way and this in turn will affect the rentals which they feel are appropriate to the properties and thus potentially the economics of operating stock. It is clear therefore that the total cost of operating the stock must be known so that in extreme cases complete renovation or replacement may be undertaken where the total costs of the property may reach an uneconomic level. If the data base is not co-ordinated between the various parts of the organisation it will not be easy for management to establish from the data that policy needs to be reconsidered in respect of the operation of certain of their properties.

The scope of data required for overall management is potentially very wide and although the case is made here for co-ordinated data bases it is not suggested that all of the data which are required for management at various levels of the organisation should be interchangeable or accessible at all levels. What is suggested is that the system should allow for data aggregation and reporting to senior management, with the proviso that management may then call for reports in more detail from operational departments on an "as and when" basis. Areas will normally have been chosen in accordance with policy of the authority which may have been to ensure that relatively equal workloads are distributed throughout the areas and grades of staffing employed. The need to initiate programmes of refurbishment or large maintenance projects means that the workload in one area may change radically in respect to the other areas. This might require the drafting in of new staff, the deployment of special project teams, or the revision of the boundaries of the areas concerned in order to equalise workloads. Whichever strategy is adopted, some aspects of the organisation and the data will be affected, such as the code which defines which property is in which management area, or which maintenance teams are working in which area.

It is likely that emergency repairs up to a certain value will be ordered immediately by housing management on the estate from local contractors on a list of approved contractors. However, over a certain value the Maintenance Department would have to be called in. The maintenance organisation is likely to be regionalised up to a certain level of authority and their referencing of the properties may well differ from housing management. As an example, it is frequently the case that housing management staff will refer to estates by name and these names may have been chosen for all sorts of reasons. The building maintenance division may well refer to the estates by codes related to the period when they were built, or the type of design that was employed, and/or the region in which they are situated. Also whilst housing management may have a name for a complete estate, it may be that building maintenance has numbers or some other reference for individual buildings on that estate. In order to begin to identify the characteristics of data so that comparative costs may be collected and management may begin to establish value for money, it is essential that whatever referencing systems are used, the computer can recognise particular properties at a level of detail which is considered appropriate to the organisation.

Discussions between the various users of data must take place at regular intervals in order to ensure that data are collected at an appropriate level. For instance, Treasury may be content to audit the costs of oil fuel at an estate level and housing management staff may not be particularly interested in this aspect, whereas construction staff would be interested in the efficiency of, for instance, energy improvement schemes. They therefore might wish to identify which blocks are making savings as a result of the improvements compared with blocks which have not been improved.

The need for an authority wide compatible system for collecting and recording data is clear. The purposes of collecting data however must be clearly understood. The Finance Department will require to keep track of spending related to the heads under which the overall budget is established and under which the monies are allocated to the authority or housing association from funding sources. Thus we are likely to see broad headings such as specially funded properties, rented properties, properties disposed of under right to buy, or sold under some other legislation. There may also be non-housing properties such as day centres, car parking areas and garages, shopping and commercial areas associated with housing, and maybe even provision for public transport and education premises. The Housing Management division will be principally interested in allocations and rentals related to type, size and location of accommodation and may order minor emergency works. They are unlikely to wish to interrogate maintenance and repair records at any level of detail. The maintenance and construction division will, however, be keenly interested in the cost and incidence of failure and will wish to monitor value for money in relation to the upkeep of the stock. Thus the finance and management systems should interlock at a strategic level with the property data base.

3 Levels of Detail of Data

The essentials of a property data base system are well known and have been summarised elsewhere 2 and consist principally of:-

(1) Asset register of physical details of properties.
(2) Condition register of principal, or important, elements.
(3) Maintenance and other cost data.

It is important that these three aspects of property data are recorded in a way, and at a level of detail, which allows exchange of information and updating of data. As an example, a renewal of a heating system recorded under (3) should trigger an updating of (1) to register a different type of manufacturer, and an updating of (2) to "new condition".

The asset register should contain estate management data plus records of significant elements and sub-elements in respect of sizes, types, manufacturers and similar data. Such data must only be recorded in the mainframe system if they relate to the other two parts of the system. More detailed data required by specialist groups such as heating engineers should be kept by them locally on a compatible micro computer. Locational data may be included if required, such as records of which dwellings are owned by the authority and which have been sold to tenants.

The condition register may be combined with the asset register, but it must be possible to obtain overall condition information and to update it. This requires a condition recording system which may be more dynamic than the asset register, and which is easily related to the budgetary process.

Cost data are likely to fall into the following categories:-

Planned maintenance
- Preventive maintenance
- Day to day emergency or unplanned maintenance
- Minor capital works
- Programmes of improvement
- Work in connection with health and safety
- Energy conservation programmes.

These categories are not always completely distinct and there is often some overlapping of work. It is assumed that preventive maintenance is that which is planned in advance with the intention of avoiding problems (reducing risk) whereas planned maintenance is that which is planned in advance in response to known or suspected problems. Many authorities attempt to increase the proportion of planned and preventive maintenance relative to unplanned in the belief that this is a measure of greater efficiency. Much of the policy in respect of these categories depends on the relative amounts of money available for maintenance. It is usually the case in the United Kingdom that constraints on the money available for maintenance means that unplanned maintenance is a relatively high proportion of the total, and one must carefully monitor the effectiveness of preventive maintenance.

The levels of detail of cost data recorded are frequently based on the headings which have traditionally formed the basis for bidding for funds in the past. These headings are often subdivided into items which are a mixture of elemental and locational descriptions based on historical needs. Frequently the level or nature of detail is not sufficiently relevant for information to be particularly informative 3, either for monitoring purposes, or for assisting with budget forecasts.

Many orders for maintenance work will fall under clear elemental headings such as plumbing, joinery, or roofing, and such work can be coded on a computerised menu basis by relatively non-technical staff. Unfortunately, larger and composite orders may not be easily coded, nor will it be economical to break down orders for such work into their component parts. Thus a logical system of incorporating composite minor works and programmes of improvement into the data must be devised. This might be based on the major reason for the work, e.g. toilet improvements recorded under plumbing, or more likely, under a numbered series of “special programmes” which can be retrieved with a brief description. As noted above, special programmes must provide for updating the condition of elements in the asset or condition register.

The method of payment for work in preventive and other maintenance may relate to schedules of rates. It is often found that the classifications of work do not bear direct relationships to cost record headings, and this is one area where computerised data bases should be made compatible. That is not to say that the whole of the data in schedules of rates should be computerised for maintenance cost record purposes. Nevertheless, it should be possible to allocate work from schedules of rates into the broader headings which are to be used for record and budget bidding purposes.

4 Codes for Data

In the introduction above it was suggested that the concept of Facilities Management is a useful discipline within which to consider the co-ordination of data for effective management.

Many FM organisations hold asset register data on computer, linked to a Computer Aided Design programme. Therefore, spaces and their contents may be coded and itemised. This is not, however, likely to be cost effective for a housing authority as the asset register tends to be relatively static. Therefore, detailed drawings and Estate Management data will usually be held on manual files, perhaps with main characteristics and layout plans only held on computers. The significant element descriptions, with quantities where appropriate, will be available for call-up on the screen and may be coded as for elemental maintenance data. Data of construction/replacement will also be held on computer. The management should be able to ask questions, such as “how many gas fired pressed steel domestic boilers do we have and where are they?”

The condition register will therefore link with the asset register codes and will be based on, say, four levels of condition, coded one to four. There are some authorities who suggest that a larger number of categories will help with prioritising planned work for budgetary purposes, but this raises problems of ensuring consistency of condition decision across a group of staff. Management, however, has another problem at times of budgeting and ordering work, and that is that other priorities also have to be considered, such as heating repairs or leaking roofs in Winter. The data may also be linked with expected remaining life of key elements which can assist with forecasts of possible failure.

Codes for maintenance and related work must provide for sortation of data for management purposes, and must be easily entered into the computer. In order that the people entering the codes feel that accuracy is worthwhile, they should, where appropriate, receive data summaries as feedbacks.

Objections are sometimes raised to using detailed codes on the grounds that they become rather lengthy and are beyond the capacity of the average operational employee to memorise. However, when ordering work, elemental codes can be drawn from the computer, based on a menu of descriptions which means that progressively the person issuing the order has to respond to questions which lead from the general to the more particular. Similarly, other information of use such as name of the contractor, the relevant schedule of rates, item numbers, the name and grade of the person ordering the work and so on can easily be incorporated.

The extent of detail to be recorded depends entirely on the requirements of the authority operating the computer system as the capacity of modern main frame computers is quite able to accommodate several levels. As an example, it is important to know which elements of service installations are breaking down regularly and these must be distinguished in the coding system such as, for instance, pressed steel boilers in domestic installations. It is likely that the value of the orders will be related to the operational levels of technical staff who are initiating the work, and they should have little difficulty in allocating elemental descriptions. In many cases, however, orders may be locally issued on estates by housing management staff and may in fact bypass the computerised system but they are likely to be of relatively insignificant value.

In the case of the composite orders which usually will be issued by more senior staff it will be up to senior management to decide how those costs will be allocated. In other words, if there is a case of a roof leak which involves consequential work to ceilings and services, then the decision may be taken to allocate the work solely against roof leak, where that work is being undertaken on an emergency basis. Similarly, work may be allocated against specific programmes as mentioned above, such as health and safety or environmental improvements for instance.

It is suggested that the principal codes for maintenance data will involve the following characteristics.

Location of the work e.g. Estate No. 3, Block 35.
Elemental and materials information e.g. flat felted roof.
Process code, e.g. inspect and repair.
Reason code, e.g. unplanned maintenance, due to adverse weather, causing ingress of water.

Location codes used in conjunction with cost codes must match the levels of detail in the asset register. Thus in multi-storey flats, in addition to identifying which block on an estate is being worked on, it is necessary to identify which flat. This can usually be a three digit code. It may need to have an orientation component if work is being done to the face of a building such as in concrete repairs.

If detailed data on failure is likely to be needed, elemental codes are best arranged on a hierarchical basis, as described elsewhere 4. Thus it is easy to incorporate as many levels of detail as are required, although a four digit code is usually sufficient for most authorities. The special programme codes can be incorporated into this system, so that all codes beginning, say, with zero, are of this category. The process code mentioned also will be associated with the elemental codes.

Reason codes have been described elsewhere by the author 5 and will be entered by technical staff possibly in two stages. The first level (policy/budget), such as "unplanned maintenance", is entered on the order at issue. The second level (cause of failure), such as "due to adverse weather", and the third level (result of failure), such as "ingress of water" may be entered at issue if technical staff are involved, or later when the invoice is confirmed. In many authorities two levels of reason codes will suffice, if carefully designed.

5 Conclusion

The co-ordinated data system described above is capable of being increased, or reduced, in scope, according to the computer system available. More importantly, it is capable of adjustment according to the staff numbers and expertise employed in an authority. The use of a menu system which asks questions on the screen and then automatically codes the answers enables useful data to be collated without the need to memorise long codes.

Such data may be collated and expressed in terms of cost per dwelling or per square metre of floor area and may be used for management, forecasting and budget bidding purposes. This of course may require priorities to be assigned to certain classes of work, or types of property and the element of human judgement will still be required where cost is not sufficient to undertake all work considered necessary. A co-ordinated data base system will, however, make it easier for management to monitor condition achieved in value for money terms.

6 References

1 Spedding Alan (1991) **Facilities Management in Proc** R.I.C.S. Research Conference, E. & F.N. Spon

2 Spedding Alan (1987) **The Need for and Uses of Data in Building Maintenance, Economics and Management,** E & F.N.Spon

3 **Terrtechnology and the Maintenance of Local Authority Buildings** (1981), LAMSAC

4 Holmes Roy (1985) A **Coding System for Building Maintenance** CIOB Technical Services, Paper No. 47

5 Spedding Alan (1988) **What do you Want to Know About Causes of Failure of Building Components in Proc.** CIB W70 Seminar, Heriot Watt University 1988

145
Refurbishment of the ‘Dennis-Wild House’

S.TODD

Abstract
A refurbishment project in Stretford Nr. Manchester involving the Dennis-Wild House is studied in detail. This form of construction appears totally traditional externally but a close examination reveals a structural steel framework with mechanical roof trusses. Condition surveys by the Building Research Establishment and Trafford Borough Council have shown a wide range of defects. These defects are analysed and the techniques used to overcome them are described in detail.

1 Introduction

In 1919 a Standardisation and New Methods of Construction Committee was set up to solve the problems of housing shortage. The Dennis-Wild system is not documented in the proceedings of the committee but it is felt that because the system was used in 1922 the initial push came from that committee.

In 1942 the Burt Committee listed James Wild & Co. (Housing Ltd.) of Blackpool as the sponsor of the Dennis-Wild system. The Dennis-Wild system sponsored by Edgar B.Dennis (Blackpool) is also listed with a house description very similar to the Dennis-Wild system. It is thought that Wild and Dennis merged to support a single system. According to the Building Research Establishment approximately 9,000 houses were built on various sites in England for local authorities and private owners.

2 Outline Specification

The Dennis-Wild system is unusual because a steel framework is used to support the main structural loads from the first floor and roof. The structural frame is of standard rolled steel members with comparatively heavy stanchions and beams which were widely spaced. The rest of the construction is conventional and therefore the external appearance is totally traditional.

3 Kings Road Estate, Stretford by Trafford Metropolitan Borough Council

There are 133 council owned and 61 private properties on this estate made up of 3 bedroom semi-detached and terraced houses. The houses look completely traditional from the outside but were all found to be of the Dennis-Wild type, the external envelope being constructed of brickwork to first floor level and then tile hanging, brickwork or rendered brickwork up to eaves level.

A survey of the properties on the Kings Road estate was carried out in 1986 from which drawings and specifications were produced for the proposed refurbishment. The estate was split into three phases with work on the first starting in 1987. The expected date for completion of the estate is early 1991. At the same time the survey was underway the Building Research Establishment also used the Kings Road Estate as an example for their work. The general arrangement drawings of a typical dwelling are shown in Figures 1 and 2 and Figure 3 shows a sectional view. A typical front elevation of a tile hung house is shown in Figure 4.

3.1 Details of Construction

The foundations are constructed from 100 mm concrete where there are only external walls and where there is steelwork this is increased to 150 mm by the use of concrete pads. The properties also have a bituminous felt dpc's at ground level.

On the main external walls the steelwork can also be seen as the casing projects from the face (Figure 5). Steelwork is also embedded within the structure e.g. the party wall as Figure 6. Support to the upper floor is also assisted by steelwork (Figure 7) which shows below the existing ceiling line. The support to the joists at the separating wall end is usually by channels which are not visible. The roofs are generally hipped end type the support being given by a cradle roof truss (Figure 3 and Figure 8). The steelwork to the houses typically consists of:

1. 3 eaves height stanchions at the front and rear, at the mid points on the flank end wall, 1 on the party wall and occasionally 1 extra to the flank wall depending on house type.
2. Connection between the stanchions is by 2 floor support channels to gable and party walls and a main floor support beam centrally supported by a single storey stanchion(in some cases this has been missed). Connection between the stanchions at chamber joist level front and rear elevation is by angle ties. All connections were bolted on site.
3. A 125×75 timber beam is connected to the stanchions at first floor level which allowed a timber framed wall to be built above for the tile hanging. Another 150 ×75 timber perimeter beam gives the connection at the top of the steel frame and also act as a wallplate for the roof.

The external walls are generally of cavity construction—two skins of brickwork and a 50 cavity (112.5 external brickwork, 50 cavity, 75 brick on edge internal leaf). The tile hung wall is of timber frame with a felt breather. It is easier to see the embedded steel framework at the timber frame wall as the overall thickness is reduced. The internal walls are generally of brick construction.

The ground floor is of suspended timber construction built directly into the external walls. 100×50 joists @ 380 c/c with solid areas in the hall and kitchen. The upper floors are generally 150×50 joists @ 400 c/c with T&G boarding for the floor and lath and plaster for the ceiling.

The roof construction is traditional hipped except for the use of a cradle roof truss. (Figure 3 and Figure 8). As can be seen in the section the steel rods located in the rafter support the purlins. This was probably included in the existing construction to limit deflection and to brace the main rafters. The presence of a cradle roof truss clearly indicates the Dennis-Wild system. The ceiling near the eaves can be sloping probably to save brickwork in the original design.

According to the Building Research Establishment only small variations of this construction method have occurred at other sites in their survey.

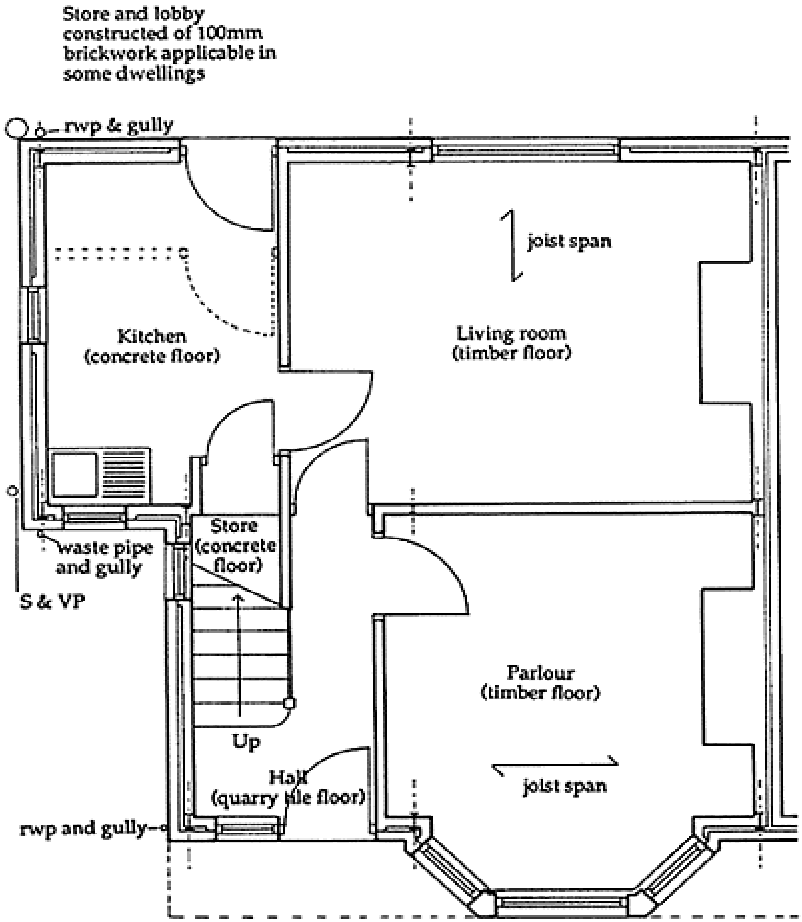


Figure 1 Ground floor plan

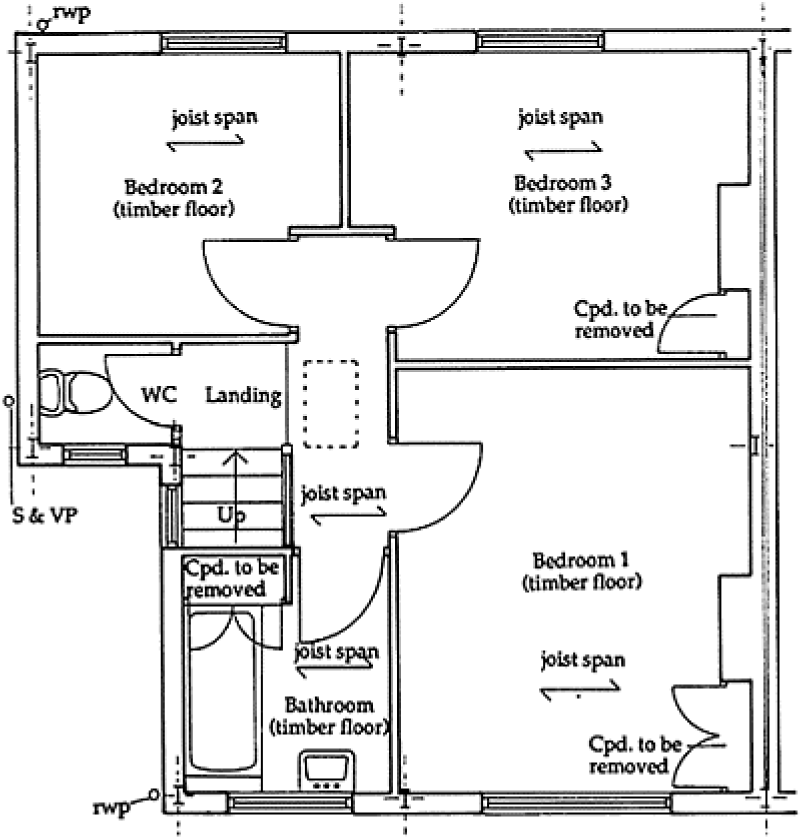


Figure 2 First floor plan

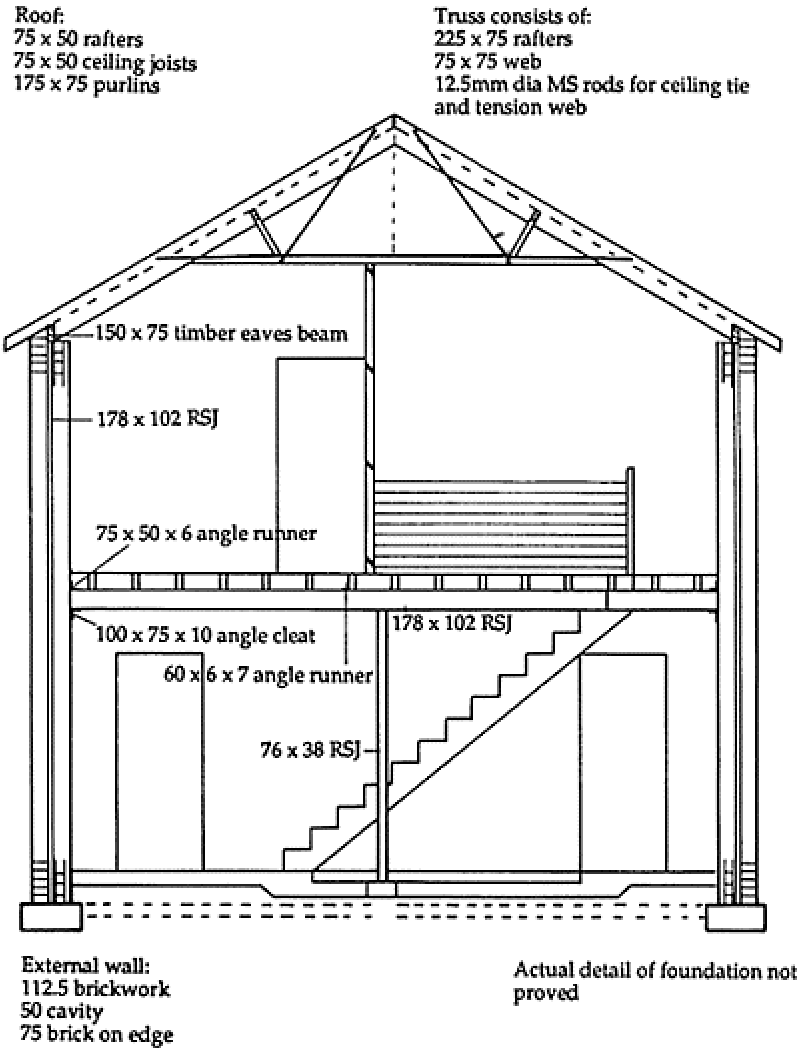


Figure 3 Typical section

Figure 4 A typical front elevation of a Dennis-Wild house

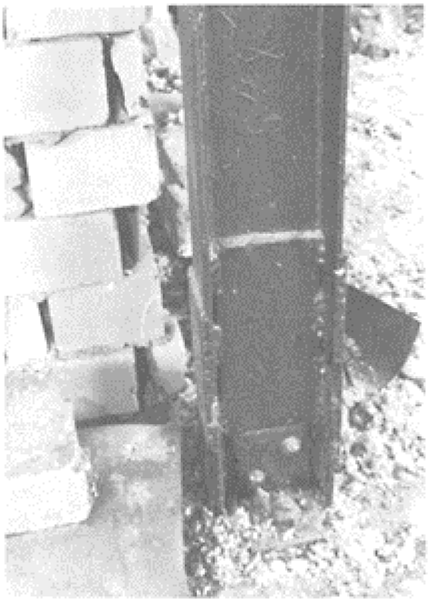


Figure 5 Steel frame exposed at base and treated

Figure 6 Steel frame embedded within party wall

Figure 7 View of internal steelwork showing main floor support at midspan

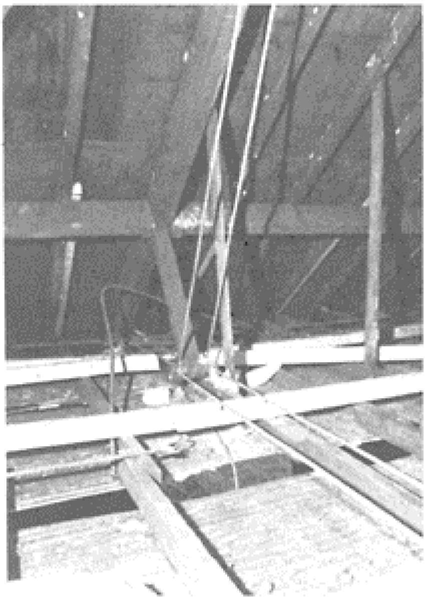


Figure 8 View of cradle roof truss giving support to purlins

3.2 Defects

Some of the defects noted in the original survey were:

Rusting of the steel frame especially on connection with the foundation concrete and where surrounded in concrete in the coal store with some loss of section. (Figure 5) Rubbish in the cavity causing bridging and rusting of cavity wall ties due to the original black ash mortar. (Figure 9)

The bituminous felt dpc's at ground level were all perished.

Bulging of the brickwork due to ineffective ties.

Expansion of steel due to rusting causing splitting in the brickwork

Local foundation failure

Ineffective timber ring beam at eaves level i.e. undersized and rotten Sagging of roof due to undersized purlins and spreading of the roof at eaves level Wear of tile hanging. (Figure 1)

3.3 Improvement, repair and alteration of a 3 bedroom house to contain kitchen, living room, store under stairs, hall, staircase and landing with 3 bedrooms and bathroom with WC

A number of properties on the estate have previously being bought by the tenants under the 'right to buy' and this refurbishment project is only concerned with the remaining local authority stock. This has led to some technical difficulties eg. linking chimneys, roofs and rainwater goods. These difficulties have being remedied by co-operation and technological solutions eg. use of a secret drain gutter between the two sections of roof; connection of new plastic rainwater goods to existing cast iron with special fittings. The average cost of the improvements is between £20,000–£30,000 per house depending on type, specification and phase.

Figure 9 Existing corroded butterfly wall tie

Figure 10 New stainless steel wall tie fixed with resin

The items of refurbishment work can be summarised as follows:

1. Take down and rebuild internal leaf of external cavity wall.
2. Take down all internal partitions and rebuild in timber stud partitions.
3. Replacing windows and front and rear external doors and frames and all internal doors and frames.
4. New d.p.c (some by injection)
5. New plumbing and electrical work including renewal of lead water main
6. New gas fired central heating
7. New kitchen
8. Roof insulation 150 mm thick

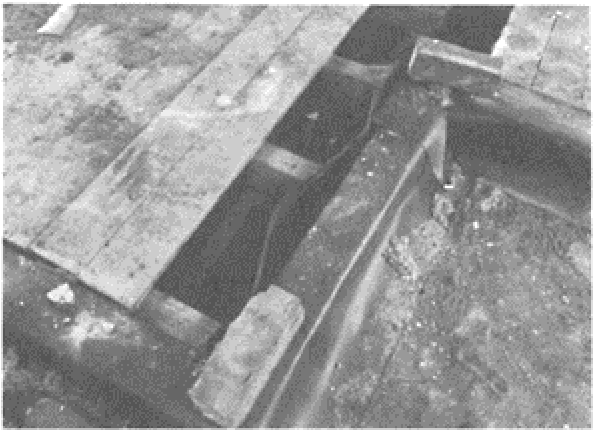


Figure 11 Treatment at junction between existing timber and new solid floor

9. Complete replaster and redecoration internal and external
10. Renew gutters and downpipes
11. Repoint all external brickwork
12. Renew canopy
13. Rebed ridge
14. Taking up and renewing defective floorboards, provide sleeper walls, renew perished.
15. Conversion of flat bay roof to pitched roof—felt, battens, 'Eternit' tiles
16. Provision of hardwood thresholds to doors
17. 100% repointing

3.4 General items Walls and Insulation

1. Take down existing brick on edge wall. Build new 100 lightweight concrete block wall in cement, lime, sand mortar (1:1:6) in stretcher bond.
2. Insulate cavity 50 with blown insulation (Rockwool) treated with a water repellent. Cavity wall ties in stainless steel BS1243 fixed with resin (Figure 10)

3. Take down all GF and FF brick/salamander/block internal partition walls and build new 100×50 stud walls with 50 fibreglass insulation, 12.5 plasterboard, 3 skim.
4. All walls to be replastered with sand/cement render backing and 'Carlite' skim coat.
5. Roof space insulated with 150 mm rockwool mineral fibre; fire stop party wall packing up to u/s of slate roof with rockwool mineral fibre.
6. New d.p.c by liquid injection to give protection to external leaf of external walls and party ground floor walls. (Where walls taken down a physical d.p.c was used— 'Hyload.'
7. New insulated loft access door by Glidevale.
8. Existing concrete and quarry tiles removed and replaced with new hardcore, 50 sand blinding, 1200 G Visqueen, 25 mm polystyrene sheet with 100 mm upstand to external walls and new concrete floor 1:2:4 19 mm aggregate finish to receive pvc tiles, 2 mm 'Polyflex.'

The window specification includes:

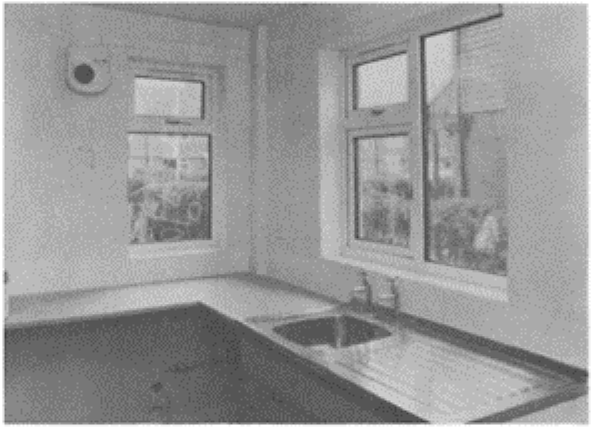


Figure 12 New kitchen and UPVC windows

Double glazed upvc with trickle ventilation, key operated security fastenings from Thyssen' range. (Figure 12).

The work to the living room includes:

1. Remove fireplace and hearth and fix combined gas fired CH boiler and gas fire.
2. Take up existing floorboards 2 boards wide to expose and inspect joist ends. Repack under existing joist ends. Treat joist ends and wrap in bituminous d.p.c and refix existing floorboards (joist ends built into new block wall or new dwarf wall to external elevations). (Figure 11).
3. Underfloor vents by Glidevale MV 250, MV252.

The work to the kitchen includes:

1. Renew concrete floor as previous and lay polyflex tiles.
2. 2No. 100 diameter p.v.c pipes below concrete floor to give cross ventilation.
3. Fix humidity and manually operated extractor fan (sleeved in wall).
4. New kitchen units including plumbing in for washer etc. (Figure 12).

The work to bedroom 1 and 2 includes:

1. Remove fireplace and brick up openings including vents.
2. Fix 15×35 hardwood threshold to doors.
3. Renew any defective floor joists.

The work to the bathroom includes:

1. New fittings and fixtures including a new p.v.c soil stack.
2. New humidity and manually operated extractor fan.
3. New cylinder cupboard.

3.5 Structural Works

Roof

All steelwork was primed off site and include blast cleaning and one coat calcium plumbate primer brush applied.

New 75×50 SW ceiling tie/bracing for gable wall. Four members per gable type house.

New 75×50 diagonal bracing members fixed to gable ceiling ties, hip rafter and nominally nailed to ceiling joists.

Bolted and plated connections of existing rafter, ceiling joist and new rafter.

A new 175×50 sawn sw beam is fixed to the existing timber eaves beam @ 600 c/c with 2No. coach screws.

To assist holding down 30×5 vertical galvanised MS straps 650 long @ approx. 1500c/c screwed to timber beam and plugged and screwed to new blockwork.

External Walls

The existing steel channel is fixed to new internal leaf of gable wall, at first floor level, using M10 resin anchors and refix 3P resin @ 1000 c/c. 30×5 galvanised MS straps 1.2 m long, bent once @ 1000 mm c/c are used for restraint.

Expose base of stanchion:

Carry out treatment A or B to:	178×102 RSJ	(Stanchion central position)
	75×75 RSJ	(Stanchion party/external walls)
	76×38 RSJ	(Stanchion internal wall)

and rebuild to match existing.

The main steelwork treatment defined in the contract documents was type A or B:

Treatment A:

1. All steelwork posts should be blast cleaned from 600mm above plinth level to and including the upper part of the plinth. After examination for loss of section etc. If loss

of section <30% due to corrosion then treatment A is continued. Otherwise adopt treatment B prior to continuing with the paint specification.

2. The exposed post and upper part of the plinth is then painted immediately with the following paint specification: (Figure 5)

   a. Primer—2 pack epoxy zinc rich. 75 microns (Epigrip J984).
   b. 2nd. coat—High build 2 pack coal tar epoxy. 175 microns (Epigrip G877).
   c. Final coat—High build 2 pack coal tar epoxy. 175 microns (Epigrip G876).

3. The brickwork is then made good.

Treatment B:

1. After blast cleaning as per treatment A the posts are examined and if there is a loss of section >30% due to corrosion, then the affected length of post should be replaced.
2. 2No. angle cleats should be fixed at least 250 mm above proposed cut line (this should be 600mm above plinth level under most circumstances). Cleats should be ex. 200×150×12 RSA's and fixed with 2No. M12 bolts.
3. 2 Accrow props are then used under the cleats to support the load of the post.
4. The posts are then cut and the existing and the existing HD bolt heads burned off and the affected section removed.
5. The concrete plinth should be thoroughly cleaned and levelled.
6. A new piece of steelwork post to match the existing is introduced.
7. The new base detail consists of 2No. 125×75×6.5 RSA cleats with a 5 mm thick m.s baseplate. The connections are bolted with M12 bolts throughout.
8. The upper part of the post is then spliced onto the existing post using plates and M12 bolts.
9. The new section of post is then painted as per treatment A and a final coat applied and dressed over the plinth.
10. The props are then removed and the brickwork made good.

Any projecting stanchions, beams or channels in the house are encased in 50×50 sawn sw framing and 2 layers of 12.5 mm plasterboard which was then skimmed.

3.6 External Works

The chimney stack was rebuilt to 300 mm above ridge and capped. Two cowls were fitted over flues to receive gas fires. 225×75 air bricks were fixed to the remaining

Figure 13 External view of the completed houses

flues.

Glidevale soffit ventilators were uses to ventilate the roofspace and some repointing was necessary.

All external brickwork pointing was removed to a depth of 20 mm deep on common brickwork and 15 mm on stock brickwork with a diamond disc cutter with dust extractor unit. The brickwork was repointed using a sulphate resisting cement and sand with a ratio of 1:3.

Tile Hanging

The existing framing was fixed to the internal leaf of new brickwork of cavity wall with Vista frame cramps. The existing vertical tile hanging was removed and the framed wall battened and felted.

75 mm Rockwool insulation was placed between the studding and 265×165

Acme century tiles with 65 lap were then layed on 38×19 treated battens on felt underlay.

The rainwater guttering was renewed with Key Terrain and a new door canopy was fixed to match the existing.

Roofing

The existing slates were removed and stored for reuse. The existing felt, battens and all lead work were stripped off and the roof checked for level and durability. New felt to B.S. 747, 1977 Type IF was fixed over spars and trusses with minimum 150 laps, 38×25 sw treated battens were fixed at 425 c/c and roof slates were refixed with aluminium nails and the verge, ridge and hip tiles were rebedded in cement mortar (1:3). Flashings to chimney and tilting fillet were renewed. A ventilation ridge tile to match the existing allows a through flow of air from the eaves 'Superstrip' vent.

400×38×3 galvanised ms hip irons to hip rafters. The canopy to the front elevation was removed together with rosemary tiles, battens and felt. This was then reroofed with new 'Marley Modern' roof tiles on 38×25 battens on felt and fire stopping at party walls. (Figure 13).

4 Summary

We have shown in detail the construction of Dennis-Wild houses and their apparent defects. Further information may be obtained from the BRE Report Dennis Wilde Steel Framed Houses 1988.

Trafford Borough Council have systematically surveyed and recorded the condition of these properties and devised systems to cope successfully with the defects. The principal officers concerned with the project were as follows and I am grateful for their help and encouragement in producing this paper.

Mr. A.Nixon—Principal Architect (Housing)
Mr. I.M.Jones—Supervising Officer
Mr. E.Baggley—Clerk of Works

5 References

The Burt Committee (1948) **Post War Building Studies No. 25 House Construction-Third report** HMSO.

Building Research Establishment (1988) **Dennis-Wild steel framed houses,** Report DOE.

Trafford Metropolitan Borough Council (1990) **King's Road improvements, contract documents,** Trafford.

146
Cost simulations based on building elements: application to residential facilities for the third age

F.de TROYER

Abstract
This paper describes a model for cost simulations and its application to old people's homes. First the principles of the model are explained. In this model a building is subdivided in functional parts, called "macro-elements", of two types: "space-delimiting-macro-elements", (like walls, floors, roofs) and "space-equipping-macro-elements" (like space-heating, lighting, water supply). Construction cost and heating cost per bed and per square metre floor area are calculated.

In order to compare the effect of different lay-outs the unit rates for the construction cost of those macro-elements are kept constant. Characteristic for this model is that only a limited input is needed when comparing different lay-outs.

As a conclusion relevant parameters are determined and aspects requiring further analysis are pointed out.

Keywords: Cost simulations, Building elements, Residential Facilities

1 Introduction

Housing the third age is a challenge in many European countries for the coming decades due to both the aging of the population and a shift in lifestyle. For almost every family the present way of life makes it impossible to take care of older relatives within the family. As a consequence nowadays in many cases older people stay in hospitals for a longer time after an emergency hospitalisation. This has two main disadvantages: on the one hand a hospital is not a pleasant environment where people can feel at home and, on the other hand, the hospital infrastructure is too sophisticated (and thus too expensive) for the care needed.

In response to that problem the Belgian government is stimulating the construction of "homes", the subject of this paper.

2 Problem definition

In recent years the government is spending quite a lot of money on such new homes. The average floor area per bed being 52 m2 and the average price per square meter floor being 785 ECU, the cost per bed are as high as 40,820 ECU (17 % V.A.T. and 7 % design fee included). Out of those 52 m2/bed on average 35 % (18 m2) is used for the rooms including sanitary facilities, the rest for different kind of shared facilities. The latter can be subdivided in two groups: facilities for the project as a whole (administration, central kitchen,…) and facilities for subgroups (decentralised kitchen, decentralised living-rooms,…).

Existing standards on staffing of those homes lead to groups of ±15 inhabitants. Two of those groups normally share certain facilities and staff members. A typical project is shown in fig. 1. In total in this case there are 60 rooms. Each of the four wings of 15 rooms has his own living room and other facilities (storage, toilets,…). Two wings of 15 rooms share some other facilities (kitchen, bathing facilities,…). This group of 30 is repeated twice in this project. A double hatching (in fig. 1.) indicates the facilities for the whole project, single hatching the facilities for one of the two identical double wings.

There is an increasing demand for better quality: larger rooms, more equipment (sanitary, electrical,…), wider corridors, more facilities for the different wings, better acoustical insulation, more luxurious finishing,…

In addition to this evolution there is a trend towards buildings with a ground floor only, giving access to the garden from every room. This has not only an effect on land occupation but also on the price per square metre floor area of foundations, of roofs of access roads for fire brigades. Those effects will be analysed further in the model.

3 Model implementations

The model elaborated for this research is based on the element method for cost control. There are many variants of this method (ref. 1). Table 1 illustrates the core of the method.

For each element one line is used. The content of the different columns from left to right is:

– a description of an element (including the code, see ref. 2).
– the element unit cost (unit is specific for each type of the elements)

Fig.1. Typical lay-out

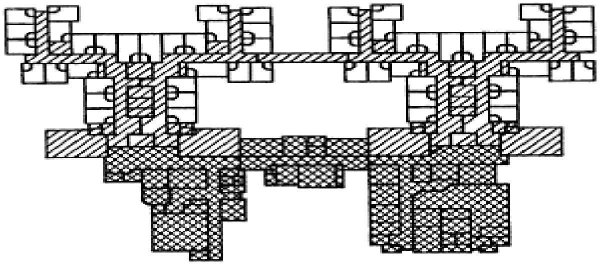
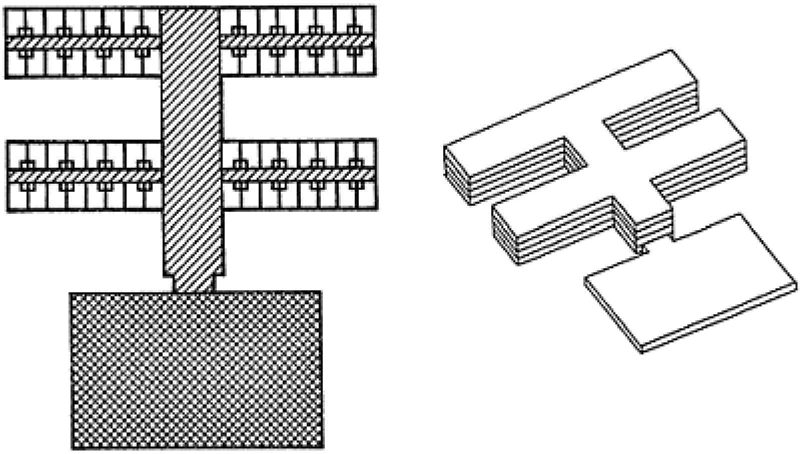


Fig.2. Lay-out of model



– the ratio, this is the number of units of an element divided by the floor area.
– the cost per floor area of that element, calculated as the product of unit cost of an element and the ratio. Ratios are helpful when comparing projects of different scale and/or having a totally different lay-out. If the calculation of a ratio is too cumbersome compared to the cost of an element the cost per floor area is entered directly in column four.
– the total cost of each element is calculated as the product of the cost per floor area and the total floor area.

If the cost of an element is not influenced by the floor area, this cost is entered immediately in the fifth column.

The sum of the element costs gives the project cost. Dividing this sum by the floor area gives the price per floor area all elements included.

Table 1: Estimation of project costs via elements and ratios (total floor area=3000 m2)

Elements	unit cost of elem.	ratio of elem.	cost per m2 floor	cost of element
…	……	……	……	……
(21)++Ext.wall, incl. openings and finishes	1.000 F/m2	0, 2500 m2/m2	25	75.000
…	……	……	……	……
(63) Lighting			5	15.000
…	……	……	……	……
(90) External works				90.000

TOTAL	60	180.000

In order to compare the cost consequences of different layouts the unit rates for the different macro-elements are kept constant for the following simulations, this means:

– the price per square metres of floors on the ground, of external walls, of openings in external walls, of internal walls, of internal floors, of stairs and of roofs.
– the price per linear metre of strip foundations and access roads for fire fighting.
– the price for installations and equipment per room.

The model is conceived in such a way that only a limited input is needed on three levels: the room, the wing and the project as a whole.

This was only possible by accepting a very simple lay-out as a starting point for the simulations (see fig. 2):

– rooms: only rooms for one bed, having a rectangular form (sanitary cell included), clustered side by side are considered.
– wings: they are composed of (1) a row of rooms at one or both sides of a corridor (In the latter case the number of rooms should be even) and (2) other spaces including space for circulation.

  A double wing is repeated several times and can be put one on top of another. In order to simplify the model the restriction is accepted that the number of double wings is always a multiple of the number of storeys.
– common facilities for the whole building: they are situated on the ground floor and the global form in the horizontal section of this construction is rectangular. This rectangle is linked with the rest of the building by a rectangular corridor.

It should be stressed that the only aim of this model is to compare costs; the architectural qualities of the model are poor. This can be illustrated by comparing the model (fig. 2) and the project of figure 1. In this project the impression of a long narrow corridor giving access to the rooms is avoided by splitting the corridor in three parts. At the turning-points extra architectural qualities are offered: a specific view to the outside environment, roof lights creating an other atmosphere, meeting points,…. As to the rooms there is also a lot of variation in spite the fact that they are equal sized: form and orientation changes, relation with outside is different,….

4 Input and output of the model

Table 1 is an example of the output of the model. Changeable parameters are printed in bold. In the top left zone inputed the geometrical characteristics are printed; at the top right one finds calculated geometrical characteristics, with at the bottom the square metres floor area per bed in total, for the rooms, for the other spaces of a wing and for facilities providing services for the project as a whole. Below, the construction cost is estimated via the element method. Unit rates for macro-elements can be changed. The share of every macro-element in the total budget is indicated.

At the bottom heating costs are predicted. This point is not elaborated in this text.

Following the same approach other costs-in-use can be analysed.

5 Results of the simulations

Together with a detailed description of the different geometrical parameters some conclusions concerning their importance are formulated.

5.1 Rooms

It is evident that the height of the storey, the floor-area and the width of the rooms are parameters of the model. The depth of the room is calculated and printed at the right. In a first approach the dimensions of the sanitary cell are kept constant.

The aim was to check if a limited increase of the size of the rooms has an important impact on the cost. This effect proved to be much less important then predicted by intuitive estimations. It is clear that the size of the room is important for the living conditions of the inhabitants, but rooms representing only 35% of the total floor area have only a limited impact on the overall cost. The experience that projects of the fifties, with rather small rooms are not attractive any more, suggests that “oversizing” the rooms is probably a good solution in the long run. If it is necessary to reduce other spaces in order to stay within the budget one should include in the masterplan the possibility for expansion of those functions in the future.

Changing the form of the room so that the quantity of external wall increases is also not that important.

5.2 Wings

The width of the corridor was a very controversial point. On the one hand people argued that wide corridors that are necessary in hospitals for the circulation of beds and for the evacuation of beds in case of emergency were not needed in those projects, on the other hand people claimed that the corridor should not only be seen as a technical tool for circulation: it is a covered street where the doors of the rooms are the “front doors” of the inhabitants “houses”, it is a meeting places, it is an important area for daily walks,…. Also in this case the effect of increasing the width of the corridor upon the cost was overestimated. For sure when multiplying the extra floor area with the average unit rate per square metre floor one is overestimating the effect: some costs (e.g. installation, equipment) are practically not influenced and the ratio of walls (=m2 wall/m2 floor area) is reduced if the width increases. Of course the total floor area per bed will grow. The importance of the growth depends on the width of the rooms and the choice for rooms at one or both sides of the corridor or not. This is a clear example of the very common situation where the effect of changing one parameter depends on the value of other parameters.

Table 2: Output from cost-simulation-model

Room							
storey height	–	2.80					
width of room	–	3.60					
area of room	–	18.36	depth of room		–	5.10	
Wing							
beds per wing	–	16.00	width of wing		–	28.80	
width of corridor	–	2.40	depth of wing		–	12.60	
rooms at 1 or 2 sides	–	2	area of rooms+corridor		–	363	
area utilities/wing	–	132.8					
projection of utilit.	–	12.0	width of utility area		–	5.40	
average area of rooms	–	18.0					
width/depth-ratio	–	0.667	ratio internal walls		–	1.35	
Building							
number of wings	–	12	number of beds		–	192	
			total area of wings		–	5,949	
number of levels	–	4					
depth of utility block	–	28.8					
width of utility block	–	84.6					
depth of connection	–	3.6	area of utility block				
width of connection	–	7.2	and connection		–	2,462	
average area of rooms	–	23.9					
width/depth-ratio	–	0.667					
			total floor area		–	8,411	
			total external wall		–	3,619	
			ratio internal wall		–	1.32	
			ratio external wall		–	0.43	
			floor area/bed		–	43.8	100%
			subdiv.:	rooms	–	18.4	42%
% openings of ext.wall	–	30%		rest wings	–	12.6	29%
				utility blck	–	12.8	29%
Construction cost							

Element	price/unit.	ratio	price/m2f1	%	
(00) pro j. in general			0	0%	
(13) ground floor+	88	0.4696	41	7%	
(16) foundations	71	0.2663	19	3%	
(21) extenal wall+	112	0.3012	34	6%	
(31) Sec. elem. ext. wall	286	0.1291	37	6%	
(22) internal wall++	86	1.3211	113	19%	
(23) int.floors+stairs	90	0.5304	48	8%	
(27) roofs++	118	0.4696	55	9%	
(5–)/(8–)serv.+fittings	10,714	0.0228	245	40%	
(9–) external elements	357	0.0384	14	2%	
		price/m2	606	100%	
	759 ECU/m2 index 100	+7%+17%	758	–index :	100
	39,612 ECU/bed index 100	per bed	33,226	–index :	84
Heating cost					
ventilation rate –	0.75	discount rate	–	8%	
price/kWh –	0.0444	growth rate energy pr.	–	4%	
equivalent degree days –	2,000	life time (years)		60	
			before insul.	after insul.	
	extra-R	basic-R	ECU/yr*m2	ECU/yr*m2	%
(13) ground floor	0.75	0.40	2.50	0.87	21%
(21) external wall+	1.50	0.71	0.90	0.29	7%
(31) sec. elem. ext. wall	0.15	0,18	1.54	0.82	20%
(27) roofs++	1.50	0.40	2.50	0.53	13%
Cost per year and per m2f1 due to transmission–			7.43	2.51	61%
	due to ventilation–		1.61	1.61	39%
	IN TOTAL–		9.04	4.12	100%
	K-value following NBN-K128				–K42
Sum of present value of heating cost–			211	96 ECU/m2f1.	
			9,231	4,204ECU/bed	

Beside those geometrical linkages the effect upon the cost per bed anthe cost per floor area depends on the different unit rates for the macro-elements. At this point the power of a model like this becomes evident: when an intuitive guess is contradicted by the model only after a further reflection the logic of the results becomes clear.

The ratio for the internal and external wall of the other rooms of a double wing depends on a lot of factors. This is illustrated in a rather abstract way in fig. 3:

– considering the same form, a square, the ratio of the external wall decreases if the total floor area goes up (fig. 3.A.)
– the more the length/with-ratio differs from 1, the more external wall per square metre floor area (fig. 3.B.). Form and size of the rooms being equal, a reduction of external walls goes hand in hand with an increase of internal wall
– two more realistic plans with the same ratio's as in fig. 3.B are sketched in fig. 3.C.
– the shift from internal wall to external wall is illustrated by the ground plans of fig. 3.D. Compared with 3.B. the ratio of the external wall is higher due to the complex perimeter. The schematic plan at the left has the same ratio's as the more realistic plan at the right.
– If the perimeter is the same and the average surface of the rooms is the same the ratio of the internal wall is greater if the width/depth-ratio shifts away from 1. (3.E. left and middle). Nevertheless the same perimeter, the same width/depth-ratio and the same average floor area for the rooms do not lead to an identical ratio for the internal walls (3.E. right).

In the model an approximation for the ratio of external and internal walls of a wing is based on: the total area, the global form, the average surface and width/depth-ratio of the other rooms of the wings.

5.3 Total building

At this point four decisions are important: the number of wings, the way wings are clustered, the total floor area of the utilities providing services for the whole project and the lay out of those utilities.

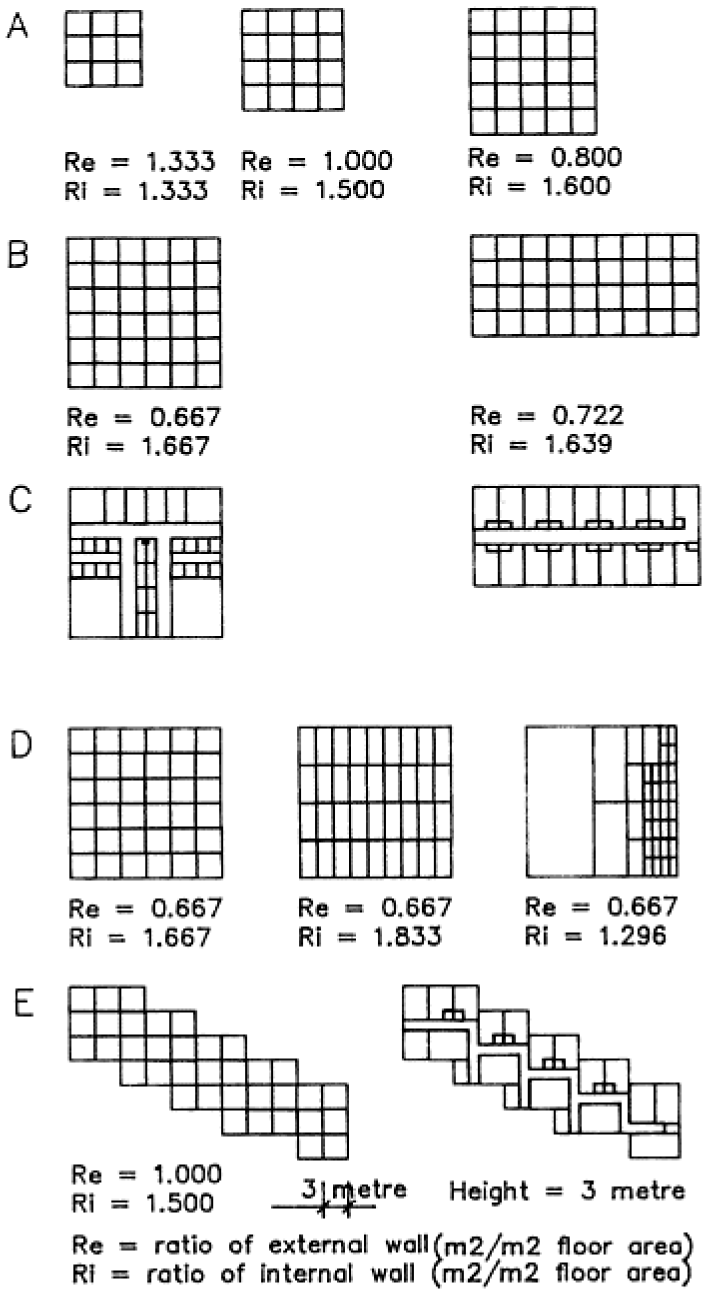
As for the latter parameters the same approach is followed as explained for the wings. Concerning the total floor area the hypothesis is made that, in the range from 50 up to 200 beds, the required area is only partially proportional to the number of beds e.g.:

required area=803,52 sq.m+8,64 sq.m/bed (1)

The model provides the opportunity to check the consequences of an hypothesis like this together with the effect of different lay-outs of the wings.

As examples the following results of simulation-runs can be given.

Fig. 3.: Lay—out and ratio's



All parameters are the same as table 2 except the parameters mentioned. Prices are compared with those of table 2.

– if the storey height increases with 8 %, costs are growing with 2% only
– only one level instead of 2: the ratio of many elements change, some effects compensate each other, cost increase with 9%
– only rooms at one side of the corridor: the floor area per bed rises to 56, 5 m2, the price per sq.m. floor will go up with 1%, so that the cost per bed will increase with 9%
– if the number of wings is 12 and thus, the number of beds per wing being 16, the total number of beds is 196: the total floor area for services for the whole project is, following equation (1), 2.462 sq.m.. As a consequence the floor area per bed is only 43,8 m2. The price per square metre is for one, two and four stories respectively +13 %, +3 %, −2 %. The price per bed is respectively −5 %, −14 % and −18 %.

6 Conclusions

If we accept the hypothesis that unit rates for macro-elements can not be reduced without an unacceptable reduction of the performances of those elements, the model proves that it is unrealistic to cut down the cost significantly by reducing the floor area of the rooms or the width of the corridor. Decisions concerning the global lay-out and the area for utilities for the whole project are much more important. The hypothesis that the area needed per bed for those functions can be reduced by increasing the number of beds per project, should be checked more in detail.

7 References

1. Kelly, J., R., (1987) Report on Session B: Design optimisation, **CIB Proceedings of the fourth international symposium on building economics,** Danish Building Research Institute, Copenhagen, pp. 11–19
2. De Troyer, F., (1990) Cost breakdown in functional macro-elements and sub-elements: a design tool, **CIB Symposium Building economics and construction management—Volume 2 Design economics** (eds. V.Ireland, H.Giritali, Cl.Roberts and M.Skitmore) University of technology Sydney, Sydney, pp. 100–111.

147
Identification of funds for managing public housing maintenance

S.N.TUCKER and M.RAHILLY

Abstract
The allocation of adequate funds for maintenance and refurbishment of large stocks of public and government housing is a continuing and growing problem as housing expectations increase and stock ages. Quantitative techniques to estimate and justify the expenditure are essential for the financial management of such large numbers of dwellings. Maintenance cost forecasting models have developed from aggregation of simplistic single-house single-year estimates, through evaluations of life cycle costing of small stock populations over building lifetimes, to statistical models which focus on the required output for management purposes. These forecasting approaches are reviewed and illustrated by practical examples of models used to assist managers of housing stock.

Keywords: Asset Management, Maintenance Management, Housing, Life Cycle Costing.

1 Introduction

Determining the appropriate level of funding for maintenance and refurbishment of large stocks of government housing is a continuing and growing problem as housing standards increase and stock ages. Managers have begun to realise that the needs of a changing house stock require a more systematic approach to both the current demands for maintaining the stock and the future requirements necessary to ensure the stock provides the services needed over the whole life cycle of every unit in the stock.

In Australia, where the largest proportion of the housing has been constructed since the 1950s, the resources needed to keep housing up to current standards are increasing at a faster rate than the number of houses. This inability of housing authorities to provide the required resources has prompted reassessment of housing assets and development of techniques to quantify the expanding demands, particularly the allocation of funds to carry out the work. Simply increasing the total annual funds by the amount of inflation and correcting for changes in total housing stock is recognised as being far from adequate.

The main contribution to the accelerating demand is the aging of the stock which, like any manufactured item, requires little maintenance, replacement or rehabilitation in the first part of its life but more regular attention as it ages, until it becomes uneconomic to continue investing in a deteriorating asset, when total replacement or disposal become the only options.

Housing management has focused predominantly on asset registers and recording of work performed; but good management needs much more. Asset management considers the utilisation of an asset over its whole life cycle which includes procurement, on-going support, rehabilitation and eventually disposal, demolition and replacement. Efficient and effective management includes consideration of the business aspects as a long-term owner of a large housing stock.

Forecasting maintenance costs over the life of a building is a difficult task. There have been few published examples of models or techniques which can assist the asset manager in considering the future demand for maintenance services after acquisition of stock. Amongst the few are the deterministic models of Bromilow and Pawsey (1987) and the matrix version by Bon (1988); both of which include the long cycle effects of periodic maintenance and rehabilitation. Stochastic effects have been modelled by Mathur and McGeorge (1990) who focused on the variation of maintenance costs and Tucker and Rahilly (1990) who allowed for distributions of timing of maintenance activities.

This paper reviews developments of maintenance forecasting models from the simplistic single-house single-year estimates, through evaluation of life cycle costing of typical stock over building lifetimes, to statistical models which focus on the output requirement for management purposes. Examples are taken from a current study into Australian single-family dwellings.

2 Housing maintenance costs

Maintenance is usually defined as ‘all actions necessary for retaining an item in, or restoring it to, a specified condition’ (Milton, 1986). Maintenance of housing in this context includes complete replacement of an item as well as the additional rehabilitation to a new standard.

A simple maintenance cost model consists of assessing the total costs over the life of a dwelling and averaging over its life. With intermittent rehabilitation included, the total annual cost as a percentage of replacement value is far too high, particularly in the early years. By ignoring the large occasional expenses, the estimates are far too low to sustain a house over its whole lifetime. The wide variations in age, type of construction and location of stock only compound the problem from an overall management point of view.

A maintenance cost model which better reflects the time profile of costs over the whole life of a dwelling consists of an approach similar to that used in a model developed for nearly two thousand single-family houses owned by the Government Employee Housing Authority (GEHA) of Victoria, Australia (Tucker and Rahilly, 1990). In this model, the house is divided into (nineteen) discrete elements. The life span and cost of maintenance activities needed to keep each element at an acceptable level of serviceability are then estimated. The chosen costs and replacement periods imply a formal standard of dwellings based on an individual's appreciation of an acceptable dwelling.

It should be noted that these forecast maintenance costs are those ideally estimated to be necessary to maintain the houses to a standard determined by each authority. As such, the costs may be a little higher than those actually incurred in practice, regardless of any shortage of funds.

The model has the following characteristics:

- The house is divided into component parts on which differing types of maintenance take place (replacement of windows, external painting, etc.).
- Each component normally gives rise to recognisable maintenance activity, or physical replacement, differentiable from other components (e.g. roof, external walls, internal walls).
- An initial capital cost is attributed to each component.
- The service life before replacement is needed, and the cost of replacement is defined for each component. The usual method of maintenance of the designated components would be by replacement in whole or in part, e.g. painting can be regarded as replacement of a surface coating.
- Different maintenance schedules are created for different housing types, particularly construction type.
- The scheduling of the next occurrence of a cost is determined by the manager/ supervisor supplying a 'next due' date for each category of cost. Subsequent costs reoccur each service life interval after that. The 'next due' dates are updated whenever the house has maintenance activity performed on it.

At any particular point in time, each dwelling will be at a different part of its life cycle with the result that some will have little need for maintenance. Others will require large replacements or rehabilitation. The determination of 'next due' dates is, in essence, a statement about the current condition of the dwelling and the expected deterioration in the near future.

Comparison of such models with past history is practically impossible as the historical cost data are exceedingly difficult to acquire over the long life spans involved. Data collection of an appropriate form have only become available in the 1980s through computerisation of maintenance records and then more for accounting purposes than in relation to the components of a dwelling.

3 Deterministic forecast

The maintenance costs of a house over time using the basic model show great lumpiness over time, as shown in Fig. 1. The presence of a few very large peaks in the costs is mainly caused by the replacement cycle times which are often estimated as multiples of 5 or 10. This is not surprising because it is convenient to round such estimates of cycle time to the nearest decade due to lack of precision in the available data.

Bromilow and Pawsey (1987) applied a similar technique to a small number of university buildings. Investigating every house in such a detailed mode is a formidable task for public housing authorities which may have tens of thousands of dwellings.

This type of forecast, whether from the date of construction or the present time, is useful mainly for assessing the economics of owning that particular dwelling; the value of the house, the rental income and the maintenance and operating costs must be considered together to obtain a life cycle discounted cash flow.

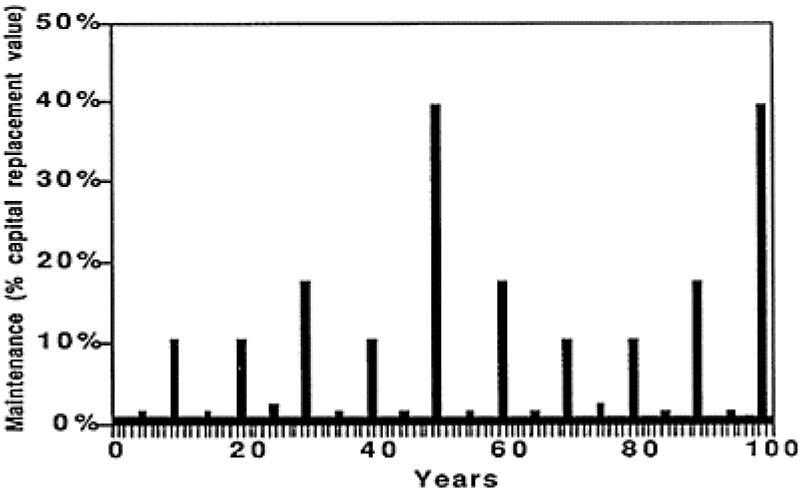


Fig. 1. Forecast maintenance for a single house over 100 years.

4 Stochastic forecast

It is well known that maintenance done on schedule is the exception rather than the rule. To explore the situation where delays occur, or work is brought forward, stochastic simulation of the timing (not the cost) of the non-annual maintenance can be implemented.

One model of distribution of timing of maintenance activities which has been used (Tucker and Rahilly, 1990) is a Beta distribution with (a) only 20% of items done between 90 and 100% of the scheduled time, and (b) the remainder completed by 190% of the scheduled replacement time. The most likely time for maintenance is the scheduled time.

The distribution reflects experience with maintenance in practice; it is frequently deferred, although if the component has deteriorated more rapidly than expected, it may be scheduled in advance of what was expected.

While the above distribution is based on interviews and experience, the true form of the distribution has not been determined due to lack of sufficient data. Likewise, variations for different building components or locations have not been identified.

Application of just a single stochastic form to maintenance timing reduces the lumpiness of the forecasts. Figure 2 shows one example of the effect of all the expected timings of maintenance activities, for the same house as in Fig. 1, being randomly selected according to the Beta distribution described above.

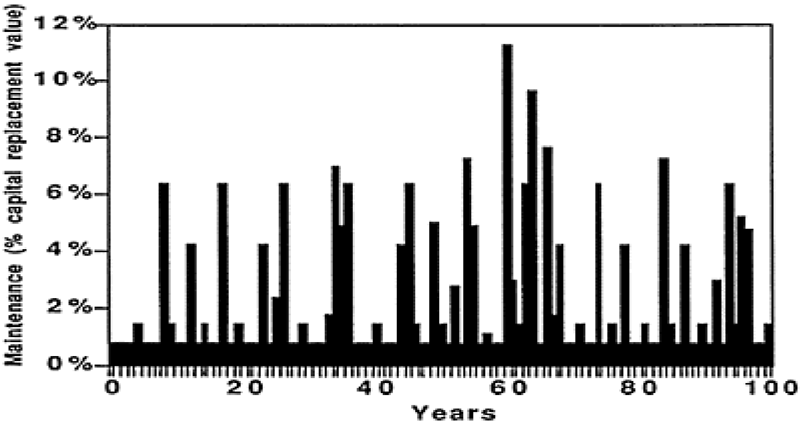


Fig. 2. Example of forecast maintenance for a single house over 100 years with stochastic effects implemented.

5 Long-term trends

The ideal solution for an owner of a large portfolio of dwellings would be to aggregate, over all houses, the forecast expenditure for each house, calculated in a stochastic manner as outlined above. However, it is unlikely that the condition monitoring required for 'next due' dates and details of tens of thousands of dwellings would be available at a single point in time and updated at least annually.

An alternative approach is to consider what the effect is if large numbers of similar houses are analysed in a similar stochastic fashion.

In practice, houses can be divided into a number of categories, based on construction type, region and/or size, each with its own age distribution, maintenance costs and time intervals. Such categorisation of houses is reasonable for houses which are very much alike although not identical.

From experience (and the forecasts shown in Figures 1 and 2), the scale of the lumpiness of the costs of the maintenance profile increases as the house ages. An alternative to the profiles in Figures 1 and 2 is needed to demonstrate how the total maintenance demand varies with time.

One method of showing the variation in maintenance demand over time while simultaneously averaging the effects is to calculate the average expected maintenance to date and compare the values as the house ages. The average maintenance to date, M_t, is defined as

$$M_t = \frac{1}{t} \sum_{i=1}^{t} m_i$$

where m_i is the expected maintenance cost in year i, and t is the age of the house.

The value of m_i for a house can be estimated for 100 years from the date of construction. The long time span is necessary as a number of elements of houses are assessed to have lifetimes of 80 years, with some giving the estimated life of some components as 100 years. A number of component lifetimes are given as 40 years or more, with several no longer than 10 years.

The values of M_t for the maintenance costs (as a percentage of capital replacement value) for the same basic data shown as for Fig. 2 are displayed in Fig. 3 averaged over 100 identical houses with stochastic effects implemented. The most striking feature of the curve is the sudden rise in average maintenance costs to date at 10 years of age followed by a fluctuating but generally rising value up to the age of 60 years. The curve is then generally flat with a small decline towards 90 years of age.

Thus, the expenditure needed to maintain a house is very dependent on the age of the house. Once over about 60 years, the average annual maintenance costs can effectively be assumed to be constant. However, houses under the age of 30 years have average maintenance costs to date under two-thirds of the long-term average, and under the age of 10 years just one-third of the long-term average.

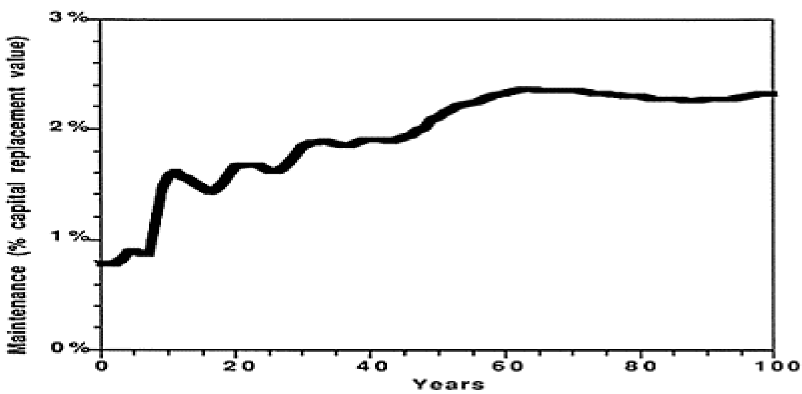


Fig. 3. Average maintenance costs to date averaged over 100 identical houses for 100 years.

6 Levels of maintenance funding

For comparative and target purposes, the use of annual maintenance expenditure as a percentage of capital replacement value is becoming recognised as a sufficient performance indicator. However, it is not totally independent of the characteristics of the housing stock to which it is being applied. As mentioned earlier, the age distribution of the houses has a marked effect on when and how much maintenance is required at any point in time.

Most state public housing authorities in Australia appear to be spending insufficiently on maintenance and rehabilitation even if the currently accepted level of 1–1.5% of current replacement value is deemed to be the desirable level. Only one authority has reported that over 1% was spent, all the others reporting that maintenance expenditure exceeded 0.5% but was less than 1% of capital replacement value.

The main determinant of the current requirements of a large stock of housing is the existing age distribution which will have been determined by present and past acquisition policies. Since most stock owned by the public housing authorities is relatively young, the current maintenance costs, even when averaged over all stock, would be considerably less than the expected costs when a large portion of the stock is over 40 years, i.e. if current maintenance expenditure is 1% of the capital replacement value, this percentage should be expected to increase to at least 1.5% as the stock ages.

For a growing stock increased by new houses, there will be more houses in the young age categories; for a stable stock the greatest number will be in the middle aged categories (see Fig. 4).

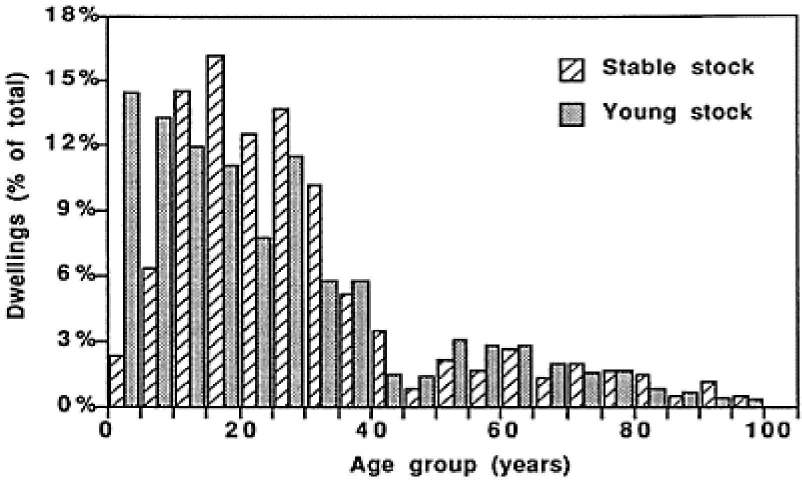


Fig. 4. Age distributions for housing stock: (a) stable after a period of growth, and (b) growing by adding large numbers of new dwellings.

Combining the current age distribution with the average maintenance costs (Fig. 3), results in the value expected to be required for maintenance in the current year. To evaluate the effect of age, the two age distributions in Fig. 4, when applied to the house shown in Fig. 3, give a reduction in average maintenance costs from the long-term value of 2.36% of capital replacement value to 1.70% (for the stable stock) and 1.56% (for the young stock).

These variations translate into large sums of money for a housing authority and give markedly different results depending on the stock characteristics. Also the trend with time needs to be assessed.

The effect on the level of maintenance expenditure is displayed in Fig. 5, for three different scenarios.

The full curve illustrates the case of a stable stock continuing to be expanded at its currently low rate. The dashed curve illustrates similar continuation of the current trends but with a young stock having a high expansion rate. The dotted curve shows the impact of changing the high expansion rate of the young stock to that of the stable stock.

The graph indicates that maintenance demands will increase for any stock unless there is a very high growth rate. Although not shown, a similarly high disposal rate for old stock would also reduce the increase in maintenance expenditure level.

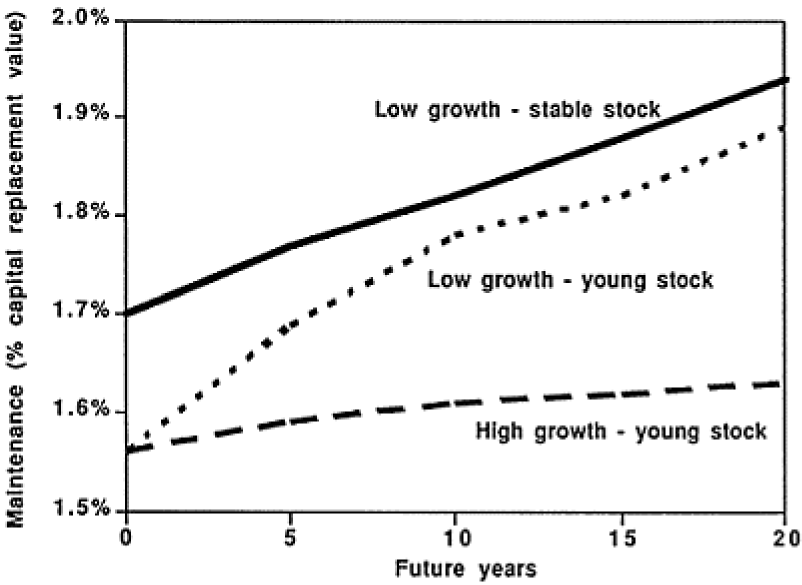


Fig. 5 Maintenance as a percentage of capital replacement values in future years.

7 Conclusions

The management of large stocks of housing requires quantitative data on the state of the stock and the future demands for maintenance if nominated standards are to be achieved. A reasonable requirement is a complete set of details of the physical characteristics of each house and historical records of expenditure. Such a database would enable determination of actual distributions of such information on stock age, replacement cycle times and proportions replaced. These statistical distributions could then be included in computer models to assist managers in defining the level of maintenance expenditure needed. The results of applying such models indicate that:

- the age profile of the housing stock is very important in determining a maintenance cost policy based on a percentage of capital replacement value of the whole stock;
- typical maintenance profiles for all major types of houses would be necessary for an average maintenance cost based on age profile and stock type;
- the long-term average maintenance costs of houses in the Australian context are of the order of 2.5% of the capital replacement value;
- the average maintenance costs over a portfolio of houses would normally be much lower because of the variation in age of the current stock.

8 References

Bon, R. (1988) Replacement simulation: A framework for building portfolio decisions. **Construction Management and Economics,** 6, 149–159.

Bromilow, F.J. and Pawsey, M.R. (1987) Life cycle costs of university buildings. **Construction Management and Economics,** 5, S3–S22.

Mathur, K. and McGeorge, D. (1990) Property maintenance costs—A simulation approach, in **Building Maintenance and Modernisation Worldwide,** Vol.1 (ed. Quah Lee Kiang), Longman, Singapore, pp. 182–191.

Milton, H.J. (1986) **Glossary of Australian Building Terms.** National Committee on Rationalised Building, Melbourne, 336 pp.

Tucker, S.N. and Rahilly, M. (1990) Life cycle costing of housing assets, in **Building Maintenance and Modernisation Worldwide,** Vol.1 (ed. Quah Lee Kiang), Longman, Singapore, pp. 162–171.

148
The principles of condition assessment of buildings

Y.TUPPURAINEN

Abstract
A condition assessment prior to renovation needs information of the aims of teh renovation. These aims are given by the developer, designer and the demands of authorities (such as fire safety). The aims (standard of quality) varies in the different parts of the building. The so called existing condition can be measured in the condition assessment. The comparation of the existing condition and the aimed standard of quality shows the amount of repair work needed and the cost of renovation.
Keywords: Old buildings, Planning, Condition assessment.

1 Basis for renovating planning

The qualities of a building and the requirements placed upon it change in the course of its use, so that it may meet these requirements less well than before. The result of this is that a decision has to be made between the following alternatives: renovation, change of use, or postponement of any decision.

The reasons for renovation may be normal deterioration, breakage or premature damage to functional elements. The most common reason for renovating a building is change in the requirements placed on it by the user.

When the operating time for the essential functional elements runs out, it is reasonable to demolish the building. Other reasons for demolition may be a rise in the value of the site (planning) or a change of use (e.g. for street area construction).

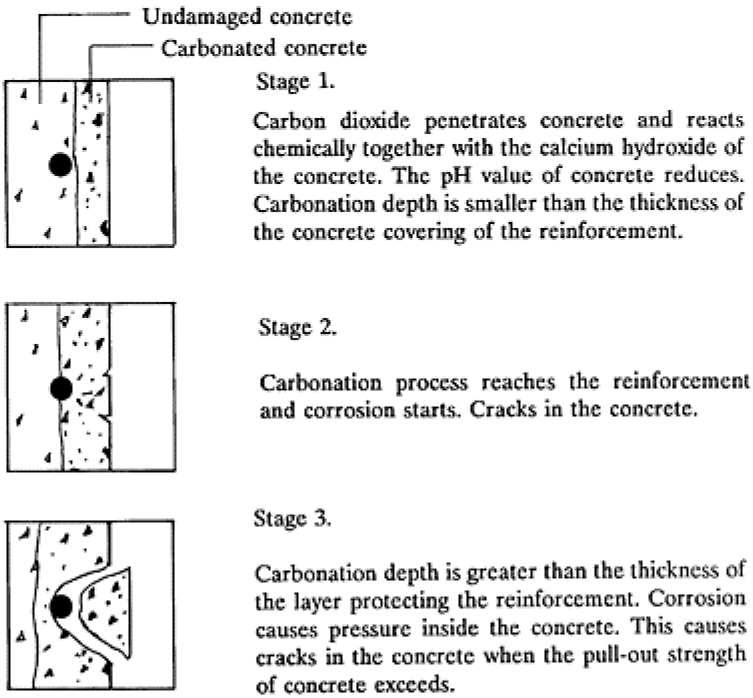


Fig. 1. Mechanism of a damage to a functional element; peeling of concrete caused by corrosion of the steel reforcement in the concrete.

2 Planning of the object of reparation

Repairs differ from normal building from the point of view of the goals set, the planning undertaken and the techniques used for implementing these plans. A building must be examined from the point of view of its entire lifetime, the correct target level must be set the repair work and a suitable means of carrying it out must be chosen. On the other hand, there is a building that already exists as the basis for the planning, and fundamental information on it can be obtained by means of condition and usability assessments. Old drawings are often incorrect, and consequently measurement drawings must be constructed. At the same time it is possible to obtain more information, e.g. about its structures and surface materials.

Renovation also differs from construction from the point of view of its planning. Original planning documents often prove to be incorrect, and the notes in them inadequate. The drawing system created to serve the purpose of construction work (e.g.

for applications for building permits) lack means of representing demolition or fine detailes.

Building specifications are drawn up to be obscure, and too much is decided on the site. This often makes it impossible to produce a tenable cost estimate. Room-cards are used only unofficially, although these would be highly suitable for repair work. Likewise, there is an obvious need for general quality requirements for repair work. The opportunities offered by computers and videotaping should also be made use of when collecting information about a building to be repaired, writing a specification or preparing room-cards. General quality requirements for repair work should be compiled in the form of a computer-based data file.

The directions given in the general quality requirements for repair work can be divided into two definitions, a unique definition and definition of the influences and qualities of the structure concerned (the functionality viewpoint). The first describes only the structure as accurately as possible, or else how the structure can be achieved using specific working stages.

3 Inspection and repair techniques

A central problem in renovation lies in the techniques employed, which differ from construction techniques, and the lack of suitable materials. The different kind of planning involved, and chiefly the lack of reliable initial information of the kind required for planning and decision-making, was also seen as problematic.

3.1 Facades

It is important to estimate the condition of the facade before making the final choice of the measures to be taken. If the condition of the facade has not been estimated, and the causes of the damage have not been removed, the repared facade may not last very long. A facade can also be repaired too thoroughly, i.e. too expensively in relation to its condition.

Principal attention has been given to non-destructive (NDT) methods and the determination of their usability are when evaluating methods for restoring facades. Prominent destructive methods for estimating the condition of facades include definition of the moisture content properties of the foundations, definitions of the consistency of materials and assessment of the extent of the damage.

The suitability of thermal or IR imaging for estimating the condition of facades has been tested under both laboratory and field conditions, and it has been found to be a promising method for locating damp areas and loosened slabs, paint and plastering in facades since it also allows invisible forms of damage to be identified.

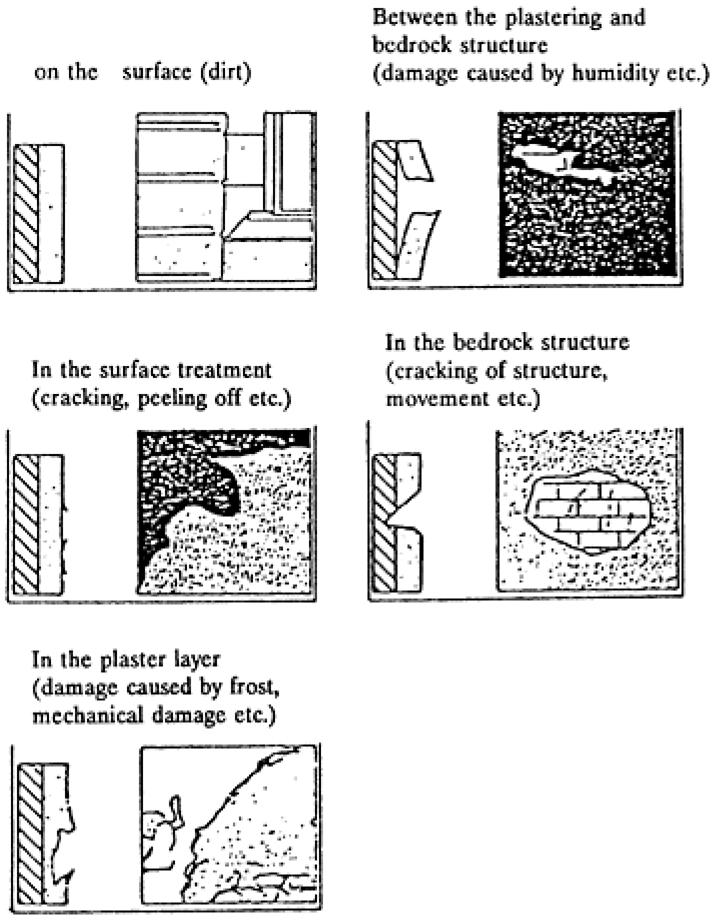


Fig. 2. Different types of faults in plastered facades.

Measurements of potential, used to determine the degree of corrosion in reinforced concrete, can also be used in to estimate the condition of concrete facades. The strength of the concrete can be assessed by ultrasound scanning.

Damage to joints between facade elements is quite common nowadays, being primarily caused by faulty dimensioning and timing of the jointing work. Correct jointing can achieve a serfice life of over 20 years. The condition of the element joints is estimated by eye and by studying the properties of the mastic and the prepared surface.

The most essential future topics of research concerning the repair of facades will concern determination of the service life of such repairs. It will be important to develop non-destructive on-site assessment methods and methods for studying ageing, applying new measurement techniques and techniques for examining the microstructure of materials. Another important topic from the point of view of both building and renovation will be the microclimates of facades and the further development of techniques for their measurement.

Table 1. Reasons for damage to facade elements.

Interval before appearance of damage	Reason for damage
0–2 years	– loose material in joints – damp (weakens adhesion) – joints of wrong shape and/or too narrow relative to the size of the elements (drying shrinkage is fastest at the beginning, figure 3)
3–6 years	– fatigue in the filler or loosening of the adhesion due to joints of the wrong shape and/or large size of the elements – use of poor-quality filler
10–25 years	– filler layer cracks when the elements move, due filler hardening (=not weatherproof) – maintenance painting causes extra strain on an old joint. This causes the filler to crack.

3.2 Roof structures

Condition estimation for roof structures and principles for repairing different kinds of roofs were examined. Experiences were collected together from reports on roof damage covering several decades, earlier research and results from other Nordic countries.

When estimating the condition of a roof attention must be paid at least to the extent of the damage caused by moisture. Important details are the condition of the roof covering, the draining of water from the roof, the joints of inlets, the eaves and possible air leakage spots.

IR scanning, capacity measurement and radioisotope radiation methods based on reflection are non-destructive methods applicable to the estimation of the condition of roof structures. Destructive methods include sampling and electrical moisture sensors.

Table 2. Studying flat roof damage using an infra-red camera.

Object of evaluation	Method of evaluation
measures of the products, mass, density (identification of the product)	– according to product standard or general methods of measuring
moisture content	– weighing and drying – measuring the relative humidity
mechanical properties (pull-out strength,	– according to product standard

extension, bend)	– the influence of humidity and temperature on these properties
analyses and studies of the micro structure	– defining the content of the product – studies of the micro structure of the product using a microscope – cracks – porosity – thickness of the coating
other properties of the products that influence on their function	– frost resistance – dimensional stability – covering materials – insulating materials – adhesive strength – covering, coating etc. – extent of rot – wooden structures – extent of corrosion – metal products

3.3 Potential measurement in concrete structures

Measurement of electrical potential can be used to locate areas of corrosion in the reinforcement of concrete structures. The method is simple to use and demands a minimum of resources. It has been used to study the massive con-crete structures of bridges, for example, but it can also be applied to house building.

Potential measurements are closely connected to the cathodic protective system used for reinforced concrete structures, the effectiveness of which can also be studied by this means. Examination of the cathodic protection can be seen as complementary to and a natural continuation of the measurement of electrical potential.

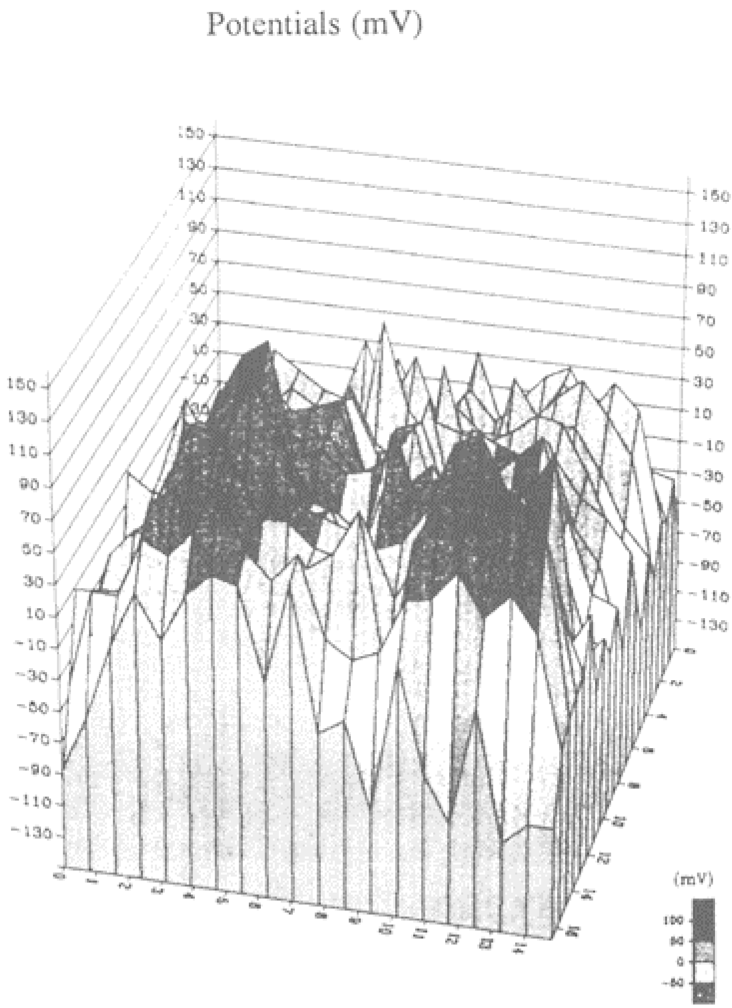


Fig. 3. An equal set of curves drawn by a computer from electric potential measurements made on a concrete structure.

3.4 Estimating the condition of plumbing

The cold-water pipes in buildings erected before 1960 were almost without exception made of hot galvanized steel tubes. The joints are wire-wrap joints, using hemp and tube cement as compression materials. The use of copper tubes for cold-water pipes began in the 1950's, although hot water pipes have always been made of copper. Copper pipes were originally fitted with brass joints, but other materials and capillary joints have been used since 1960.

Estimation of the condition of a plumbing system is based on a knowledge of its age, materials and installation and of the damage that has occurred to it. The examinations and inspections of plumbing can be divided into four groups:

– inspections by eye without technical instruments
– inspections using optic viewing devices, tv filming and ultrasound meters
– ocular inspections and sampling
– laboratory analyses of samples.

The internal features of a plumbing system can be examined more efficiently using various kinds of optic vie-wing equipment, e.g. an endoscope, fibroscope, video endoscope or video camera. Other non-destructive methods include magnetic powder examination, circulating current examination, ultrasound examination and radiographic examination (X-ray and isotope photography).

If it is possible to take samples, the condition of a plumbing system can be determined in the laboratory. Light microscopy examination of the depth to which corrosion has proceeded, the thickness of the zinc layer in a hot galvanized tube and graphitic corrosion in cast iron, while the dezincification of brass can be estimated and measured in polished microsections made from one sample.

Estimation of the condition of a plumbing system should be decentralized as a function of the time of use. Check points with easy access should be installed at critical points in the network in order to be able to estimate the condition of the plumbing. In that case the evaluation can be based on information obtained from this monitoring.

Condition monitoring methods should be connected with modern maintenance systems in a flexible manner. In addition, a classification of condition evaluations should be created for plumbing and equipment in apartment buildings of certain ages. The development of non-destructive examination methods, the reduction in the size of equipment and the combining of different methods (e.g. video technique for filming plumbing, ultrasound techniques etc.) create opportunities for the development of new methods.

4 References

Tuppurainen, Y. 1991. Research Programme on Renovation 1986–1988. Final Report. Oulu. Technical Research Centre of Finland, Building Laboratory, pp. 17–37.

149
BUILDER: a systematic approach to building maintenance planning

D.R.UZARSKI, R.DROZD, J.E.FIELD and R.W.HARRIS

Abstract
BUILDER represents a systematic approach for building maintenance planning and budgeting. Currently under development/ this approach will interface people with the technological aspects of a system to facilitate decision support so an optimal level of building M&R can be planned and accomplished at the lowest cost. System components include inventory, inspection, condition evaluation through indexes, work planning, and budgeting features, all interfaced in a microcomputer environment.

Keywords: BUILDER, Engineered Management System, Building Maintenance

1 Introduction

This paper presents the various concepts and goals behind an Engineered Management System (EMS) for buildings, called BUILDER. Although currently in an early developmental stage, the BUILDER system focuses on the integration of various building components for maintenance management purposes, condition assessment through inspection and condition indexes, and the development of annual work plans.

The concept of EMS for facility maintenance management has been developed by the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (USACERL). The various components of EMS include inventory, inspection, data administration, network and project level management. The first of the EMS's to be developed was a system of maintenance management of pavements. Even though the technology is different, the same basic concepts used in that system are also used in other EMS's currently under development by USACERL.

An EMS is defined as the systematic use of engineering technology to determine when, where, and how to best maintain facilities or facility components. Generally, these systems are microcomputer supported, but that is not a prerequisite to system use. Key to the EMS concept are the structured techniques, procedures, and processes necessary for effective maintenance management. Included is the need for facility or component inspection information.

2 Why EMS?

EMS was defined as the use of engineering technology to best maintain facilities. The use of technology permits maintenance management to be accomplished proactively, rather than reactively. A reactive management strategy becomes expensive, hampering the effective and efficient use of personnel and material.

For example, as a roof condition deteriorates, the funds needed for M&R increase several times. Figure 1 demonstrates, in a generic sense, the direct relationship between time and quality or condition. As time passes, quality or condition decreases, and M&R costs greatly increase. A similar relationship would be expected to hold for building components. Thus, if deterioration curves can be established for different facilities or components, facility managers can determine where on the curve they are at any point in time so that they can make the prudent decisions regarding when and what work to do.

Also, depending on the course of action chosen at the time of M&R, the shape of the curve could be altered. This results in scarce M&R funds being allocated most appropriately and a significant cost avoidance can be realized. Over time, the net result is a higher level of condition for given expenditures. The difficult task in accomplishing this is that no single deterioration curve would be expected to apply to all facilities or building components.

A BUILDER goal is to establish those curves for building components and the building as a whole through engineering technology. The EMS concept has been proven to work for pavements, railroad track, and certain roofing systems.

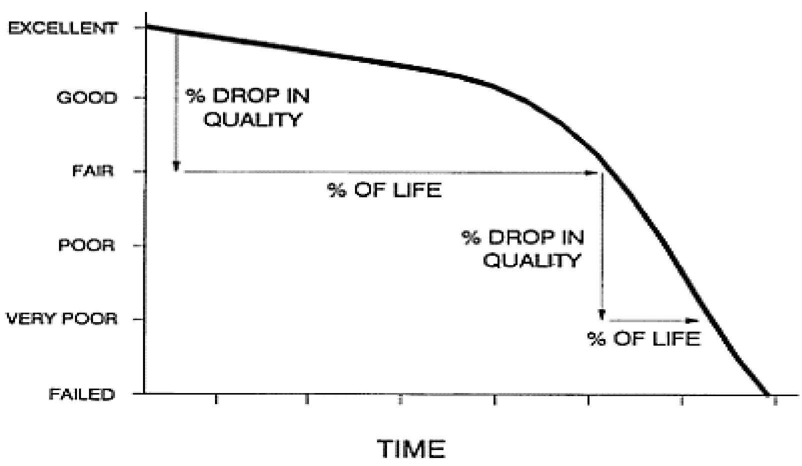


Figure 1. Deterioration Curve

3 BUILDER Components

As illustrated in Figure 2, five major components make up an EMS.

3.1 Inventory

This is one of the two EMS inputs. It is imperative that managers know what and how much to manage. This includes, in part, such items as the number of buildings being managed, their uses, and floor area.

A building system is divided into components. This division is essential for:

- Identifying the major features of a building.
- Identifying areas requiring different inspection skills.
- Defining dissimilar building areas for M&R planning and action.

A consensus of facility managers suggested that 8–12 building components would be appropriate for properly planning the Army's building maintenance needs. Too many components add unnecessary administrative burdens without any technological or managerial benefits. Too few components, although simple, restrict managerial attention needed for effective maintenance management. Accordingly, the BUILDER component division is as follows:

1 Roofing
2 Exterior Closure
3 Interior Construction
4 Exterior Painting
5 Interior Painting
6 Heating, Ventilation, Air Conditioning (HVAC)
7 Electrical
8 Plumbing
9 Other

Where appropriate, a further breakdown into subcomponents is made. Also, structure is included in both the Exterior Closure and Interior Construction components.

Additionally "management units", called sections, must be defined as part of the inventory. Each building or component to be managed requires a division into identifiable, relatively uniform, physical units. This uniformity considers use, age, materials, etc., and forms the foundation for the maintenance management process. Due to

Figure 2. EMS Components

uniformity, each section will have a unique deterioration curve. Each section is a single entity so inventory, inspection, and other pertinent data are to be collected for each one.

Because of building complexity, use, age, different material types, etc., components or subcomponents may not be uniform throughout a building. As a result, a given component or subcomponent may have different functional, performance, and M&R requirements within the same building. M&R strategies can then be developed specifically for each.

An example of a specific building component divided into sections is illustrated in Figure 3. The letters and numbers denote different subcomponents and sections, respectively. Note in this example that the physically separated windows are in the same section since they are presumed to be similar.

Inventory data collection is a "one-time" procedure that requires updating only if physical changes occur through M&R or alteration. Specific inventory needs are a function of the individual EMS.

3.2 Periodic Condition Survey

This is the other basic EMS input. A periodic condition survey is performed on each section so that the manager can establish the deterioration curve. Once established, current conditions can be assessed and future conditions predicted. The condition survey should relate not only to assessing condition, but to provide direct input for determining M&R needs by identifying and locating specific problems.

The condition survey procedures are being developed concurrently with the overall system development. The goal is to have the inspection and evaluation process require the smallest amount of labor time possible. Thus, the use of photography, video disc

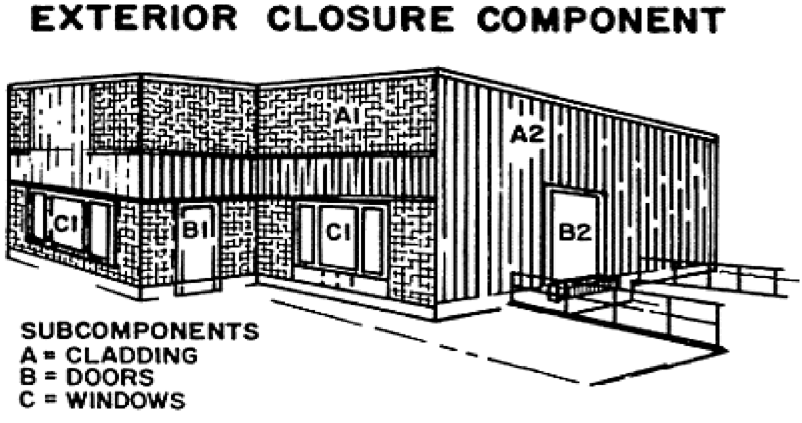


Figure 3. Example management units.

technology, and other forms of artificial vision information collection and storage are being investigated.

The condition survey normally consists of identifying the type, severity, and amount of distress present. Each of these three is significant in determining the overall amount of deterioration. If any one is ignored, developing a meaningful condition index is not possible. For each distress, typically three severity levels are defined using the following general criteria:

- Low Severity—some deterioration; no repair required.
- Medium Severity—distress repair should be scheduled for repair during the next M&R cycle.
- High Severity—immediate repair is required.

3.3 EMS Database and Engineering Tools

The inventory and inspection data that are collected for each section forms the basis for the BUILDER database.

The EMS engineering tools are developed based on the collected data and include a condition evaluation and rating procedure, condition prediction, M&R guidelines, and life-cycle cost analyses. Appropriate BUILDER engineering technology specific to component are utilized in order to perform other decision support tasks.

An important engineering tool is the condition evaluation and rating procedure. This tool takes the form of a condition index (CI). The CI utilizes a rating scale from 0 to 100 with 100 being excellent.

Table 1 defines the entire rating scale indicating the significance on M&R needs applicable to BUILDER. The condition index represents a measure of "health" of a specific section, or the entire group or subgroup of sections.

An example of a condition index developed for the roofing component is the membrane condition index (MCI). It was developed by summing all visual distresses over their severity and density levels using appropriate weighing factors. Similar condition indexes that combine the effects of several different types of distresses, several possible degrees of severity for each type, and a wide range of amount or density for each combination are being developed for the remaining building components.

The mathematical model for each condition index is:

$$CI = C - \sum_{i=1}^{r} \sum_{j=1}^{m_i} a(T_i, S_j, D_{ij}) F(t,d) \quad (1)$$

where CI= Condition Index

C= a constant depending on the desired maximum scale value

a()= deduct weighing value depending on distress type T_i, level of severity s_j, and density of distress D_{ij}

i= counter for distress types

j= counter for severity levels

r= total number of distress types for component under consideration

m_i= number of severity levels for the ith type of distress

F(t, an adjustment factor for multiple distresses that varies with the total summed deduct d)= value (t) and number of deducts (d)

It is through the use of the index that the deterioration curve is established. Once established, condition index predictions can be made which allows for the timing of M&R to be established. The CI can also be used to correlate M&R needs; the lower the index, generally, the more extensive the M&R needs are.

The overall Building Condition Index (BCI) is a composite index made up from component condition indexes, such as brick masonry units, exterior windows and doors, and interior floor coverings.

Another engineering tool within EMS is an engineering economics module. This permits the user to perform life-cycle cost analyses, when needed, of various M&R alternatives and strategies.

3.4 Network Level Management

Network level management is an EMS output that focuses on the entire group of building, building components, or component sections. Network level management encompasses large scale decisions focusing on the "where" and "when" aspects of facility management as well as budget planning.

The condition index plays a key role at this level. As discussed earlier, current and future condition assessments can be made. This, in turn, leads to the identification of candidate sections or components for M&R which then must be prioritized for actual work accomplishment to meet budgetary constraints. Short and long range work plans result. Budgets can be optimized at this level through the best use of available or planned dollars.

Network level management through EMS permits "what-if" analyses to be made. For example, the costs (budgets) associated with establishing a minimum acceptable condition index at various target levels can be made. Also, the effects of deferred maintenance or budget cuts, in terms of index value reduction, can be determined.

As mentioned earlier, inspection information is needed in order to make this happen. Fortunately, at the network level, the inspections need not be greatly detailed nor extensive. Network level inspections are envisioned to be accomplished only every 2–3 years (average).

3.5 Project Level Management

Project level management is only performed on sections or components, such as specific roofs, scheduled for M&R in the next annual work plan. A detailed condition survey is performed at this level. This level focuses on problem diagnosis, cost analyses, and selection of a most appropriate preliminary design. The management effort associated with this level is dependent on the work that is to be performed.

In order for BUILDER to be an effective decision support tool, it must be robust enough to facilitate the network and project level management activities. However, recognizing that it will take years to develop a complete system, BUILDER is being created in modular form to facilitate early transfer to the field.

3.5.1 Objective Condition Assessment

This assessment will be accomplished through the use of appropriate inspection procedures and condition indexes. By averaging BCI's, an index can be attained for a network or subnetwork of buildings. This will allow facility managers to establish and compare conditions between individual building components within a single building, the buildings themselves, building groups, and components within the group.

3.5.2 Establish Minimum Acceptable Condition Criteria

Minimum CI values can be established which will trigger M&R actions. Once established, buildings, components, and subcomponents can be identified for early attention when M&R costs are relatively inexpensive.

3.5.3 Contractor Performance Monitoring

Considerable M&R work is accomplished by contractors. Also, over the past few years, there has been an increased desire to use performance instead of process or method specifications in those contracts. The compliance process for performance specifications can be augmented by establishing required condition index values in the contract. These values can be monitored as a measure of contractor performance.

3.5.4 Condition History and Prediction

Through the use of the condition indexes, condition over time can be recorded. Deterioration curves similar to the one shown in Figure 1 are anticipated. The past trends will serve factors in future condition prediction modeling. Rates of deterioration can be determined and used in the decision making and budgeting process.

3.5.5 Component Reinspection Scheduling

Previous inspection CI values, rates of deterioration, and maximum desired reinspection intervals can be used for planning the future reinspection program. This schedule will help focus limited inspection resources into areas where they are needed most.

3.5.6 Budgeting

Since CI's are a measure of health, a correlation between a component CI and M&R costs exists. Thus, M&R costs versus predicted CI values can be established and used to produce required budgets.

3.5.7 "What-if" Scenarios of Condition Versus Cost

By coupling cost versus CI values with condition prediction, many scenarios can be analyzed. Predicted conditions associated with certain budget targets can be studied. Also, the budgets needed to attain certain condition levels can be determined.

3.5.8 Annual Prioritized Work Plan Development

Traditionally, the development of an annual work plan (AWP) has been a very time consuming effort. Also, since it rapidly becomes obsolete it loses its effectiveness. With BUILDER, the AWP will be produced rapidly and by the dynamic, alterable document needed by management.

4 Development Status

To date all major components and subcomponents of BUILDER have been identified and catalogued. Furthermore, for condition index development some specific components and subcomponents have been detailed for types of distresses, severity levels, and measurement methodology. Field testing has been performed to verify the validity of those details.

The nature of the condition assessment involves direct physical observation. In order to expedite, log, retrieve, and verify the distress information, photo logging using laser videodisc is being investigated.

5 Conclusions

This paper informed the research and user community of the concepts behind the BUILDER EMS concept. Although the research to support this concept is still ongoing, the concepts and procedures have been proven for other facility types and BUILDER module testing. When completed, the BUILDER system will serve as an extremely versatile tool to help building managers understand the condition of their facilities, how fast certain components are deteriorating, and what the future physical conditions will be under differing M&R scenarios. The net result will be buildings maintained at the optimum level for given expenditures or a maximum condition level at the lowest cost.

6 Acknowledgements

The authors wish to express their appreciation to the U.S. Army Construction Engineering Research Laboratory, specifically Paul Howdyshell; the U.S. Army Engineering and Housing Support Center, specifically Chester Kirk; and the Naval Facilities Engineering Command, specifically Richard Caldwell for their continued funding and support for this research effort.

Table 1

Building Condition Index (BCI) Concept

INDEX SCALE	DEFINITION	CONDITION DESCRIPTION
86–100	Excellent	Very few noticeable defects. Building function is not impaired. No immediate work action is required, but minor or preventive maintenance could be scheduled for accomplishment.
71–85	Very Good	Minor deterioration. Building function is not impaired, but appearance may be less than desirable. No immediate work action is required, but minor or preventive maintenance should be scheduled for accomplishment.
56–70	Good	Moderate deterioration. Building function may be and appearance will be somewhat impaired. Moderate maintenance or minor repairs may be required.
41–55	Fair	Significant deterioration. Building function is impaired, but not critically. Moderate maintenance repairs are required.
26–40	Poor	Severe deterioration in localized portions of the building. Building function is seriously impaired. Major repairs required.
11–25	Very Poor	Critical deterioration has occurred over a large portion of the building. Building is barely functional. Major repairs or less than total restoration is required.
0–10	Failed	Extreme deterioration has occurred throughout the entire building. Building is no longer functional. Major or complete restoration is required.

7 References

Bailey, D.M., D.E.Brotherson, W.Tobiasson, and A.Knehans, **ROOFER: An Engineered Management System (EMS) for Bituminous Built-Up Roofs,** Technical Report M-90/04, (USACERL December 1989).

Shahin, M.Y., D.M.Bailey, and D.E.Brotherson, **Membrane and Flashing Condition Indexes for Built-Up Roofs, Volume I: Development of the Procedure,** Technical Report M-87/13, (USACERL September 1987).

Shahin, M.Y., M.I.Darter, and S.D.Kohn, **Development of a Pavement Maintenance Management System, Volume I: Airfield Pavement Condition Rating,** AFCEC-TR-27 (U.S. Air Force Civil Engineering Center [AFCEC], November 1976).

Shahin, M.Y., and J.A.Walther, **Pavement Maintenance Management for Roads and Streets Using the PAVER System,** Technical Report M90/05, (USACERL, July 1990).

Uzarski, D.R., E.D.Lawson, M.Y.Shahin, and D.E.Brotherson, **Development of the BUILDER Engineered Management System for Building Maintenance: Initial Decision and Concept Report,** Technical Report M-90/19, (USACERL July 1990).

Uzarski, D.R., D.E.Plotkin, D.G.Brown, **The RAILER System for Maintenance of U.S. Army Railroad Networks: RAILER I Description and Use,** Technical Report M-88/18, (USACERL September 1988).

PART FOUR
INFORMATION TECHNOLOGY

150
The boundaries for building design informatics

M.R.BEHESHTI

Abstract
The information technology and computer-based design techniques have contributed to changing building design in the last decades and the emergence of building informatics as a new discipline encompassing activities of members of the design coalition team. The possibilities offered by building informatics have begun to transform the building design practice, affecting design methods as well as design working environments. One of these implications are steps towards European Building Standards, providing a data exchange facility, based on protocols approved at a European level, also corresponding to the notion of '1992 EEC Open Borders' the year marking 'border-crossing data flow'.

Keywords: Building Informatics, Design Coalition Team, Knowledge-base, Design-rule, Concurrent Design, Change

1 The building design in transition

This century has witnessed great changes in the ways of practicing building design. These changes are breaking away from an evolutionary process of the design activity. In the first place they have affected ways of thinking about design and means of implementing them. Despite all these changes, certain aspects of building design still remain unchanged. From Vitruvius to Le Corbusier, to Sterling, Rogers, Krier and Rossi, the intentions of building design activities remain the same, influencing and improving the built environment (Nornberg-Schulz, 1965). Nevertheless, the paper emphasizes the necessity for building designers to accept the challenge of the computer and information technologies and adapt their practices accordingly. These are new tools offered by these technologies that concern us. Since these technologies are presented to us and intend to develop further and offer more possibilities, it is our duty, as building designers, to play an active role in influencing these developments and to turn them into means appropriate to our ways of thinking as well as our requirements, criteria, norms and standards.

1.1 The traditional design tools

Building design activities have been concerned with the transformation of the built environment. The building design process, particularly in the last three decades, has been transforming into an empirical science. These efforts at least refer to dividing the involved issues into tools and rules which accompany the use of these tools, whether these discussions are just 'hypotheses', thus theories whose probability has yet to be investigated, or 'laws', hence possessing high empirical probability. In any case, the realm of theories and the substance of design thought and intention remains to be independent of tools, while some aspects of it can be influenced and improved by design tools.

1.2 The transformation of tools

We can take the view that the influence of new technologies and development of new tools on changing rules can be regarded marginal if the design environments remain unchanged. It is necessary to consider that it was not the design tools which changed the way of design thinking, but the changing awareness and social factors which influenced new design theories as well as design practices. It was also the new modes of production which required a more efficient means of tackling design activity and brought about a new face to the practice of building design.

At present, the computer and information technologies, independent of the requirements of building design, influence almost every aspect of life, labour and production. It can be argued that it is about time that also building designers anticipate the greater impact of these technologies on their profession.

In this respect we should not look to hardware tools offered for the practice of design, which will inevitably take over the outgoing tools technology, but to domains which can influence our way of thinking and will benefit the existing theories of design. The challenge of this readiness to accept transformation of the practice, will be an effort by building designers to gradually understand the nature of these technologies.

1.3 Building design informatics: a case-study

The result of a survey carried out by the author shows an increasing tendency amongst Dutch building designers to make use of the latest developments in office automation, data-bases and computer-aided building design (Beheshti, et al., 1986b).

This research aimed at investigating the information flow of the building design practices in the Netherlands, considering all members of the design coalition team. Members of the design coalition team, are all those involved in, affected by or able to exert direct or indirect influence on the process of designing the built environment (Beheshti, 1986a:122). The outcome of this comprehensive case-study on existing information requirements, data flow and the attitudes and tendencies of building design firms towards a fully automated building design practice, revealed a great deal of interesting facts. A number of remarks can be made with regard to the manner in which these developments are taking place:

Firstly, these developments tend to gravitate towards the internal functioning of the company concerned. Data communication between the various participants within the building process or the construction team (e.g. builder and supplier) is practically or virtually non-existent.

Secondly, the confidence of those interviewed in the present state-of-the-art of technology is very limited; it is widely thought that the quality of the available soft-ware is not yet satisfactory. In particular, the lack of adequate methods to check the completeness and the consistency of the information is experienced as a negative point.

Thirdly, the attitude of the building industry towards taking the initiative to develop software is rather indolent, contrasting sharply with other sectors of industry.

Finally, the fact that most of the companies surveyed were unable to define their own priorities and bottle-necks with regard to automation developments would seem to indicate only a very limited level of knowledge of the information sciences and their application possibilities.

The above mentioned results are further compared with earlier surveys in the Netherlands (BNA, 1985) and similar studies in the UK (RIBA, 1981), the USA (Wagner, 1985), etc. The similarity of these results are significant, illustrating the inevitability of a change of environment in the traditional ways of practicing building design.

These environments will eventually benefit from automation of not only the design activity but also of all organizational aspects of a professional building design firm, such as administration, planning, co-ordination, marketing and research. Consequently, the complexity of such a system should correspond to the complexity of the design tasks.

1.4 The outline of information requirements

In order to design a system capable of being a complete intelligent building design assistant, it is best to define all activities of building design practices and the requirements for each activity. Introducing automation into the practice of building design will change the working conditions of architects, civil engineers, surveyors, contractors, etc.

One of the requirements of the building design activity is adequate information about the project at different phases from the feasibility study to its realization, management and maintenance. The designer must collect all this information from various sources and has to transform and structure these data for use at the design stage. Most of these information will be obsolete after some time. The system to be proposed provides an information environment, containing databanks with all information required for the design of the built environment. This data will be available in different types, it can be graphical data in the form of drawings, graphs, maps, plans and charts; numerical data like tables, figures, numerical norms and standards; pictorial data like photographs of existing or historical buildings; or it is textual data such as descriptive norms and standards related to design of various projects, building regulations, etc. The main sections of the system to be proposed will be available to members of the design coalition team.

2 The design environments

The practice of building design is indirectly in debt to the developments of computer and information technologies. These developments in many cases were not intended to be used by building designers, but were adapted up to certain degrees to the environments of building design activities. It is fascinating to observe these efforts. It seems these efforts are mainly concentrated on improving the design activity from the technical point of view, trying to take away burdens of repetition and helping to win the time factor as well as introducing an improved marketing element into the building design processes. By this we can refer to advanced computerized drawing and rendering techniques. The latter has had a greater influence on architectural design activity in terms of imposing its limitations to morphological aspects of architectural design, considerably improving presentation possibilities. This influence has been more positive for building and civil engineering designs, because they are more concerned with calculation, norms and rules (For instance calculations of finite element boundaries or the use of diagnostic expert systems for building physics considerations).

2.1 The traditional design requirements

Evidently any discussion of the building design environments contains a closer look at the design requirements which can be divided into two distinct groups. Firstly, those referring to the designer's ability to design: creativity, intuition, talents, attitudes, training and expertise. Secondly, one can refer to the building up of experience and enrichment of human knowledge which inevitably have a greater influence on the act of designing as well as methods of using the existing design knowledge in a broader sense of the term.

2.2 Projected design environments

An attempt can be made to project some of the afore mentioned requirements to the future, at the same time combining it with a parallel development in the computer and information technologies. This is not an effort to replace building designers by so-called intelligent design machines (see also Oshuga, 1989; Zeigler and de Wael, 1986) but the benefits can be drawn from the employment of these technologies in appropriate ways to improve productivity of this powerful mental process of creativity.

The distinct difference of human actions with the one of a highly developed design machine will remain untouched, the ability to make decisions based on uncertainties and factors such as feeling, dislike, association, desire, etc. It can be argued that the act of designing is the product of an innate human faculty. It is the embedded design ability of a building designer developed during his or her career which cannot be replaced by any machine.

3 Design rules

The act of designing requires that certain patterns be followed, some being technical procedures and others overlaying patterns of thought and the design philosophy. Here we have to define “design rules” in both designer and tool related aspects. The latter can arguably be totally transformed to suit potentials of the new technologies. The designer, however, will follow a pattern associated with cultural, political and social developments and can only partially change the rules but not the intentions. The designer related aspects form a body of knowledge and can be universal, following an evolutionary process of perfection, endowment, enhancement, improvement and enrichment.

3.1 Design theories, methods and techniques

The introduction of these new technologies will not contribute to make design theories obsolete. Such a redundancy cannot be totally related to these developments. Hence a sound design theory will be redundant on its own merit and at an appropriate time. It is arguable that redundant design theories will remain part of the design knowledge. They may sometimes reappear in individual cases in an adapted or modified version or even in their original forms while redundant technologies seem to become obsolete for good. The purpose of this discussion is to point out that those design theories which reflect intentions of building design will remain more or less unchanged. What tend to change are ways of approaching the design activity and means of tackling design problems. Therefore, the main area of concern is appropriate design methods and their required design techniques. Arguably the latter, tools-related aspect of design, will suffer a greater degree of transformation than the former.

3.2 The design rule-base systems

The greater responsibility of building designers would be to define the realms and rules of building design processes in the context of possibilities offered by these new technologies. In this respect a parallel development of the design rule-base systems will be a first step towards a fully integrated design information environment. In order to achieve this a model of the design activity have to be found with layers and rules corresponding to that of a design information environment.

3.3 The design domain specific

To construct a model corresponding to the above mentioned requirements, the design activity has to be structured in a manner suitable for our purpose. The model considers design as a problem-solving activity where each state can be obtained by the application of an operation to the previous state. We can refer to each problem-solving process as a chain or network of states (which are data) and operations (which are processes) in such a way that loose-ends are also attached. The task of problem solving corresponds to finding the right sequence of operations (or action path) that transforms the problem description state into the solution state.

Building design is a hierarchical process, controlling the sequence of operations to be performed. It seems the design process in certain stadia conforms to a relational structure. Thus in constructing the model we have to cope with both hierarchical and relational structures. In order to achieve the integration of these structures, the complexity of the process has to be disaggregated into chains of simpler conditions of input/output, related to the logical action path of the design activity. The complexity of relationships and their subsequent disaggregation can provide a basis for concurrently executed problem-solving activities. Concurrent design and navigational design will allow a flexible approach and will fit into the

notion of network structures. This model adopts an structuralist (Piaget, 1976:480) approach as its basis to replace atomistic attitudes or holistic explanations. The structuralist view of the design process can provide a chart of the design activity wherein all elements and their relationships can be explained in unity. Structures are adequate modes of analysis that can be developed further in the actual design process or synthesis step, also providing relevant attributes to discuss the possible effects that is likely to be produced by the design activity. The determining factor in this model is change which will take place at a rate that is appropriate to the process and is related to the time intervals of the design process, defined as phases.

The actual process of design will be a chain of design events each followed by design decisions, in turn leading to a new design event or coming to an end. The possibilities offered by the new technologies will enable the building designer to keep track of different courses of action, to foresee consequences of each design event and implementation of required changes to the process, implementing design knowledge and expertise, making appropriate decisions based on analysis, calculation and evaluation.

3.4 Computer-aided building design

One of the difficult tasks of a building designer is co-ordination of activities of members of the design coalition team, very often requiring changes of the original design. The proposed system will contain a mechanism for checking the consistency of design data throughout the whole process and designs related to each designer or party involved. This could prevent construction problems, which may occur due to mismatched working drawings of different experts.

4 The design decision support system

The above mentioned arguments can be further expanded beyond the discussions of the design domain specific and its boundaries in terms of content as well as quality and modes of reasoning (see Lansdown and Roast, 1987 for a more detailed discussion of this issue). The content of discussions are decided by the rules of the design activity which will set the framework for establishing design knowledge-base system and its specific design expert systems. To complete the picture of the design information environment, it is necessary to establish norms, rules and means of assisting design decisions.

4.1 Decisions and the information environment

In order to establish the link between decision-making in current building design and that of a design decision support system, similarities should be traced to define overlapping structures. Such an effort will certainly demands reshaping the design decision-making process in terms of mechanisms suitable to a decision support system as defined by the rules and boundaries of the artificial intelligence.

The main concern in this activity will still remain the adequate determination of the consequences of design decisions with regards to different design alternatives. The complexity of the process and the nature of decisions as well as the employed design tools and design rules will increase with the complexity of the employed system. As this complexity of the system (design tools) increases, the necessity of defining and establishing new design rules will also increase accordingly.

4.2 The design decisions

One major difference of building design decisions with other forms of decision-making processes is the element of the design intention which can only be defined by the individual designer involved. In this respect, there exist a variety of elements which cannot be programmed and cannot be contained in the system (Beheshti and van der Veer, 1988b:242).

The goal of any expert system is to contain as much as possible the essential and crucial parts of expertise of as many experts in a structured form with a well established set of rules and reasoning. The problem with the transfer of the building design expertise to an intelligent integrated design system, would be to find recurrent patterns to establish some general rules, applicable to different situations. As such rules cannot be easily established, it can be argued that only those parts of a designer’s expertise can be included in a design expert system which to a great degree are of an objective nature. The subjective rules will remain to be complex as far as translating them into a system is concerned. The present state-of-the-art of the technology does not suggest that subjective rules can be effectively included in a design decision support system. Nevertheless the goal of any design research activity can be to overcome this complexity in order to provide a broader horizon for the designer.

5 Benefits of building design informatics

Arguably the advantages of such a development outnumber its drawbacks. The main negative points are chiefly related to limiting the designer’s creativity in the traditional sense of the design activity. Nevertheless, to advocate the proposed system, the following favourable issues can be mentioned:

– ability of the system in offering required data and or information on the particular project;
– ability of the proposed system to offer procedures to the building designer to carry out the building design process, or creating his/her own choice of building design methodology;
– ability of the system to allow generation of a greater number of alternative solutions than traditional methods of the building design process. The latter would be more

time-consuming and in practical terms is usually not feasible, especially for professional designers, due to lack of time and economic factors;
– ability of the system to show the consequences of each alternative solution with regards to his/her set of criteria,
– ability of the system in offering the feedback mechanism as a time-saving factor.

6 Conclusions

Like any other technological revolution, the introduction of the computer and information technologies will transform the designers' working environment. This paper noted that the most significant of new potentials would be an ability to oversee the consequences of changes brought about in the process of designing. The key-word in this system is change and the term navigational design referred to the presence of the designer at all phases and steps of the design process, controlling the quality of the product by implementing new ideas as they come and when they come.

Designing in an information environment allows a designer to benefit from a design decision support system implemented in the environment which is based upon a comprehensive design knowledge-base system, supported by a variety of design expert systems. Also, the design information environment offers its greatest challenge, that of conducting concurrent design and the involvement of members of the design coalition team.

Arguably the designer in this environment will exercise more freedom for the expression of design ideas and arriving at more accurate decisions. The purpose of designing in an information environment is arriving at designs which can stand up to higher standards and can serve their purpose more effectively.

The introduction of this environment does not necessarily replace the friendly face of a drawing table and sketch-paper with the unfriendly face of a computer screen. The state-of-the-art of the technology shows the possibility of introducing a totally integrated electronic design office, ergonomically designed with the help of designers and for the designers (Moshe and Sheviv, 1988:137).

7 References

Beheshti, M.R. (1986a), Editorial: The future of the design coalition team, **Design Studies,** special issue, 7:3, 122–124

Beheshti, et al (1986b) **Research Reports,** Vols. 5, 7 and 9, Eindhoven University of Technology, Eindhoven.

Beheshti, M.R. and Monroy, M.R. (1988a) Steps towards developing an architectural design information system, in **CAAD FUTURES'87** (eds T.Maver and H.Wagter), Elsevier, Amsterdam, pp. 149–170

Beheshti, M.R. and Veer, P.van der (1988b) Decision support environment for civil engineering design, in **EuropIA'88** (The application of artificial intelligence and robotics to building, architecture and civil engineering), Hermes, Paris, pp. 235–246.

BNA (1985) **The building information matrix,** BNA (Royal Society of Dutch Architects), Amsterdam.

Lansdown, J. and Roast, C. (1987) The possibilities and problems of knowledge-based systems for design, **Planning and Design,** 14:3**,** 255–266.

Moshe, R. and Shaviv, E. (1988), "Natural language interface for CAAD systems, in **CAAD FUTURES'87** (eds T. Maver and H.Wagter), Elsevier, Amsterdam, pp. 137–148.

Norberg-Schulz, C. (1965) **Intentions in architecture,** MIT Press, Cambridge.

Ohsuga, S. (1989), Toward intelligent CAD systems, **CAD,** 21:5, 315–337.

Piaget, J. (1972) General problems of interdisciplinary research and common mechanisms, In **Main trends of research in the social and human sciences:** Part one: Social sciences (eds Friedman, S. et al), Mouton/UNESCO, Paris.

RIBA (Royal Institute of British Architects) (1981) **Handbook of architectural practice and management,** RIBA, London, UK, p. 438.

Wagner, W.F. (1985), "The result of a survey: How are firms with computers faring, and what are the non-users waiting for?", **Building Design Record,** 173:7, 37–39.

Zeigler, B.P. and Wael, L. de (1986) Towards a knowledge-based implementation of multi-faceted modelling methodology, in **AI applied to simulation** (eds E.J.H. Kerckhoofs et al.), SCS, CA.

151
The project database, its codification structure and relation to CAD drawings and construction management systems

B.BINDSLEV

Abstract
The project database is becoming an important instrument for quality management and for control of cost and time. Its effective implementation and use depends on its logical codification structure, the education of skilled database managers and the availability and flexibility of computer software. Problems are complex and are becoming more complicated because of the need to integrate the discursive forms of construction management documents with the geometry of CAD drawings. The paper will propose codification structures and suggest requirements for integration of drawings with alpha-numeric documentation.
Keywords: Project Database, Codification, CAD Drawings, Construction Management, Classification System.

1 The project database

A project database is defined as a computerized database holding all design, recording and control decisions relating to the project, organized in such a way that it is possible to generate, i.e. produce, modify and maintain, all project management documents during the construction and use periods, such as drawing lists, specifications, bills of quantities, cost budgets, time schedules, cash flow diagrams, cost accounts, progress reports, analyses, statistics, etc.

In order to extract the dimensions of the project, documents should be processed by means of a project management system that is linked to the CAD-system for drawing production. The project management system should include a database management module that allows proper file management, restructuring, reordering, selecting, merging, calculating and printing.

The project database should be structured in columns and rows as a so-called relational system. “In traditional terms”, says C.J.Date (1986), “a relation resembles a file, a tuple a record (occurrence, not type), and an attribute a field (type, not occurrence).

Those correspondences are at best approximate, however. A relation should not be regarded as "just a file", but rather as a disciplined file—the discipline in question being one that results in a considerable simplification in the data structures with which the user must interact." "The major features of relational "files" that distinguish them from traditional "undisciplined" files are as follows:

1. Each "file" contains only one record type.
2. The fields have no particular order, left to right.
3. The records have no particular order, top to bottom.
4. Every field is single-valued.
5. The records have a unique identifier field or field combination called the primary key."

A relational project database could be structured as shown in principle in fig. 1. This structure should only be seen as an example. As mentioned before the computer program should allow columns to be added, omitted, reordered, etc., as required by circumstances. Both single line and multi-line items should be allowed. Merging with other files must be possible.

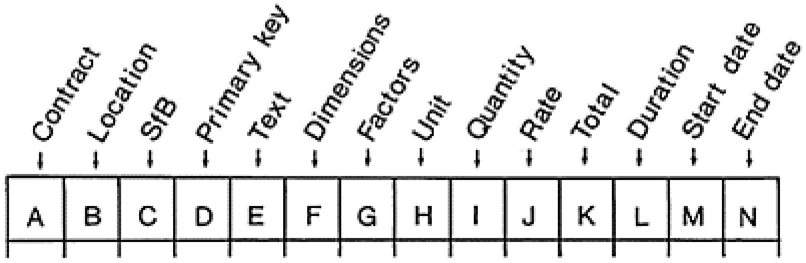


Fig. 1. Example of column structure.

In database management it is the text items (E) that are our main concern. They express the intended or actual properties (quality) relating to the spaces, activities and resources of the project. In order to be processed by the computer, these items should be identified by a unique reference number, i.e. a primary key (D). They should be classified according to a system that fulfills the user's analytical requirements, e.g. SfB (C). Furthermore, for quantity management each item should be allocated to relevant project oriented locations (cells), i.e. buildings, storeys, departments, rooms, etc. (B). Finally, as required, activities and resources should be related to such professions, trades, contractors, sub-contractors or persons who are responsible for their execution (A).

The structure of the project database should allow columns for all necessary attributes, such as: dimensions, i.e. length, width, height (F), multiplication factors (G), unit of measurement (H), quantity (I), rate (J), total price (K), duration (L), start date (M) and end date (N).

In American database terminology all codes are denoted as "keys". There is a distinction between "primary keys", i.e. reference numbers, and "foreign keys" which is a name for all other codes. Says C.J.Date (1986): "Foreign-to-primary-key matches represent references from one relation to another; they are the "glue" that holds the database together. Another way of saying this is that foreign-to-primary-key matches represent certain relationships between tuples."

In practice a primary key in a project database may be a sequential number of 4, 5 or 6 digits, depending on the size of the project. Whereas elaborate classification codes may be avoided on the geometry of CAD-drawings, a primary key is absolutely fundamental for the operation of the relational model and for reference to alpha-numeric, discursive documents.

2 Classification system

A classification system is necessary—but not sufficient—for the arrangement or grouping of text items in the database according to some logical principle. It is equally important for purposes of analysis in terms of searching, sorting, selecting, merging, calculating, etc. A classification system should act as part of the so-called "digital model" of the building project.

A classification system normally consists of classification tables, each comprising a number of classes designated by codes in the form of numbers, letters of the alphabet, etc. Each table should describe relevant facets of the project, regardless of profession or trade.

For international data communication, analyses and studies agreed classification tables should be available. The international SfB system published by CIB seems to be the only facetted classification system that is generally available. Its structure makes it applicable in relational databases. Its three basic tables correspond to the well-known three levels or layers which in cybernetics have been termed "black box", "grey box" and "white box".

Similarly, according D.R.Hofstadter (1980), "we can separate out fairly clearly three levels of information (1) the frame message; (2) the outer message; (3) the inner message. The one we are most familiar with is (3), the inner message; it is the message which is supposed to be transmitted: the emotional experiences in music, the phenotype in genetics, the royalty and rites of ancient civilizations in tablets, etc."

Furthermore: "The outer level is perforce an implicit message, in the sense that the sender cannot ensure that it will be understood. It would be a vain effort to send instructions which tell how to decode the outer message, for they would have to be part of the inner message, which can only be understood once the decoding mechanism has been found. For this reason, the outer message is necessarily a set of triggers, rather than a message which can be revealed by a known decoder."

Fig. 2 shows that a functional building element, e.g. an external wall, can be understood in three ways, corresponding to the decision process in building design:

1. As a frame message denoted by the class symbol (21). This message may be seen as a trigger of the outer message, i.e. of the activities that can satisfy the frame message. Note: Using SfB it is important to interpret symbols of table 1 as classes of frame messages, not classes of inner messages.
2. As an outer message denoted by the class symbol $(21)^{\sim}$. The outer message may be seen as a trigger of the inner message, i.e. of those resources that satisfy the activities of the outer message.

3. As an inner message denoted by the class symbol (21)˜˜. The inner message forms the basis for the motor activity that realises the message. In other words, the inner message is a trigger of work execution in the factory and on site.

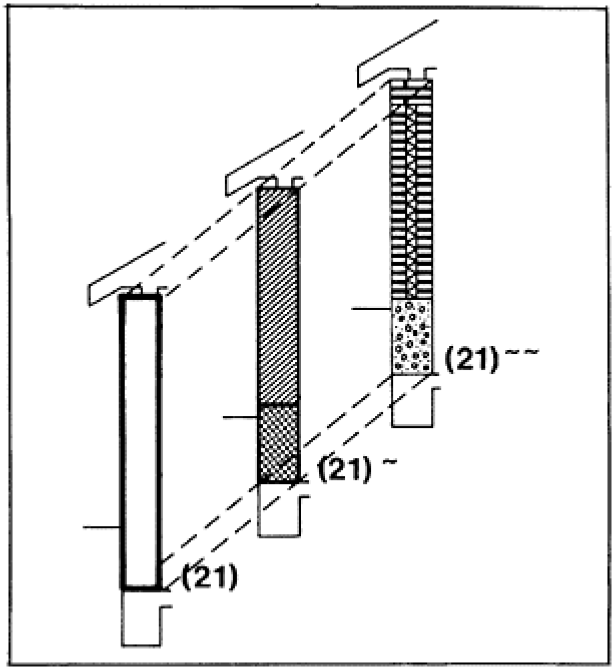


Fig. 2. Three “layers” of an external wall.

Under all circumstances we deal with an external wall, but the message about the wall varies, depending on whether we talk about its form of appearance, its production and use or the resources that are consumed during its production and use.

CIB/SfB (1986) is not sufficiently developed to fulfill all requirements of database management. For this reason I have proposed extensions to the official tables, all based on the class operations of symbolic logic. I have also proposed extensions regarding sub-classification of administration, labour, tools, operations, materials and works.

3 Class operations

By a class operation is understood an operation on two or more classes to form a new class. The following class operations signifying certain logical relations among classes should be present in each of the SfB classification tables mentioned below, cf. A.M.Hilton (1964).

3.1 Universe classes

A class that contains all elements in the universe of discourse is called a universe class. Verbally this is expressed by any statement about everything. By introducing the symbol of tilde "~" for the universe class it is possible to codify the totality of a certain set.

3.2 Complement classes

Two classes which have no mutual members and which by dichotomy divide the universe in for example classes a and not-a, are called complementary because they need each other to form the universe. By introducing symbols for complement classes it is possible to differentiate between dichotomies such as: Town-country; Building-site; Production-use; Site fabrication-prefabrication; Work-administration; Materials-operations; etc.

3.3 Union classes

The sum of two classes within the universe of discourse forms a new class. If we consider a universe of discourse which contains a class of "pretty girls", which we will call class A, and a class of "intel¬ ligent girls", which we will call class B, we can group all of them together in a new class C. Class C now includes intelligent and pretty girls. It is, in other words, composed by the sum of A and B. This class operation is called disjunction by the logicians, union by the mathematicians and the OR-operation by the engineers. For example, the class of "work" is the union class of "labour", "tools" and "materials".

3.4 Intersection classes

The product of two or more classes from different tables consists of those elements that combine the properties of the classes. The new class, formed thereby, may be denoted class D. For example, if there is a class A (pretty girls) and a class B (intelligent girls), we hope that we can find a subclass D (pretty and intelligent girls). The product of the classes A and B is formed by the operation, which is called conjunction by the logicians, intersection by the mathematicians and the AND-operation by the engineers. For example (21)Fg2 is the intersection of the classes (21), F and g2.

4 Classification tables

There is need of the following—or similar—classification tables in database management. Those mentioned are all based on SfB or versions of SfB.

4.1 Table 0

A classification generated as a calculus of form elements of the town, i.e. their geometry, incl. environmental elements belonging to the town. This geometry should be understood as space for production and use activity inside and outside the town. The society, as universe of discourse, is divided in classes so that each main class is denoted by the symbols 0 to 9. The table is further subdivided by numbers to cover all classes from 00 to 99. The main grouping is as follows:

0	Conditions (environment)		$ xx
1	Administration	$ xx	
2	Industry	$ xx	
3	Commerce	$ xx	
4	Health	$ xx	
5	Recreation	$ xx	
6	Church	$ xx	
7	Education	$ xx	
8	Housing	$ xx	
9	Town & country (excl. environment)		$ xx
~	Total society		$ xx

The table includes civil engineering classes 91–98 relating to roads, bridges, squares, parks, canals, railways, harbours, etc., and the classes 01–08 covering the complementary user spaces in the town. The classes 00, 10–80, 90 stand for classes of buildings relating to the country, whereas the classes 09, 19–89, 99 stand for the complementary elements in the town. Cf. CI/SfB (1976).

4.2 Table 1

A classification generated as a calculus of form elements of the building, i.e. their geometry, including environmental elements. This geometry should be understood as space for production and use activity inside and outside the building. The universe of discourse is divided in sub-classes so that each class is denoted by a number in brackets from (0) to (9). The table is further divided to comprise all classes from (00) to (99).

(0)	Conditions (environment)		$ xx
(1)	Foundations	$ xx	
(2)	Superstructure	$ xx	
(3)	Completion	$ xx	
(4)	Finishes	$ xx	
(5)	Engineering services	$ xx	
(6)	Electrical services	$ xx	
(7)	Fittings	$ xx	
(8)	Furniture	$ xx	

(9)	Built-up area (excl. environment)	$ xx
(~)	Total built-up area	$ xx

The table includes room classes (91)-(98) relating to general user functions, such as access, work, cooking, hygiene, etc., and the classes (01)-(08) covering the complementary spaces for user activity in the building. The classes (00), (10)-(80), (90) stand for classes of elements relating to the site, whereas the classes (09), (19)-(99) stand for the complementary elements in the building.

4.3 Table 2

A classification generated as a calculus of human activities, partly comprising the activities in connection with production in factory and on site, partly comprising the activities in connection with use of the finished building. The universe of discourse is divided in main sub-classes denoted by capital letters as set out below. If required the user may subdivide by addition of further symbols.

A	Production conditions (activities in use)		$ xx
B	Demolition works	$ xx	
C	Earth works	$ xx	
D	Construction conditions (prefab works)	$ xx	
Y	Construction works (works on site)	$ xx	
Z	Production works (excl. activities in use)		$ xx
~	Total function		$ xx

Two matters should be noted. First, the inclusion of class A, comprising production conditions, i.e. activities in use, including operation and maintenance. In conjunction with table 1 symbols we get, e.g.:

(0)A	General conditions of contract
(31)A	Use of external wall completion (windows, etc.)
(32)A	Use of internal wall completion (doors, etc.)
(56)A	Use of heating services

Second, the inclusion of class D, comprising construction conditions, i.e. activities in prefabrication. According to Ranko Bon (1987) “Input-output analysis, introduced by Leontief (1936), is based on the central insight that commodities are needed in the current production of other commodities.” And further: “Total resource utilization, both direct and indirect, deserves special attention in the study of the construction sector precisely because of its assembly character. Therefore, in the case of the construction sector it is essential that the analysis captures the sectoral interdependence in terms of both demand and supply patterns.”

With regard to a common database structure, based on SfB, prefabricated products manufactured by suppliers should be given under D. In conjunction with table 1 we get, e.g.:

(0)D	Conditions for prefabrication
(23)D	Products for suspended floors (e.g. large slabs)
(31)D	Products for external wall completion (e.g. windows)
(56)D	Products for heating services (e.g. radiators)

Site fabricated products (building elements, buildings) should be given under Y. In conjunction with table 1 we get, e.g.:

(0)Y	Conditions for site construction
(23)Y	Construction of suspended floors
(31)Y	Construction of external wall completion
(56)Y	Construction of heating services

or, alternatively, with a detailed subdivision E to X, e.g.:

(21)E	Construction of external walls with concrete in situ
(21)F	Construction of external walls with bricks and blocks

etc.

Since production results of prefabrication act as material resources in site construction, product codes (demand) should be transformed to material codes (supply). Example: A prefabricated floor slab denoted by the output-code (23)D˜ ˜ will change to a resource input-code f2. This material resource, when used in construction on site, will appear under the code (23)Gf2.

4.4 Table 3

A classification generated as a calculus of human activity factors or resources. In a project database each activity type, e.g. (21)F, (23)G etc., should carry a resource specification. The universe is divided in sub-classes denoted by lower-case letters a to z with addition of numbers 0 to 9. The main grouping is:

a	Administration		$ xx
b	Labour	$ xx	
c	“Tools	$ xx	
d	Operations	$ xx	
y	Materials	$ xx	
z	Work		$ xx

Total activity	$ xx

A database should preferably be structured with text-items for each activity type under a Administration, d Operations and y Materials according to the principle of Operational Bills of Quantities as described by E.R.Skoyles (1976).

Administrative items for each activity could be given according to the following sub-classification:

a0 General administration

a1 Planning of functions (outline design)

a2 Planning of activities (scheme design)

a3 Planning of resources (detail design)

a4 Recording of resources

a5 Recording of activities

a6 Recording of functions

a7 Control of resources (comparison a3/a4)

a8 Control of activities (comparison a2/a5)

a9 Control of functions (comparison a1/a6)

Operational items for each activity could be given according to the following sub-classification (d isomorphic in relation to a):

d0 General operations (site establishment)

d1 Setting out of primary points (principal dimensions)

d2 Setting out of secondary points (incl. formwork)

d3 Setting out of position points (e.g. holes)

d4 Preparatory operations (incl. transport, cutting)

d5 Placing of materials (fixing in position, assembly)

d6 Operations in use (incl. caretaking, supplying)

d7 Regulation of resources (making good before placing)

d8 Regulation of activities (making good during construction)

d9 Regulation of functions (maintenance in use)

Material specifications for each activity may be given according to the material classes e to×in CIB/SfB. Alternatively, a sub-classification of material resources y0, y1, y2…y9 may be given which is isomorphic to the operational classes. Such isomorphism will simplify the automated production of work-items in cases where bills of quantities are measured according to traditional rules, cf. Fletcher/Moore (1965).

Consequently, an activity oriented project database with items for operations and materials given separately (cf. EDIFACT) could be set up according to the following example, cf. Bindslev (1987).

<u>Stage a0: Clients brief</u> (project geometry)

71 <u>SCHOOL</u>

State requirements according to client's brief.

<u>Stage a1: Outline design</u> (building geometry)

71(21) <u>EXTERNAL WALLS</u>

State functional requirements.

<u>Stage a2: Scheme design</u> (list of activities)

71(21)E <u>CONSTRUCTION WITH CONCRETE IN SITU</u>

State activity requirements.

<u>Stage a3: Detail design</u> (list of resources)

71(21)Ea3	Planning of resources
71(21)Ea8	Control of activities
71(21)Ed2	Setting out secondary points
71(21)Ed3	Setting out position points
71(21)Ed5	Placing of materials
71 (21)Ed8	Regulation of activities
71(21)Eh2	Steel reinforcement
71(21)Eq4	Concrete mass

Automatic quantity take-off by the CAD-system should be limited to main quantities on activity level (stage a2). Transformation of 3D-quantities on activity-level to detailed quantities on resource-level (stage a3) is most practically made via the project management system. According to this principle code references on drawings could be limited to primary keys in combination with location codes for "cells" (storey, section, room, etc.), related to the layer-system. If required, SfB codes could be left out on drawings or just added for search purposes.

It has been rightly said that if the integrated CAD-system should be able automatically to produce a complete bill of quantities, then the complete bill of quantities could also produce the complete set of drawings. This is on condition, of course, that each object (space, activity, resource) is unambiguously located in the project's system of co-ordinates. From this point of view there is an isomorphic coherence between drawing and bill of quantities because they have the same pattern and represent the same product. The difference is that drawings are space-oriented representations of a static entity, while bills of quantities are discursive models of a set of dynamic processes which demand that statements come one after another, even if their objects are in reality—and on the drawing—placed inside each other. The term “bill of quantities” should not be taken in the ordinary sense, but rather as a time-oriented knowledge base for management purposes which holds the universal information of the project, cf. fig. 1. Accordingly, there is a kind of Einsteinian space/time relation between the geometrical model of the line-drawings and the linguistic model of the knowledge base. A coding system as described briefly above is the glue that holds them together.

5 References

Anon. (1986). A Practice Manual on the use of SfB. The Classification System for Project and General Information in the Building Industry. CIB Report, Publication 55.

Bindslev, B. (1987). Database Structure for Building Works according to CBC/SfB (including PROXIMA diskettes). Kokkedal.

Bon, R. (1987). Direct and indirect resource utilization by the construction sector: The case of the United States since World War II. CIB Proceedings of the Fourth International Symposium on Building Economics. Copenhagen.

Date, C.J. (1986). An Introduction to Database Systems Volume I, Fourth Edition. Addison-Wesley Publishing Company.

Fletcher, L. and Moore, T. (1965). Standard Phraseology for Bills of Quantities. London: George Godwin Ltd. for “The Builder”.

Hilton, A.M. (1964). Logic, Computing Machines and Automation. Meridian Books.

Hofstadter, D.R. (1980). Gödel, Escher, Bach. An Eternal Golden Braid, Vintage Books.

Ray-Jones, A. and Clegg, D. (1976). CI/SfB Construction indexing manual. RIBA Publications Limited.

Skoyles, E.R. (1976). Materials wastage—a misuse of resources. Building Research and Practice.

152
The development of cost-time profiles for selected building activities using an expert system

J.CHRISTIAN and G.KALLOURIS

Abstract
Cost-time profiles, modeled on typical construction trades in educational, office and apartment building projects constructed in New Brunswick, have been developed. Data was gathered from the progress reports of the activities in twenty-eight projects; details of the cost-flow patterns for the different activities were normalized into percentages of the total activity cost and time. Appropriate mathematical models were then obtained by regression analysis. A prototype knowledge-based system, using an expert system shell, has been developed to accommodate the knowledge and experiences gathered concerning the activity cost-time patterns. The rule-based expert system simulates a consultation between an expert and a user, where the microcomputer represents the expert and the user is either a prospective owner or contractor. The output of the consultation shows how the cost of the various trades will most likely be distributed over their duration. This enables the prospective contractor or owner to anticipate the probable financial commitment each month.

Keywords: Construction Management, Cost-Time Profiles, Expert System, Activities.

1 Introduction

The financial management of a construction organization is the key factor to its success. Many construction organizations experience financial failures as a result of poor budgetary planning. Funds become so thinly spread among the organization’s projects that individual activities in some of them lack enough working capital to be continued in the working capital cycle. Predictive cost-time profiles therefore provide a useful planning tool for both parties involved in the construction process.

It has been a tradition in the construction industry, over the last few decades, to assume a standard “S” type graph for predicting all kinds of cost-time progress for all types of facilities being constructed. Although numerous investigations have been made to anticipate the financial cost-flow of overall projects (Peer, 1982; Singh and Woon, 1984), only a few have examined the characteristic construction curves for individual activities (Carr et al, 1974).

The purpose of the research described in this paper was to investigate the characteristic cost-time profiles for different construction trades associated with educational, office and apartment building projects in the province of New Brunswick. Such modelling of cost-time profiles for major activities can be extremely useful to the project owners and contractors in their financial planning.

In addition, the prototype knowledge-based system, used in conjunction with the trends established, provides the capability of considering various parameters affecting the variations of these profiles. In a global sense, factors contributing to variations in progress, and consequently cost-time patterns, of construction activities may be countless. Consequently, the determination of the significant parameters, and knowledge of how they affect the cost-time variation of building activities in New Brunswick, has been acquired from experts and professional practitioners in building construction.

2 Data Collection and Model Development

Usually the cost schedule, for building projects in New Brunswick, is prepared using the same general divisions similar to those that appear in the specifications. Progress is customarily measured in terms of estimated percentages of completion of the major job components or activities. In this paper, the cost pattern of the following construction trades will be addressed:

(a) Site Work (including excavation, backfilling, seeding and topsoil, paving and site services),
(b) Concrete (including reinforcement and formwork),
(c) Masonry (including brickwork and blockwork),
(d) Steel and Metals (including structural steel frame and metal decking),
(e) Mechanical Services (including plumbing, HVAC and fire protection) and,
(f) Electrical Installations.

A total of twenty eight steel-framed, with brick and block infill, building projects were investigated in this research. Ten of them were of the educational type, another ten were apartment buildings and the final eight were office projects. Their cost varied from CAN $1.5 million to CAN $6 million with an average cost of CAN$3.2 million. The projects were completed in various locations in New Brunswick, Canada, during the period of 1985–1988. Their duration ranged from 6 to 13 months with an average of 10 months. Table 1 shows details of the total cost and duration of the activities.

Cost data of the various trades in the projects was collected from the progress reports of each individual trade. To compress the data on a common scale, the monthly totals of the cost of activities

Table 1. Total Cost and Duration of Trades

ACTIVITY	DURATION (Months)				COST ($1000's)			
	Avg.	Std. Dev.	Range	Median	Avg.	Std. Dev.	Range	Median
Site work	6	1.3	5–8	6	204	103	98–404	166
Concrete	6	1.4	4–8	6	206	100	96–332	185
Masonry	6	1.6	4–8	5	230	64	131–340	216
Steel & Metals	7	1.1	5–8	7	218	113	100–420	189
Mechanical Services	8	2.1	6–12	8	406	150	186–640	436
Electrical Installations	8	2.1	6–12	8	318	141	175–538	207

and time elapsed were normalized to percentages of the total activity cost and time, respectively.

Regression analysis was employed to establish the appropriate model for the data relationships. On the basis of the sampled data, the value of the dependent variable (completion cost) corresponding to the value of the independent variable (time elapsed) were modelled. Exponential, geometric, reciprocal, hyperbolic and polynomial functions were examined to find the type of best-fit model. A reasonably accurate cost-time forecast was possible by means of a single formula utilizing the two parameters. In addition, the knowledge-based system developed, used in conjunction with the trends established, provides the flexibility of considering various parameters affecting the variation of these profiles.

As an example, Table 2 shows the results obtained. A sample of the graphical display of the data concerning concreting in educational and masonry in office buildings is shown in Figures 1 and 2 respectively.

Data gathered reflect the collective influence of all critical factors that have influenced the cost-time profiles of building operations in New Brunswick since 1987. Critical factors responsible for cost-time variations, their level of influence on each activity and how experts handle them, in conjunction with the cost-time profile variation, was another part of the knowledge acquisition process that has been stored in the knowledge-based system.

A survey was conducted, among thirty-five expert and professional practitioners, to identify parameters significantly affecting the cost-time variation in New Brunswick. The sort of information required was the expert's experience and knowledge concerning the cost-time profiles. Answers to questions such as:

Table 2. Cost-time Models of Construction Trades in Educational Buildings

Trade	Cost-Time Profile	R^2	$^{\sigma}y$	n
Site Work	$Y=2.85X^3-4.67X^2+2.756X+0.04$	0.83	0.12	112
Concrete	$Y=1.01\ X^{0.62}$	0.84	0.11	94
Steel & Metals	$Y = 1.52\ \frac{X}{(0.36+X)}$	0.87	0.08	70
Masonry	$Y=-1.07X^3+1.40X^2+0.70X-0.02$	0.96	0.06	70
Mechanical Services	$Y=-1.36X^3+1.64X^2+0.76X-0.04$	0.92	0.09	101
Electrical	$Y=2.95X^3+4.84X^2-1.01X+0.06$	0.91	0.10	112

Y=cumulative cost
X=time elapsed (Both expressed as fractions of the total cost and time)

R^2=coefficient of determination
n=number of data points
$^{\sigma}y$=standard error of estimate

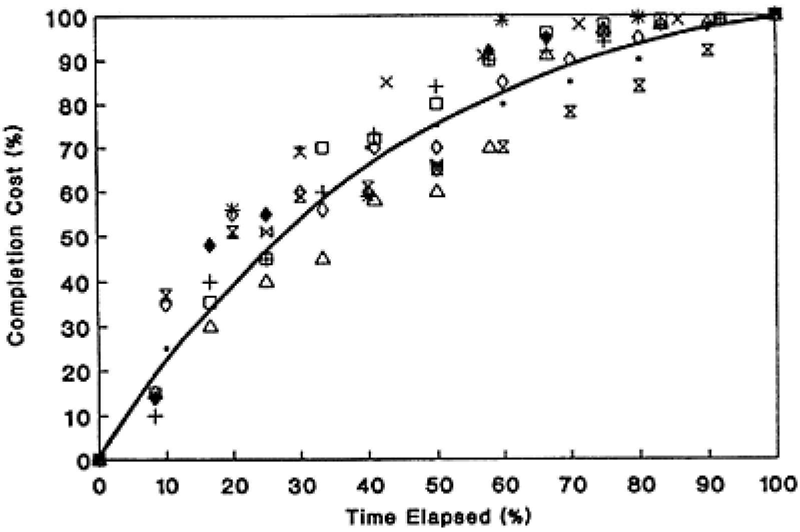


Figure 1. Cost-Time Profile—Concrete—Educational Buildings

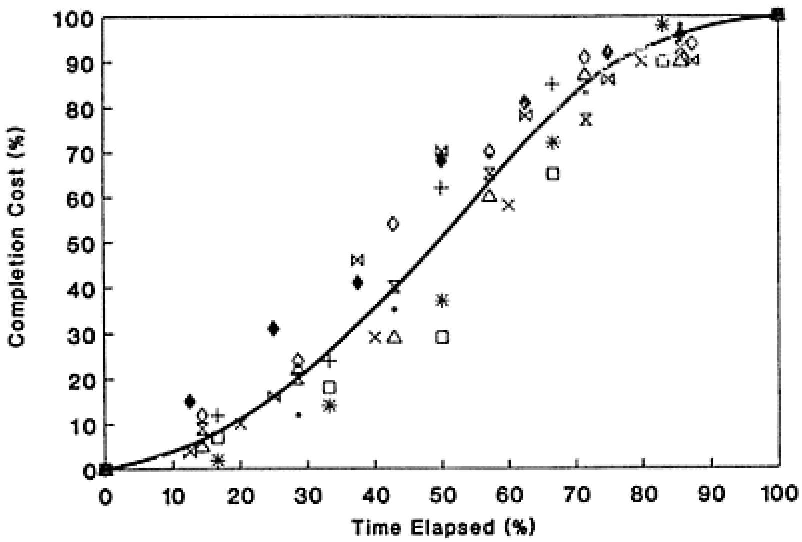


Figure 2. Cost-Time Profile—Masonry—Office Building

What factors have an impact on cost time variation?

What level of influence do they have?

Which of them are critical and common in New Brunswick?

How does the expert classify them and what assumptions and hypotheses does he/she make to arrive at a solution?

were obtained for inclusion in the knowledge base.

3 The Knowledge-Based System

3.1 The Model

The knowledge base contains a collection of facts, parameters, heuristics, assumptions and rules for the prediction of cost-time profiles of building construction activities in New Brunswick. The shell (Personal Consultant Plus) uses the knowledge base to interact with the user and the database, created from the twenty-eight building projects, to deliver the required advice. In order to separate the rules into logical divisions, the knowledge base is divided into 11 rule groups. These divisions are: knowledge-based rules, site-work, concrete, masonry, steel, wood, thermal, finishes, door, mechanical and electrical rules.

The operation of the system can be thought of as a dialogue between an expert and a prospective contractor, or owner, who is at the early phase in the development of a project. If the user needs additional information to respond to a particular question, he can use the F1-key to interrupt the normal flow of the dialogue to obtain a display of text, explaining the meaning of the request and data to be entered.

A review option is incorporated in every stage of the consultation to enable the user to modify the answers. Furthermore, at the end of the consultation, the user can print the consultation history, or save the input/output in a file.

The knowledge representation (also called classification model) of this system is similar to the one proposed by Weiss and Kulikowski (1984). Three lists contained in the knowledge base are:

1) list of hypotheses
2) list of observations
3) list of rules relating hypotheses and observations.

The typical rule based system IF…THEN…logic form flow was used. IF expresses the hypothesis or hypotheses to be met before the shell can carry out the action. On the other hand, THEN expresses the actions to be taken if the conditions of the IF statement are applicable. Although the shell itself is written in LISP, all rules were written in a language called Abbreviated Rule Language (ARL). This useful feature of the PC Plus shell program makes the expert system development easier, quicker, and more\ efficient.

3.2 Mode of Operation

The mode of operation consists of a series of questions linked by IF…AND…AND…OR…THEN logic. The consultation process can be thought of as a dialogue between an expert (a microcomputer) and a prospective contractor, or owner, who is at the early phase in the development of a project.

The system begins by providing a menu of the different types of construction operations in building projects. A second menu concerning the type of building allows the user to choose the required type. Once the goal (activity) has been defined, the system will ask information about the parameters influencing cost-time. The required input by the user depends upon the anticipated conditions prevailing during the construction operation.

An impact index is classified into three ranges. Good conditions prevailing during the construction operation are reflected in the range of 0–0.33, average conditions fall in the range of 0.33–0.67 and relatively bad conditions in the 0.67–1.00 range.

An example of a masonry rule link to a knowledge base rule group (which evaluates the effect of each parameter causing variation to the cost-time profile) is as follows:

```
IF:
         BUILDING="Educational" and
         ACTIVITY="Masonry" and
         DURATION BT 6 TO 9 Months and
         INDEX BT 0.33 TO 0.66
```

```
THEN:
          IMPORT(QUOTE(LOTUS-WKS "MASON2A") MASONRY-
PROFILE)
          (BT is a numeric predicate function for
between).
```

The output from the above rule, when the duration is six months, showing the value of works (as a % of the total cost) is as follows:

End of month 1, value of works=12%
End of month 2, value of works=30%
End of month 3, value of works=55%
End of month 4, value of works=80%
End of month 5, value of works=92%
End of month 6, value of works=100%

Since the index falls in the 0.33–0.67 range, the regression profile, representing average conditions, is given to the user as advice. That is, the most likely total cost distribution from the owner's perspective, for masonry during month 1, 2, 3, 4, 5 and 6 will be 12%, 18%, 25%, 25%, 12%, 8% respectively. Although the conclusion given at the end of the consultation session can be used directly for the owner's perspective, the time lag between the contractor's costs and cash disbursements, as well as accrued income and cash receipts, should be taken into consideration for the contractor's point of view.

4 Conclusions

Predictive cost-time models provide a useful decision support tool for prospective contractors and owners. As capital budgetary planning is made prior to the development of any detailed cost estimate or schedule, the amount and timing of future financial resources is crucial for any managerial decision-making. A mathematical approach (fast, inexpensive, simple, and reasonably accurate) can be employed to predict the distribution of the costs of individual trades against time.

Progress planning of building projects requires numerous assumptions that the various factors will have on variations of the cost-time profile. Therefore, the input of human expertise and heuristics, along with the facts (cost-time trends) obtained, give the contractor a more extensive forecasting tool for the financial pre-planning of building operations. The owner, in turn, who should be informed of the likely financial commitment at a very early phase in the development of a project will have a guideline, produced very rapidly, of the cost-time flow.

Another aspect of the pre-planning of cost-flows of forthcoming building activities is the preparation of an operations forecast, or a prediction of how much work can be undertaken. This is particularly crucial for small and expanding firms where the availability of a cost-pattern will determine the company's ability to handle new work. The emergence of LISP shells, such as the software package used, is one of the key developments allowing a more efficient creation of expert systems for microcomputers.

This is particularly important in building and construction where the availability of such engineering tools makes the process of designing and implementing expert systems easier, clearer, quicker and more efficient. The expert system has been brought up to the research prototype stage. Provisions for future development such as new rules and parameters can be easily added to account for new or refined knowledge, practices and technology. Hence, continuous up-to-date information is required in order to avoid large discrepancies between forecast and reality.

Established models constitute the first opinion on probable future costs. No matter how much the budget has been qualified and regardless of how well any subsequent revisions will be documented, the first budget tends to have an undue influence on future, more accurate alterations and revisions. Therefore more effort, such as the work described in this paper, should be put into the evaluation of the first budget or estimate.

5 References

Carr, R.I., Brightman, T.O. and Johnson, F.B. (1974). "Progress model for construction activity." J. Constr. Engrg. and Mgmt., ASCE, 100 (C01), 59–64.

Hart, A. (1986). Knowledge acquisition for expert systems. McGraw-Hill Inc., New York, N.Y.

Peer, S. (1982). "Application of cost-flow forecasting models." J. Constr. Engrg. and Mgmt., ASCE, 108(2), 226–231.

Personal consultant plus. (1987). Reference guide manual. Texas Instruments, Austin, TX.

Singh, S., and Woon, S. (1984). "Cash flow trends for highrise building projects", Proceedings of the 4th International Symposium on Organization and Management of Construction, University of Waterloo, Waterloo, ONT, pp. 841–846.

Weiss, S.M., and Kulikowski, C.A. (1984). A practical guide to designing expert systems. Rowman and Allenheld, Totowa, N.J.

153
The technology of change

A.DAY

Abstract
This paper is about the impact of new technology or the construction industry, and in particular on the production of housing. The relationship between technological change and social change is discussed and the current patterns of computer use within the industry are described. An idealised model of how computers could be used in the housing sector is presented and the paper concludes with a speculation on how the industry might change in the future.

Keywords: New technology, computers, housing production, social change.

1 Spinning Wheels and Steam Engines

When James Hargreaves invented his spinning jenny in 1764 he was at the start of a process of change which we now know as the Industrial Revolution. Of course, at the time, he was unaware of the full in plications of his actions but he introduced a technology which changed how people work, and ultimately affected the very structure of society itself.

As a result of the technological changes which took place during the early part of the Industrial Revolution the way in which the basic raw materials of wool and cotton were transformed into textiles was altered. This in turn changed the job of the textile worker from a home-based subcontractor to a factory based employee working a machine in a highly regulated environment. The factories, powered first by water and then by steam, in turn gave rise to the industrial town as workers relocated themselves within walking distance of their jobs. New kinds of social relationship then emerged, at home and at work.

Although the facts of the Industrial Revolution are well documented and, in the main, not disputed, there is considerable debate over the general relationship between technology and social change. ge. Do changes in technology determine social change or is technological change merely one factor in a much more complex process? Such a question is of more than academic interest at the present time as many commentators believe that we are in the middle of a new kind of technological revolution, the effects of which will be as profound as those of two hundred years ago. The cause of this revolution is the technology which has been spawned by developments in computing. Initially this new technology affected those industries, like chemical production, where the main focus of attention was on a process which was highly amenable to automation. With the introduction of new technology the job of the operator shifted from one of direct management to the monitoring of an automatic control system.

We now find ourselves in a position where new technology has diffused throughout the workplace to the point where most jobs are affected to some extent. For example, airline pilots now routinely take off from one airport and then engage an automatic pilot which flies the aeroplane to its destination several thousand miles away without human intervention until after touchdown. The pilot is there, not to fly, but to make sure that the computers do not fail and to inspire confidence in the passengers.

Like other sectors the construction industry has its share of new technology. Most organisations in the industry use computers to some extent and their introduction is changing the way in which many people work. So far this has not fundamentally altered the structure of the industry, but we do not know whether this situation will continue, or whether the time will come when the industry must change in response to these technological pressures?

2 The Diffusion and Uptake of New Technology

Lui et al (1990) suggest that the process of technological change can be characterised by three distinct stages.

1 In the first new technology is introduced and immediately affects the content of jobs and the requirement for particular skills and qualifications.
2 As time passes it becomes clear that the existing organisational design is not particulary well suited to the new technology and that the performance of the system as a whole is sub-optimal when compared to the opportunities which new technology offers.
3 At this point there is then the possibility of a new organisational design being introduced. However if the existing institutional interia is too great to permit this what then happens is that new organisations grow up with working methods based around new technology.

Like the woollen industry of southern England during the eighteenth century the old organisations can continue as before but, being unable to compete effectively, tend to wither and die as new organisations, using new technology, take hold. So although the relationship between technology and change is not simply deterministic, as the technology diffuses structural changes do occur.

3 The Construction Industry

Where, one might ask, is today's construction industry in such a process? The design of a building is not like producing a motor car which can be carried out under factory conditions with considerable opportunities for automation. The operations involved in getting most buildings built are highly fragmented with a large number of people coming together in order to design a unique product. Over the past twenty years various parts of the design and construction process have become amenable to computerisation and we are now at the point where the impact of new technology is beginning to have a discernable effect on organisational structure.

Historically the development of new technology has been from processes which can easily be described mathematically and represented by alphanumeric characters to more complex proceedures which allow many degrees of freedom and which are represented graphically. Computer-aided design and draughting is now attracting a great deal of interest, not just from within the industry, but also from vendors of computer hardware and software. Most of the information which is passed around during a building project is in the form of drawings and so if computers are to reach the core of the industry they have to be able to deal with this kind of graphical information.

Graphics are expensive. High resolution screens are needed and, if complex drawings are to be stored and manipulated quickly, there has to be lots of processing power available. Realising this the computer industry has targeted the Architecture-Engineering-Construction market segment as an potential growth area for their products. Clients, particularly sophisticated ones, realise from their own experience that there are considerable benefits to computerisation and are putting pressure on the industry to adopt an integrated approach to the implementation of new technology. This manifests itself in the requirement placed on participants in new building projects to use a particular CAD system in order to standardise on a least one aspect of project communications.

4 The Benefits of New Technology

So there are pressures on the industry, both from within and externally, to computerise. However the advantages and disadvantages of such a strategy are often ill understood and are worth brief elaboration. The benefits of computerised draughting are regularly extolled in the professional press and are similar to those achieved through the use of a word-processor. The work done can be described as have three distinct stages.

1 INPUT of data
2 MANIPULATION of data
3 PRODUCTION of hard copy

Stage 1, the input stage, will probably take as long to do on a computer as to do manually. Manual methods combine stages 1 and 3 and for some kinds of work, especially where there are few input errors, this is fastest way to get the job done. However in most instances changes have to be made and it is here that computers score. With a CAD system the same piece of data can be used any number of times, changes can be made to a drawing very quickly, and the final result can by produced at any scale. So in practice most users reckon to get a productivity increase of between two and three times through computerisation.

However speed is not the only benefit. CAD allows the data which makes up a drawing to be stuctured in a number of different ways. The simplest, and the one that is cited most often, is through the use of layers. Layers are like a series of transparent overlays and any drawing can be broken down into a number of layers which might represent the work of the various trades involved during building operations.

This highlights the second benefit of computerisation, improved co-ordination. By effectively combining a whole series of drawings into one drawing through the use of layers one can see potentional clashes much more quickly. Also, as CAD drawings are effectively being input at a scale of 1:1 there are none of the problems which often arise through inaccurate or poorly dimensioned drawings. These are the kind of benefits which are already being realised through the use of CAD in many practices, but they are not the only ones available.

Existing working methods necessitate a range of different organisations coming together on a building project. Most of these organisations will have invested in computers but, in the main, their use will be restricted to internal operations. Computers will be used to automate processes which were previously being done manually, but will not be used to communicate between organisations. It is in this area that a second set of benefits become possible. If one can achieve a consistent, single set of data which exists throughout the life of a project, rather that a series of overlapping sets of data held by the various participants, then many of the current frustrations of project working can be overcome.

At the moment too much time is spent translating information from one format to another as it is exchanged between offices. For example most CAD systems now offer the user a facility for defining the various elements of construction and then automatically counting the number of times each element is used in the building. Thus doors, windows, electrical symbols and so on can be counted and output to a database for use by the quantity surveyor. Similarly the construction of various surfaces can be defined, their areas calculated, and the appropriate cost per square metre applied, or overall heat losses calculated. However at the moment many of these features are not used and the raw data, in the form of drawings, are passed to others for manual analysis. The reasons for this are complex but are, in part at least, due to incompatibilities between computer systems.

As the process of computerisation has been carried out piecemeal with each organisation buying the particular combination of hardware and software which meets its needs at the time we are now in the position where incompatibility is virtually endemic. If one were setting up a new system then the best solution to this problem would be for everybody on a project to use the same computer system. If that system were also networked then one would at least get round the problem of compatibility.

If all design team members use the same computer system, and if there is sufficient hardware available for all team members to have their own computer, then the problem which exists on most traditional building projects, that of communication of information, disappears. Everyone now has access to the most up-to-date version of the building model as it emerges. Technically we have an integrated design system which acts as a kind of central storehouse for project information. The benefits of this may be summarised as follows:

1 CONSISTENCY of information
2 ACCESSIBILITY of information
3 ECONOMY of information

Because there is only one set of information, as in a traditional database, anything that is produced from it, such as drawings, specifications or schedules must, by definition, be consistent. -If all team members are using the same system then they all have equal access to the information that it holds and, as the information has only to exist as a single instance, then considerable economies are achieved.

5 Social Barriers to Integration

What has been outlined above is the kind of idealised technical arrangement which could begin to make the full benefits of computerisation available to the building industry. What we have at the moment—is a melange of hardware and software which makes two out of three of these benefits difficult to achieve. A certain amount of economy has already been realised but accessibility and consistency are still problematic. However things are changing. The problem of differing standards has been recognised for some years and there are now a number of initiatives directed towards a solution. Within the next few years, as common standards become increasingly demanded by users and as out of date, incompatible sytems are replaced, this particular problem will undoubtedly diminish in significance.

What will then be exposed is the much more serious problem of entrenched professional roles and outdated working methods. It has long been recognised that the existing organisational stucture of the industry is not an ideal one when it comes to designing and constructing buildings, (Higgin & Jessop, 1965; Day, Faulkner & Happold, 1986) . For the parties concerned this fragmentation may have benefits when it comes to diffusing blame for poor performance but there are considerable penalties in terms of project performance as a whole.

New technology works best in situations where there is vertical integration. Data can then be passed from one stage to the next with a minimum of translation. However for such a system to work in practice there has to be a commonality in working methods between the various parties involved. This is where the issue of data structures becomes important. The present system is tolerant of differences in working methods because data, in the form of drawings and specifications, are standardised at the point of exchange. The problem is that this standardisation operates at the level of the lowest common denominator and there has to be a lot of work on either side of the exchange boundary before the data can be reused. Computers can help to circumvent this problem, but only if those who are upstream in the data flow have knowledge of how the data will be used downstream.

The best way to establish a commonality of working methods between the various design team members is to abandon traditional methods and move towards a multi-disciplinary approach. Ideally multi-disciplinary design teams, which are highly integrated and where the team members work together on a number of projects, should be formed. Professional boundaries are then eroded and team members develop a direct knowledge of how the information they produce is actually used.

So although computers provide considerable opportunities for improvement in the quality of information produced, as well as savings in its cost, these opportunities will only be realised if the social organisation where the work is produced is complimentary to the technology. Technology on its own is not sufficient. In order to operate effectively design teams need common computer systems and common space. Working together in the same physical space allows social networks to form which, in time, can become stronger than pre-existing professional allegiances.

6 Computers and the Production of Housing

House building is an area where there would seem to be considerable scope for such an arrangement. There is a high degree of standardisation in the final product and, in many respects, housing is the nearest the building industry gets to fully integrated industries like automobile production.

A great deal of housing, particularly when it comes to larger projects, is undertaken by organisations which carry out all the work in-house. Although there are opportunities for multi-disciplinary working within these organisations, this seldom happens as they are internally divided into professional groups. Such an internal stucture may offer some advantages over traditional methods but integrated computing will probably not be one of them. Internal divisions tend to lead to separate budgets and autonomy when it come to purchasing equipment, such as computers. In such an environment hardware and software incompatibility is almost inevitable.

As has already been discussed there is a real possibility that such an organisation would find the kind of change necessary for full integration too traumatic. The benefits which could be achieved through internal automation would probably be thought sufficient.

7 An Idealised Model

If one were in a position to propose a new kind of organisation, designed specifically to make the most of new technology, what would it be like? Obviously its first characteristic would be integration, both social and technical. The focus of the operation would be on the task rather than on professional roles with design teams being formed so as to contain all the skills necessary to complete a project, from land acquisition to client hand-over. As far as computers are concerned the choice of which particular brand of hardware and software to use is of much less importance than making sure that all the team members can access the information which this equipment holds. That means sufficient hardware and a big investment in training. If professional staff, rather than dedicated technicians, are to use computers then machines have to be available when staff want to use them, and not when a timetable says that they should. This implies a lot of redundancy within the system.

Training is also crucial. Dedicated technicians can learn to use the most complex of systems, indeed many revel in their skills at doing so, but professional users are different. They will only be using a computer for part of their time and will be put off if their learn ing curve is not fairly steep. The maintenance of skill levels is also difficult when using a system intermittently and having to come back to it after a break. So what is required is a system which is inherently user-friendly and a comprehensive training programme specifically designed for a variety cf users. A central part of this training, indeed of the whole computer management system, relates to structuring the data in such a way that users can find the information they need with little difficulty. Integrated working methods, high levels of computer provision, good training and a considerable investment in appropriate data structures are therefore critical elements in such a system.

8 Standardising on Flexibility

This kind of system works best if there is a high degree of standardisation in the things that are being produced. All volume house-builders acknowledge the need to rationalise the components that go to make a house, but things have changed since the days of industrialised building. The houses no longer look like standard, factory produced products as the market demands a traditional appearance with a great deal of variety, even on a small estate. Ironically the whole process is probably as industrialised as ever with an increasing number of the 'traditional' components being factory produced.

The original idea of the factory was based on a standardised method of production with the overall task being broken down into a number of simple operations. Each operation could then be undertaken by a relatively unskilled worker who would spend his day repeating the same task many times. Although such a system was cost-effective it did demand a large market for the product and was inflexible when it came to variety and change.

A very significant benefit of computerisation in such an environment is that it leads to much greater flexibility. The automobile industry provides a good example of this. The introduction of computer-aided design and manufacturing has meant that the production line is much less static. More that one model can be assembled on the line at the same time as the control system is sophisticated enough to make sure that the correct parts arrive in the right place at the right time. The assembly robots can be reprogrammed to carry out a new task as the situation demands. So what is happening is that the assembly line itself is beginning to disintegrate. The making of cars is being controlled by the flow of information rather than by the flow of parts.

It is doubtful that house production is going to move wholesale into the factory but it may be that the new factory-methods can move to the building site. The robot navvy is still some way off but integrated information is not. New technology allows fewer people to control more information. If fewer people are involved in a project then there is less opportunity for break-downs in communication. The tendency towards increasing specialisation can be reversed as computer-based tools and knowledge systems begin to provide the expertise needed for most tasks. Houses are relatively simple things and there is no reason why a whole range of different professionals are needed to design and build a housing estate. Experience shows that where CAD systems have been used in multi-disciplinary practices for some time many of the users develop new interdisciplinary skills simply because of the kind of environment they are in.

Computer-aided systems therefore offer a number of advantages when deployed in an appropriate environment. As fewer people are needed to encompass the required range of skills tighter project control can be achived. This is enhanced by having a single repository for all project information which can be accessed by any team member at any time. As this information is always up to date overall costs can be reduced and quality improved.

The flexibility which such a system offers can be used in a number of different ways. Alternative housing layouts and mixes can be tried out at the early design stages and this can improve the financial viability and the design quality of a project. Prospective house purchasers can see what they are going to get through the use of computer visualisation and animation and there is even the possibility of using the inherent flexibility of the system to give purchasers an opportunity to make design alterations which can be accurately costed on the spot. A much higher degree of customisation than is practiced at the moment therefore becomes possible.

9 An Integrated Future?

The scenario outlined here has argued that there can be significant advantages to using new technology, particularly if an appropriate organisational environment is set up in parallel with the computing investment. These advantages are not limited to the housing sector, it is just one example of what is possible. If the advantages are real then they are likely to lead to fundamental changes in the industry as a whole.

Technological change does not determine social change and there is no law that states, ‘if an organisation computerises then its internal structure will change.’ There are many documented cases where computers have been introduced into an organisation and nothing has changed. Ways have been found to render the technology useless or, at best, to use it well below its optimum performance as to do otherwise would upset existing relationships. However, if there are significant advantages to using new technology in a particular way then someone will start to do so and will have a competitive advantage in the market-place. So in time things will change, but not necessarily within particular organisations.

Within the construction industry there are currently two competing trends towards computerision, integration and fragmentation. Integration has already been discussed but it should not be fogotten that there are advantages to an alternative approach. Fragmentation is where different, perhaps incompatible, computers are used at different stages of a project to do different jobs. Typical of this kind of use is the growth area of CAD visualisation. It is now possible to use a relatively cheap micro-based CAD system to produce perspective views of a proposed project with the building represented in colour, with shade and shadow. Soon it will be possible to do the kind of real-time ‘fly through’ presentation which, at the moment, is only possible using expensive, specialist equipment.

These applications are particularly attractive to architects. They are popular with clients and enhance the architect’s role during the early design stages. When it comes to producing the working drawings these may well be done using a separate 2D draughting package, or may even be done manually. So although computers might be used at every stage of a job, each stage is likely to be compartmentalised with few of the potential benefits of electronic communications being realised.

This way of working is complimentary to existing working practices. Information is not transferred electronically and architects, QSs and engineers are generally content to communicate with one another conventionally, using drawings and written specifications.

Using the e integrated approach a primary requirement is to use a single computer system, or at least a series of fully compatible systems, for all stages of a job. This is very difficult to organise as all the various parties working on a project must come to an agreement about which computer system to use and how to structure the data. This requires considerable discipline within the various participating organisations and normally implies either a very clear requirement being made by the client, or some form of multidisciplinary design and construction organisation which has decided that such a *modus operandi* is worth the costs. It also requires one of the major CAD packages which has been designed with networking in mind and which is capable of handling large quantities of data in a sophisticated way.

The difficulties of getting such an ambitious strategy operational in an unsympathetic organisation make it unlikely to be realised in many existing set-ups. So the economic advantages of integrated CAD are most likely to be realised by new organisations, specifically set up to make the most of new technology.

This has significant implications for today's building industry. Building projects naturally break into two parts. The first is the design stage, up to receipt of planning permission and client approval. The second includes the creation and co-ordination of all production information *and* the work on site. Both stages are amenable to computerisation but are different, and can easily be separated into two discrete parts where there is little advantage in making the electronic output from the first the input for the second.

Indeed it is very likely that the drawings produced in the first stage will not be dimensionally accurate in any case, and even when electronic communication is possible it is often better to start again and use the drawings produced from stage one as a kind of diagram to be accurately worked up throughout the production information stage.

So, at the present time we have two very different strategies towards computerisation co-existing within the industry. The fragmented approach suits existing working methods and presents no real challenges to the established professional groups, or their working practices. We can all do the things that we already do, but do them rather quicker and, perhaps, rather better. The integrated approach, on the other hand, offers significant benefits to the overall project but, to work, requires considerable changes to existing working practices.

If current trends continue then there is a real possibility that we will see the two kinds of CAD use formalised within a new structure for the industry. The economic sense behind integrated CAD is unlikely to be resisted in the longer term. If existing organisations do not use CAD in this way then new organisations will grow up, either within the UK or imported from overseas, to make the most of new technology. They are most likely to focus on the production information and site organisation stages of a project as it is here that there is the greatest economic advantage. That will leave others, such as architects, to concentrate on scheme design up to client approval and planning permission. Their involvement with the project may then cease leaving the detailed design and construction to new kinds of firm which will have invested heavily in computers and organised themselves on a multidisciplinary basis.

So new technology may not be a neutral force within the industry. Changes may occur and these could be more fundamental than many in the industry anticipate.

10 References

Day, A.Faulkner, A. and Happold, E. (1986) **Communications and Computers in the Building Industry,** Construction Industry Computing Association, Cambridge.

Higgin, G and Jessop, N. (1965) **Communications in the Building Industry,** Tavistock Publications, London.

Lui, M., Denis, H., Kolodny, H. and Stymne, B. (1990) Organisational Design for Technological Change. **Human Relations,** 43, 1, 7–21

154
CAD in structural design of buildings

M.de F.FARINHA, A.A.BEZELGA and A.V.AZEVEDO

Abstract
This paper is intended to present a model that is being developed for use in the design of buildings with a reinforced concrete reticulate structure.

First a brief reference is made to the applicability of the model, next the main requirements to be fulfilled by the system are mentioned, and lastly the main developments carried out are presented.

The general use of integrated design systems is introducing several changes in the different phases of the design of building structures. Designers can free themselves of arduous and repetitive work and have more time available for conception and optimization of solutions. Then the necessary conditions are created for increasing design quality, which will certainly contribute to a better quality of the buildings.

Keywords: Building Structural Design, CAD, Integrated Design Systems.

1 Introduction

Building structural design has known important development in recent years, mostly owing to the introduction of computers in this branch of activity.

Nevertheless the evolution of computer means has been very quick and design activities have not taken thorough advantage of available potentialities.

This paper presents a model that is being developed, in which the potentialities of the CAD systems are applied to building structural design [5].

An attempt is made at creating an integrated design system that can be applied for designing reinforced concrete reticulate structures of buildings. This integrates the structural analysis, the reinforced concrete analysis, the automatic production of writen documents and drawings, the quantity and cost estimation, and the planning of execution.

Improvement of the quality of building design is expected to be achieved as well as an increase of the output of design offices.

2 Model applicability

The model has been developed as a result of the need of integrated building design systems, felt by the Portuguese technical middle. Few Portuguese systems have been developed and moreover they present some limitations. The systems produced abroad, namely in Europe and in United States of America, are not easily adjusted to Portuguese regulations, main reason why they have not been widely accepted in Portugal.

The use of integrated design systems by Portuguese professionals is likely to expand significantly soon, as it already occurs in other countries, owing to the following main reasons:

Increasing requirements as quality and time.

Increasing complexity of problems involved.

Difficulty or almost impossibility of complying with regulations in force without using automatic computational means.

Lower cost of hardware together with increase in
storage capacity, rate of processing, and graphical potentialities.

Great facility of use of the new packages, without needing fairly specialized knowledge of computers.

Advent of more and more powerful drawing systems, making the traditional system out of date.

3 Requirements to be fulfilled in conception and implementation of the model

A first stage in the development of the model consisted of the formulation of requirements which the system must fulfill.

In order to formulate requirements, the following was done: a) analysis of the historical evolution of CAD from 1950 up to now; b) survey of the main CAD systems available in the Portuguese market; c) characterization of design activity; d) characterization of the Portuguese technical middle.

The main purpose in the characterization of the Portuguese technical middle was to know the size and needs of the enterprises working in building design in Portugal. With this aim a questionnaire was drawn up [7], and contacts were made with a wide range of enterprises of various sizes whose head offices are located in the north, centre and south of the country.

The general requirements to be fulfilled by an integrated design system are as follows:

Being based on reliable and accurate algorithms.

Presenting a modular form, to permit separate or integrated use of the different blocks according to the users' needs.

Ensuring integrity of data, without redundancy of information.

Limited access.

Great interaction with the user, so that intermediate human verification and alteration may always be possible.

Automation of all repetitive operations that would involve tedious calculations and would not imply specific design decisions.

Presenting the form of an open system, that can be interconnected with other packages and grow according to the user's needs and to possible future developments, without putting in risk the initial investment.

Making it use in microcomputer possible, in a way compatible with several hardware trademarks and economically interesting.

Being easy to operate by people without specialized computer knowledge.

Decreasing the time of execution of design.

Increasing design quality.

The main specific requirements are as follows:

Answering the practical needs felt by the Portugueses' structural engineers, which mostly lie in the area of design of reinforced concrete reticulate structures. Being fit to be applied to all buildings with a reinforced concrete reticulate structure.

Thoroughly complying with the relevant national regulations.

Producing most writen documents and drawings in an autonomous way.

Making possible to introduce corrections/changes to take into account the designer's personal experience, specific needs of the project or special practices of the building enterprise.

4 The integrated design system—phase I

The model is implemented in programmes developed in PASCAL language, and the processor used has been the Borland Inc. TURBO PASCAL version 5.0 [6].

As support for the graphical processing of information, CAD systems are used. Information transfer is done through files in the DXF (drawing interchange file) format.

The model was conceived to be used in compatible microcomputers. The minimum hardware necessary is an AT 386 system with 2 Mb RAM and a 40 Mb hard disk unit. Output peripherals are also necessary, consisting of a printer for alphanumeric files and a plotter for drawings.

Any system whose configuration exceeds that mentioned will allow substancial improvement in execution times.

As already said, the model is still being developed. The modules already complete are the followings:

Structural analysis and structural analysis post-processing;

Reinforced concrete analysis;

Drawing of reinforced concrete columns;

which will be dealt with hereinafter.

4.1 Structural analysis and structural analysis post-processing

Although structural analysis is part of the model drawn up, it has not been developed for this model. With this aim a finite element programme developed in the United States of America was used.

The first module that is a model development is the structural analysis post-processing.

This module comprises the following tasks:

Calculating the envelope of internal forces.

Graphical display of the structure.

Creating files to link to subsequent modules.

Compiling and organizing information for the technical report of the project.

In scope of the task permiting the graphical display of the structure the system will create a set of files: NOS.DXF, VIGAS.DXF, PILARES.DXF, LAJES.DXF and MD_VIBR.DXF, which will make it possible to plot the structure in CAD systems that accept the DXF format.

After these files are read by the CAD system, the graphical display to be obtained (plans, elevations or perspectives) will depend on the potentialities of the system selected. It is up to the operator to make the best use of these potencialities, in such a way as to verify if the structure under analysis was correctly discretized (Fig. 1).

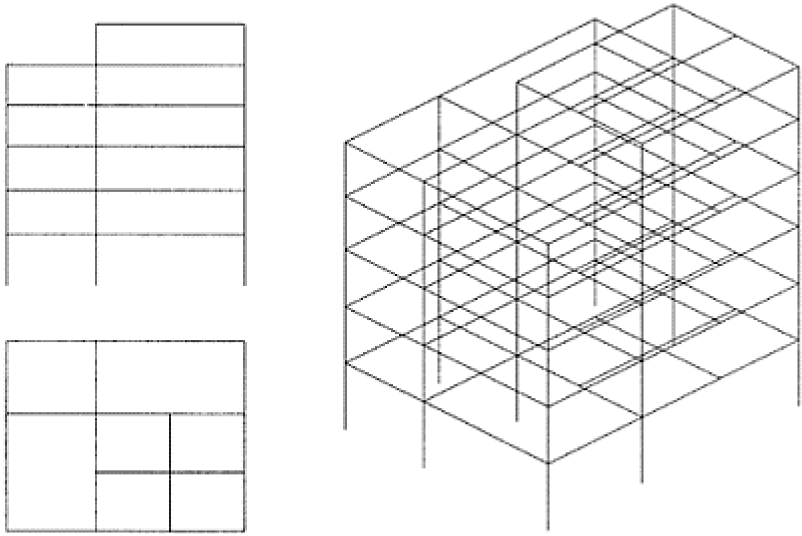


Fig. 1

The possibility of visualizing the structure is offered by the structural programme. Some limitations were found, however, which should be overcame. The production of DXF files and the potentialities provided by CAD systems made it possible to overcame those limitations.

4.2 Reinforced concrete analysis

The main aims of this module are as follows:

Design of reinforced concrete slabs, beams, columns and foundations.
Creating files to link to the reinforced concrete drawing module.
Compiling and organizing information for the technical report of the project.

The system makes it possible to design the following elements:

Solid slabes reinforced in a single direction.
Solid slabes reinforced in two orthogonal directions.
Precast hollow slabs.
Beams—on basis of actions.
Beams—on basis of internal forces.
Beams—data from the file originated in the structural analysis post-processing module.
Columns under normal forces—calculation of reinforcement on basis of internal acting forces.
Columns under normal forces—calculation of internal resistant forces on basis of reinforcement.
Columns under normal forces—list of internal resistant forces.
Columns under combined bending.
Columns under double combined bending—on basis of internal forces.
Columns under double combined bending—data from the file originated in the structural analysis post-processing module.
Foundations—isolated footing under normal internal forces.

Within this module, the designer is provided with options whose functioning is totally independent of the structural analysis post-processing module and thus of the structural analysis programme; he can also use other options linked to these programmes.

By this way it is possible to perform design of buildings in which the forces are calculated through the structural analysis programme as well as the design of single elements whose actions or forces are known.

For designing single elements, data are integrally introduced by the user interactively. The user only has to answer to the questions put by the system, and sometimes has to select one among several options. Units to be used are always indicated and it is always possible, after the data had been introduced, to change some of them without need to restart the entire process. Design results are displayed and only when the designer has accepted them they are stored on file. These files contain all information about the designed element and can be integrated into the technical report of the project.

When the system operates in an integrated form, only some data are requested from the user; the remaining are read from files in machine-language, which were created in the structural analysis post-processing module. Design is carried out in an autonomous way, and results are kept on file. In this case the designer has to look up the files to verify the design carried out.

Calculation time is short, reason why the designer will not restrain himself from making changes, searching to optimize the structure to be designed.

The design is carried out in accordance with Portuguese relevant regulations [8, 9], and sometimes CEB recomendations [2, 3, 4].

4.3 Drawing of reinforced concrete columns

This module intends to produce the detail drawing of columns of the reinforced concrete reticulate structure designed in the preceding modules.

The user is first queried about the working scale, paper format and name of drawing. Based on results from the earlier modules, the system selects the longitudinal and transverse reinforcement for each section analysed.

It is up to the designer whether to accept the solutions given by the system. One of the alternative solutions can always be chosen. After the designer has finished to verify the sections of the several columns of the structure under analysis, the system carries out the following tasks: a) gives a designation to the sections; b) prepares a column table; c) arranges the sections within the paper format chosen by the user; d) creates the DXF file that allows all plotting to be done in the scale defined by the user.

Figure 2 presents the drawing obtained after reading the DXF file in the AutoCAD system [1] for a 5 story building with 32 structural columns.

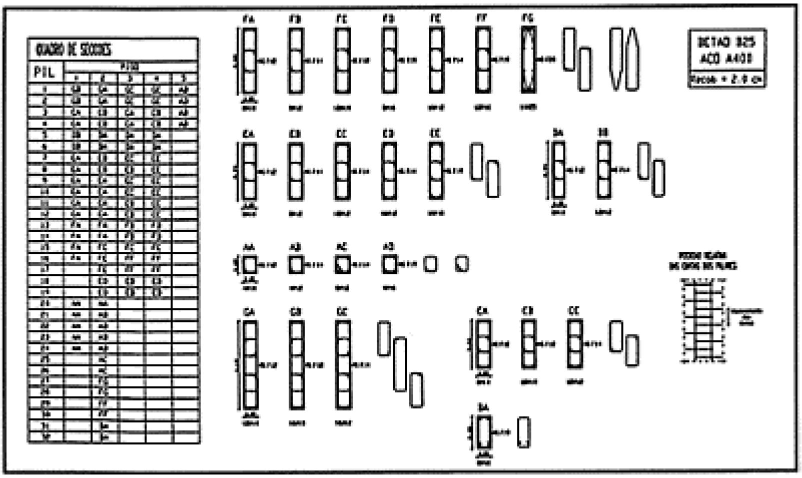


Fig. 2

5 Future developments

On a short term the following developments are expected to be implemented:

Drawing of beams;
Drawing of slabs;
Drawing of staircases;
Drawing of foundations;

which will complete phase I of the integrated design system.

In a second phase of the development of the system, it is foreseen to implement the automatic estimation of quantities and costs for the different structural elements.

Phase III will involve planning of execution of the different structural elements.

Although the inicial conception of the model, that includes these three phases, only concerns the structural design area, this is open to use in otheres areas such as architectural conception, special installations, and thermal verification of buildings.

Lastly another aspect of the developing system may be related to use of an expert system shell as the best tool to support decision-making required for design.

6 Bibliography

[1] AutoCAD 10.0 Reference Manual. AUTODESK AG, 1988.
[2] COMITE EUROPEEN DU BETON—Bul. 73 Recommendations Internationales pour le Calcul et l'Exécution des Ouvrages en Béton. CEB, 1970.
[3] COMITE EUROPEEN DU BETON—Bul. 158 F Manuel du CEB Fissuration et Deformations. EPFL, 1983
[4] COMMISSION OF THE EUROPEAN COMMUNITIES—Eurocode Design of Concrete Structures. Part1: General Rules and Rules for Buildings. 1988.
[5] FARINHA, Fátima—Contribuição para um Sistema Integrado de Projecto Assistido por Computador em Engenharia Estrutural. Dissertação de mestrado. Lisboa, 1991.
[6] JAMSA, Kris; NAMEROFF, Steven—Turbo Pascal Programmer's Library. Osborne McGraw-Hill, Ed., 1988.
[7] JAREAU, Claude—L'Enquête par Questionnaire. Bruxelles, Edition de l'université de Bruxelles, 1985.
[8] Regulamento de Estruturas de Betão Armado e Pré-Esforçado—Decreto-Lei 349-C/83 de 30 de Julho.
[9] Regulamento de Segurança e Acções para Estruturas de Edifícios e Pontes—Decreto-Lei 253/83 de 31 de Maio.

155
Neural networks—technique tested on classical bidding strategy data set

A.GAARSLEV

Abstract
This paper gives at short introduction to the idea of neural networks. It tests a commercially available software on a bidding strategy problem using a data set collected by Broemser (1968). Results are compared and the paper concludes with some thoughts on the applicability of the technology tested.

Keywords: Neural Networks, Bidding Strategy, Construction Management.

1. Neural networks

First we will give a short introduction to neural network theory and the software used, Lawrence (1990).

The human brain is made up of billions of cells called neurons. Each of these cells is like a tiny computer with extremely limited capacity—yet, connected together, these cells form the most intelligent system known. Neural networks are a new class of computer systems formed from hundreds or thousands of simulated neurons, connected to each other in much the same way that the brain's neurons are connected.

At a fundamental level, all neural networks learn from associations—that is, when the network sees an input A or something like A, it responds with output B, or something like B. When a neural network is being trained, it is presented input-output pairs. We call these inputoutput pairs facts. The output portion of a fact is called a training pattern.

The specific type of neural network used by the program in this study named BrainMaker is called a backpropagation network. It learns in much the same way that people do, that is by example and repetition. It is not programmed with rules, like an artificial intelligence system. It is trained by presenting a set of facts over and over again to the network. Any data presented to BrainMaker must be in the form of an ASCII file, and all that it does is pattern matching. The objective might be optical character recognition, image recognition using pixel information obtained from a device such as a scanner or just forecasting numerical data as in the study reported. Each time an input is presented, the network sends back an answer of what it thinks the output should be. When it is wrong, the network makes corrections to itself internally. BrainMaker goes through the fact list, presenting each fact once in turn and making corrections as necessary. When the entire list of facts has been presented, BrainMaker starts over at the beginning of the list. This training process is repeated until the network gets all of the facts correct. Having obtained a good training pattern the neural network is ready to help forecast future outcomes represented by the actual set of input values.

The neurons in BrainMaker's neural network are organized into layers. The input data is presented to the input neurons which send the information to the hidden layer. Each neuron in the hidden layer connects to every input neuron. The hidden neurons send their results to the output neurons. Each output neuron connects to every hidden neuron. The output of a network, is information from the output layer. The structure looks like this:

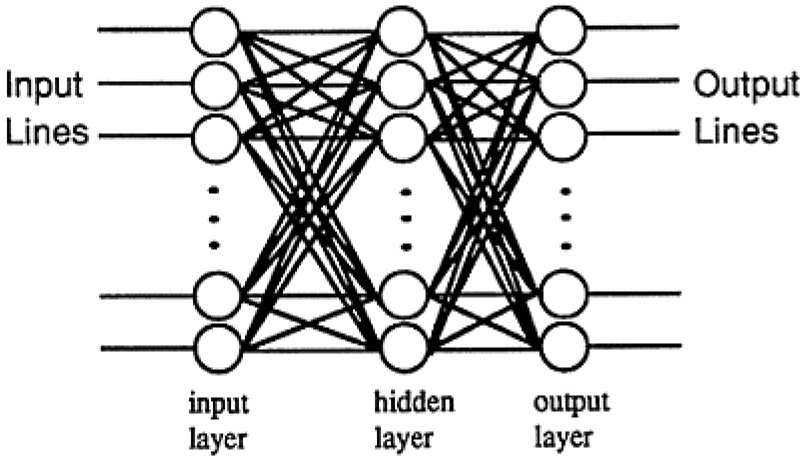


Fig. 1. A sample neural network.

An individual neuron is actually a simple device. The neuron receives many input signals. Each input line to the neuron has a connection strength. If this connection strength is 1, the input signal is used by the neuron exactly as it was received. This signal will make the neuron tend to fire. If the connection strength is less than 1, the input signal is multiplied by the value. Again, the signal will tend to fire the neuron, but not as much. If the connection strength is negative, it will tend to inhibit the neuron from firing. When a network is told that its guess is wrong during training, the network changes its connection strengths so that the next time it sees that input, it will be more likely to get the right answer.

Real neurons, such as those in the human brains, are extremely complicated devices, with a myriad of paths, sub-systems, and control mechanisms. They use a variety of electrochemical pathways to communicate with each other. We believe that the interesting behavior exhibited by real neural networks is the result of many neurons interconnected in certain ways. Neural networks are formed from hundreds or thousands of simulated biological neurons, connected to each other in much the same way that the brain’s neurons are.

Naturally, BrainMaker does not model biological neurons in a chemically accurate fashion: rather, it models aspects of brain capacity. The basic neuron used in BrainMaker look like this:

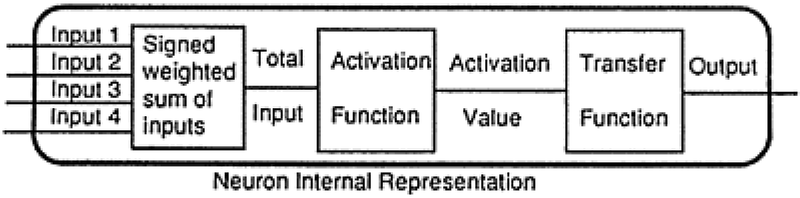


Fig. 2. The function of a neuron.

The heavy line box represents a single neuron. It is receiving 4 distinct inputs from other neurons. Neurons send a single output to the rest of the network. This is represented by the outgoing line labeled: Output.

The input may be excitatory, or they may be inhibitory. The inputs are combined somehow into a signed single value. This result is the total value. The total input is run through another function: The activation function. Finally, the activation value is passed through a function called: The neuron transfer function, which produces the neurons output.

Now that your network is trained, we want to ask it questions. The questions are presented in the form of facts similar to the training facts, except that there are no answers. We let the trained network provide the answers.

2 Bidding strategy models

Researchers have for many years attempted to produce mathematical models to provide an optimal bidding strategy for a construction company. Probably, it all started with Friedman, Friedman (1956). He developed a statistical model for optimum bidding behavior based on data collected on potential competitors. The number, and the identity of the competitor was essential in his model. Later Broemser, Broemser (1968), used regression analyses to forecast the low bid in a competitive construction bidding situation. He collected data from a Californian contractor on the bidding situation and the outcome, ran it all through a regression analysis and produced his model. In later years Park, Parker (1979), has written extensively about the bidding situation seeing bidding as an extremely important factor in the strategic management of the company.

In Broemser (1968) we find a complete data set for a local contractor and a fully documented regression analyses of the data presented. In our study we will use the same data set as Broemser.

The data are collected from a local contractor in San José, California. Broemser collected data on 76 bids, showing: number of competitors (called NUM), the local company's estimated cost of the job in thousands $ (called COST), the estimated percent of work not subcontracted (called NOT_S), the estimated job duration in calendar days (called DUR) and finally the lowest competitor's bid as a percent of the local company's cost estimate (called LOW).

Before going into the regression analysis Broemser discussed important factors competitors will consider when they determine their percent markup on a job bid. He concludes, among other things, that the work not subcontracted would affect the bid or that the ratio of our estimated cost to do our portion of the work to our estimated total cost to be important (reflected by the variables: NOT_S, NOT_S^{-1} and NOT_S^{2}) . He also concludes that it's logical that a contractor's markup will depend on the size and the intensity of the job. These would be, in a sense, surrogate measures of risk to the contractor. Further discussions result that these can be measured by variables as:DUR^{-2}, DUR^{-1}, $(DUR/COST)^{-1}$, $(DUR/COST)^{2}$ and $(COST)^{-2}$.

These 8 independent variables are then used in his regression analysis and his dependent variable is lowest competitor's bid to our cost (LOW). Broemes then runs a linear least squares regression and finds a good fit.

Testing the model presented a problem to Broemser. Since the contractor not had bid on a sufficient number of contracts since the analysis was made he was unable to test the model on new bidding situations. The best, then, that he could do was to test the operation of the model on the same 76 jobs that he used for the probability assess-ment work. This is a classical mistake! The result showed that the contractor would have improved his performance 23% using the model but given the test conditions this really doesn't say very much. His testing is in this way not convincing but still the model is a good estimate of a model for bidding behavior. One interesting fact that he found was that the number of competitors had no influence on the result which was in clear conflict with Friedman's models.

3 Modelling Broemser's case in BrainMaker

Broemer (1968) offers an excellent data set for building a simple numerical neural network model.

We tested 3 different network structures:

1. input neurons Broemer's raw data: NUM, COST, NOT_S and DUR. Output neuron: LOW.
2. input neurons the result of Broemer's regression analysis: NOT_S, NOT_S^{-1}, NOT_S^{2}, DUR^{-2}, DUR^{-1}, $(DUR/COST)^{-1}$, $(DUR/COST)^{2}$ and $(COST)^{-2}$. Output neuron: LOW.
3. 11 input neurons including all variables listed. Output neuron: LOW.

After building the models, which was a rather simple job, training was started. Only 68 data set was selected for training as 8 data set were randomly picked and reserved for test purposes. The data sets were loaded into LOTUS123, regression variables calculated and the final data set was as printed in figs. 4 and 5 at the end of this paper. The data set was then loaded into BrainMaker. After 2½ hours of training of each of the models on a very fast 386 processor on a machine with largely extended memory we found:

Model 1: Total number of bid situations tested 377, 660. Able to forecast 39 bid situations of 68 within +/−10% Testing 8 new bid situations: 4 good, 4 bad within +/− 40%

Model 2: Total number of bid situations tested 245, 254. Able to forecast 46 bid situations of 68 within +/−10% Testing 8 new bids: 4 good, 4 bad within +/−40% Model 3: Total number of bid situations tested 203, 007. Able to forecast 50 bid situations of 68 within +/−10% Testing 8 new bid situations: 4 good, 4 bad within +/− 40%

As model 3 showed the best progress training was resumed. This net has 11 input neurons, 11 hidden neurons and 1 output neuron. After 15 hours and approximately 1,200,000 bid simulations the network was able to forecast 66 of 68 cases within the same +/−10% Testing the 8 new cases resulted in: 6 good, 2 bad within +/− 40%, 3 good, 5 bad within +/−10% and 1 good, 7 bad within +/−5%

The results show that learning in the models is a very slow process. Using the result of Broemser's regression analysis as input neurons was expected to speed up learning considerably. It was superior to using the raw data only but using all data as input was still the fastest way.

4 Conclusions

This study has shown that it was a rather simple problem to model the bidding situation in a neural network and to study the behavior of this net with the commercially available software: BrainMaker.

The study also showed, that machine learning even on fast modern equipment and even for a simple problem like the one tested is very slow.

More interesting is probably to discuss the validity of the results. A direct comparison with the behavior of Broemser's alternative model is without meaning as Broemser's model not was evaluated on new data sets but on the same data as he used to produce his model.

First of we must realize that the model is not able to produce results with an accuracy needed for practical purposes. If a model like the one tested should have any practical impact a forecast with +/−40% is of no value at all, pure guessing is probably much better! The needed accuracy is probably around the 5% and our tests show only 1 chance out of 8 to meet this target which for practical purposes are of no interest.

Fig. 3 gives some indication of the stability of the network. The figure shows the sensitivity of the output (LOW) to variations in the value of the 11 input neurons. The sensitivity is measured in 4 situations right after each other on the fully trained net. The data shows that the results are very unstable and this observation probably means that the forecast is not very valid and if it gets it right it's probably by pure chance not by any build-in intelligence.

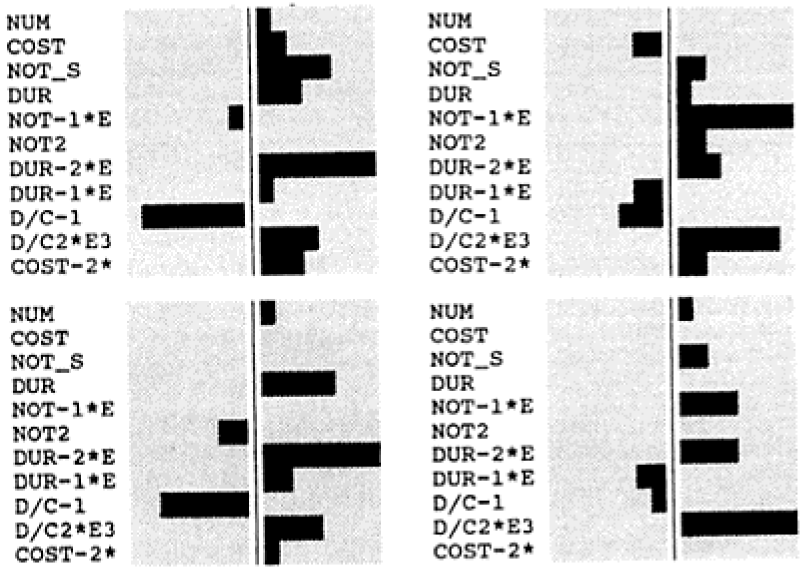


Fig. 3. Testing stability of network.

In almost all of the sensitivity tests the variable NUM—number of bidders—showed some, but minor, impact on the low bid. As mentioned earlier this problem has been treated many times in the literature. Our analysis supports Friedman's assumption, that the number of bidders are of importance for the low bid contrary to Broemser's own analysis of his data. But it is alarming to observe that an increase in the number of competitors has a positive impact on the output variable, which means that increasing the number of bidders increases the low bid contradicting with all economic theory.

Based on these observations we must conclude that we did manage to construct a neural network for our bidding situation. But we did not manage to train the model so that it was able to produce valuable results. This might be true due to the technology used or due to limitations in the data available. We must admit that Broemser probably managed to produce a better model with minor effort than we did. The neural network theory might in certain cases work wonders but we were at least by our study unable to support such promises.

5 References

Broemser, G.M. (1968) Competitive Bidding in the Construction Industry. Stanford University, Department of Civil Engineering, Stanford, CA.

Friedman, L. (1956) Competitive Bidding Strategy. Operations Research, 4, 104–112.

Lawrence, J. and Lawrence, M. (1990) Brainmaker Professional. California Scientific Software, Grass Valley, CA.

Park, W.R. (1979) Construction Bidding for Profit. John Wiley & Sons, New York, NY.

NUM	COST	NOT_S	DUR	LOW	NOT-1*E3	NOT2	DUR-2*E6	DUR-1*E3	D/C−1	D/C2*E3	COST-2*E8
5	3191	30.9	420	100.99	32.36246	954.81	5.668934	2.380952	7.597619	17.32387	9.820789
8	380.9	10.8	200	99.93	92.59259	116.64	25	5	1.9045	275.7008	689.252
4	288.9	18.3	150	91.1	54.64481	334.89	44.44444	6.666667	1.926	269.5799	1198.133
10	1039.4	9	360	100.95	111.1111	81	7.716049	2.777778	2.887222	119.9609	92.56239
4	1302.5	27.7	210	100.46	36.10108	767.29	22.67574	4.761905	6.638095	22.6941	51.46055
11	659.4	18.4	110	102.18	54.34783	338.56	82.64463	9.090909	5.994545	27.82835	229.9864
12	1394	9	210	97.17	111.1111	81	22.67574	4.761095	6.638095	27.82835	229.9864
4	1217.8	30.6	260	85.82	32.67974	936.36	14.7929	3.846154	4.683846	45.58214	67.42921
8	239.9	42.1	150	101.43	23.75297	1772.41	44.44444	6.666667	1.599333	390.9507	1737.559
6	98.8	8.1	60	102.96	123.4568	65.61	277.7778	16.66667	1.646667	368.798	10244.39
9	2105.5	27	180	102.27	37.03704	729	30.8642	5.555556	11.69722	7.308605	22.55742
8	676.7	29.1	240	103.32	34.36426	846.81	17.36111	4.166667	2.819583	125.7854	218.3774
8	1444.8	28.6	270	94.44	34.96503	817.96	13.71742	3.703704	5.351111	34.92304	47.90541
7	1422.8	21.4	180	96.49	46.72897	457.96	30.8642	5.555556	7.904444	16.00506	49.39833
13	3097	15	450	102.09	66.66667	225	4.938272	2.222222	6.882222	21.11264	10.426
10	829.5	27.8	150	103.37	35.97122	772.84	44.44444	6.666667	5.53	32.70015	145.334
2	559.3	19.6	180	102.38	51.02041	384.16	30.8642	5.555556	3.107222	103.5751	319.6762
7	2391.9	18.6	420	99.24	53.76344	345.96	5.668934	2.380952	5.695	30.83277	17.47889
5	4228.7	19.2	600	107.25	52.08333	368.64	2.777778	1.666667	7.047833	20.13208	5.592246
10	5257.3	15.1	420	102.57	66.22517	228.01	5.668934	2.380952	12.51738	6.382239	3.618049
10	1566.8	33.1	260	91.48	30.21148	1095.61	14.7929	3.846154	6.026154	27.53719	40.73548
10	81.6	26.3	120	89.25	38.02281	691.69	69.44444	8.333333	0.68	2162.63	15018.26
8	1234	29.9	150	104.29	33.44482	894.01	44.44444	6.666667	8.226667	14.77584	65.6704
9	129	22	120	96.58	45.45455	484	69.44444	8.333333	1.075	865.3326	6009.254
7	1115.3	14.8	240	91.38	67.56757	219.04	17.36111	4.166667	4.647083	46.30619	80.3927
11	1120.2	28.6	270	91.15	34.96503	817.96	13.71742	3.703704	4.148889	58.09468	79.69092
3	2493.1	41.7	365	109.3	23.98082	1738.89	7.506099	2.739726	6.830411	21.43415	16.08869
10	1707.7	16.4	150	103.29	60.97561	268.96	44.44444	6.666667	11.38467	7.715416	34.29074
7	925.8	26.9	270	106.44	37.17472	723.61	13.71742	3.703704	3.428889	85.05369	116.6717
9	503.7	16.6	252	99.03	60.24096	275.56	15.74704	3.968254	1.99881	250.2979	394.1451
10	824.6	47.5	180	110.8	21.05263	2256.25	30.8642	5.555556	4.581111	47.6495	147.0664
9	592.5	28.7	150	93.33	34.84321	823.69	44.44444	6.666667	3.95	64.09229	284.8546

7	222.3	36	120	95.91	27.77778	1296	69.44444	8.333333	1.8525	291.396	2023.583
6	3449.1	29.4	475	99.88	34.01361	864.36	4.432133	2.105263	7.261263	18.966	8.405981
8	2254.7	35.8	450	103.03	27.93296	1281.64	4.938272	2.222222	5.010444	39.83341	19.67082
14	1073.9	39.2	300	95.23	25.5102	1536.64	11.11111	3.333333	3.579667	78.03956	86.71062
4	1802.7	15.6	300	101.68	64.10256	243.36	11.11111	3.333333	6.009	27.69463	30.77181

Fig. 4. Data set used in our study (part 1).

NUM	COST	NOT_S	DUR	LOW	NOT-1*E3	NOT2	DUR-2*E6	DUR-1*E3	D/C-1	D/C2*E3	COST-2*E3
6	1298	29.2	150	103.31	34.24658	852.64	44.44444	6.666667	8.653333	13.35467	59.35409
4	3731.1	30	630	96.03	33.33333	900	2.519526	1.587302	5.922381	28.51066	7.183337
7	789.4	36.6	200	106.46	27.3224	1339.56	25	5	3.947	64.18976	160.474
4	1560.8	36.5	240	98.54	27.39726	1332.25	17.36111	4.166667	6.503333	23.64438	41.04927
5	223.3	9.7	150	100.43	103.0928	94.09	44.44444	6.666667	1.488667	451.2374	2005.499
5	233.4	25.1	180	102.42	39.84064	630.01	30.8642	5.555556	1.296667	594.7621	1835.686
9	89.1	20.4	150	110.93	49.01961	416.16	44.44444	6.666667	0.594	2834.178	12596.35
5	155.6	30.7	120	100.25	32.57329	942.49	69.44444	8.333333	1.296667	594.7621	4130.293
9	3892.5	25.6	540	96.65	39.0625	655.36	3.429355	1.851852	7.208333	19.24555	6.599982
7	405.6	14	180	97.42	71.42857	196	30.8642	5.555556	2.253333	196.9469	607.8608
10	493.3	34.9	150	86.7	28.6533	1218.01	44.44444	6.666667	3.288667	92.46136	410.9394
4	1726.6	25.7	365	91.39	38.91051	660.49	7.506099	2.739726	4.730411	44.68917	33.54413
6	2105.4	19.2	420	102.31	52.08333	368.64	5.668934	2.380952	5.012857	39.79508	22.55957
5	3721.8	26.9	365	91.47	37.17472	723.61	7.506099	2.739726	10.19671	9.617887	7.219281
4	2035.6	20.1	240	102.18	49.75124	404.01	17.36111	4.166667	8.481667	13.90073	24.13321
4	207.4	28.6	150	105.3	34.96503	817.96	44.44444	6.666667	1.382667	523.0763	2324.783
5	150.7	23.7	120	96.57	42.19409	561.69	69.44444	8.333333	1.255833	634.0682	4403.252
5	168.6	20.7	120	103.1	48.30918	428.49	69.44444	8.333333	1.405	506.5792	3517.911
7	140.2	22.5	120	86.04	44.44444	506.25	69.44444	8.333333	1.168333	732.5992	5087.495
5	137.1	15.4	150	101.19	64.93506	237.16	44.44444	6.666667	0.914	1197.037	5320.165
6	822	31.4	157	101.15	31.84713	985.96	40.5696	6.369427	5.235669	36.48007	147.9982
8	2545.5	18.6	240	104.17	53.76344	345.96	17.36111	4.166667	10.60625	8.889478	15.43312
7	655.8	15.5	300	99.36	64.51613	240.25	11.11111	3.333333	2.186	209.2665	232.5183
4	575.7	47.5	300	103.85	21.05263	2256.25	11.11111	3.333333	1.919	271.5502	301.7224
5	1015.1	9	180	101.65	111.1111	81	30.8642	5.555556	5.639444	31.44324	97.04705
3	224.1	29.1	120	99.53	34.36426	846.81	69.44444	8.333333	1.8675	286.7337	1991.206
7	1020.5	24	150	101.2	41.66667	576	44.44444	6.666667	6.803333	21.60511	96.02272

4	310.8	8	92	102.51	125	64	118.1474	10.86957	3.378261	87.6221	1035.233
6	250	25	180	105.48	40	625	30.8642	5.555556	1.388889	518.4	1600
5	1320.4	38.8	330	87.21	25.7732	1505.44	9.182736	3.030303	4.001212	62.46214	57.35734
6	1126.7	24.1	174	98.84	41.49378	580.81	33.02946	5.747126	6.475287	23.84964	78.77409
3	2684.3	43.8	390	99.26	22.83105	1918.44	6.574622	2.564103	6.882821	21.10897	13.87835
6	2790.1	32.8	365	97.71	30.4878	1075.84	7.506099	2.739726	7.64411	17.11379	12.84578
5	237.6	32.5	105	97.52	30.76923	1056.25	90.70295	9.52381	2.262857	195.2926	1771.361
7	1291.4	10.7	150	91.84	93.45794	114.49	44.44444	6.666667	8.609333	13.49152	59.96232
10	1920.5	36.2	330	98.37	27.62431	1310.44	9.182736	3.030303	5.819697	29.52564	27.11261
7	3409	30.3	420	93.12	33.0033	918.09	5.668934	2.380952	8.116667	15.17905	8.604903
6	1257.7	19.8	250	105.35	50.50505	392.04	16	4	5.0308	39.51172	63.21875

Fig. 5. Data set used in our study (part 2).

156
Expert systems in design, construction and housing administration

K.KARSTILA, R.HYNYNEN, L.KOSKELA, A.KOSKENVESA,
K.KÄHKÖNEN and J.PALLAS

Abstract
The paper discusses the use of expert systems in decision-making in building design, construction and housing administration. Firstly this paper focuses on the use of expert systems in the early building design phase and construction project management. Secondly, expert systems in applying regulations in the public sector are discussed. Thirdly, expert system examples for comparing building frame systems, planning the construction site's production methods and scheduling, and assessing municipal housing benefits are presented.
Keywords: Expert systems, Building design, Construction management, Housing administration.

1 Expert systems in construction

The construction industry has been considered as a potential application area for expert systems since extremely varied knowhow is often needed in complex construction projects and because of the fragmented nature of the industry (Wager 1984). Expert systems could be used in accumulating and distributing knowledge to be used in solving many ill structured problems in construction.

Expert systems developed in the construction industry can solve problem types such as the following:

– the application of codes, regulations and instructions
– the generation of preliminary designs
– the selection of technical solutions
– the diagnosing of error situations and structural damage.

Fig. 1 shows the distribution of the types of a sample of some ninety expert systems developed for the construction industry. Seven of them are in operational use and the rest of them are prototype systems.

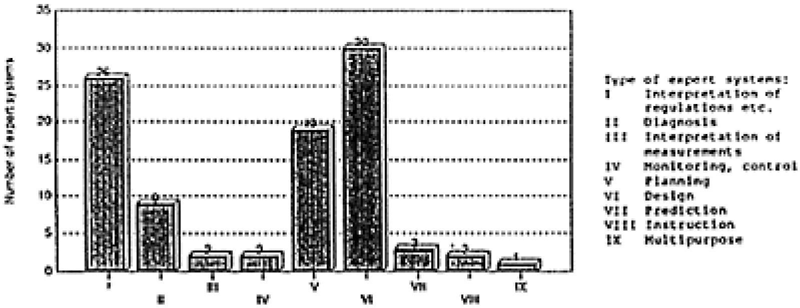


Fig. 1. Distribution of the types of a sample of expert systems developed for the construction industry. (Koskela et al. 1989).

The objective of this paper is to present example expert systems pointing out the profitability of expert systems in supporting and improving the quality of decision-making in various domains of housing: building design, construction management and housing administration.

1.1 Expert systems in building design

In the field of building design, small expert systems can be developed for replacing instructions, tables and calculation methods now found in regulations, manuals and product files. Expert systems will have a more profound impact on building design when they are merged with Computer Aided Design (CAD) systems.

An example of systems combining conventional CAD-systems and knowledge based technique are knowledge based design systems developed by Scema Ltd (Scema 1988). These design system use object oriented description of product structure, i.e. product parts and relations between them, and knowledge base comprising design rules for designing the product. Benefits gained from knowledge based design systems are:

– routine design tasks can be automated which will lead to shorter design time
– better management of complex design problems than in conventional CAD-systems
– design work changes from work of separate designers towards teamwork focusing on R&D of new products
– improvements to train inexperienced designers and to orientate themselves to design work.

1.2 Expert systems in construction project management

Construction project management has been the subject of increasing number of expert system development projects. The planning and control of building construction projects requires considerable personal skill and expertise. Many problems which arise are usually solved in an intuitive way, based on the project engineer's knowledge and experience. Typical examples of this type of tasks are:

– the determination of work breakdown structures
– the determination of dependencies between site activities
– resource selection
– the estimation of site activity durations
– risk analysis
– the interpretation of project control data.

Typical applications of expert systems for construction management are systems for:

– the generation of an initial plan and schedule proposals
– the initial selection of site machinery, equipment and working methods
– the analysis of the feasibility of project plans and schedules
– the interpretation of project data in order to identify the real meaning of the data; for example for the purposes of project control and performance prediction.

Both construction companies and research institutes have been active in developing expert systems for project management. Several systems are in operational use among Japanese contractors (Suzuki et al. 1990). An expert system termed ELSIE, originating from the UK, is intended for the strategic planning of new office building projects (Brandon et al. 1988). Currently there are nearly 200 ELSIE users and the system itself is continously being developed (Twinch 1991).

From the project manager's point of view, expert systems can have a clear effect on his or her work. With the aid of expert systems, the planning and control of a project becomes a more systematic and rapid process. Initial plans and resource selections are prepared automatically and therefore the construction manager is released from some routine but timeconsuming tasks and he or she has more time for the actual decision-making. Furthermore, expert systems for construction management purposes are naturally based on coherent management methods and therefore it is obvious that the quality of project management will improve. As a whole, this development will result in projects which can attain their cost, time and quality objectives more often than present.

1.3 Expert systems in housing administration

The public sector is entering a period of far-reaching changes in many countries. At the same time as expenditure is maintained at the same level as before, or even cut, citizens expect and demand better service and effeciency from the public authorities. This puts a strain on the public sector employees who should be providing this service in situations where legislation is changing all the time and becoming ever more complex. In many countries expert system technology has been seen as one of the possible solutions; where routine work could be transferred to computers, thus providing the authorities with more time to deal with the needs of their clients.

Advice-giving related to regulations and application procedures, as well as support for decision-making of administrators are the main areas for using expert systems in public agencies. This type of expert system development activities has been done also in Finland. For example an expert system for estimating housing costs and planning the financing of different housing options of households has been developed by Consumer's Research Centre (Lehtinen & Aatola 1989). System is used in planning and advice-giving in various public organisations. Also a demonstration expert system concerning construction project of detached houses has been developed. System is intended for officials advicing inexperienced constructors. System gives information about authority permission actions in different project phases, construction schedule estimates and other general information about project execution.

2 RUTU—expert system for comparing building frame systems

The RUTU expert system is an example of a system for preliminary design phase. RUTU is intended for comparing the impact of different frame systems and building methods on the duration of the frame erection and construction costs.

RUTU is based on the data of RATU-production files. RATU-files consist of information about work methods, unit times and material rates of construction. Files are used in construction scheduling and managing, in estimating construction costs and in education. The development of computer technology has created an expanding demand for computer aided production files and applications. RUTU is the first stage in moving towards computer-aided RATU-production files.

In the early stage of the design process, available data concerning the building is very limited. To solve this lack of information RUTU uses empirical model for estimating the quantities of columns, beams and slabs. This is done by using such information as the total floor area of the building, the number of floors, floor height and payload. The model is expressed as rules in the knowledge base. The information about unit times of different work methods, work gangs and dependencies are stored in a RATU-production database. RUTU uses this database information for estimating right unit times levels. These unit times are then used for construction management and production scheduling. RUTU's functions are shown in Fig. 2.

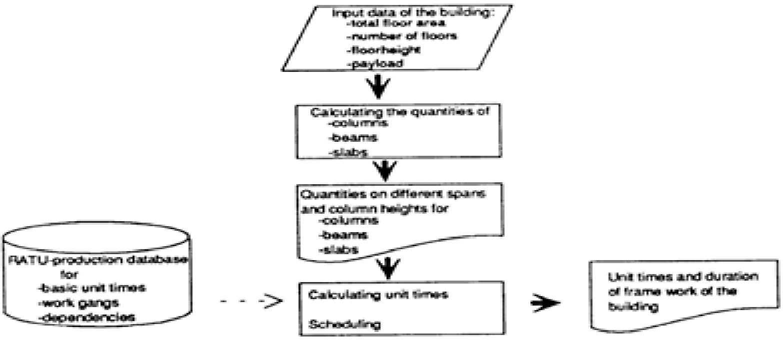


Fig. 2. Functions of RUTU expert system.

RUTU has been developed by using a Level5 expert system shell and dBase III databases. The knowledge base of the application consists of eight separated knowledge bases, including altogether about 250 rules. At the moment RUTU is a prototype system. Further development has already been started using an expert system shell incorporating an object-oriented programming technique with multiple inferencing strategies and a graphical user interface.

3 ATOP—an expert system for generating and managing construction schedules

ATOP is an example of an expert system for generating and managing construction schedules. ATOP starts by defining a breakdown of locations. After that, one identifies the activities needed to accomplish each defined location. The identification process is assisted by the activity type library from which activity types are selected and corresponding activities are assigned to a particular location of a project. Next, the program generates an initial schedule on the basis of optional activity information obtained from the activity type library. Finally, one can analyse and improve the schedule by the use of special tools provided within the system (Fig. 3).

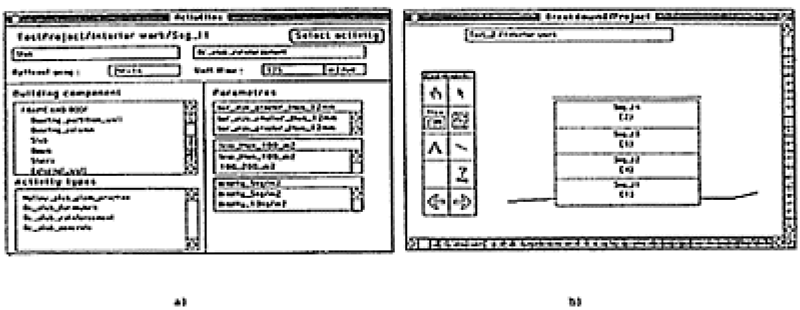


Fig 3. Examples of user interface of ATOP. (a) A browser of the activity type library for the definition of project activities, (b) Graphical project breakdown of locations.

The activity type library forms an important knowledge source. The defined activity type forms a link with the activity type library from which the system obtains the following optional information :

– activity identification properties: code, name and measurement unit
– resources: materials, gang size and plant
– dependencies: typical dependencies with other activities
– other activities needed; procurement, receipt of design information.

This information and project descriptions defined by the user are used when the initial schedule is generated by the system.

At the moment ATOP is a prototype system. It runs on a Macintosh II microcomputer. The development environment consists of an expert system shell, NEXPERT and SuperCard, a tool for building the user interface. A more detailed description of ATOP can be found in (Kähkönen et al. 1990).

4 Expert: system for housing benefit:

The expert system project for a housing benefit system was begun in 1987. The objective of the project was to build an expert system to be used in the municipalities and to gain experience of the impact of expert systems in public organizations.

The expert system, called Aatu, is aimed at authorities who give advice on and who make decisions about housing benefit. It is primarily intended for small municipalities where those who are involved in the housing benefit system do not have enough experience and expertise to give proper information. Aatu's knowledge is based on regulations concerning housing benefit.

The Aatu expert system consists of two main parts: advice-giving and decision-making. In the advice-giving part a rough estimate of the housing benefit is calculated from the answers to some basic questions in the situations where a client makes an initial inquiry to the possibility of obtaining this benefit and does not have all the accurate data. An estimate of the housing benefit, with proper explanations can also be printed out and given to the client.

Decisions can also be made directly in the decision-making section, in which all special cases are checked. The result can be printed out on an official decision form. Furthermore, the program uses database for storing applicant information.

Aatu runs on IBM-compatible microcomputers. It has been developed with the Guru expert system shell. There are about 250 rules in the system and they account for approximately 35 % of the whole program. Calculations, screen handling, printing and database functions are programmed with Guru's own programming language and its other special features. The development work of Aatu took about 20 working months over a three-year period. As of now (spring 1991), the Aatu system is in use in 46 municipalities around Finland, and it has also some other users.

A follow up study (Hynynen & Salokivi 1990) which was carried out during the project shows that considerable benefits have been experienced by the municipalities that use the Aatu expert system. Lengthy routines have been shortened and the work has become more efficient. In small municipalities the advice-giving is no longer dependent on single key-persons who are acquainted with the housing benefit system. This has meant better customer service. It has also had its impact on the organization as work sharing has become possible. In this sense the expert system has enabled specialists to become rather more 'generalistic' with the result that by using the system they can handle cases outside their own area of competence. The advice the municipal authorities give to applicants has become more accurate and the latter have also been able to obtain explanatory information more quickly.

5 Requirements for succesful expert system introduction

In the Aatu expert system development project it was found out that there seem to be various criteria as to why the Aatu has so readily been accepted by its users. Firstly, there must exist a clear need for the expert system among the users so that the incentive to use it comes from inside the organization rather than it being imposed from outside. The users must see the benefits of an expert system within a few minutes (we call this “the five-minutes-rule”) so that they become enthusiastic and also be able to convince other possible users.

Another factor for a successful expert system introduction is that the system also contains other functions and performs tasks (eg. printing, filling in forms, updating databases, external communications) other than simply the expert system part. The greater the part of a problem that can be solved with the system, the more satisfied the users will be. The problem an expert system is supposed to solve must also be real and clearly defined and the users must be aware of the limits of the system.

One very important criterion for a usable expert system, which unfortunately does not always get enough attention, is that the expert system should be as easy to use as possible and that it really is designed for the users and their needs and background. In the Aatu project this has been particularly vital as Aatu has, in many cases, been one of the first contacts the users have had with computers and computer programs.

Motivated users and a close cooperation between them and the developers of the expert system (knowledge engineers) has been one of the key success factors. This is most important in developing expert systems for technically naive environments, i.e. for users with little or no experience of computers. A concrete functioning system rather than some vague ideas and detailed technical descriptions has in this way enabled users to see the benefits and gains they can obtain from using an expert system and has provided further personal motivation.

Also an important factor in disseminating expert system technology in organisations seems to be an authoritative support for the system. To assure the users that the answers the system gives are accurate and valid, the expertise must come from the best experts in the field and, if possible, from the highest administration level. This is especially important in legal expert systems which must give exact answers.

6 Conclusions

Several expert system prototypes and one commercial application for construction related problem solving have been developed by the authors. Variety of problems (comparison and selection of building frame systems, generation and management of project schedules, interpretation of authoritative regulations) solved by these systems reflect multifarious uses and possibilities of expert systems for construction industry.

The experiences gained from the Aatu expert system show the importance of user oriented expert system development. In order to introduce an expert system successfully to users one needs to study carefully and take into notice user’s way of working, major problems of work and needs as a whole. This has to be done already in an early phase of expert system development work.

References

Brandon, P.S., Basden, A., Hamilton, I.W. & Stockeley, J. 1988. Expert Systems—The Strategic Planning of Construction Projects. The Royal Institution of Chartered Surveyors, London. 100 pp.

Hynynen, R. & Salokivi, J. 1990. Applying Expert System Technology to Housing—Exemplified by Housing Allowance (in Finnish). Technical Research Centre of Finland, Laboratory of Urban Planning and Building Design, Puclication 1120. Espoo, Finland. 41 pp.

Koskela, L., Kähkönen, K., Rantanen, J., Rauhamaa, A., Salokivi, J. & Serén, K-L. 1989. Expert Systems in Construction (in Finnish). Technical Research Centre of Finland, Laboratory of Urban Planning and Building Design, Puclication 1044. Espoo, Finland. 79 pp.

Kähkönen, K., Laurikka, P. & Kiviniemi, M. 1990. A Computer Program for Generating and Managing Schedules for Construction Projects. Proceedings of the 7th International Symposium on Automation and Robotics in Construction, 5–7 June 1990, Bristol, England, Bristol Polytechnic, pp. 311–318.

Lehtinen, T. & Aatola, L. 1989. AKU—A Model for Estimating Housing Costs of Households (in Finnish). Consumer's Research Centre, Publication 1/1989. 92 pp.

Scema. 1988. New Generation Expert System for Engineering Design. Scema Ltd. Espoo, Finland. 17 pp.

Suzuki, A., Koyama, S., Aoki, T. & Kumano, T. 1990. Present Status of Expert Systems in Construction Companies. CIFE symposium proceedings, Stanford University, March 26–27.1990. 31 pp.

Twinch, R. 1991. ELSIE the expert system. Construction Computing 1991(1), pp. 15–17.

Wager, D. 1984. Expert Systems and Construction Industry. Construction Industry Computing Association. 128 pp.

157
Using automation to improve the management and performance of design review

J.G.KIRBY and G.W.BRIDGESTOCK

Abstract
This paper will discuss the solution provided to the management of the United States Army Corps of Engineers' multi-billion dollar design review process by the Automated Review Management System (ARMS), the progress on the development of an automated checklist and hypertext system to assist with the execution of biddability, constructibility and operability design reviews (BCO Advisor), and the concept of an umbrella system that will analyze the design review comments recorded in ARMS and build rules that are incorporated into the BCO Advisor.
Keywords: Design Review, Constructibility, Hypertext, Management

1 Introduction

Project designs produced by both Architectural/Engineering (A/E) firms and by inhouse designers for the United States Army Corps of Engineers typically are reviewed independently at least three times during their development. Each of these design reviews usually involve a large number of geographically remote reviewers due to the fact that several types of reviews are performed in this design review process. The types of reviews include: (1) the Corps of Engineers performs a technical review on both A/E contract and inhouse designs, (2) Corps of Engineers' employees also review the structure of the contract documents to insure their biddability, (3) the Corps of Engineers' construction field office reviews the design package to check constructibility issues, (4) the using Army agency typically performs a functional review, and (5) the military post engineer, who will be responsible for operating and maintaining the facility after completion, performs an operability/maintainability review. Since a typical Corps District office manages hundreds of designs concurrently, tracking the status of individual design reviews or checking on the actions required by individual design comments is an almost impossible task to accomplish manually. The time available to complete these reviews and the number of personnel who are skilled in all aspects of design review are both limited. These factors make the accomplishment of a thorough and complete design review in a timely manner for all projects a difficult process.

2 Approach to improving the process

The US Army Corps of Engineers manages the annual multi-billion dollar construction program for both the Army and Air Force. To produce quality construction the Corps has established the aggressive manual design review program outlined above. Even with this extensive review process, 23% of change orders that occur during construction are related to design errors. A three part approach to improve the management and performance of the design review process currently is about one-half completed at the United States Army Construction Engineering Research Laboratory.

3 ARMS

3.1 Description of ARMS

The Automated Review Management Systems (ARMS) provides design project managers with the ability to electronically:

- Assign design reviews.
- Track the status of design review activities.
- Selectively retrieve design comments.
- Retrieve historical performance records or comments on past projects.

ARMS allows design reviewers and managers to both obtain review assignments and enter comments electronically. Workload information, assignment scheduling information, and the ability to retrieve review comments are available to all level of users. Comments can be retrieved by project, author, discipline involved, location in the design documents, text strings, or any combination of the above. The minicomputer (or local area network personal computer) based ARMS interconnects all reviewers and managers allowing real-time review management and comment retrieval. Because of this capability, ARMS improves the quality of the design and hence reduces the number of design errors encountered during construction.

Corps of Engineers' customers are strong supporters of ARMS because it keeps them informed on design progress and design decisions and it also lowers facility costs by reducing design errors. A Corps Efficiency Review Team estimated that ARMS would improve the design review process by 5% which would translate into a potential reduction of over 1 million dollars of construction change orders per year in a single District such as Sacramento.

All Districts within the South Pacific Division of the Corps of Engineers converted to exclusive use of ARMS in July of 1988. To date over 1100 people are already using the system. Currently over 860 design reviews with a constructed value of over $300M are being managed by ARMS. This figure represents 15% of the Army continental United States military construction program.

3.2 Development process

The development of ARMS has followed a structured process that has included early end user involvement in the formulation of the

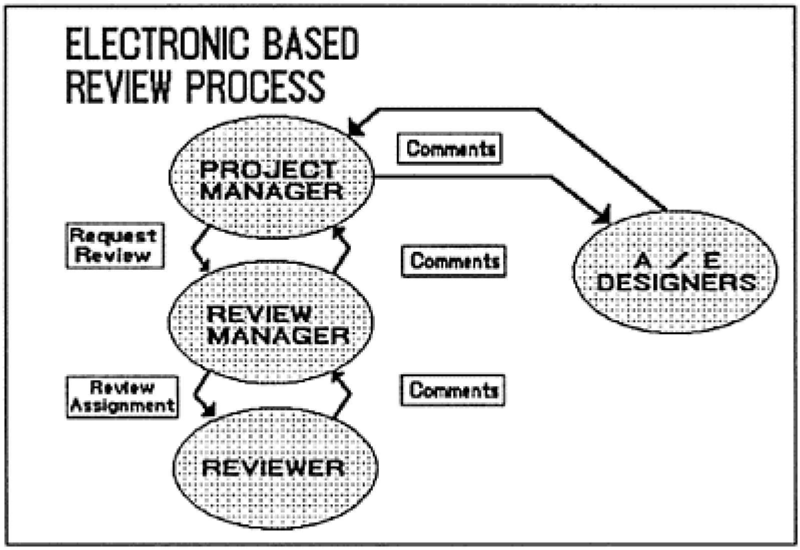


Fig. 1. Automated Review Management System (ARMS)

development objectives, early field testing of a prototype system, comprehensive review of the prototype test results, operational demonstration testing of the completed product and examination of the demonstration test results prior to a top management decision to implement the system Corps-wide.

In April of 1990 the Chief of Engineers designated Sacramento District as the Corps Technical Center of Expertise and has funded and staffed them to implement ARMS Corps-wide. The funding level in 1990 was $507,000 and five (5) personnel slots were dedicated to this effort. Implementation is progressing from the South Pacific Division. Missouri River Division, Baltimore District, and St. Paul Districts are current users and within the next few months Savannah, Ft. Worth, Philadelphia, and Albuquerque Districts will become users. Baltimore District is scheduled to use ARMS to manage the Ft. Detrick Medical Laboratory and Pentagon Reconstruction projects. The Corps North Central Division has been trained and most other districts will be trained by the end of 1991. The United States Air Force is an ARMS user and the United States Navy is testing the system. ARMS has been mandated by Corps of Engineers for use with all Superfund environmental clean-up projects. Other agencies such as the Department of State, Jet Propulsion Lab (JPL) in Pasadena California, Smithsonian Institute, and construction departments of foreign countries have expressed an interest in ARMS.

4 BCO Advisor

4.1 Description of BCO Advisor

The Biddability, Constructibility and Operability (BCO) Advisor is an automated review guidance checklist system that assists project design reviewers in performing their task more accurately and efficiently. It is a personal computer-based system that provides guidance on what constitutes a complete design review by defining biddability, constructibility and operability issues, in the form of standardized and specialized checklists, which need to be examined on a project. This tool will improve the reviewer's ability to affect bid package quality, minimize design/construction interface problems and promote user satisfaction.

4.2 Development process

To ensure that a detailed review of a project is accomplished, especially by reviewers who have little or no BCO background or who tend to concentrate on their own area of expertise, a guide is neces sary to direct reviewers through the complete review. This guide is typically in the form of written checklists. Checklists for conducting BCO reviews have had a fundamental conflict: ease of use versus comprehensiveness. An easy to use checklist is short, simple and requires little time to utilize. However, to attain this goal the checklist cannot be very detailed nor provide much information which will endanger the completeness of the review. A comprehensive checklist, on the other hand, can cover numerous items that should be examined, but this type of list is difficult to use effectively and also requires considerable time to utilize.

Research has been ongoing at USACERL since 1989 to develop an "automated" system to assist the completion of a design review. Automation provides the ability to handle a substantial database of checklist information and with the appropriate design, can allow easy access to that information. Proper system design can limit the information provided to only the most suitable information required to satisfy the user's needs.

The BCO Advisor uses two types of recently developed interactive computer-based information technologies which are able to eliminate the difficulties of using hardcopy BCO checklists. The first of these tools is expert systems which are programs that can reach conclusions or provide selective information by matching programmer-defined rules against facts obtained from the system user. The second of the newly developed information systems' tools is referred to as hypertext. Information presented in this manner uses an associative (relational) linkage of information instead of a serial (sequential) relationship, thereby allowing the user to branch to different texts that fully define an issue. Hypertext documents function as a series of nested references, allowing the user to branch to separate text that contains more information on a particular topic or word but only on an "as-needed" basis.

A recently available expert system shell called KnowledgePro successfully combines expert systems with hypertext. This software was selected for the development of BCO Advisor because it allows the establishment of checklist interrelationships and controls the level and direction of the information presented. Hence, the BCO Advisor can present various levels of advice and guidance without excessive or unwanted detail. Also, the hypertext feature provides a capability to explain terms that are used in the questions or checklists but only if the user requests those definitions.

The initial step in developing the BCO Advisor involved the examination of several sources of information to determine if they contained relevant BCO review information. Among those sources was the Military Design Review Manual prepared by the U.S. Army Corps of Engineers Training Management Division at Huntsville, AL, several Corps of Engineers' databases which contain comments and lessons learned from project design reviews and construction evaluation inspections, twenty (20) Corps of Engineers' District and Division BCO checklists developed for conducting BCO reviews, industry and academic research papers which discussed the methodology of reviews and current practices relating to BCO issues in both the government and private sector and the Redicheck Interdisciplinary Coordination System which is a structured review process of procedural instructions and checklists that addresses the point of interface between design disciplines. Approximately 750 BCO comments, amounting to 130 pages of checklists, have been obtained from those sources and inputted into the BCO Advisor system.

After studying the various methodologies and checklist sources of BCO review guidance, work began on the development of a prototype program. Utilizing the expert system and hypertext technologies offered by the selected software package, a basic framework for the program was developed that reflected review techniques currently in use by Corps of Engineers' District and Division offices. The first prototype included a complete system structure that divided the review process into two general types: a 35 percent Concept Design Review and a 95 percent Final Design Review. This prototype was demonstrated to engineers in the Constructibility Review Section at the Corps of Engineers Omaha Nebraska District office. As a result of comments generated by this demonstration, additional checklist classifications were included in the program, the display format for the checklists was modified and the terminology used for some of the categories was revised. Perhaps the most significant alteration was the addition of a Special Issues Review category, complementary to the Concept and Final Design Review categories, to provide guidelines on special topics unfamiliar to most reviewers.

To ensure that the system design was both comprehensive and responsive to user needs, a review workshop was organized and held at USACERL in early 1990. Corps of Engineers' personnel involved in BCO reviews were given a briefing on the project approach and system design. Following a demonstration of the BCO Advisor, they were allowed to give an in-depth commentary on the program structure and user interface. Several suggestions were made about the domain for BCO reviews, the program structure, additional topics for review, the classification of review information and input/output capabilities. Other sources of BCO knowledge were also identified and plans were made for a follow-up workshop and limited distribution of a revised prototype reflecting this input.

Based upon the comments and suggestions from the workshop a final system design iteration was undertaken over the last half of 1990. The system structure and input/output requirements were finalized and several new requested features were incorporated into the program. In addition, an extensive data collection effort was undertaken to build the checklists which make up the essential part of the program.

The current program format still classifies review topics according to the type of review being conducted (i.e. 35 percent Concept Review or 95 percent Final Review) along with a Special Issues Review category. The 35 percent and 95 percent review categories are divided into seven basic design disciplines. The disciplines under 95 percent are further split into their applicable Construction Specifications Institute (CSI) divisions due to the availability of more detailed design information. Each discipline (35 percent) or CSI Division (95 percent) contains its own set of review guidelines to which the reviewer refers to while checking the contract documents. This breakdown reflects the manner in which construction drawings are normally arranged and distributed to various reviewers. It also allows for the concurrent review of drawings and specifications—the typical and most comprehensive approach to reviewing a particular design project. Only the Special Issues Review uses its own unique classification of review topics. These topics are usually very project-specific and are most likely to be customized to the differing needs of each District and Division office. They are provided for experienced reviewers who do not need to be “led by the hand” through either the Concept or Final Design Review but require information on BCO issues encountered on an infrequent basis.

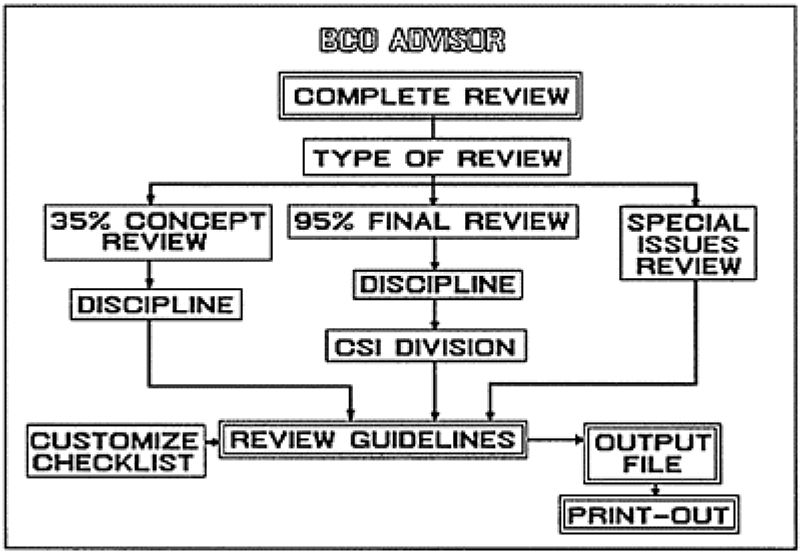


Fig. 2. BCO Advisor Logic Tree

A typical review session would have the reviewer requesting guidelines within a particular review category from a series of menus. The guidelines provided by the program would then be used as a basis for checking for deficiencies in the contract documents. The complete review would involve examining the documents following the guidelines listed under the applicable topics of the BCO Advisor. Within every checklist the reviewer has the option to export any relevant guidelines to an output file and to edit those guidelines into specific review comments pertaining to the particular project being reviewed. When more than one session is needed to completely review a set of contract documents, the same output file can be used, with additional comments merely appended to that file. The system also allows for cross-checking between disciplines at the Final Design Review stage, thereby ensuring a more complete review. The system can be queried by each user discipline for guidelines that are outside their area of expertise but are relevant to reduce conflicts among disciplines. Also, this system allows each reviewer to customize the checklists to fit their own particular needs.

This latest prototype version was demonstrated to the design, construction-operations and technical support branches of the Corps of Engineers' Sacramento District in late 1990. Their response validated the latest system structure and program features. Also, this latest version was recently distributed to other Corps District and Division offices along with a questionnaire to acquire comments from the field. The response has been very positive and great interest has been expressed in getting reviewers to use the system.

4.3 Testing

Field testing of the prototype system is scheduled to begin in early April 1991. A user's manual is currently being written and the system is due to be installed at nine Corps of Engineers' District offices and one Army Installation post engineer organization. Fielding testing will last approximately four months.

4.4 Finalization

Based on field results, the full scale BCO Advisor can be developed into its final format. Fielding strategy for the system will be completed in 1992 and Corps-wide implementation will begin in the latter part of that year. A logical extension to the BCO Advisor is to add modules to cover other design review activities such as Value Engineering and environmental compliance.

5 Future Integration Efforts

The effective linkage of ARMS and BCO Advisor will provide a comprehensive design review process for the Corps of Engineers. ARMS currently contains thousands of design review comments. This information must be analyzed and the findings of this effort should be used to generate new rules and checklists that can be incorporated into the BCO Advisor. Therefore, the linkage system (DESIGN SYSTEM) will provide the feedback loop needed to use the experience captured in ARMS to update the review guidance BCO Advisor provides to the design reviewer.

The DESIGN SYSTEM will be able to identify the primary problem areas in the design process and generate corrective actions. In addition, the effectiveness of these corrective actions can easily be tracked. If a reduction of occurrences of these problems is not observed, the actions taken were not effective and therefore should be modified. Work on the development of the DESIGN SYSTEM will begin in 1992.

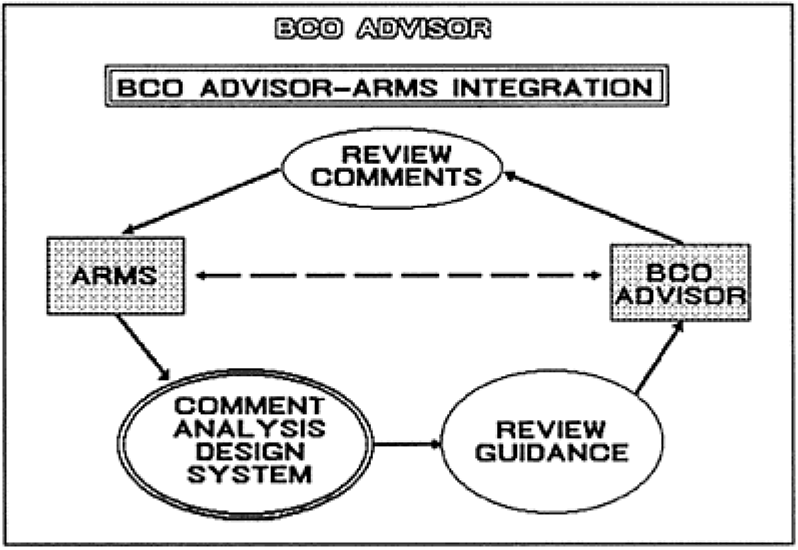


Fig. 3. ARMS-BCO Advisor Integration

6 References

Construction Industry Institute Constructability Task Force (1986) Constructibility, A Primer. Construction Industry Institute Publication, publication 3–1, 1–13.

Kirby, J.G., Furry, D.A. and Hicks, D.K. (1988) Improvements in Design Review Management. Journal of Construction Engineering and Management, Vol. 114, No. 1, 69–82.

Kirby, J.G., Tupas, M.I., Robinson, P.C. and Bridgestock, G.W. (1990) Concept Development of an Automated Construction Design Review Advisor, US Army Construction Engineering Research Laboratory Interim Report (ed G.L.Cohen), US Army Corps of Engineers, pp. 7–18, 31.

Nigro, W.T. (1987) Redicheck Interdisciplinary Coordination. The Redicheck Firm, Stone Mountain, GA.

158
Case-based reasoning in knowledge-based design

R.E.OXMAN

Abstract
Current applications of expert systems technology to design employ rules and schemas to represent generalized knowledge in modeling experiential reasoning. Case-based reasoning is proposed as a paradigm for extending experience-based capabilities in knowledge-based design systems. The relevance of cased-based reasoning to knowledge-based design systems is discussed. Adapting and repairing prior designs to fit current design situations are identified as research issues. The application of these issues in cased-based reasoning in knowledge-based design systems is developed. Housing design is illustrated as a domain for the exploration of cased-based reasoning concepts and techniques.

Keywords: Knowledge-based design, Case-based reasoning, Design prototype, Refinement, Adaptation, Housing design

1 Introduction

One of the aims of knowledge-based design has been to develop models of reasoning processes based upon experiential knowledge in order to support design processes. Current approaches to design reasoning employ rules and schemas which represent generalized knowledge. These formalisms have been proven efficient in refinement processes in prototypical design. However, such systems do not support reasoning from the specific knowledge which is associated with the designer's detailed experiences. Experienced designers cite precedents of which the current situation reminds them and adapt previous designs which they recognize, or have worked on. Adaptation is modification of particularized examples to achieve a new design. Cased-based reasoning has been proposed as a model which accommodates reasoning from specific examples (Riesback and Schank, 1989). It has developed adaptation and repair concepts which appear to have relevance for design.

In the following section the distinction between generalized design knowledge and specific knowledge is presented with reference to current themes in knowledge-based design. The third section explores the potential role and significance of case-based reasoning in knowledge-based design. The fourth section presents the problems in the application of case-based reasoning to design. The final section demonstrates an approach for the employment of both generalized knowledge and case knowledge in a housing domain. This approach incorporates the generative and refinement capabilities of a general design schema, and the adaptive and repair capabilities of case-based reasoning.

2 Modeling experiential knowledge in knowledge-based design

The objective of this paper is to propose a framework for reasoning in design which incorporates both high-level, generalized knowledge as well as the knowledge gained through specific design experiences. Refinement and adaptation are considered to constitute two distinct ways in which knowledge is employed by designers which is relevant to generation in design. Each is based on a different computational paradigm. In refinement processes a generalized schema is specified; in adaptation, a specific case is modified. In order to clarify these issues, concepts in artificial intelligence which deal with reasoning from experience will be briefly reviewed and their relevance to refinement and adaptation will be discussed.

2.1 Generalized knowledge as design rules

Rule-based systems have been employed to model expertise through rules in narrow and well-defined domains. Rules encode generalized knowledge in order to accommodate common, frequently encountered situations. Thus knowledge encoded in rules is based upon many repeated experiences. It represents generic knowledge, free of the cases from which the rules were originally derived. Rule-based design systems have proven efficient in design when all design situations are clearly interpretable and where every decision is based upon generalized knowledge. However, in the real world, design consists of situations which are not easily interpreted; situations may be specific, unique and, sometimes, even contradictory. Frequently no rule, or direct mapping between a current situation and the generalized solution, exists. In such situations, designers rely on their direct experience. In an approach which accommodates precedent-based design, reasoning systems for design should provide for referencing from specific design experiences.

2.2 Generalized knowledge as design schemas and design prototypes

Rules are separate modules of general compiled knowledge. Schemas, on the other hand, are structures of general knowledge (Sowa, 1984). The schema concept has been implemented in artificial intelligence variously as frames (Minsky, 1975); and scripts (Schank and Abelson, 1977; Schank, 1982).

Design schema are structured representations which incorporate structured generalized knowledge about designs. It has been proposed that such structured design knowledge is stored and retrieved as a compiled series of abstract schemata called ‘prototypes’ (Gero, 1987). Such existing design schema have proven to be efficient in well-defined design solution classes. GPRS is a generative prototype refinement schema, based on a hybrid representation of rules and frames which supports a process of generation through refinement in a routine design (Oxman 1990b). The refinement processes of prototype instantiation do not always map directly into current requirements. There is a need for an extension of such representation formalisms which will support an extended form of design reasoning such as adaptation.

2.3 Specific knowledge as a design case

If a generalized solution cannot be applied, designers tend to adapt prior designs when they recognize in that design some previous situation that resembles the one at hand. Recent work in case-based reasoning appears to be relevant to such adaptive design models, since it is based upon applying and adapting knowledge of particular cases to current situations. In distinction to rules and schema, case-based reasoning questions the fundamental assumption that reasoning relies on general rules, or generalized knowledge such as that of schema. In the application of case-based reasoning in knowledge-based design, the theoretical emphasis is placed upon the accommodation of knowledge from specific and episodic experiences (Oxman, 1990a).

3 The prototype and the case

The integration of prototypes and cases may establish a potential model of reasoning in design which can accommodate not only the refinement of prototype schema in routine design, but the repair and adaptation of cases in adaptive design. In order to develop this concept, the differences in the contents and the computational processes of the prototype and the case will be discussed.”

The distinction between a design process with a prototype and a design process with a case in knowledge-based design (Gero, Rosenman and Oxman, 1991) reflects the fundamental difference between refinement and adaptational processes. Designing with prototypes entails the generation of a specific instance in response to a given problem. This process includes specialization by selecting appropriate structure variables and their instantiation by finding the values which will satisfy given requirements. The relations and the dependencies between the components of the prototypes, e.g. design variables, are produced through instantiation. They are created through specialization, from the generic to the specific. The resultant instance does not record the episodic history of its making, for example, the constraints which may have been in effect in an actual design case. By contrast, according to case-based reasoning, specific designs are solutions to problems already specified which need to be retrieved rather than computed again. Specific cases are stored as complete experiences which retain their design history including the reasoning processes. New cases are produced as variations on the previous case by employing a modification process. The differences between prototype and case may be summarized as follows:

1. The prototype is a powerful formalism for design generation in knowledge-based design. It contains generalized knowledge separated from the history of its creation. It supports generation of possible designs by re-running its generation and refinement process.
2. The case represents a specific exemplar and does not contain a state-space description. It is not generative. While in a prototype instances are not available until they are instantiated, in specific cases previously computed and ordered steps are available,

We assume that designers have the capacity to employ both the episodic experiences of case histories, as well as the general knowledge of design prototypes. The richly detailed semantics associated with the case history has potential advantages in knowledge-based design. Among these are the augmented level of "details" which enhances the process of retrieval of appropriate concept schema. Case-based reasoning also provides adaptive and repair techniques—techniques which are lacking in prototype-based reasoning.

4 The relevance of case-based reasoning

Theory and implementations in cased-based reasoning (Schank, 1986; Kolodner, 1988; Riesbeck and Schank, 1989) deal with how to derive knowledge from a case, and how to apply it in a current situation. A case-based reasoner adapts previous solutions to the current situation by taking into account differences between the current and previous situations. The development of case-based reasoning was based on Schank's theory of Dynamic Memory (Schank, 1982). Kolodner's CYRUS system (Kolodner, 1988) was the first implemented case-based reasoning system based on Schank's general theory. Dynamic Memory theory postulates knowledge structures called memory organization packets (MOP's). MOP's are composed of lower-level components which can be shared by a number of MOP's. It models the organization of episodic memory, integrating new episodes into its previous knowledge and using a range of strategies to generate indices for retrieving information.

The concept of episodic memory is relevant in design, since it is a potential model for storing unique design cases in memory. The theory of Dynamic Memory provides a means to differentiate between a prototype and a case, since one issue of this distinction is how encoding in memory is achieved. According to the theory, what is stored in memory are the cases that differ from the general. In such a view, generic knowledge must be a part of a structure of dynamic memory and must be capable of modification. Therefor, the experiential knowledge of original designs (cases) are stored and encoded in a way that enhances both accessibility in memory and the efficient adaptation of the schema of the case. In order to elaborate on the relevance of case-based reasoning to design, some of the central concepts, processes and techniques are briefly reviewed.

4.2 Concepts of cased-based reasoning

Case-based reasoning is a model of reasoning based on retrieving, applying and adapting stored cases. In case-based reasoning inferences are based directly on previous cases rather than by the approach of representing general knowledge. This raises certain central methodological issues.

a. Indexing and retrieval

The way in which problem-solvers apply knowledge depends upon searching through memory in order to select relevant knowledge. Among important issues are the indexing and retrieval of relevant cases and memory organization for efficient retrieval… Indexing and matching processes are responsible for retrieving the most relevant stored cases from the case-based memory. Previous approaches have relied upon inductive methods in order to reduce the index set. Case-based reasoning suggests that indexes should be organized according to the logic of the domain from which they are derived and from principles of how the domain works.

When presented with a new situation a case-based reasoner must locate a design case which is similar to the new one. In design, cases have to be indexed both by goals and situations. A design case might satisfy the same goal in different ways in different situations. For example, a goal such as 'provide an organization of dwellings' may be realized differently in a high-density site than in a low-density site. The question is how to reduce the search when there are many cases and the matching process is not exact. Indices must be generalized, otherwise only an exact match can be the criterion for a case capability. Mappings between general structures such as function, behavior or structural descriptions that are extracted from a given design may help to label design for retrieval.

b. Selection

The selection process is responsible for choosing the most relevant case of the set of cases retrieved by the indexer/matcher. The research issues relate to techniques for selection of the the most relevant case, or cases. Existing systems retrieve several cases which are then ranked in order of similarity to the new case. In order to determine best match, a reasoner requires some concept of similarity between design goals. This similarity can be expressed by placing goals in a hierarchy such as the one used in JULIA (Kolodner, 1988). It employs two types of hierarchies: an abstraction hierarchy which deals with the question of the similarity between goals, and a value hierarchy which determines which goal is most important. 1520

c. Adaptation and Repair

When a case is adapted to the current situation, what knowledge is required in order enable adaptation? What process should be initiated, if an adaptation process fails to accomplish a goal? This process is termed, repair.

d. Memory storage of new cases

How are new cases acquired over time, and how are they stored and indexed for future retrieval?

In the following section we consider problems of the application of case-based reasoning to design.

4.3 Some problems of modeling design with case-based reasoning

Certain domain applications of case-based reasoning introduce issues that are relevant to the development of a model of adaptive reasoning in design. CHEF (Hammond, 1986) is a program that works in the domain of Chinese cooking. It generates new Chinese recipes by adapting old recipes. It is relevant to design, because it deals with the construction of an object which must satisfy several goals simultaneously. CHEF begins with a library of 20 working recipes. Given a list of goals such it develops a recipe. The relevant processes in CHEF are its modification and repair techniques. It can learn from its failures and can modify its case library. PLEXUS (Alterman, 1986) is a program that adapts old plans to new situations. It deals with the domain of riding on a subway. It is of interest to design because of the adaptive mechanisms it employs in adapting old plans. It discovers generalizations which connects between previous, pre-stored situations and new situations, given a difference that has occurred. In each abstraction level it tries to find a specialization that will work in the current context. Its ascending of the abstraction hierarchy is accomplished by maintaining the explicit purpose of each step. Although it appears that case-based reasoning cannot be directly applied to design, it provides powerful strategies and techniques for indexing, adaptation and repair.

5 Integrating prototype and case knowledge in knowledge-based design

Knowledge-based design systems should accommodate reasoning with both a library of prototypes and a repertoire of cases. The prototype and the case represent two distinct models of reasoning in design. The prototype is efficient in the representation of design generation and refinement. What is lacking in current models of the prototype are the techniques for indexing, storage, adaptation and repair which are characteristic of case-based reasoning.

The framework proposed in this section combines both cases and prototypes. Like PLEXUS (Alterman, 1986), it is suggested that a reasoner should work with both general and specific knowledge. Such a schema should have the capacity to reason with both pre-stored specific cases and general prototypes. It would employ cased-based reasoning to propose a solution. Because the case encodes its history, there is access at any point along the route to the particular instantiation which was used in its creation. Accessing the prototype at that level and re-running can then provide a new instantiation.

Examples from the domain of housing design are provided to demonstrate these ideas. The refinement may be seen as traversing several levels. We have considered four general levels of refinement in design: conceptual, typological, elemental, and detail. An example of these levels as illustrated in a housing design are:

conceptual:	high-level concepts of dwelling types
typological:	types such as one storey row-house, etc.
elemental:	element variables such as stair, kitchen, etc.
detail:	values such as room sizes

Figure 1 illustrates the first two levels of conceptual and typological refinement knowledge in a row-house prototype.

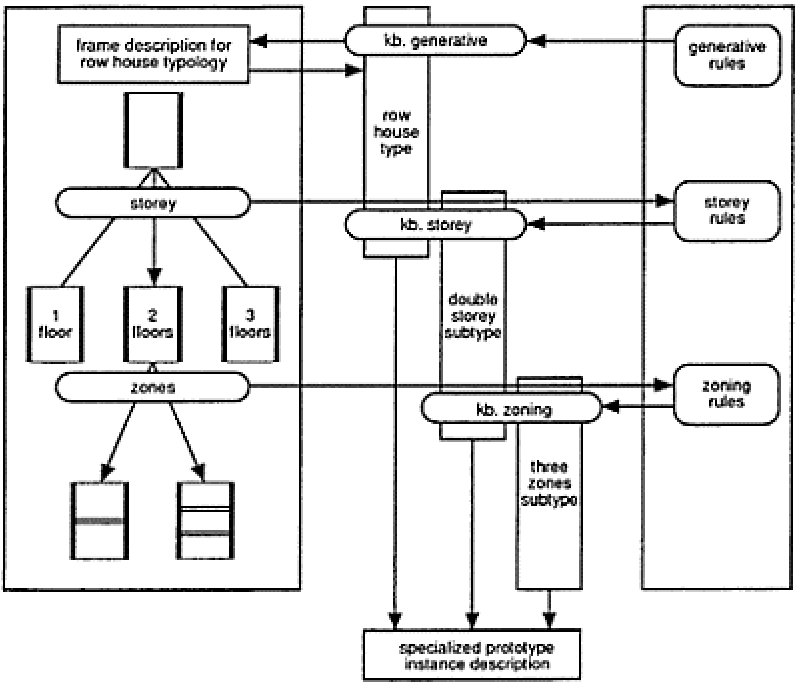


Fig. 1. A refinement process

Design by refinement is initiated by a high-level description of the schema and works in a top-down fashion through these successive levels. Design by adaptation of precedents, on the other hand, begins with a detailed representation of a design case. Adaptation can be modeled as a process which starts from the detailed level and proceeds in higher conceptual levels when failure occurs.

In adaptation, several general adaptational strategies may be distinguished. For example in the domain of housing design we can illustrate the following adaptational strategies:

a. Parametric modification: adaptation may be derived through parametric modification. This involves the change of values of variables at the detail level. For example, the length and width of room dimensions according to required area.

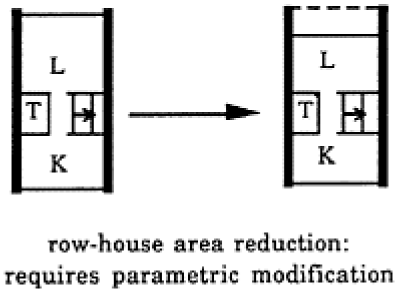


Fig. 2. A parametric modification process

b. Substitutional adaptation: this is adaptation through substitution of elements. When a newly derived value fails, a higher-level change may be required and new element variables must be constructed. This may require re-instantiations in which the method that was used to generate the prior design can be re-used once the substitute element has been introduced. For example, when a newly derived width of dwelling is too narrow to accommodate the existing stair design, another stair design may be required.

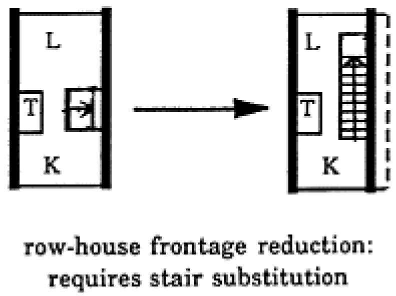


Fig. 3. A substitutional adaptation process

c. Typological adaptation: when a newly derived element fails, access to the next higher-level is required for the construction of a new typological structure. For example, when a change at the level of circulation elements fails, a change at a higher level such as spatial structure of the building type may be required.

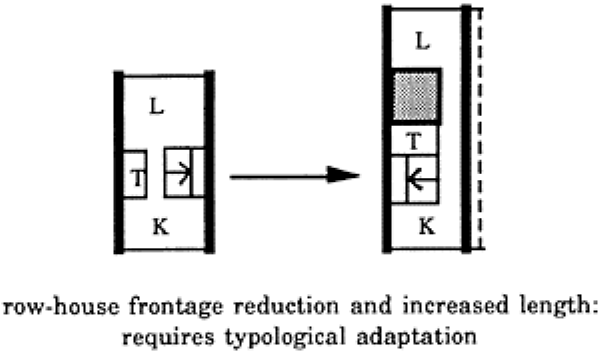


Fig. 4. A typological adaptation process

The integration of design cases with design prototypes allows for the modification and repair of a design case through the generating and instantiating capabilities of the design prototype. Because a design case encodes its history, including which design prototypes and knowledge are associated with the derivation of values, the respective design prototype can be accessed and the respective knowledge re-run to provide a new instantiation through value modification.

6 Conclusions: modeling design experience with interacting general and specific knowledge

This paper has compared two paradigms for the modeling of experiential knowledge in knowledge-based design: prototype-based reasoning and case-based reasoning. The distinction between the use of general knowledge and specific knowledge in design was made in order to explain the relevance of each of these models. The attributes and deficiencies of these models were identified and a combined schema which incorporates both cases and prototypes has been suggested in order to support adaptive design. Through combining both specific and general knowledge in design reasoning the case and the prototype may work together, each complementing the representational and reasoning strengths of the other.

7 Acknowledgements

This research was begun in the Department of Architectural and Design Science of the University of Sydney. I am grateful to Professor J.Gero for his guidance and support. The work has been continued at the Technion with the support of the VPR Fund.

8 References

Alterman, R. (1986). An adaptive planner in **Case-based Reasoning, Proceedings of Workshop on Case-Based Reasoning, (ed.** J. Kolodner), Sponsored by: DARPA, Florida.

Gero, S.J. (1987). Prototypes: a new schema for knowledge-based design, Working Paper, **Architectural Computing Unit, Department of Architectural Science,** University of Sydney

Gero, S.J.Rosenman, M. and Oxman, R.E. (1991). What's in a case, in **CAAD FUTURES'91,** (ed. G.Schmitt), Zurich, Switzerland (to appear).

Hammond, K.J. (1986). Case-based planning: an integrated theory of planning, learning, and memory, **PHD Thesis,** Department of Computer Science. Yale University.

Kolodner, J.L. (1988). **Case-based Reasoning, Proceedings of Workshop on Case-Based Reasoning,** Sponsored by: DARPA, Florida.

Minsky, M. (1975). A framework for representing knowledge in The **psychology of computer vision** (ed. P.H.Winston) New York, MacGgraw-Hill.

Oxman, R.E. (1990a). Prior knowledge in design, a dynamic knowledge-based model of design and creativity, Design Studies, Vol. 11, No. 1. pp. 17–28.

Oxman, R.E. (1990b). Design shells: a formalism for prototype refinement in knowledge based design systems **Artificial Intelligence in Engineering**, Vol. 5, No. 9, pp. 2–8

Riesbeck C.K. and Schank, R.C. (1989). **Inside Case-based Reasoning,** Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Schank, R.C. and Abelsonn, R.P. (1977). **Scripts, Plans Goals and Understanding: An Inquiry into Human Knowledge Structures,** Lawrence Erlbaum, Hillsdale, New York.

Schank, R.C. (1982). **Dynamic Memory: A Theory of Reminding and Learning in Computers and People.** Cambridge University Press.

Sowa, J.F. (1984) **Conceptual Structures,** Addison-Wesley, Reading, Massachusetts.

159
ICADS: an intelligent building design system

J.G.POHL

Abstract
This paper describes the design and implementation of a prototype working model of an Intelligent Computer-Aided Design System (ICADS). It is the objective of the ICADS project to demonstrate the feasibility of a computer-aided design partnership in which the user orchestrates the evolution of a design solution with the intelligent assistance of the computer. The vehicle for this demonstration is a prototype CAD system shell serving as an intelligent interface between the building designer and a variable assortment of project related databases and knowledge bases.

Keywords: Computer-Aided Design, Expert System, Blackboard, Knowledgebase, Prototype, Cooperating Agents.

1 Introduction

The ICADS research project started with the narrow objective of increasing the level of automation in CAD systems. What was realized is that the human designer has the potential for making important contributions in a computer-based design environment, and that to exclude the designer by automating the entire design process would be counterproductive. Instead, it was found that the productivity level of the design activity and the quality of the final artifact can be substantially increased by treating the designer as an agent with natural intelligence interacting in a cooperative system among other agents with artificial intelligence.

Phase I of the ICADS project commenced in 1987 with a strong focus on interdisciplinary collaboration, to promote the application of existing principles and theories in the development of a new integrated computer-aided design model. The principal findings of Phase I suggested that: any design process is necessarily based on the assembly and interpretation of a substantial body of knowledge, which should be made available to the designer in the CAD environment; a knowledge-based CAD system will require on-line access to databases containing factual technical information, knowledgebases containing generalized solutions based on previous design experience, and intelligent design tools capable of validating design decisions; the evolving design solution must be represented as an assembly of interrelated objects, each described in terms of its geometric and non-geometric characteristics; and, the human designer plays an important role as orchestrator of the resources made available by the knowledge-based CAD system (Poh1 et al. 1988a).

A CAD system shell, incorporating an intelligent user interface and control system to bind together a variable assortment of internal and external design resources in a distributed environment, was proposed as a preliminary conceptual ICADS model (Fig.1). It was suggested that the shell should serve three roles. First, to control and coordinate the concurrent operation of numerous intelligent agents that continuously monitor and evaluate the evolving design solution. Second, to provide an appropriate 'external view' of the network of heterogeneous databases that are required in support of the design process. Third, to provide a seamless transition into and out of the operational domain of the CAD drawing functions, the multi-media presentation facilities, and any number of tool kits that afford the designer an opportunity for customizing and enhancing the user environment.

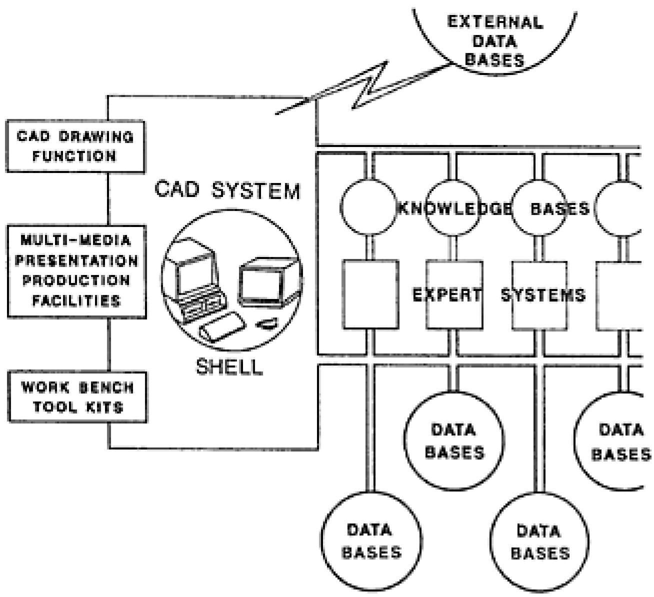


Fig.1. The CAD System Shell Concept

Phase II commenced in early 1988, proceeding in annual stages with 1990 marking the completion of Stage 3. Stage 1 focussed on the design of an ICADS implementation model, the development of a frame-work for the representation of design knowledge, the design and implementation of a geometry interpreter capable of extracting objects from the point/line schema of an existing CAD drawing system, and the prototyping of expert systems to be later adapted as intelligent design tools (IDTs) in an ICADS working model (Pohl et al. 1988b).

The implementation model proposed a blackboard control system for the coordination of all resources and intelligent agents that inter-act within the ICADS environment. The primary characteristics of the control structure were defined as: rule-based representation of the control paradigm; hierarchical structure; global identifiers operating within a disciplined philosophy; and, inter-module communications conducted strictly through the identifiers.

The relational database model was proposed for storing both prototype knowledgebases and reference databases in an ICADS working model. Interfaces were developed to facilitate the various interactions between the designer, the intelligent design tools and the blackboard control system, thereby insulating the designer from the operational aspects of the relational database environment.

In addition, the Stage 1 Report established several general principles for the design of the ICADS user environment. First, the functionality of the ICADS environment should not be hidden from the designer. In other words, the designer should be able to monitor the inferences made by the cooperating intelligent agents of the advisory facility. Second, the user interface must provide for customization, enhancements, modifications and the establishment of future connections to new external information resources and communication media. Third, the user interface should be capable of acquiring knowledge about the user. Fourth, the designer should be able to communicate with the user interface at a level compatible with the designer’s view of the evolving design solution.

Stage 2, completed in December 1989, produced ICADS Working Model Version 1 (DEMO1) based on the implementation model designed in Stage 1. Following the initial recommendation of the Phase I Report, DEM01 was developed mostly with off-the-shelf software systems. Where the necessary tools were inadequate, enhancements were added and modifications made (Pohl et al. 1989). The relational database management system, SQL-RT (Oracle), was found to be entirely adequate for accommodating the prototype knowledgebase and reference database components of the ICADS model. The CLIPS expert system shell, developed by the Artificial Intelligence Section at NASA/Johnson Space Center and distributed by COSMIC (Athens, Georgia), was used for all intelligent design tools (IDTs) and the blackboard system (NASA 1989, Giarratano and Riley 1989). With the availability of CLIPS source code, written in the ‘C’ language, necessary changes were made to the basic CLIPS package to provide for the ICADS advisory components to execute as separate parallel processes in a distributed environment.

Focussing initially on the building design application field, DEMO1 included typical Building Type and Site/Neighborhood knowledge-bases, several Reference databases containing material and manufactured component information, an Expert Design Advisor comprising four IDTs (representing the structural, thermal, acoustic and lighting domains) and a Blackboard Control System, the MountainTop CAD (drawing) package marketed by Accugraph Corporation (El Paso, Texas), and a Design Interface. DEMO1 was designed to operate as seven integrated parallel processes, distributed over one or more networked IBM-RT workstations. Although limited in scope, the working model clearly demonstrated the feasibility of an intelligent knowledge-based CAD environment.

2 Description of ICADS DEMO2

The purpose of ICADS DEMO2 is to consolidate and enhance DEMO1 as a test base with sufficient functionality to support a meaningful investigation of the characteristics and behaviour of a cooperative, knowledge-based CAD environment. The original ICADS DEMO1 implementation model has been extended in three areas. First, the design sequence covered by DEMO2 has been broadened by the addition of a Predesign Module that supports the earliest analysis of relationships among low level objects drawn from textual design specifications. Second, a new Design Interface with dynamic display capabilities has been developed for monitoring the interactions among the various intelligent agents within the Expert Design Advisor. Third, the functionality of the Conflict Resolver resident in the Blackboard has been extended to accommodate two additional intelligent design tools (IDTs) and to allow interaction with the designer in the case of irreconcilable conflicts.

Fundamental to the concept of a knowledge-based design system is the availability of a wide range of information resources in support of the design process. Minimally, these must include the specifications that define the boundaries of the design space and establish the performance requirements of the designed artifact, factual reference data such as material properties and other known constants, and knowledge pertaining to experience with past similar projects (Fig.2). While only a single prototype knowledgebase has been provided in DEMO2, the full ICADS model envisions multiple secondary knowledgebases to support the exploration and combination of alternative solutions drawn from broader domains.

In the transition from DEMO1 to DEMO2 the information resources available in the ICADS working model environment have been marginally extended to include abstract objects representing conditions that impact physical objects, and subsiduary levels of dependent attributes of physical objects. Typically, an abstract object may be used to describe the local context, such as climatic conditions in building design or local manufacturing factors in the mechanical design domain, within which the design solution will be implemented (ie., constructed or manufactured).

The provision of subsiduary levels of object attributes was considered necessary in DEMO2 to describe hierarchically related sets of attributes, pertaining to the same object class. For example, in building design the object class ‘space’ has single level attributes that describe the nature of the space (eg., lighting requirements and access properties) and multiple level attributes that describe the characteristics of activities performed by the different user groups that occupy the space.

The information resources provided by DEMO2 include a prototype building type knowledgebase for a Rural Community Center, a site/ neighborhood knowledgebase for a typical site located at Pismo Beach

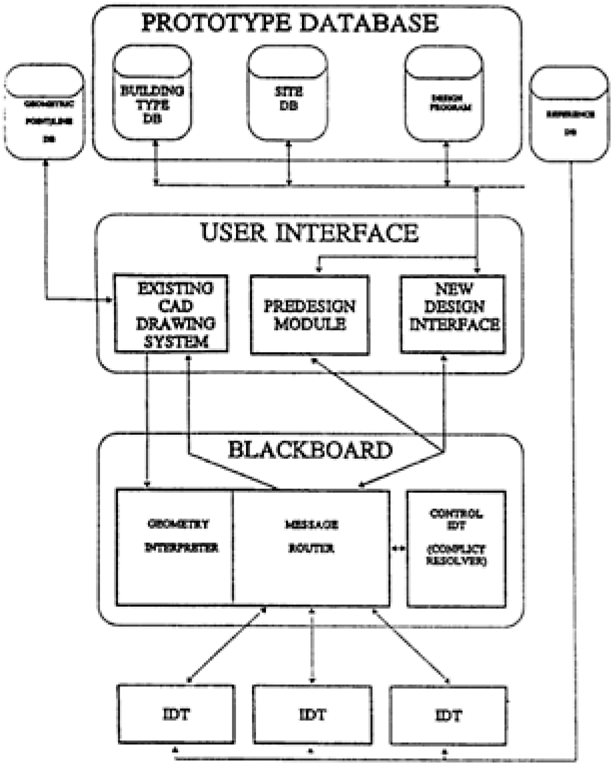


Fig.2. System Diagram of ICADS DEMO2

in the California Central Coast region and a number of reference tables containing material, constructional and environmental information. The six domain experts (ie., intelligent design tools or IDTs) of the Expert Design Advisor have been chosen to represent primary areas of concern in building design; namely, construction cost projection, space access determination, daylighting, sound control, structural system selection, and thermal control.

A complete demonstration sequence commences in DEMO2 with the designer entering the predesign stage, to explore the relationships among spaces identified in the design program of the building project under consideration (Fig.3). The starting point of the predesign stage is a graphics screen display template that consists of a blank central work area, surrounded by a border of circles representing building spaces, drawn in size proportional to the typical suggested area of each space, and color coded according to space type. A horizontal function bar at the top of the screen provides the tools for the designer to select any subset of spaces that will form the basis of the initial exploratory process.

The designer is able to SELECT, ADD, COPY or DELETE spaces. Selected spaces are automatically moved into the central work space together with name and area labels.

Additional spaces may be cloned from the existing objects or created by the designer. In the latter case the designer is requested to establish a set of minimum attributes to be attached to the new space. Apart from these designer defined attributes the created space will inherit attributes from the designated space type. Since the need to add or delete objects may occur at any time during the predesign process, the designer may return to the Space Selection Stage at any time.

Having selected the desired set of spaces the designer moves into the core functional domain of the Predesign Module. This is referred to as the Space Grouping Stage, and allows the designer to explore the relationships among spaces and their attributes within the context of the desired performance criteria of the final solution. The tools provided to the designer by DEMO2 to facilitate this conceptual design process may be divided into two categories: information query tools; and, locational manipulation tools.

The information query tools allow the designer to view any of the selected objects in the context of its attributes. These attributes are divided into two groups: 'building criteria' such as user activities that are performed in a space, external access needs, privacy requirements, and space adjacency properties; and, 'site criteria' including daylight, noise and climatic conditions, as well as neighborhood features such as views, bounding streets and surrounding structures. Typically, the designer is able to specify whether the selected attributes should be displayed for one or all spaces and can then proceed to modify attributes. Any such modifications are automatically incorporated in the design specifications and performance requirements that guide the design process.

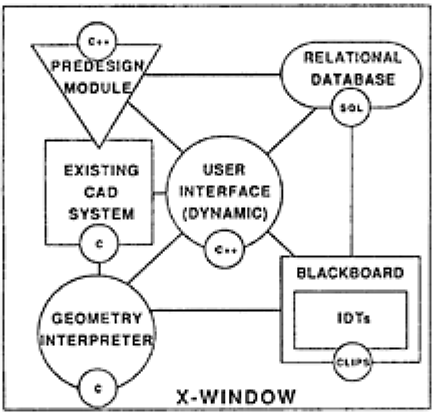


Fig.3. DEMO2 Software Modules

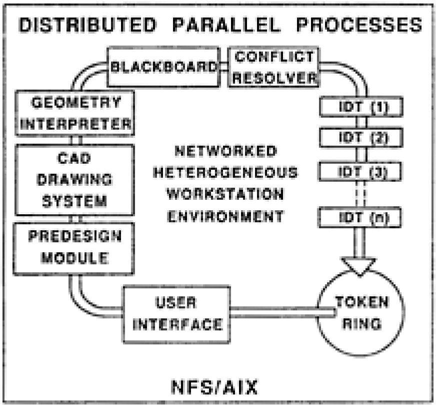


Fig.4. Operational Environment

The locational manipulation tools allow the designer to progressively rearrange the location of spaces on the screen to better reflect their attribute relationships. The progressive rearrangements of spaces represent space relationship diagrams in the evolution of a floor plan. A Layout Generator tool is provided to automatically generate new relationship diagrams based on weighted criteria selected by the designer. Typical criteria include space type, space dimensions, environmental factors (eg., allowable background noise levels and lighting requirements), user activities and space adjacency properties.

In addition the designer can interactively MOVE, LOCATE and FREE spaces following the generation of a relationship diagram. The ability of the designer to participate directly in the progressive assembly of the floor plan is fundamental to the ICADS model, and has been discussed previously in Pohl et al. (1988b and 1989). During this stage of grouping objects, the displayed representation of the objects may be changed to reflect their physical form. In DEMO2 only the architectural characterization of this function has been implemented, allowing the designer to automatically substitute rectangular space shapes for the amorphous circular representation. The implementation of this function in other application fields, such as mechanical design, will require more complex 3-D object representations.

It is important to note that the Predesign Module does not require the design process to be conducted in any chronological sequence other than that most of the stages presuppose the existence of at least an initial set of selected spaces. Having met this minimum requirement the designer is able to move back and forth between the various predesign stages described above, to accomplish his task in any iteratively ordered sequence.

The final stage of the Predesign Module provides tools for the designer to refine the space relationship diagram, to facilitate the evolution of a floor plan. These tools include MOVE, ROTATE, RESIZE, REPROPORTION and CONFLICTS. Here again, the emphasis of the DEMO2 environment is to optimize the contributions of the designer by providing assistance rather than preempting the human role through automation. It is expected that in the Layout Refinement Stage the designer will make relatively minor adjustments to the position and proportional size of individual objects, while confirming compliance with the original or modified design specifications.

In this respect the CONFLICTS option is of particular importance. It alerts the designer to possible problem areas within the current state of the solution that have been identified by the Conflict Resolver in its continuous background consultation with the domain experts (IDTs). While the designer has been interacting with the predesign environment the Expert Design Advisor has been actively evaluating the evolving design solution in those knowledge areas that are represented by domain experts. Rules have been added to several of the DEMO1 IDT versions to allow these to participate during the predesign stage. Similarly, the new Design Interface can be used at any time by the designer to obtain more detailed information relating to any particular IDT or the Conflict Resolver's view of all IDTs.

At the conclusion of the predesign stage the designer may move directly into the design development stage provided by the original DEMO1 version of the ICADS working model. Although the transition interface between the Predesign Module and DEMO1 has been designed in principle, its implementation is still in progress. The interface module will accomplish the transition in two stages. First, a Geometry Validator will examine the final object relationship diagram produced in the Predesign Module environment and correct poor alignments among spaces within the assembly of spaces. Second, a Geometry Translater will utilize a macro language (available for the MountainTop CAD package used by DEMO1) to regenerate the relationship diagram as a drawing in the DEMO1 CAD environment.

Since the DEMO1 environment has been previously described in several publications (Pohl et al. 1989 and 1990, Myers and Pohl 1990 and 1991) it will suffice here to consider only those features that have been modified in DEMO2.

Foremost among these is the increased functionality of the new Design Interface. Located on a separate monitor, the Design Interface allows the designer to access three related knowledge domains:

> The prototype and local context knowledgebases that represent the 'experience' component in the ICADS model (in the demonstration setting of DEMO2 they are the Rural Community Center building type knowledgebase and the site/neighborhood knowledgebase of the Pismo Beach site in the locality of the California Central Coast region).
>
> The design specifications and performance requirements (ie., the design program).
>
> The recommendations sent by the IDTs to the Blackboard and the decisions made by the Conflict Resolver.

of particular significance is the ability of the designer to monitor the interactions of the IDTs and the Conflict Resolver in real-time. For example, after selecting the IDT option the designer clicks onto a space (using a screen pointing device such as a mouse) to generate the corresponding display template. The values in the template, representing frame slots in a semantic network, are updated dynamically to reflect any ongoing changes in the state of the design solution. It is expected that designers will be encouraged to utilize this capability to monitor the impact of experimental design strategies in specific domains.

ICADS DEMO2 currently operates on several IBM-RT workstations networked together. Each component executes as a separate process and processes communicate with each other through UNIX sockets (Fig.4). On less than six IBM-RT workstations the working model is relatively slow. However, experience with the DEMO1 version on the IBM-RS/6000 platform suggests that two networked RS/6000 workstations will provide an ideal hardware environment for DEMO2. Superficial benchmark tests conducted with DEMO1 found the latter to execute almost three times as fast on a single RS/6000 workstation than six networked IBM-RTs.

3 Functional and Operational Considerations

The conduit through which the Expert Design Advisor communicates with its experts is a classification framework of design object frames, referred to as the Semantic Network in the ICADS model. A frame-based representation was chosen for two reasons. First, to provide a common representational form for the diversity of information formats required by the various components of the model. For example, the Geometry Interpreter extracts objects in C language structures, the Predesign Module recognizes the same objects as a frame class library, the database queries return tuples in SQL format, and the domain experts and Conflict Resolver assert CLIPS facts (Assal and Myers 1990).

During the system initialization phase the Attribute Loader, resident in the Design Interface module, loads the design specifications and performance objectives (ie., the design program) from the relational database into the Semantic Network. In DEMO2, the design program is mostly a predefined subset of the prototype and local context knowledgebases. Some specifications are inferred by the Attribute Loader from several information items contained in these knowledgebases, and a minimum number of constants are preset for the demonstration environment. In the future it is planned to develop a Design Program module to facilitate the definition of design objectives and performance requirements under the guidance of the designer (Fig.5).

The design objectives and specifications loaded by the Attribute Loader define the context within which the designer and the domain experts operate. In the ICADS model the distinction between design context and design solution has led to the separation of the Semantic Network into two logical sections (Fig.6).

> Project Design Object (PDO) frames comprising one frame for each of the objects represented in the supporting knowledge-bases. These frames are loaded by the Attribute Loader during the system initialization phase, as described above.
>
> Solution Design Object (SDO) frames comprising one frame for each physical object included in the current design solution. In DEMO2, these frames are established both by the Frame Manager in the Predesign Module and the Geometry Interpreter in the MountainTop CAD environment. Relation frames are added by the domain experts and the

Conflict Resolver during each evaluation cycle of the Expert Design Advisor.

Detailed descriptions of the structure of the frames within these two logical divisions that have been included in previous publications relating to DEMO1 are still relevant (Pohl et al. 1989). Only minor additions have been made in DEMO2 to accommodate the Cost and Access IDTs.

While the slot values of PDO frames could not be changed by the designer during the design process in DEMO1, this restriction no longer applies in the DEMO2 version. The Predesign Module allows the designer to change design specifications, and these changes replace existing slot values in the corresponding PDO frame of the Semantic Network. However, the changes are currently not transmitted to the original copy of the design program in the relational database.

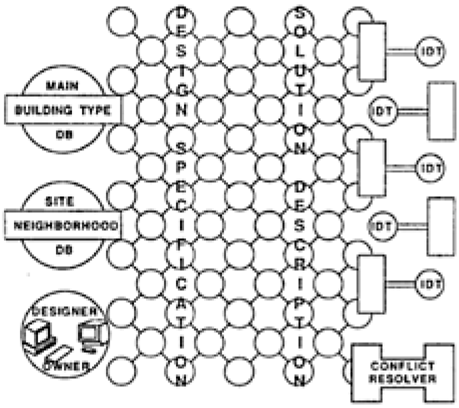


Fig.5. DEMO2 Semantic Network

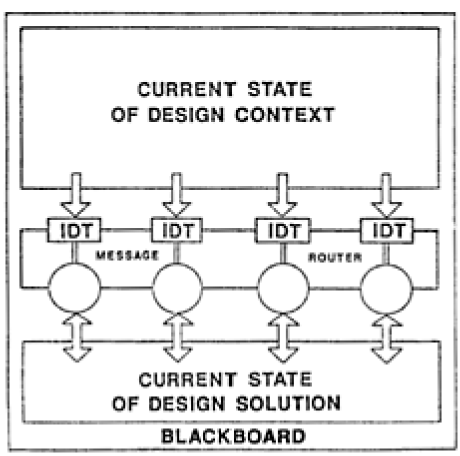


Fig.6. Object Frame Types

Following system initialization the operation of DEMO2 follows very much along the same lines as the previous DEMO1 version. The Expert Design Advisor, through its cadre of experts, continuously monitors and evaluates the evolving design solution. The latter is represented as an assembly of objects that are either extracted directly from textual design specifications, as in the Predesign Module, or interpreted from the geometric database of an existing CAD package. Any changes in slot values of SDO frames in the Semantic Network that are part of the input template of a domain expert will immediately activate this IDT to undertake an evaluation sequence and transmit its findings through the Blackboard to the Semantis Network (Fig.7).

The Blackboard, through the Conflict Resolver, continuously examines the domain expert slots in the SDO frames and compares these with its own 'current value' slots to identify conflicts. Typically, several domain experts will send different suggestions for the same evaluation parameter of a particular object. The Conflict Resolver, based on its own knowledge and reasoning capabilities will propose a compromise 'current value' which may differ from all of the suggested values. This action will precipitate a new round of evaluation by all domain experts (IDTs) that are now in conflict with the 'current value'. The focus of this reevaluation is to assess the impact of the Conflict Resolver's proposal on the domain of each IDT. The reevaluation may result in agreement with the 'current value', acceptance of a degree of disagreement that is acceptable to the IDT, or an alternative proposal to the Conflict Resolver. Experience with

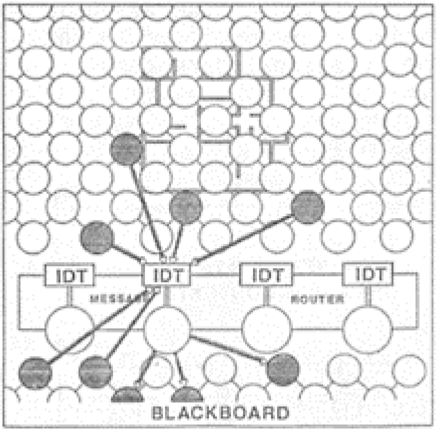


Fig.7. IDT Evaluation Sequence

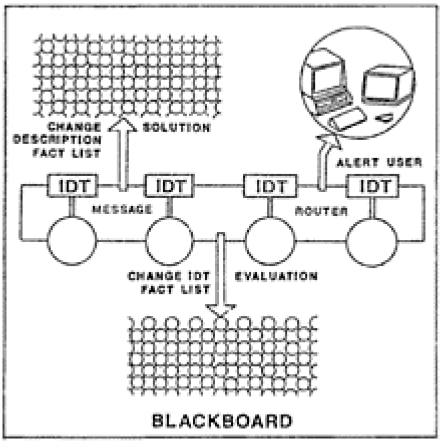


Fig.8. Blackboard Actions

both DEMO1 and DEMO2 have shown that in the majority of cases this consultative cycle is quite rapidly concluded to the satisfaction of the experts involved (Fig.8). In DEMO2, the only course of action available to the Blackboard if it cannot reach agreement with the domain experts is to notify the designer. Under these circumstances the designer is presented with a set of alternative actions, such as change a slot value in a PDO frame or modify the current design solution.

4 Acknowledgements

The ICADS project has been supported with research grants by several industrial and government sponsors including IBM Corporation, Accugraph Corporation, and the Department of Energy via Battelle Pacific Northwest Laboratory.

Participation in the ICADS project extends beyond the authors to an interdisciplinary team of researchers, including: Hisham Assal, Arthur Chapman, Laurian Chirica, Coe Johnson, Dean Johnson, Leonard Myers, James Snyder and James Taylor.

5 References

Assal, H. and Myers, L. (1990) Implementation of a Frame-Based Representation in CLIPS, in **Proc. First CLIPS Users Conference,** Johnson Space Center, NASA, Houston, TX, August 13–15.

Giarratano, J. and Riley, G. (1989) **Expert Systems: Principles and Programming**. PWS-Kent, Boston, MA.

Myers, L. and Pohl, J. (1990) ICADS DEMO1: A Prototype Working Model, in **Proc. Fourth Eurographics Workshop on Intelligent CAD Systems,** Paris, France, April 24–7.

Myers, L. and Pohl, J. (1991) Computer-Based Intelligent Design Assistance: Concepts and Strategies, accepted for First International Conference on Artificial Intelligence in Design, Edinburgh, Scotland, June 25–27.

NASA (1989) **CLIPS Architecture Manual** (Version 4.3). Artificial Intelligence Section, Lyndon B.Johnson Space Center, TX.

Pohl, J., Chapman, A., Chirica, L. and Myers, L. (1988a) **ICADS: Toward an Intelligent Computer-Aided Design System.** Tech. Rep. CADRU-01–88, CAD Research Unit, Design Institute, Cal Poly, San Luis Obispo, CA.

Pohl, J., Chapman, A., Chirica, L., Howell, R. and Myers, L. (1988b) **Implementation Strategies for a Prototype ICADS Working Model.** Tech. Rep. CADRU-02–88, CAD Research Unit, Design Institute, Cal Poly, San Luis Obispo, CA.

Pohl, J., Myers, L., Chapman, A. and Cotton, J. (1989) **ICADS: Working Model Version 1.** Tech. Rep. CADRU-03–89, CAD Research Unit, Design Institute, Cal Poly, San Luis Obispo, CA.

Pohl, J., Myers, L., Chapman, A., Chirica, L., Snyder, J., Assal, H., Taylor, J., Johnson, C. and Johnson, D. (1990) **Knowledge-Based CAAD and the CLIPS Expert System Shell.** Tech. Rep. CADRU-04–90, CAD Research Unit, Design Institute, Cal Poly, San Luis Obispo, CA.

Pohl, J., Myers, L., Chapman, A., Snyder, J., Chauvet, H., Cotton, J., Johnson, C. and Johnson, D. (1991) **ICADS Working Model Version 2 and Future Directions.** Tech. Rep. CADRU-05–91, CAD Research Unit, Design Institute, Cal Poly, San Luis Obispo, CA.

160
The application of EDI to building industry and quality of housing: present situation in France, trends and problems

J.Y.RAMELLI

Abstract
This paper describes the conditions in which the French Building industry—a major sector of the economy—negotiates its policy regarding professional information and interprofessional communication, prior to the opening of the European market.

This policy aims to further the integration of the actors' efforts to improve the productivity and quality of building operations. It involves setting up new communications networks based on traditional relations. It is implemented in coordination with the computerization of the sector and in close collaboration with the concerned professional bodies. It is applied gradually as part of an overall approach designed to structure the various information sources used for managing construction projects, design studies, technical calculations, technical administration of housing stock, etc.

CONTENTS:

This paper describes the conditions in which the French Building industry—a major sector of the economy negotiates its policy regarding professional information and interprofessional communication.

I The context

Construction of a building involves a very large number of professions: property owners, architects, engineers, building contractors, building inspectors, materials suppliers, components manufacturers etc.

As distinct from most other industrial sectors, the involvement of these different trades and professions is not always coordinated within large integrated units.

In the Building industry, each construction project requires the constitution of specific pluriprofessional teams, whose composition varies as the project advances, and which last for limited periods. This gives rise to very-complex problems of communication, due to the need to establish bilateral relations between actors with generally different backgrounds and interests.

Another specific feature of this sector is the absence of actors of sufficiently large scale to be able to impose their own requirements on a major section of professionals, as regards the organization of the design-construction-maintenance process for construction operations. Therefore the situation in the Building industry is not the same as in the automobile or aeronautics industries, since the “large groups” of construction companies only represent 11% of the sector’s turnover, while 300,000 small building contractors (of less than 10 persons) account for 44% of the total.

However, this sector is also faced with the same challenges as other sectors of the economy: international competition—as indicated by the balance of payments deficit for components with respect to the E.E.C.; pressures associated with environmental factors (energy savings, noise control etc.); market requirements (a major increase in demand for improved quality/cost ratio); and the need to improve working conditions (50% of industrial accidents are connected with the Building industry). The obligation to meet these challenges has thus led the Building industry to adopt a policy involving work programmes comparable to those launched by other industrial sectors. These concern different fields: building materials (technological innovation); project management methods, industrialization, advanced information technology etc.

This is also a matter of national importance, considering the economic weight of this sector. Its annual turnover is equivalent to the total of the automobile and textile industries, or the total of the chemical, aeronautics construction, railway rolling stock and industrial working stock industries: it employed 1,272,000 people in 1988; and it accounts for 50% of France’s fixed capital.

It is a matter of European importance because most of the typical features of this sector in France are also found in the other countries of the E.E.C.

II The basis of the policy adopted

In France, it was seen that major productivity gains could be obtained by intervening in the area of interprofessional relations and modes of organization.

This result was obtained experimentally on the basis of 217 pilot schemes, corresponding to more than 9,000 dwellings, carried out in real life, as part of the Habitat 88 programme between 1982 and 1989 organized by the PCA (Plan Construction et Architecture).

Thus almost 2/3 of these experiments resulted in costs more than 13% below the reference prices, due to the streamlining of transitions between the different stages of the building project and, consequently, the establishment of cooperation that implied the desire for better, more efficient communication between the various parties involved.

In other words, these experiments showed the importance of integration of the actors' approaches in the effort to solve the problems that the Building industry is faced with.

The question then arose of applying the conclusions of these experiments on a large scale. This obviously involved going further than usual in the promotion of research.

It is clear that, taken alone, communication or publication have limited impact, at least on a large-scale operational level, since, by their very nature, these experiments each correspond to a specific situation. Thus several conditions must be combined simultaneously in order to be able to achieve in-depth modifications of traditional practice. Promoters of technological innovations have often reached this same conclusion.

In the Building industry, a major obstacle is created by the existence of old teaching methods that date back to the trade-guilds of the Middle Ages. Today, even if trades unions and professional associations have carried on where these traditional forms of organization left off—with the "trades"—everyone in the Building industry is well aware that, when a profession imposes its point of view, it is in fact its culture that it imposes on others, and that, by acting in this manner, it guarantees itself more powers and more employment opportunities.

For this reason, at the request of the professional bodies themselves, the authorities defined areas for negotiation where discussions can take place without altering the balance of forces.

III The policy implemented from 1985 to 1989

Particularly in 1985, the professions and public authorities became aware that computerization of the sector could play a key role in working towards the goal of integration.

They realized this when analyzing the possible reasons for the low rate of company computerization (particularly the smaller companies) especially as regards technical applications.

This study showed that companies were waiting for a range of products and services adapted to their needs. As a result, in close collaboration with the professions, a general policy of incentives and motivation was outlined, aimed at providing the Building industry with tools and services for information, communications and data processing that were more suitable for its specific requirements.

This policy was implemented gradually. Its objectives can be summarized as follows:

- to facilitate the structuration, centralization and upgrading of existing data banks, in order to provide expanded, coordinated, reliable services, taking into account the new openings created by the development of the sector's computerization;
- to support the definition and promotion of "communications standards", common languages, protocols for exchanges of messages, and data structure models, in order to

help information technology and videotex suppliers to industrialize their products and to facilitate the subsequent integration of their tools;

- to encourage cooperation between the actors of the Building industry and their professional organization, in order to assist in the formulation of coherent requirements;
- lastly, with a view to the European deadline in 1993, to progress step by step, to avoid major upheavals that would leave the way open to excessive foreign influx, while taking into account any progress achieved in the field of standardization on a European level.

The Club Informatique et Bâtiment {Information Technology and Building Club) was given the task of spearheading interprofessional cooperation. However, within the framework of the IN.PRO.BAT programme, the PCA was given the responsibility of providing incentives for IT and videotex suppliers, and mobilizing research and experimentation.

IV In. Pro. Bat: Structuring the provision of Information Technology products and services

The first condition to be met to work towards integration of supplied products and services is the establishment of relations on the basis of mutual trust with the developers of application software and suppliers of videotex services (data bank producers etc.).

For this reason, these suppliers were consulted on a specific topic each year between 1985 and 1989: computer-assisted design and computer-generated images in 1985, expert systems and artificial intelligence in 1986, CIM (computer-integrated manufacturing) and robotics in 1987, and technical administration of housing stock in 1988.

These consultations facilitated the constitution of interdisciplinary and interprofessional teams, bringing together software publishers, the companies' research and development teams, research units and IT manufacturers. This led to very open approaches and the establishment of new links between the producers and users, as well as between short-term development work and long-term research.

Research projects of several years' duration were launched independently of these consultations. They concerned broad topics, within both medium and long term perspectives. For example, the uniformization of technical data structures concerning building projects, which requires progress to be made regarding the overall modelling of design problems and the multitechnical nature of the data.

Another topic is the modelling of knowledge for application in areas considered as key issues for interprofessional relations, e.g. the dimensional coordination of prefabricated components, which plays a key role in the integration of specifications-production engineering; planning etc.

Lastly, research has been started on the semantics of building—a strategic topic—with structuration of the data layers necessary for the future definition of electronic exchanges of technical data. For example, any improvements in the exchange of computerized graphical documents (in a non-uniform environment) requires the development of common semantics for description of the construction works that are represented in graphical form.

V The CIB: Structuring the users' demand

Led by the Construction Department of the Ministry of Public Works, the CIB (Information Technology and Building Club) operates in a deliberately informal and open manner, bringing together people from very different fields who, previously, never had the opportunity to cooperate and communicate on a regular basis: professional bodies, government bodies, service companies, data bank producers, large building companies, specialized journalists etc.

The purpose of these meetings is to invite discussion of the main projects backed by the authorities and, in certain cases, to give the participants the opportunity of becoming involved in monitoring and steering these projects.

The Club's members can take part in more specialized working groups which may eventually be institutionalized. This was the case in 1988, with the establishment of EdiConstruct—which now represents the Building industry on the Board of EdiFrance for the standardization of computerized messages and documents (EDI). It was also the case for the Bati-lnfo association—which is a veritable group of companies that associates data bank producers, who have decided to bring their services together for the purposes of placing their banks on a network.

Thus, within the framework of the Club, the work programme for computerization of regulations and technical rules was launched in 1987, directed by the C.S.T.B. (France's Building Research Centre). The Fartec project thus works in two types of area: firstly, the complete digitization of (para-) regulation documents, which is now completed; and secondly, the provision of the means for using these computerized documents, to facilitate the <u>integration</u> of statutory requirements by the developers of technical application software or by developers of videotex services.

Also, as part of the Club's activities, a certain number of interprofessional projects were launched. Their purpose was to develop common models for structuring technical data, as a preliminary step to prepare for better <u>integration</u> of working methods and corresponding technical tools.

VI The Communication-Constraction Programme

Five years ago, telecommunications technology only offered limited possibilities to the developers of applications and services. This is the main reason for the compartmentation of the two separate worlds of microcomputers and "data banks".

The situation has progressed greatly since then. The improved technical performance of networks (particularly Numeris), the provision of new message services (× 400 message services) and the development of new data storage technology (CD-ROMs) have created previously inconceivable possibilities for the strategy of communication between actors, particularly as these developments have been combined with a general trend of reduced data transmission costs.

For this reason, the policy applied by the authorities since 1985 was modified a year ago, resulting in the Communication-Construction programme, which replaced the In.Pro.Bat programme.

The goals assigned to Communication-Construction reflect these developments. They give priority to the following four main areas: development of Added Value Networks and Services (RSVA); standardization associated with the widespread use of EDI (Electronic Data Interchange); qualification and requalification of trades in accordance with the development of these new means of interprofessional communication; and valorizing the improvement in the quality of construction works and building projects.

Work started in 1990 within this new framework gave priority to the structuration of a first core of supplied added value services as well as speeding up work in the pre-standard research field (structuration of exchange messages, exchanged documents and exchanged data), which broadly corresponded to the programme’s first two lines of action. This choice was the result of pragmatic considerations, inasmuch as it seemed more practical to work towards the other two aims in connection with experiments on the ground, which are only starting now. Therefore all the lines of action of the Communication-Construction programme can only be considered together as a whole from this year onwards.

Thus the situation has today progressed in comparison with the policy previously applied in In.Pro.Bat, especially as regards communications services—with the development of a first generation of SRVA services. In particular, all previously started work with a long-term structuring effect on the complete production channel has been continued on a greater scale than before.

VII New action programmes

In March 1990, four operators were selected by the PCA to develop and market these new interprofessional exchange and communication services: the subsidiaries of the Cogecom (France Telecom) group, particularly the new Edival company, specially founded to develop specialized building services and products; and Bull, Sligos and Axone (an IBM subsidiary specialized in networks).

Special cooperation agreements were then defined with each of these operators (with professional bodies, specialized Research and Development teams, services companies, etc.) to formulate specifications of the services to be developed and the corresponding marketing policies, and to specify detailed procedure for validating and monitoring the first experiments.

A vast area is covered by these agreements: construction site management, relations with suppliers of materials and components, exchanges of graphical documents, capital flows, setting up and conceiving operations etc.

In addition, three pilot regions have been selected: Nord Pas de Calais (northern coastal region), Aquitaine and the Provence-Riviera area. In each of them, a Regional Technical Committee has been set up, chaired by the Regional Department of Public Works, to inform local professionals, to constitute networks representative of those potentially involved, to give impetus to the process started, to mobilize training organizations, and to prepare for and promote future experiments.

Lastly, a national coordination committee has been set up to share experience acquired at the regional level and provide liaison with the EdiConstruct association and the professional bodies.

At the moment, the first generation of these new services is nearing completion and it should result in fifteen pilot operations this year.

These first services are based on general message services that were previously developed by each of the operators; these have been enhanced by specialized applications that are now centralized on specific servers interfaced with message service servers. In future, it is planned to develop chaining of operators' servers with those of the sector's most highly computerized companies (large building groups, building owners, major engineering firms, traders etc.) using re-routing techniques. This has a dual purpose: firstly, to broaden the functionalities of the initial servers, and, secondly, the gradual integration of computerized services. Naturally, this work will be carried out in close collaboration with EdiConstruct.

VIII Conclusion

Throughout the last few years, one point has been common to all work carried out on the topic of interprofessional communication in the Building industry. This is the established fact that, in order to involve all potential actors, the development of the sector's integration must conform to specific information channels that result from traditional relational practice. In addition, the relative failure of "data bank" approaches based on a producer-server-user sequence illustrates the limits of off-line external systems. Information obtained with these systems often has a low added value for the users because it is difficult to use: it is usually necessary to recapture and restructure data so that it can be used by application software.

Considerable progress has been achieved by networking on-line data banks or their integration into new electronic storage systems—such as the digital optical disk. This is particularly true since they result in an improved service that is obtained by the customization that they allow. However, this progress will still remain insufficient as long as no solution is provided for the problem of integrating the supplied data into technical or management applications used by the professionals. Trends shown by CD-ROM publishers confirm this observation: more and more applications are proposed that can use the supplied information in an operational manner. This is the case, for example, with aids for the preparation of estimates and bills of quantities, where the information supplied is in the form of a manufacturer's catalogue; or in office automation aids (for drawing up model documents) where the information supplied concerns legal matters; or in technical calculation aids, where the information supplied concerns technical regulations (in particular, with chaining to Fartec data).

In order to meet the users' requirements, it should be possible to integrate information from external (and usually non-uniform) sources at the workstation itself. This necessarily involves the development of common data structures for use by both the information producers (downloading) and the application software (particularly those developed by the IT suppliers). For this reason, standardization is very important as well as the work carried out by EdiConstruct.

The development of added value service operators is also very important in this context. In practice, the integration function shall be provided by these operators in a first stage (by means of the applications proposed, that are even accessible to the non-computerized users via the Minitel public videotex system). In addition, since they aim at all parties involved, valorization of the results of experiments will be possible on a very large scale. Lastly, since the proposed services closely match traditional relations (particularly concerning the construction site) they should spread by “snowballing”.

Many conditions are now right for the adopted policy to be successful in the near future, in particular, new impetus is given by the motivation of the new added value service operators. Developers of technical applications are working in the same direction: they have expressed their willingness to adapt their products and services in accordance with standards. Thus these factors increase our chances of success. However, there are some risks which must not be ignored. Some unknown factors remain, particularly the costs of using the new services: it will have to be possible to balance these costs with undeniable savings. But these savings are difficult to assess because, at a first stage, they will concern an overall scale (i.e. savings in the complete construction operation due to rationalization of exchanges) and it will probably be difficult to take them into account for an individual actor if his traditional organization does not change (in which case the use of these services is considered as an additional expense). Another decisive factor for success is the ergonomic quality of these new systems: they must be easy to use. Lastly, it is necessary to convince the market leaders of the necessity of these systems.

All these factors show the importance of continuing and reinforcing the forward-looking policy adopted in collaboration with the sector’s professionals.

PCA: Construction and Architecture Project

Established in 1971, Plan Construction et Architecture (Construction and Architecture Project) is an organization responsible for promoting research and experimentation in the Building sector. Its work is funded by the Ministry of Research and by the French equivalent of the Department of the Environment—the Ministry of Public Works, Housing, Transport and Maritime Affairs. In certain cases, it may be funded by the Ministry of Industry and Regional Development. It is administered by the Direction de la Construction (Construction Department of the Ministry of Public Works).

Since 1990, the PCA has been assigned to a mission with a dual objective: to meet the sector’s new demands and to place its work within a European perspective.

This mission is accomplished by four finalized programmes:

Cité Services:	to ensure that everyone is housed according to his needs, by using modern technology (house automation) to take advantage of appropriate services
Eurorex:	to help the sector’s companies to place their innovation efforts on a European scale
Cité-Projets:	to promote architecture as a means for accomplishing urban development strategies
Communication-Construction:	to increase the efficiency of communications in order to improve the quality and productivity of the Building industry

In parallel with these finalized programmes, three work programmes are carried out on the following topics:

- New building materials and products
- Jobs—Qualifications—Training
- Socio-economic study and long-term plan for Housing

161
Integration of building design computer systems

A.RECUERO and A.PROKOPIOUS

Astract
Computer systems are an essential tool in the building design process. Although offering powerful mathematical models and sophisticated graphical capabilities to the designer they are not actually improving the design process model itself and the diffusion of expertise throughout the industry. They are a reflection of the fragmentation of many building design disciplines and their specialization. An architectural system does not communicate with a structural system and vice versa, which means that at least 50% of the information and other work has to be done again. This results in poor decisions and downgrade performance of the final construction.

It is necessary to create an integration environment developed around an open and expandable database able to handle the building design conceptual objects and its data structure and organization. The current research is directed to this integration, stating that the low and declining productivity of construction industry compared with that of manufacturing industry is due to the lack of coordination among the different experts who serve the building design process.

-Keywords: CAD, CAE, Integration, Object Oriented Data Base, Experts Systems, Building Design.

1 Introduction

Construction projects are developed in three consecutive parts: design, planning and construction. The first phase, that of design, represents only 10% of the total project cost but it decides on the remaining 90%. It is therefore critical to improve the performance on the construction design cycle, not only to reduce its direct costs but also, and more important, to enhance the quality of the decisions made in this phase which affect the construction itself and its lifetime performance.

Computer systems are an essential tool in the building design process. Although offering powerful mathematical models and sophisticated graphical capabilities to the designer they are not actually improving the design process model itself and the diffusion of expertise throughout the industry. They are a reflection of the fragmentation of many building design disciplines and their specialization. An architectural system does not communicate with a structural system and vice versa, which means that at least 50% of the information and other work has to be done again. This results in poor decisions and down grade performance of the final construction.

It is necessary to create an integration environment developed around an open and expandable database able to handle the building design conceptual objets and its data structure and organization. The current research is directed to this integration, stating that the low and declining productivity of construction industry compared with that of manufacturing industry is due to the lack of coordination among the different experts who serve the building design process. Making the right decision in selecting design and construction alternatives could save considerable design time and result in a more durable, marketable and cost effective construction. The aim is to create an open integration environment for computer aided building design consisting of a well documented building design process model; a reliable conceptual model of the building entity clearly defining the building objects hierarchically and the corresponding data structures; a database management system reflecting the conceptual models and dealing with objects rather than data; and common principles for user interface which meet the specific needs of building design.

This should improve the quality of the decision-making of the building designer, the overall productivity of the building design process, the management of the building construction, the cost performance ratio, the cost of the actual construction and the building maintenance and repair cycles.

2 The Building Design (BD) Process

Construction of Buildings has attracted the attention of mankind since the beginning of civilization. Regardless of the status of science and technology throughout history, man constructed various buildings, some of which are still standing, as witness to the wisdom, the will and the power of the ancients.

In every case and without any exception, three main phases were applied in the construction of a building. There was always, first, a Design Phase where the needs, the form and the materials of the construction were defined. Then, a construction Planning Phase had to be accomplished, in order to manage the available resources, the design requirements and the time limits. Finally, there followed the actual Construction Phase to materialize the Building according to the design and the resources. The only difference, throughout the ages, has been the supporting technology.

The Egyptian Pyramids were designed by inspired, “empty-handed” engineers and were constructed by people, rock and some primitive tools and mechanics, taking many years, for each one, to be completed. Today’s New York Skyscrapers are designed and scheduled by computerized engineers and constructed by people using sophisticated materials and Robots, taking only a few months to build.

The three major phases of the Construction process and the Maintenance & Repair process along with the Building "Documentation", are outlined in figure 1.

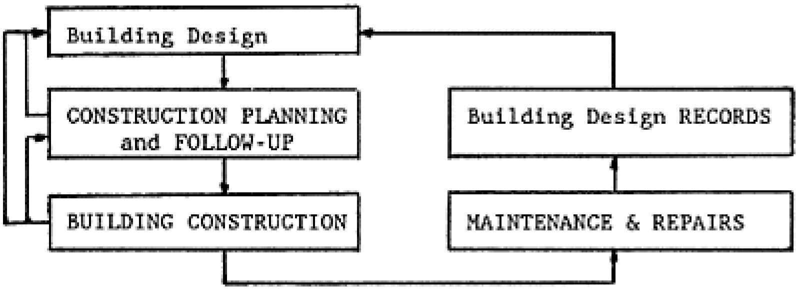


Fig. 1 Construction Life Cycle Schematic

As shown in Fig. 1, there is a close interaction between the three phases of the construction process. The Construction Planning may alter the designer's decisions and always imposes minor or major modifications to the initial plan. The construction of the Building provides the designer with feedback information which may cause him to alter minor design details or update the initial design with last-minute, on-site changes. The latter is extremely important for the maintenance cycle and the repair program of the Building, and it would be a great benefit if the documentation of the final construction could be stored in detail, integrated, updated, easily accessible and retrievable.

The previous diagram outlines also future potential integration (al design systems) of the Building Design systems with systems supporting the Construction Planning activities and automated robots carrying out the actual construction.

The BD process can be divided into 10 main, distinct phases, each one of which is served by completely different traditions, sciences, methodologies, disciplines, expertise and practices. A listing of the BD activities, in a reasonable sequence can be:

1 . Building Specifications

2 . Landscape Architecture

3 . Urban/Environmental Design

4 . Architectural Design

5 . Civil Engineering

. Structural Design

. Structural Analysis

6 . Energy Engineering

. Insulation

. Heating

. Air Conditioning

7 . Facility Engineering

. Electrical

. Plumbing

. Piping

. Under-Piping

8 . Sound Engineering

9 . Interior space design/Decoration

10 . Material selection and Bill of Materials

The BD process is basically sequential but also includes a lot of iterations and interactions between its various activities. Being sequential means that an activity has to be completed first, before the next activity can be developed. Although iterations may occur, the model has to follow the sequential path and run, every time, from top to bottom, in order to pass the changes made to the next activity.

3 Problems of the BD Process

The previously mentioned list of BD activities could be shorter or longer, depending on the view and the emphasis placed by the given approach to the subject. But, short or long, the items are sequentially developed and successively processed. This results in a set of problems.

One serious problem arising from this sequential nature of the BD activities is that the decisions taken in one activity impose serious limitations on the next, in such a way, that there is little or no room for decision- making in the last stages of the BD process.

Usually supported by independent computer systems, this sequential hierarchy of activities faces serious limitations from the conflicting decisions and/or from the non-compatibility of the supporting systems.

A second problem is lack of sensitivity. In everyday practice, the BD process is more or less a one-way process. The iterations and the interactions may occur only when facing dead-ends.

It is common to see an Architect who disregards some critical client's requirements in favour of the aesthetic, a Civil Engineer who ignores the functionality of the interior space in favour of the stability of the buildings, or a Facility Engineer who constrained limited by the previous two, "reconstructs" the building in order to find the "critical path" for the piping.

The cost, the time and the effort required to review any previous design step, in order to improve the performance of the next steps, is rarely undertaken. On the other hand, this "one-way" of the process is strongly fostered by the wide distribution and fragmentation of the expertise throughout the Building Design industry. The cost of coordinating individual experts who are trying to maximize their own performance, is always against the optimization of the final result. And all these without referring to the degree of the competition between the experts, that reduces even more the quality of the final design.

Even when supported by computer systems, a true sensitivity analysis (recurring “what if” capability) is rarely found in DB systems. Computers may improve the decision review capabilities of a designer, but in reflecting the fragmentation of the expertise, they too are specialized as well. The systems, being dedicated, cannot communicate, thus causing a lot of re-creation and re-processing of common information.

Being sequential, the BD process deals with common extended information which, in most cases, is recreated in each step. It is estimated that an Architect needs at least 25% of the Civil Engineer’s information, while the Civil Engineer uses 50% of the Architectural information for his/her design, information that already lies in the blueprints of the Architect and the Structural Designer. Another problem is that the wide experience gained from the numerous construction projects by the many experts of the industry is presently stored in the personal memory of the experts who may comunicate and deliver a part of it to newcomer experts, in the form of on the job or on-site advices or University courses. This is not the best way of saving information.

A lot of expertise “dies” because there is no way for it to be stored permanently. Finding a way of storing this expertise will be a blessing.

4 State-of-the-Art

Architectural, Civil Engineering and Construction (AEC) computer applications, are among the oldest and represent a major application area because of the sheer size of the projects involved. (Approx. 478 billion ECUs were invested in construction during 1990, in Europe).

As previously stated, the Building Design process is performed today by a multi-disciplinary and rather sequential set of highly fragmented and specialized expert activities. The existing computer applications imitate, in general, the same fragmented scheme, satisfying particular expert needs but ignoring the high degree of work duplication, cumulatively generated along the sequence of the successive Building Design activities.

The CAD (D for Drafting, not for Design) Systems available, being general purpose drafting tools, though impressive with their capabilities in visual outputs (3D shading models, plots, etc.), cannot deal with the features of the building objects (walls, columns, pipes, etc), while the mathematical modelling and simulation applications (FEM, BEM, etc.) are too specialized and poor in drawing capabilities to provide the final construction blueprints.

The existing integration of AEC systems is mainly based on the data exchanges between systems, used by the different Building Design actors, using either standard neutral file-formats or conversion schemes translating data from one system to another. Still, this technology deals only with graphics which, though essential, cover only a small part of the Building object.

An acceptable degree of integration of Building Design disciplines is provided only by specialized, private, closed architecture and rather expensive integrated environments, on

Minis or on Workstations (ex. INTERGRAPH AEC family of applications on VAX and PC based Microstation).

Considering that the low and declining productivity of the construction industry, compared to that of Manufacturing industry, is due to the lack of coordination (read : integration) between the "islands of expertise" that serve the Building Design process, current research is re-directed towards open integration of AEG applications.

There are already some initiatives that promote the idea of open integration in the AEC industry worth mention, such as CIFE (Center for Integrated Facility Engineering) of Stanford University (USA), CIB Working Commission 78 (Conseil International du Batiment), the CIBAO project from CSTB (Centre Scientifique et Technique du Batiment), Paris (France), the CAD/CAM Data Exchange Technology Centre, Leeds (UK), the AEC Systems series of conferences, and the work done at the Institute Eduardo Torroja, Madrid (Spain), to mention a few.

5 The Proposed Solution: Open Integration

Open Integration is defined as the act or process of making different complementary systems behave, though modular, as one.

Integration is not the merging of systems but rather a cooperation and coordination of systems directed towards a synergetic result.

Integration may overcome most of the previously mentioned problems of the BD process improving not only the performance of the process itself but also the quality of the final construction with considerable tangible and non-tangible benefits.

Through Integration, and without violating the basic flow of the BD process, the decisions taken in any stage could be evaluated in a very short time under multiple-criteria incorporated, at the beginning of the process, by the different actors. Integration then will play the role of the "manager", who is now absent among the many "islands of expertise" of a BD project.

The cost of revising the decision will be more cost effective, compared to the benefits of improving the cost and the quality of the Building. The iterations and the interactions will be feasible, as the systems communicate automatically, transferring the required data from one system to another, in a very short time. The "what if" analysis and the design alternatives may become every day practice, while the experts will recognize their own potentials and drawbacks on the "mirror" of the display, looking at or reading the combined results of their decisions.

All Building data would be kept in the same format and in some cases in the same mass storage. The information would be passed from one expert to another through a diskette, if they were independently, or through an access call, if the experts are linked together on a Network or a Multi-User system. The time saved may then be invested in exploring better construction alternatives and in more-timely responses to deadlines and bids.

Itegration alone cannot ensure intelligent storage of information, but it can lead the way to achieving this. Integrated environments can and should be linked with AI and Expert systems to analyze the information gathered and transform it into rules, statistic and case studies, for the benefit of the younger experts.

There may be many alternative solutions applicable to the BD process productivity problems.

We think that integration should be promoted through their research effort rather than Segmentation (Specialization), as the first appears to be a more justifiable and challenging solution for the BD process problems. In our opinion, integration respects and absorbs, from each individual system, its unique view, while it coordinates and directs all the outcome to one final, multi-aspect concept or result. Through systems integration the designer could run up and down, among any group of activities, even from top to bottom and bottom-up, as much as he/she feels it is necessary in order to spot a more efficient and less conflicting resolution before any final, no-way-back decision. With integration “What if…” would then be feasible, while “What’s best…” would sound a lower-risk adventure.

6 Integration Steps

Training of a company’s staff in multi-disciplinary systems is not at all a productive investment, due to the increased turnover, especially in expert jobs. Trusting human ability not to make errors in transferring information from one system to another often proves to be an unforgivable mistake. On the other hand, independent experts are always too busy to learn to use more than one system to use.

A “first degree of integration” is based upon data exchange techniques that may export data from one application and input them to another. This method is more or less the common practice of the software industry.

By-passing the particularities of the different data structures of each application, these data-exchange files transfer limited and essential information only. IGES, STEP and DXF-files are some of the methodologies used for the exchange of graphics data between CAD systems. Any possible logic or feature of the object described cannot be transferred to another CAD environment through this method.

Developing a special data-exchange file format, for the building entity, would overcome this restriction. This methodology is already applied in well-known products such as Moldflow, ANSYS etc. The problem of such methods is the flexibility and upgradability in case of incorporating new systems using different data structures.

A second step to integration consists of making the systems talk the same language through a common database, in this case, the “key” to integration is a common database containing virtually all building-object data structures. Every distinct system joining this database will create, store and retrieve only a part of the multi-dimensional features of the Building objects, the information the system is made to deal with. For example, a CADrafting system could create and display only the geometric data of a column or a wall, while a mathematical modeling system could calculate and attach the stress applied on these elements. The third step should be adding a comprehensive user interface.

The question to be discussed here is wheter the users, already accustomed to certain systems or environments, would prefer a new special purpose user interface instead of their own good old shell and change their habits in favour of the integration.

The answer is “no, not yet”. We have concluded that the users are not ready to accept any changes in their habits, unless someone could prove that substantial benefits could be derived from a possible integration of their systems.

A common user interface will not substantially improve the overall performance of the BD process because the different systems are used by different experts. Unification of user interfaces could benefit only integrated environments (ex. Large companies covering a wide range of BD activities) but again, only in terms of common know-how, training and maintenance. Even in these environments the different disciplines are also carried out by different experts.

7 Conclusions

AEC CADesign systems, using “real-object” concepts, features and parametrics are not yet found in the market. The Design phase, also called the Concept phase, is where most of the major decisions about style, materials performance and energy consumption takes place. These decisions have the greatest impact on overall Building cost and marketability, and require the most sophisticated design tools. During this phase a variety of alternatives may be explored with the aid of performance simulation and cost-estimating models.

Most CADrafting systems are not well suited to conceptual design tasks. However, given enough support, one may be able to overcome the tools’ inherent clumsiness, and turn them into cost-effective aids, by integrating the various disciplines and technologies able to support the conceptual design phase.

This requires the involvement of databases dealing with objects and cost-estimating databases, Spreadsheet programs to analyze cost data, critical path scheduling programs to develop and redefine schedules and decision milestones, solid-modelling dealing with Building object attributes, surface-modelling tools for the definition of complex plate surface, finite element analysis tools to evaluate stress and heat transfer, personal modelling aids which let Engineers develop “quick and dirty” mathematical models of engineering systems, drafting and animation tools for development of layouts and interior details and many other technologies capable to enhancing the decisions made by the Building designers.

Such systems are being developed separately or are increasingly migrating from mainframes to the Workstation and Personal Computer levels, driven by a major downward trend in the cost of desk-top intelligence and a corresponding upward trend in performance. At the same time as the Workstation CAD revolution is progressing, AI and Expert Systems technologies are changing the expectations of users in AEC area.

If future conceptual CADesign systems can combine the visual glamour which only graphics can achieve, with the intelligence of the decision support systems, then they will ultimately offer the greatest potential in both Building Design productivity and actual construction improvement. Making the right decision in selecting design and construction alternatives, the designer could save considerable design time and results in more durable, marketable and cost-effective construction.

The next maturity step of the Building Design systems' integration will allow a higher degree of integration with the actual Construction systems, that is integration of Application Software, NC machines and Construction Robots.

Now, one of the first objectives should be to create an Integration Environment for Computer Aided Building Design (BD) systems, consisting of:

– a well documented Building Design process Model.
– a reliable conceptual Model of the Building entity, clearly defining the building objects' hierarchy and the corresponding data structures.
– a database management system reflecting the conceptual Model, dealing with objects rather than data.
– common principles for an industrial user interface, meeting the specific needs of the Building designer.

This should improve:

– the quality of the decision-making of the Building designers,
– the overall productivity of the BD process
– the management of the BD projects
– the cost/performance ratio and the quality of the actual construction
– the Building maintenance and repair cycles.

8 Acknowledgements

The work done at the Institute Eduardo Torroja is part of the project "Developement of CAD systems for the Complete Design of Concrete Structures" (PB0344), financed by DGICYT. The cooperation between Institute Eduardo Torroja and N Systems stems from the preparation of a research proposal presented to Brite Euram, aimed to open integration of Building Design Systems.

9 References

1) Kernel, K., Nowack, H. (1988)—Exchange of model presentation information between CAD systems—Computer & Graphics, vol 12, pp. 173–180.
2) Bourdeau, M. (1989)—Structuration des donnes pour una conception technique integree—Proceedings of XIth International Congress CIB 89, Paris, Theme III, Vol 1, PP 325–341.
3) Recuero, A. (1989)—Integrated CAD for Buildings—Proceedings of XIth International Congress CIB 89, Paris, Theme III, Vol 2, pp. 485–491.

162
Expert system for selection of construction activities and methods in support of tactic planning

F.L.RIBEIRO and A.A.BEZELGA

1
Introduction

Abstract

This paper describes the work done in conceptual development of an expert system for selecting construction activities and methods. The study is concerned with application of expert systems technology in some operations of the construction plan formulation at tactic level. The process of activities and methods selection is guided by the type of building, site conditions, soil conditions and design constraints.

Keywords: Expert systems, Knowledge Representation, Construction Activities, Construction Methods.

This paper presents a summing up of work done to develop a prototype expert system for selecting construction activities and methods in order to support the project planning at tactic level. The work developed was based in the following assumptions:

a) Tactic planning can be decomposed in a set of partial steps, for instance:

i) Recognition of simple functional components of the building.
ii) Identification of activities,
iii) Definition of precedence relations among the activities.
iv) Selection of construction methods. etc…

b) Starting from the decomposition of the building into its component parts, following a functional and technological viewpoint, it is possible to formulate construction activities and their precedence relations in a more accurate way.

c) There is interdependence between activity identification and selection cf construction methods.
d) Execution of the works at the construction site can be considered as a system partially defined by objects and construction methods, whose boundaries are constraints such as time limits, costs, quality, safety and site conditions.

According to this conception, one may consider that: Objects form the simple functional components of the building (for instance: beams, columns, external walls, etc.).

Construction methods are procedures and techniques required for transforming resources in component parts of buildings.

e) The identification of construction activities, definition of precedence relations and selection of construction methods are basic operations in the phase of plan formulation.

The information necessary for the operations mentioned in e) comes basically from design, construction contract and site conditions.

A significant part of the decision-making processes relative to operations in the plan formulation phase are concerned with semi-structured problems which make the use of expert system technologies a methodology fit from their resolution.

2 Aim of the work

The work carried out had the following aims:

a) Developing the framework of the building classification system, which allows to structure and model knowledge on building in such a way as to facilitate its later representation;
b) Establishing the knowledge representation model and the methodology followed for:

– recognition of functional components of the building;
– identification of construction activities, including definition of their precedence relations;
– selection of teams and resources for the activities identified.

c) Developing the expert system prototype that will give support to selection of construction activities and methods. On this phase of the prototype development, selection of the construction methods is limited to consideration of type-teams and resources.

3 Structuring of knowledge

Knowledge about buildings that is of interest for the aims of the system can be divided in four parts:

– the first one consists of knowledge of a building expressed in functional, physical and construction technology terms;
– the second consists of knowledge as regards the geologic and geotechnical characteristics of common construction sites;
– the third part consists of construction knowledge necessary to convert the simple functional components in construction activities following a given sequence;
– lastly, the fourth part consists of knowledge about alternative construction methods for executing the designed component parts of the building.

3.1 Simple functional components

For the purpose of recognition of components, following the method of functional and technologic decomposition, buildings can be classified in terms of hierarchy, with the following levels:

– types;
– systems;
– sub-systems;
– functional solution;
– simple functional components;
– technological solution (materials and products).

Following this perspective, the building is subdivided into systems and subsystems that perform specific functions. For each system and sub-system there are several functional solutions. From the functional solutions, the simple functional components of the building that interest for the selection of building activities can be recognized.

Three types of buildings are considered in the work carried out: housing buildings, school buildings and commercial buildings.

As regards building systems, the following are considered:

– external system;
– substructure system;
– structure system;
– external envelope system;
– roofing system;
– internal system;
– technical system;
– incorporated equipment system.

Table 1—Building partial systematization

Building type	Systems	Sub-systems	Functional Solution	Technological
			. Nailing in ground	
		subgrade floors	. Berlin type definitive walls small bars	
			. slurry walls	reinforced
			. Piles and concrete curtain between them	concrete
	Substructure			
			. precast reinforced concrete piles	
			. reinforced concret piles cast-in-place	
			. continuous footings	
		foundations	. spread footings with foundations ties or beams	
			. foundation grate	
Housing			. slab foundation with ribs	
building			. slab foundation without ribs	
			. shear wall structure	
			. frame reinforced concrete	reinforced
		frame	precast heavy panels masony lead-bearing	concrete
			. walls	
	Structure			ceramic blocks and concrete blocks
			. compact concrete slab	reinforced concrete
		floors	. concrete mushroom	
			. slab	
			. hollow-core slab	Prestcast concrete and ceramic blocks or and concrete blocks

Depending on the functional solutions, we shall have for each system and subsystem the corresponding components. Table 1 presents an example of knowledge systematization only for two systems.

The application of the classification system for the recognition of the simples components of the building can be partialy illustrated by Figure 1.

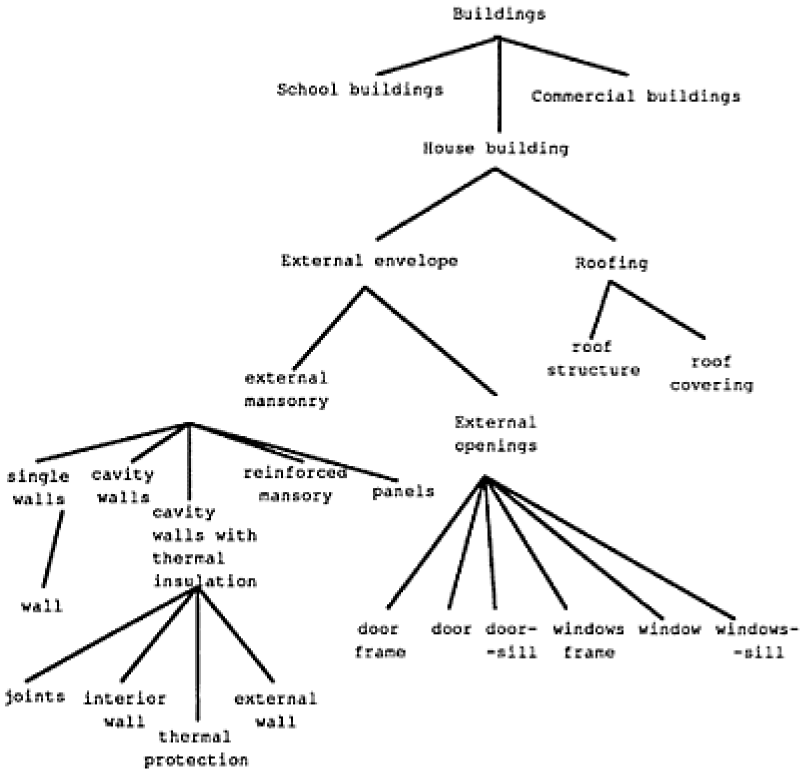


Fig. 1—An example of the application of the classification system for recognition of the simple functional components

3.2 Geotechnique et construction sites

The knowledge and consideration of the characteristics of construction sites are one of the basic conditions for reducing risk in construction work. As regards the geotechnique of the construction sites the characteristics of most interest for the plan formulation were considered. From this print of view, the following properties were considered: gralunometric, characteristics, compactness, consistency, groundwater regime, shear strength, special soils and rock strength.

3.3 Construction Activities

According to construction work, it matters to outline a set of aspects that should be considered in the identification of construction activities:

a) Functional components of the building involve a set of activities decomposed according to different places;
b) The sequence of construction activities can be governed by the following factors:—physical relation between components of a building; structural integrity;
   – availability and flow of resources;—requirements of resources;—performance of resources;—space constraints and location of work; and—regulations, standards and specifications.

The selection of the construction activities may depend on the following factors, among others: type and location of the functional component; viable construction methods; conditions of the construction site; configuration of the place where the activity is carried out.

3.4 Construction methods

Each construction method may involve mainly:—a construction strategy;—a lay-out of the method;—a package of resources;—teams; and—a set of construction operations.

The prototype under study only refers to selection of team and of package of resources as a function of the activity identified. Within this study, the construction methods are grouped into families for the purpose of knowledge structuring. The table 2 show a example of structuring of construction methods by families.

Table 2—Partial sistmatization of methods

	GROUP	TYPE OF METHOD
		Manual With crane-shovel equipment drilling with rotary-percussion dills drilling with rotary drills
	Escavating	drilling with percussion drills drilling and blasting pre-blasting and drilling soil replecement
		compaction impact manipulation
	Soil Treatment	vibration injection
METHODS		vibroflotation stone piles

Mansory	mansory panels build with the frame structure build after the frame structure
Concrete	cast-in-place cast-in-place finished Precast

3.5 Methodology followed

In order to carry out the tasks for the system, the following methodology was established:

a) Describing the building in terms of its unitary functional components, on basis of the classification system already described;
b) Identifying the construction activities required for building the recognized components, and defining their precedence relations;
c) Selecting the type-team and the package of resources for carrying out the construction activities.

4. Programming tool used

For the development of the prototype system the Arity/Expert Development Package and the Arity/Prolog are used. The Arity/Expert is a shell integrated with Prolog language.

The development environment offers two forms of knowledge representation, one based of ruler of the type “IF THEN”, and the other based on frames. The inference engine is of the type “backward-chaining”.

5 System design

Considering on the one hand the shell components and on the other hand, the results of knowledge analysis in the domain of application, the architecture of the system is presented hereinafter.

5.1 Knowledge base

The knowledge base was structured in the following way:

a) knowledges about buildings, geology and geotechnique of ground, construction activities and methods, were represented through a taxonomy of frames;
b) The rules were built on basis of information contained in the frames and serve to establish a calculation sequence.

In the taxonomy several frames are described, which are defined as a function of a finite number of properties and, sometimes, of other frames.

The taxonomy includes the frames definition which serve to represent knowledge on the following:

- geologic and geotechnical characteristics of construction ground;
- systems and subsystems of buildings, included in functional solutions and construction methods;
- simple functional components of buildings, including the corresponding building solutions (as regards materials and/or construction products);
- construction activities and precedence relations.

The knowledge base contains rules of the type "if them", which are as follows:

- rules to identify components of the building;
- rules to identify construction activities and to establish their sequence;
- rules to select type-teams and resources;

5.2 User Interface

The prototype system includes a program written in Prolog language, intended as an interface with the user.

5.3 Control

The control of the system was conceived with a view to:

- establishing the order of calculation of the values of properties;
- establishing the explanation of questions and recommendations;
- establishing intermediate results during the consultation;
- establishing questions and annunciate recommendations.

6 System inputs and outputs

The system inputs are the data of the project and construction contract. As regards project information, the following should be stressed:

- type of building;
- typologies;
- functional solutions;
- technologic solutions;
- geotechnical characteristics of the construction site.

The outputs of the program are as follows:

- lists of simple functional elements;
- lists of construction activities, including definition of types of precedence relations;
- lists of resources (labour, equipment and consumption of materials).

The system ensures good communication with the user and good efficiency as compared with manual methods.

7 Conclusions

The approach used to recognize the components of a building through a functional and technologic classification system proved very effective. On the other hand, inclusion of site and implementation conditions may significantly contribute to increase planning fitness to reality.

This work evidences the efficiency of the expert system technology to represent knowledge required for the tactic planning process of building construction.

The prototype developed was applied in support of several projects, and shown to be an efficient tool.

This work evidences that combination of expert system technology with the so-called common project management systems makes it possible to construct integrate systems that may increase productivity and fitness to reality of the planning process.

References

Adely, H. (1988) **Expert Systems in Construction and Structure Engineering.** Chapman and Hall.

Carrington, M.A. (1988) **Prolog Programming in Depth.**

Ereenwell, M. (1988) **Knowledge Engineering for Expert System.** Ellis Horwood.

Hardrickson, C. (1989) **Project Management for Construction.** Prentice-Hall.

Hardrickson, C. and Gorostize, Z. and Renak, D. (1989) **Knowledge-based Process Planning for Construction and Manufacturing**. Carnegie-Mellon University.

Levitt, R.E. and Kartman, N.A. and Kunz, J.C. (1989) **Artificial Inteligence Techniques for Generating Construction Project Plan**. ASCE Vol.144,

Merrith (1988) **Building Expert System in Prolog.** Spring Verlag

Mahoney, W.O. and Thornley, A. (1990) **Building Construction Cost Data.**

Nanmally, J.W. (1987) **Construction Methods and Management.** Prentice-Hall**.**

Pham, D.T. (1988) **Expert Systems in Engineering.** S. Spring Verlag.

Walters, J.R. and Nielsen, N.R. (1989) **Crafting Knowledge Based Systems**. John Wiley & Sons.

Waterman, D.A. (1986) **A Guide to Expert Systems.** Addison-Wesley**.**

Smith, C. (1988) **Product Configuration.** Liverpool Polytechnic.

Tatum, C.B. (1988) **Classification System for Construction Technology.** ASCE Vol. 114,

163
Towards computer integrated construction: influence on management and quality

J-L.SALAGNAC

Abstract
The increasing use of computers in construction activity leads to the development of efficient tools to design, to select products, to process management data. In the future, the control of site equipments and machines is likely to become a reality. This paper intends to draw out the main lines of future Computer Integrated Construction Process with emphasis on the impact on site management and quality.

Keywords: Computer Integrated Construction, Automation, Building.

From hand work to computer

Let us remember a plain fact: construction activity is highly manpower consumer. Manpower is needed from the early design stage to the finishing work operations on sites. Specialists may argue about differences between building construction and civil engineering but construction activity as a whole requires a high rate of manpower.

This is a millennial situation and we could dissert a long time to fully understand this lack of evolution compared to more recent activities (manufacturing industry) or to other traditional activities (agriculture for instance).

Mechanization and, later, computer technologies have been increasingly introducted in these activities. As a result, manpower directly used has significantly decreased. Construction came more recently to consider such progresses.

Mechanization is well introduced in heavy duty activities (excavation, road construction,…) but is much less developed on building construction sites, apart from the widespread use of cranes, carriers and hand tools.

Computer have first been used as administration tools for the traditional activities of the companies. Graphic capacities then captivated the construction designers and technical softwares helped to solve engineering problems.

The increasing capacity of computers and of software languages allows to introduce expertise in these information processing machines in order to solve more and more complex problems.

Computer design activities will soon include the possibilities for the user to consult on line building codes, product data bases and other expert software. The FARTEC project (software developed to facilitate the access to the French building codes and regulation) carried out by CSTB will contribute to these progresses. But, in spite of these progresses, construction activity still requires a lot of manpower.

The design activities have obviously taken advantage of the introduction of computers, but it would only be half a success if these developments were not extended to site activities. Refering first to the links between computers and building product manufacturing, we will then mention the possible links between computers and site operations as well as their consequences on site management and quality. An extension of this frame to building maintenance operations will close this overview of the future Computer Integrated Construction (CIC) concept.

From computer design to building components manufacturing

Automation has early been introduced in the mass manufacturing of identical products such as bricks, concrete blocks, steel heat emitters.

Computers and robotics techniques allow to go beyond such a fixed production process: they bring flexibility, i-e., the ability to produce different components (for instance concrete components) with nearly no extra cost compared with mass-production.

Most of the components used in the building construction are presently manufactured through a robotized process. Table 1 gives some examples of such components.

PRODUCT	COMPONENT	COMPANY
concrete	preconstraint slab	SARET PPB
wood	door and window frames	GIMM
electric cables	electric networks	OCTOPUS
plastic tubes	domestic hot water heating network	PRIMACHAUFFAGE

Table 1: some examples of existing robotized components manufacturing processes

Other examples could be added to this short list but manufacturers generally keep these developments discreet, if not secret.

An interesting point must be mentioned: all these processes refer to the same conceptual sketch (see Fig. 1) The computer has an essential place. It ensures the coherency of the subprocesses carried out to produce the specific components. None of the previously mentioned robotized processes fits exactly with such a sketch. Each industrial chooses investments according to his own constraints but this conceptual sketch may be regarded as “ideal” in the way it synthetizes the existing processes.

It must be pointed out that the development of a robotized process (for any kind of manufacture) necessitates to adapt the design of the components. Whatever robots are, they are not (and will probably never be) as skilled as human, so that the manual manufacturing process must be reconsidered in order to facilitate the work of the robot.

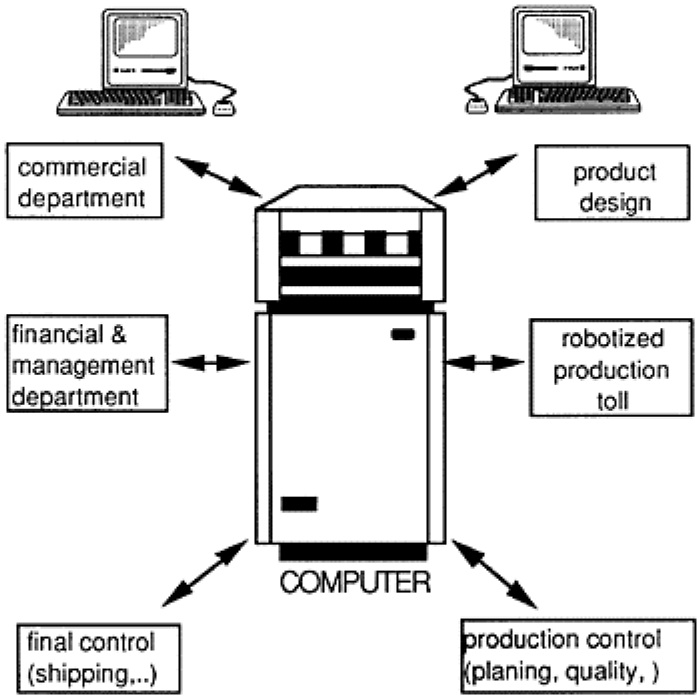


Figure 1: an integrated production process

This means that only linking a computer and a robot is not enough to make a robotized process. Manufacturing management and product design are deeply modified by the robotization. Robotization also allows a better quality control of products thanks to the supervision of computers on the whole process. An individual identification of products is also allowed. This identification gives means to organize site operations as far as information about the project is available on the construction site.

All these developments are still made independently. This means, for instance, that the concrete panels manufacturer and the electric networks manufacturer will use different data describing the building project. These data are taken from different drawings. There may result from such a process that incoherent data can be used by different manufacturers. Depending on the kind of components, this lack of coherence might lead to unacceptable situations. The next step in the development of robotized components manufacturing is the coherence of data used by all the professionals.

Softwares have been developed to allow different people working around the same project to share common data stored in a computer. But a specific difficulty of the building construction process comes from the huge widespread of industrials which are equiped with different (and often incompatible) computers.

The trend to more compatible hardware and software will probably solve this problem in the future.

From computer design and computer management to site operations

We have seen that the data describing a building project contain all the necessary information to be introduced in a component manufacturing process. They also contain information concerning the location of components on site, the assembly process, the different phases of the construction.

All this information may potentialy be transmited to automated machines to perform different tasks on construction sites. As these machines will necessarily be able to adapt from one site to another, we can name them “robots”.

A world movement to study the robotization of construction tasks (on sites) started from Japan in the early eighties. An international group has been created that has been meeting every year since 1984. The proceedings of these symposium are an up-to-date compilation of developments in this field (see Table 2).

The most recent trends can be summarized as follows:

> Most of the developments are experimental. The first robots have been designed in order to reproduce the movements of a human operator. This has lead to too sophisticated machines that have no economical future.
>
> This as also lead to (re)discover a well-known statement of manufacturers: the robotization of a process must be done when considering both the product and the process. This means that for robotizing building construction, the design of the building and of the components must be reconsidered if simple, reliable, economic robots are to be developed.

Dates Title	**17–20 june 1084** Workshop confe rence on Robotics in Constr uction	**24–26 juns 1985** Second confe rence on Robotics in Constru ction	**25–27 june 1986** CAO et Robotique en Archite cture et BTP	**22–25 june 1987** Fourth Interna tional Symp osium on Robotics and Artificial Intelligence in Building Constr uction	**06–08 jun1988** Fifth Interna tional Symp osium on Autom ation and Robotics in Constr uction	**06–08 june 1989** Sixth Internat ional Symposium on Autom ation and Robotics in Const ruction	**05–07 june 1990** Seventh Intern ational Symposim on Automation and Robotics in Constru ction
Place	PITTS	PITTS	MARSEILLE	HAIFA	TOKYO	SAN	BRISTOL

	BURG camegie Mellon Carnegie Mellon University USA	BURG Carnegie Mellon University USA	IIRIAM	ISRAEL Institute of Technology ISRAEL	JAPON	FRAN CISCO USA	GRANDE-BRETA GNE
Organizers	Carnegie Mellon University	Carnegie Mellon University	CSTB/ GAMS AU/IIR IAM	Building Research Station/ Technion	– Japan Society of Civil Engineer (JSCE) – Archit ectural Institute of Japan of Japan (RSJ) – Japan Industrial Robot Association (JIRA)	– Const ruction Industry Institute (CII)	– Bristol Polytechnic – CIB – DTI
Sponsors	– Robotics Institute – National Science Foundation	– Robotics Institute – National Science Found ation	– Ministères frànçais – Logement – Recherche – CMU	– Ministers israeliens – Logement – Reche rche – Commerce – CIB	idem	– CII	– Bristol Polytechnic – CIB – DTI
Number of participants	70	70	200	140	500	280	175
Participa tion per country (excluding organizing country)	FIN 1 FRA 1 JPN 5 SWE 1	DBU 4 FRA 1 GBR 1 JPN 2 NCR2	BEL 4 CAN 1 DBU 2 DZA 2 ESP 4 FIN 1 GBR 8 ISR 2 ITA 5 JPN 7 NOR 1 USA 11	AUS 2 BEL 1 DEU 2 DNK 4 FIN 6 FRA 6 GBR 13 HUN 1 JPN 2 NDL 3 NZL 1 POL 1 PRT 1 SWE 5 USA 17	CAN 1 CHN 1 DBU 5 DNK 2 FIN 8 FRA 20 GBR 16 HUN ISR 1 LIE 1 PNG 1 SGP 2 SWE 2 USA 20	AUS 2 CAN 4 DEU 4 FIN 6 FRA 10 GBR 11 ISR 3 JPN 48 NDL 2 SGP 1 SWE 5	AUS 3 CAN 4 DEU 4 ESP 1 FIN 5 FRA 12 ISR 1 JPN 47 LIE 2 LUX 3 NDL 6 SGP 2 URSS 3

Communic ations about robotics	11	13	21	26	94	46	38
Commu nications about informatics (IA, CAD)	2	4	29	35	12	24	43
Publisher	Robotics Institute	Robotics Institute	Hermes Paris	Technion Halfa	Japan Industrial Association (JIRA)	Constr uction Industry Institute (CII) AUSTIN (Texas)	Bristol Polyte chnic

Table 2: the seven first ISAREL

The mobility function has been identified as a key function for the future robots and special attention is paid to this point.

The tasks performed by existing experimental robots are rather simple (surface covering without any contact between the tool and the surface : spray (painting, concrete,…), handling (automated cranes), tools in contact with floor but with no effort control (concrete floor finishing, floor cleaning)).

The complex tasks (assembly for instance) are being studied with new design of components.

These developments obviously demonstrate the large efforts to be carried out to develop a fully robotized process which would take advantage of the powerfull computer design.

From now to this ultimate goal, there are a lot of steps of developments which would represent significant progresses. The electronic transmission of information (EDI concept) provides efficient tools to give site manager up-to-date information about the project. But the system that will transmit this information to the worker in order to modify its current work remains paper or vocal orders.

This appears a bit inconsistent : on one hand, hightech transmission of information, on the other hand, antic means with possible sources of errors. Who will develop, for instance, an automatic positioning system as illustrated in Fig.2? Such a system would create a rigourous link between the design computer and the operations in site. A better quality and a more efficient management of the construction would result of this process.

Some of the pieces of such a puzzle already exists, for instance at CSTB and in other laboratories and companies, but the full system requires cooperation : we know it is not the easiest thing to do.

From computer design to building maintenance

Some of the maintenance operations are difficult and sometimes dangerous to do (for instance, windows cleaning on high rise buildings). The automation of such processes has been undertaken in several companies. These developments show how difficult it is to design an automated process on an existing building. For new building, the problem is also very difficult to solve when the initial design has not taken the automated process into account.

We may expect from the introduction of computers in the design activity that:

> The maintenance process (automated or not) can be efficiently included via a detail design.

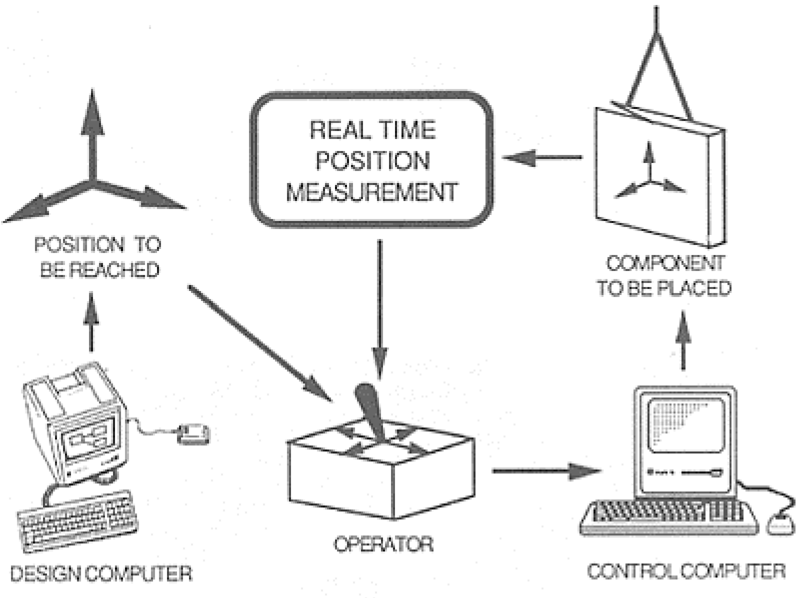


Figure 2: example of a tool to be developed between design stage and site process

> The information about the building can be saved and used when needed for maintenance operations during the life cycle of the building.
>
> The detail design can be efficiently updated when modifications of the building occur (new partitions for instance).

This last point will be particularly important in the future when automated floor cleaning processes are introduced: the detail design will allow the path planning and the control of the work. A better management of maintenance operation resulting in a better quality will result from these progresses.

Computer Integrated Construction: a step towards efficient site management and quality control

From the previous paragraphs we can point out that:

> A lot of efforts are presently made to introduce computers at the design stage of a construction process. There is a gap between these efforts and the present situation on sites.

In order to reduce this gap some additional efforts have to be made in different directions:

> A better understanding of site processes will bring usefull information to imagine new site organisation which are likely to take efficiently advantage of the information coming from the design stage.
>
> A basic study on components (and tools) assembly must be undertaken in order to imagine the handling tools (and their peripherals) of the future sites which will be controled by information coming from the design stage. A better cooperation of building owners, architects, maintenance company will result in the definition of maintenance procedures which will be rigourous in the way that consistent information will be available during the life cycle of the building.

This is a long term programme, the ultimate goal of which can be sumarized in Figure 3. Some of the communication links shown in this sketch are already in operation (building components manufacturing, site administration). The improvements in quality and process management resulting from these developments are encourageous to go further.

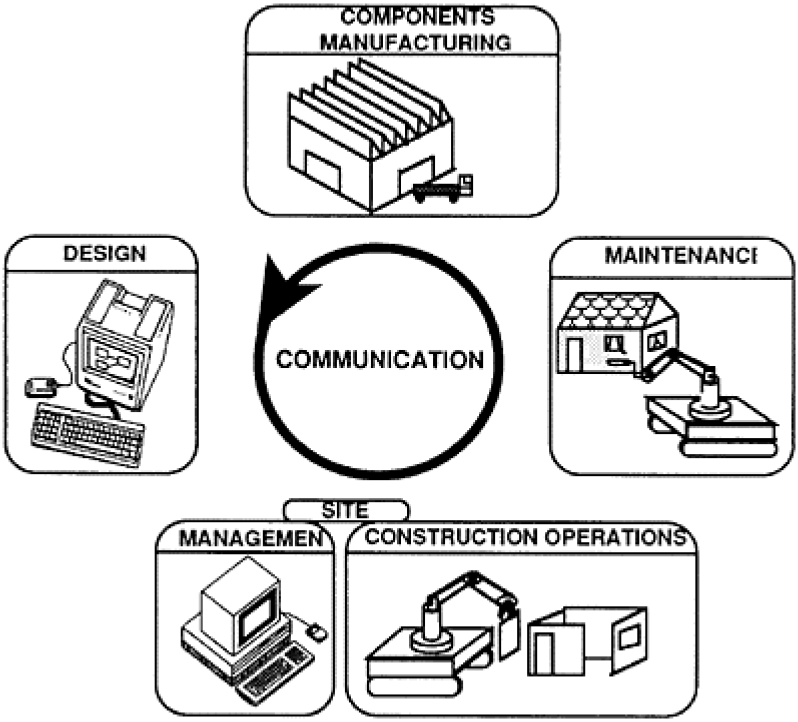


Figure 3 Computer Integrated Construction

164
CAD—'ArchiCad' in housing

R.STRITTMATTER and S.TODD

Abstract
Construction drawing information has traditionally being transmitted via two dimensional plans, sections and elevations produced by hand. Three dimensional views can be produced by hand but as they are very time consuming they have generally only been used once the design has been completed just for presentational purposes. If, however, a three dimensional solid model is built on a computer then the 2D construction drawings can easily be extracted. True perspectives or other projected views of the model can also be viewed at any stage of the design which also allows an early appreciation of the design for other professionals or interaction with clients. A 3D database can also be used to give a bill of materials which can be exported directly to a spreadsheet for further analysis.

This paper examines how one particular software program ArchiCAD can be used on the Macintosh platform and how North British Housing Association has fully moved over to producing all its new house designs and schemes by microcomputer. Examples of using individual commands in the software are illustrated with screen shots from the computer together with live project analysis.

Keywords: Computer Aided Design, Architecture, Design, Housing, Computers.

1 CAD in context

A survey of computer usage for 1989 was undertaken by the R.I.B.A who found that the percentage of architectural practices using computers has increased from 47% in 1987 to 65% in 1989. They also found that 25% of all practices use 2D CAD, 17% 3D CAD and 13% use 3D modelling. The most common computer application is word processing which is used by 59% of all practices. In order of preference the hardware platforms used were Amstrad, Macintosh and IBM.

CAD basically falls into two categories:

1. 2D drafting packages which are just a series of lines with which a building could be drawn.
2. Comprehensive 3D/2D building modellers.

The second category can also be defined in terms of their structure. This can be a horizontal, generic or vertical, specialised. The specialised architectural programs available on the Macintosh series of computers include ArchiCAD and Architrion. With a specialised program of this nature typical architectural features are basic commands of the system. A generic CAD program such as AutoCAD can be set up to provide a construction specialisation but requires the use of the AEC module to be a full building design tool. AEC utilises architectural symbol libraries and special construction and editing features. A macro command language Autolisp is also used to develop special commands from the basic commands of the system. All these programs have their advantages and disadvantages but this paper is primarily concerned with the use of ArchiCAD.

2 Background to ArchiCAD

ArchiCAD was written in Hungary and released in 1985. Since then the program has continually been developed and shortly will be updated to version 4.0. The present version of the software is 3.4.3 which runs on a Mac II (and above) with a minimum 4 MB Ram and 40MB hard disk. is a 3D/ 2D b uildi ng model ler whic h all ows a 3D model to be built up in a 2D mode from which elevations, sections and plans can be extracted together with any form of 3D visualisation e.g. axonometric, isometric or true perspectives. The 3D model database can also be used to give a quantity calculation. This database contains 3D geometric data and non geometric data e.g. material type, price etc. The program interface is shown in Figure 1.

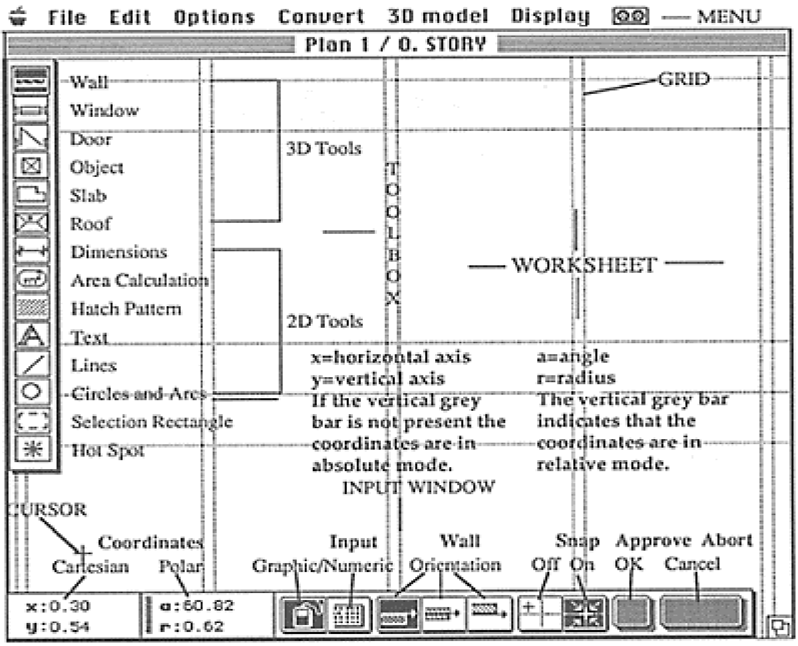


Figure 1 Program interface

3 ArchiCAD in use

Using elements (3D Tools) the plan of the building can be defined together with details about the third dimension and any non geometric data. The bottom palette also gives a continuous readout of cursor movement (Cartesian or Polar coordinates) which can be used in a relative or absolute manner. The relative state is indicated by a grey strip in the coordinate window. By using option click on the appropriate coordinate window it is possible to freeze it which is indicated by a square around the letter. Input may be by using the mouse, a digitiser or numeric values. The cursor can also be controlled more accurately by the use of snap grids and gravity.

3.1 Setting up

The first stage of any design involves setting up a sheet size and grid. This is done from the Options Menu where a construction grid, an invisible snap grid and the size of the drawing window are defined together with an origin (Figure 2). The program works in ‘real world’ dimensions so the size of the image on screen depends on zoom magnification but the actual scale is only defined at the output stage.

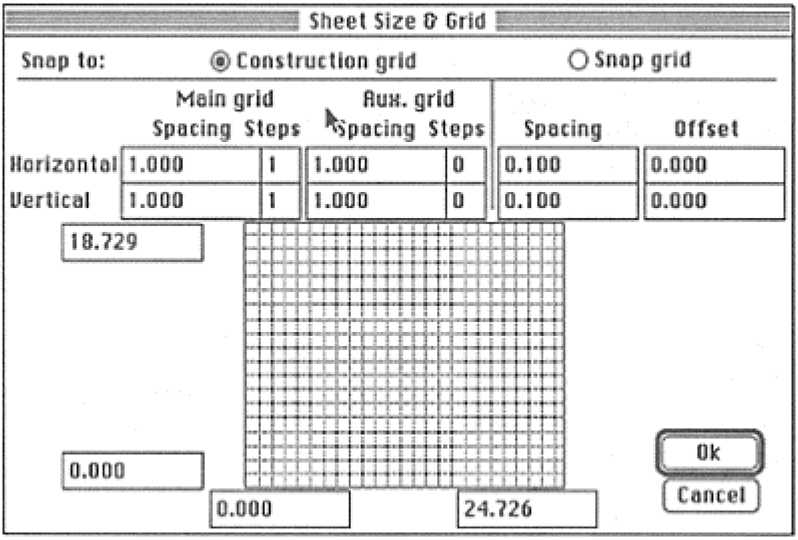


Figure 2 Setting up the sheet size and grid

3.2 Layer definition

Any element defined e.g. walls roof can be sent to individual layers. This allows layers to be turned off later on. For example there is no point producing a 3D model with furniture only to find out that it is hidden behind a wall. Turning the furniture layer off has the effect of speeding up any 3D conversions. It is also possible to copy elements from one storey to another for repetitive plans.

3.3 Setting parameters

The wall parameters can be set by double clicking on the wall icon to give a dialog box which allows input of height, thickness and material elements in the case of cavity walls. Figure 3 shows this box where up to eight layers may be specified. The wall settings box also defines where the reference line is within a wall. A curved wall may be obtained by using the arc or circle tool and the using space bar click.

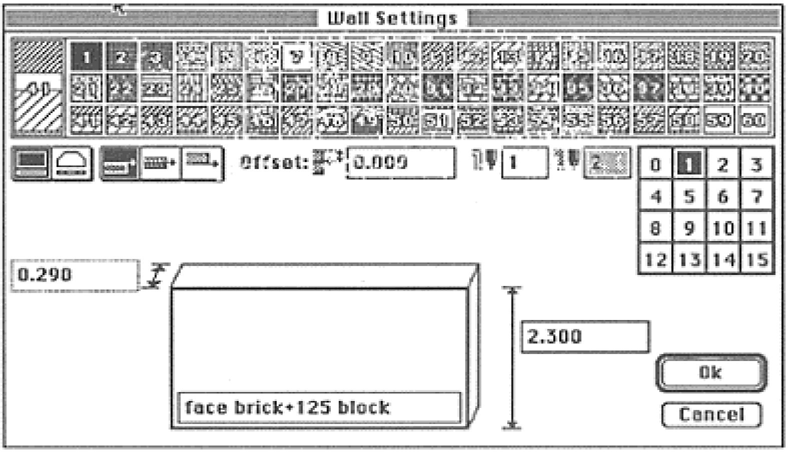


Figure 3 Setting of wall parameters

3.4 Drawing aids

To aid the drawing of walls the cursor changes shape. For the first wall a cross will show the starting point and a pencil icon shows the end (Figure 4). When a second wall is drawn the cursor can be used to snap automatically to the corner points of the first wall (Figure 4). An inverted Y is shown when the cursor is on the reference line (Figure 4) and a check mark at the end of the wall (Figure 4). This allows walls to be connected precisely to the next. To draw walls in a fixed direction e.g. x or y axis the cursor can be constrained in the same direction.

3.5 Inserting windows and doors and library items

Windows can be inserted into walls by firstly double clicking on the window icon, selecting the window type from the library and setting the parameters i.e. its height, width, cill elevation and set back. Then, by clicking on the wall reference line at the required point an opening is formed and an eye shaped icon appears. Another click after the eye icon gives its direction of opening (Figure 5). This placing may be defined by centre line or end depending on where hot spots have been positioned in the library item. A similar process exists for doors and here the clicking of the eye icon will give door opening direction (Figure 5). It is possible to create your own doors and windows by either modifying a library item or using the geometric description language (GDL). It is possible to modify the size and position of windows and doors once they have been placed. To move a window just select it and drag or stretch it. The window is directly associated with the wall and therefore it is not possible to drag it out. The direction of a door swing or its opening angle can also easily be changed by selecting it and then using the rotate or mirror command of the edit menu. The opening angle is changed in the parameter box. This ability is called parametric symbols in standard CAD terminology where variety can be achieved by varying the symbol's parameters. Furniture or other fittings can be placed using the object icon from the toolbox. When the item has been selected from the library (or defined by the user) a single click will put a 2D/3D fixture on the floorplan and 3D database simultaneously. It is also possible to place multiples of structures as objects by a single click. The size and height of objects are determined in a similar way as windows.

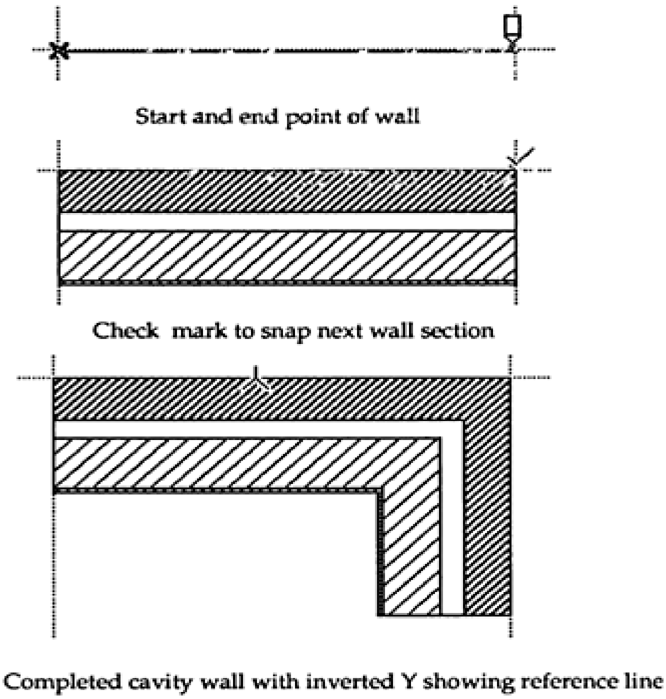


Figure 4 Wall construction

3.6 Specifying slabs

Slabs can be defined to show floor zones. This is achieved simply by drawing the outline of the polygon on the plan. These outlines can easily be modified and holes for the staircases can be defined by selecting the slab and drawing another contour polygon for the hole. The settings for the slab are defined as thickness and elevation. On elevations you can automatically get rid of the line between the slab and its adjoining walls. This illustrates the true solid modelling capabilities of the program where operations can be performed between the objects. True solid modellers can perform all three logical operations of Boolean algebra between objects—subtraction (holes for openings), unification (glued slabs to walls), intersection (section in true 3D).

3.7 Roof construction

Roofs can be defined in two ways. The first utilises the hip construction. The parameters to be set here include elevation of eaves level, eaves thickness, elevation of horizontal ridge levels (up to four levels can be defined). In order to specify the roof precise numeric coordinates can be used. e.g. A corner is located and by typing x 0.2-, Y 0.2+ would give a 200mm overhang in both directions. Once this has been completed the ridges can be modified by dragging the vertices to give the required hip form. The alternative method is to set the roof pitches individually. The elevation of the reference can be set. This reference line can be fitted to the top of the wall and the new eye cursor prompts for the direction of slope (we click on the ascending side). Now the contour of

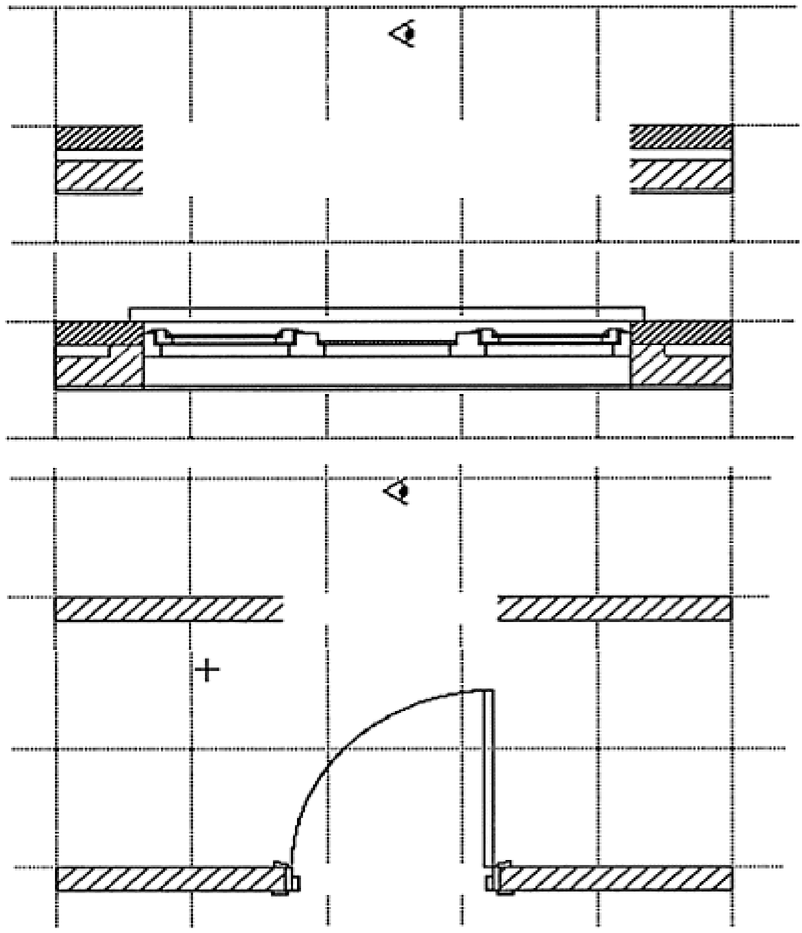


Figure 5 Inserting windows and doors into walls

the ascending pitch is drawn on the plan. The other pitch can then be constructed and fitted to the previous one. The intersection of the two planes can be calculated by selecting one of the pitch roofs and then command click on the edge of the other roof. The intersection point is automatically shown. Now the roof planes can be dragged to the intersection points. The gable walls can be adjusted to the roof by selecting the walls and increasing the height to above the roof. Then from the edit menu use cut walls to give the required gables. A skylight can also be formed by drawing a hole in the existing roof.

3.8 Dimensioning and tools

The dimensioning is fully associative and automatic. The points to be dimensioned are clicked and the place where the dimension chain is to be placed is marked. The dimension chains can be broken into parts, or merged with other chains or points in the chain can be added or deleted. If the plan is modified the dimensions associate to their physical reference point and will update automatically. The basic settings for dimensions can allow pens, font and witness lines to be changed. There are also other tools that can be used:

Area calculation	by tracing the nodes of the required area this is calculated and the value can be placed anywhere.
Hatching	a hatch pattern can be set and then applied by tracing the polygon.
Text	for labelling.
Lines	can be defined from solid to various degrees of dashes.
Circles and arcs	three clicks are used; the first two define the origin, radius, starting angle; the third closes the angle.
Selection	selects every element within the box at one time.

3.9 3D view generation and database

One of the advantages of using CAD is the quick generation of 3D views. True perspectives can be generated once the elevation of the viewers eye and target point have been set. Different views can be saved on disk and used in animation programs. Other 3D projections can be used e.g. axonometric, isometric. To create a 3D model we use the convert menu and select to 3D model and then shading with contour from the 3D model menu. The viewpoint and direction of lightsource can also be changed from the 3D model menu. The views can be generated as true solid models or surface models where elements appear to have zero thickness.

3.10 Quantity calculation

From the File Menu it is possible to obtain a quantity calculation of the design. The external/internal surfaces and volumes of the walls are given. The description is given with unit price, quantity of windows etc. and total price at the end. The properties are set with the normal dialogue box and the data is fully integrated within the 3D database. This data can be exported to a spreadsheet such as Excel for further analysis.

The program is also shipped with a utility called Plotmaker which allows drawings from a variety of sources to be included on one layout. It is therefore possible to have a final drawing made up of mixed format e.g. files from ArchiCAD, TopCAD, DXF, HPGL and PICT II. The software includes printer drivers to support the majority of pen plotters and lasers.

It is interesting now to turn to using the program in a practical situation. North British Housing Association decided to move over to using CAD for the design of their housing projects.

4 Practical applications

4.1 The drawing office

The North British Housing Association Architects Department has been using ArchiCAD and AutoCAD software for over two years for the preparation of design and contract drawings. While looking at the practical uses of ArchiCAD in a housing design office a further explanation will be given of the various tools available in the software. One of the most valuable tools in the program is that of the object tool mentioned earlier.

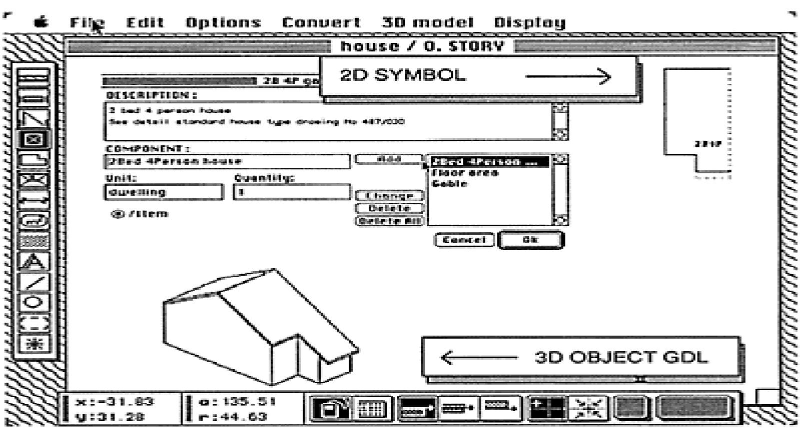


Figure 6 2D and 3D objects with properties dialogue box

4.2 Object tool

The object tool is located immediately below the door tool in the tool palette (Figure 1). Double clicking this icon will give access to library of objects supplied with software, including sanitary ware, furniture and electrical symbols, but the software also allows for customisation to individual requirements. These objects can be given properties of description, size or cost, which can be used to produce automatic schedules for outputting to spreadsheet programs for costing and other calculations such as heat loss and lighting.

4.3 Producing 2D objects

New objects can be produced in minutes by selecting Edit Symbol from the Edit Menu and choosing New from the dialogue box, then working from the origin, the desired symbol can be created using any combination of line, circle, hatch and text. Hot spots are then attached to the symbol in the desired positions to allow convenient selection and location of the object in the drawing. When this has been completed the object can be saved.

4.4 Producing 3D objects

New 3D objects are produced by opening a new drawing and again working from the origin construct the required 3D object using any combination of wall, slab or roof tools, when satisfied select Save As GDL from the File Menu. A symbol is then created, as above, to represent the 3D object in plan. The 3D GDL is then attached to the symbol during the saving process.

BILL OF MATERIAL OF Park Mill Site

by ArchiCAD

Walls	Surface A	Surfaces B	Volume	Pen	Height	Pattern	Thickness
WALL	624.91 m2	623.59 m2	62.50 m3		1 1.20m	Boundary	fence 0.10m
Boundary fence			1		m2		

Cost of boundary	38	£/m
2Bed 4Person house	1	dwelling/item
Floor area	62.4	sqm/item
Gable	1	No/item
parking bay	46	2.40m×6.80m
shrub 1	51	1.00m×1.00m
tree 1	44	6.00m×6.00m
tree2	60	3.00m×3.00m
HATCH	10,892.84 m2	site area
Component Names	Unit	Sumn
Boundary fence	m2	624.92
Cost of boundary	£	19,792.30
2Bed 3Person CAT I bungalow	dwelling	10
Floor area	sq m	2129.80
Gable	No	32
3Bed 4Person house	dwelling	2
2Bed 4Person house	dwelling	8
Car spaces	No	46
2Bed 3Person wheelchair bun…	dwelling	2
3Bed 5Person house	dwelling	10

Figure 7 Schedule of objects and accommodation

4.5 Adding properties

Properties may be added to 2D and 3D objects at any time by selecting Edit Properties from the Edit Menu. The dialogue box is illustrated in Figure 6. Any description can be typed in directly to the top box, and any component of your choice defined with its appropriate unit and quantity. It can be seen from this example of a 2 Bedroom 4 Person house that there are 3 properties defined in the right hand box, namely, 2 Bed 4 Person house, Floor area and Gable. The program will search all the objects used in the drawing and add together all properties given the same name. An example of this is given in Figure 7 showing the output from a feasibility drawing when Quantity Calculation is selected from the File Menu. It can be seen that although there are only 8 No 2 Bed 4 Person houses that there are 32 No Gables listed. The program has searched all the other house type objects to see how many gable situations can be found.

4.6 British Standards

Initial enthusiasm can lead to over elaboration in the production of these objects, which can slow down the operation of the program. British Standard B.S. 1192 Part 5 1990 which sets out some basic principles to assist in the transfer of CAD drawing between users recommends that ‘Symbols should have the minimum number of symbol elements and hatching and fill should be in limited areas only to minimize the amount of data and plotting time’.

4.7 Housing layouts and schedules of accommodation

Figure 9 illustrates a feasibility study of a site using many different objects and Figure 7

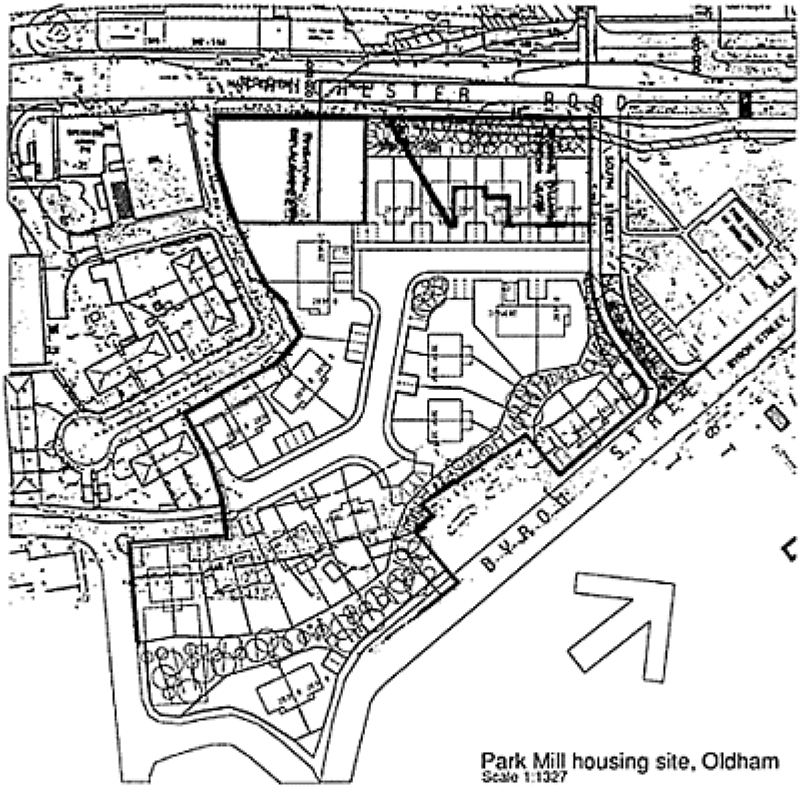


Figure 8 Site layout based on scanned image

indicates the schedule which can be obtained as soon as the drawing is complete.

4.8 Use of scanned images

The location plan of a proposed development site is scanned into the computer using a scanning device. This scan is then saved in an appropriate file format (PICT) and opened into the ArchiCAD software. The file appears on layer 15 of the ArchiCAD drawing and enables work to commence on other layers using other tools to effectively trace off in 2D or 3D the details of the site and surroundings which are of particular importance. This can be carried out in simple diagrammatic block form or in as much detail as you have time for. Once all the site details have been added, the site can be traced with the hatch or area tool to indicate the exact size of the site. The scan layer has now served its purpose and can be switched off or if no further use is to be made of it, deleted all together. Figure 8 illustrates the use of such a scan to produce a feasibility study.

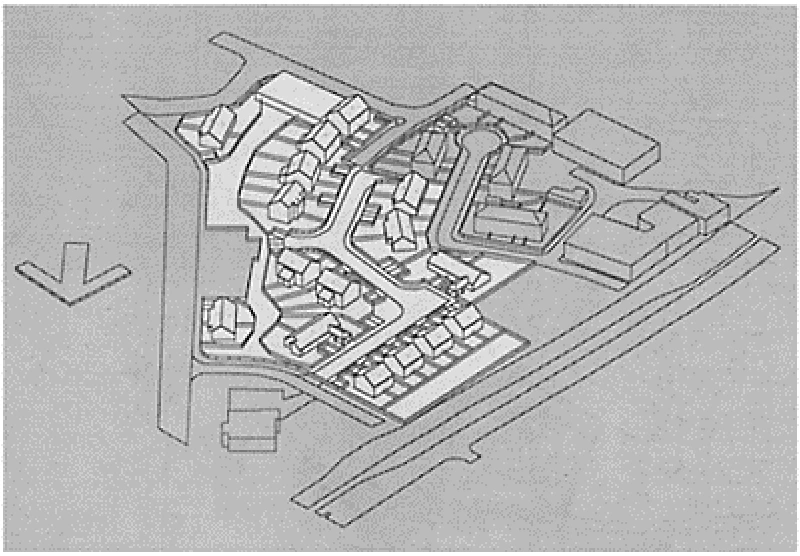


Figure 9 3D view of feasibility study

4.9 Site layout

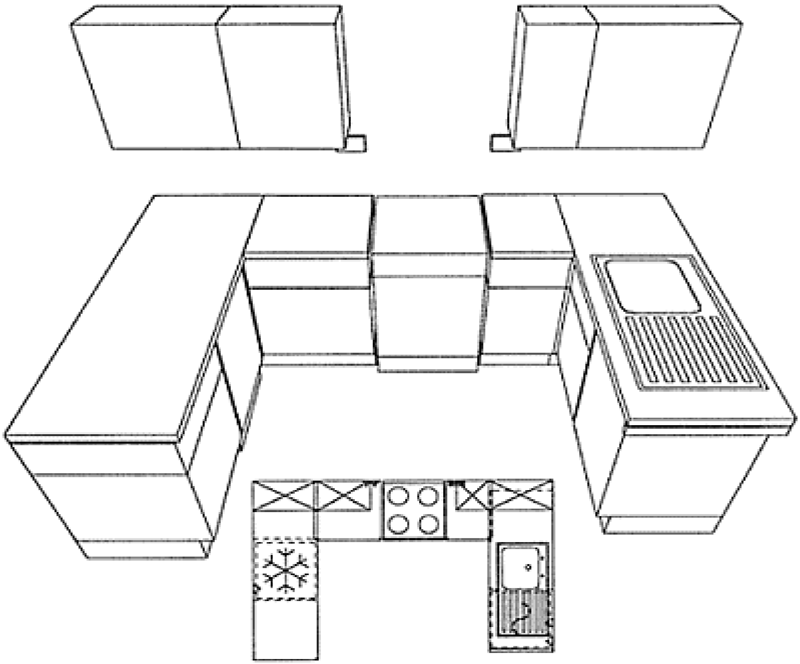
Once details of the existing site have been established consideration of the new proposals can commence. This is where each designer will employ their own methods of design. The brief together with site restrictions and access points will generally be the start. The example in Figure 8 uses a number of our own standard housing types, car bays and turning heads which have been set-up as objects. Any of these objects can be selected and manipulated using the many options available under the Edit command.

4.10 3D views

When a satisfactory layout has been achieved the proposal may be viewed in three dimensions and the resulting spaces explored (Figure 9). Following this checking the most suitable views can be selected for printing, or further treatment in another package. Clients who are not used to the development process and have difficulty in understanding plan drawings can benefit greatly for these facilities, strengthening the Client/Architect relationship and enabling design faults to be recognised and rectified at a very early stage.

4.11 Job costing

Cost information can also be included within the parameters stored with the object, but updating of cost information would involve accessing each individual object file which could be time consuming if many hundreds of objects are used. In this situation it is more efficient to use the alternative spreadsheet facility which is located under the File,



KIND	NAME	PIECES	WIDTH	LENGTH
SYMBOL	cooker panel	1	0.05	0.15
SYMBOL	Corner jointing strip	2	0.6	0.03
SYMBOL	Double H L socket	1	0.06	0.15
SYMBOL	Low level socket	3	0.07	0.09
SYMBOL	support batten	1	0.6	0.03
SYMBOL	worktop 40	1	1.73	0.6
SYMBOL	worktop 40	1	1.8	0.6
SYMBOL	worktop 40	1	0.6	0.6
SYMBOL	worktop 40	1	0.4	0.6
COMPONENT	1000 x 600 x 900 corner base un@	1		
COMPONENT	1200 x 600 x 900 corner base un@	1		
COMPONENT	300 x 300 x 600 wall unit	1		
COMPONENT	400 x 600 x 900 base unit	1		
COMPONENT	50 x 25 sw support batten	1		
COMPONENT	500 x 300 x 600 wall unit	1		
COMPONENT	600 x 300 x 600 wall unit	2		
COMPONENT	600 x 40 deep work top	4		
COMPONENT	600 x 600 x 900 base unit	1		
COMPONENT	Cooker space min 600	1		
COMPONENT	Corner jointing strip	2		
COMPONENT	Fridge space min 600	1		
COMPONENT	Stainless steel inset sinktop	1		

Figure 10 Kitchen layout and schedule

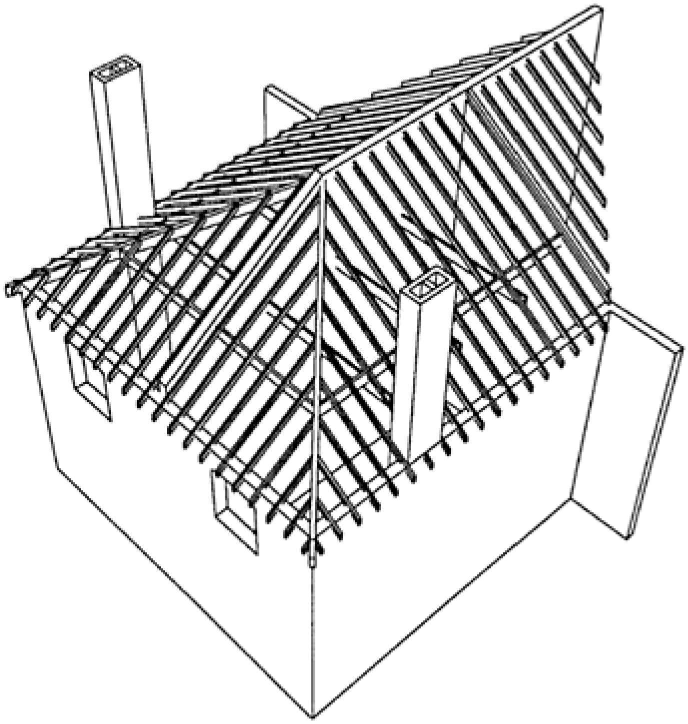


Figure 11 Roof reconstruction to existing building

Save As Menu, which provides for the drawing to be saved as an Excel file which is a powerful spreadsheet programme available on the Macintosh and in which might be kept an itemised cost listing to which the drawing spreadsheet can be linked. Having the cost information stored separately from the objects will allow easier updating.

The drawing spreadsheet is also the route to obtain the information about the external wall and window areas necessary to carry out heat loss calculations. These can also be linked to worksheets containing the various calculations and lists of materials and their properties.

4.12 Kitchen layouts and schedules

The same principles discuss above can be applied to the detail design aspects of housing. An important area is the kitchen and simple but accurate objects can be easily set up to assist in the layout and scheduling of the units (Figure 10).

4.13 Roof construction

Similar principles can also be applied to rehabilitation and repair work, with purlins and rafters in lie lieu of kitchen units and equipment. (Figure 11)

4.14 Drawing development

Production information is also produced using ArchiCAD, with features such as auto-dimensioning and (DXF) input being particularly useful. Unlike manual drawing

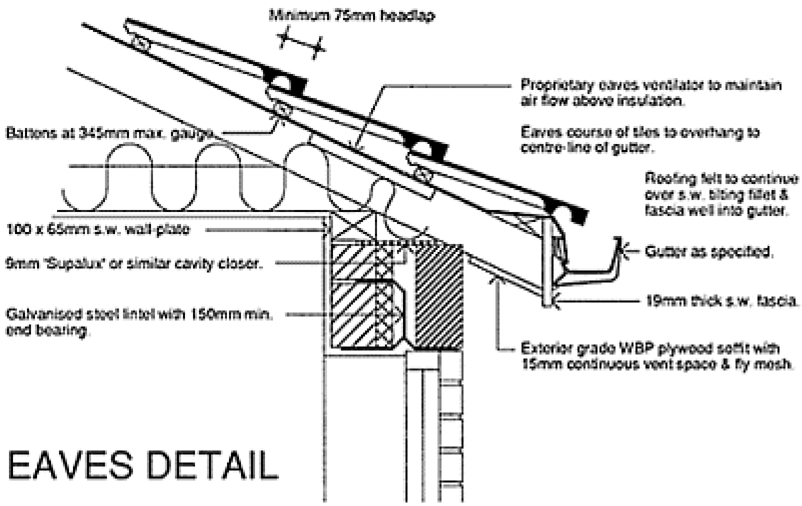


Figure 12 Eaves detail utilising manufacturer's predrawn symbols

serve this purpose. The objects, mentioned previously, and their properties can also be elaborated at this stage, enabling the further use of spreadsheets to produce finished schedules.

The facility to reproduce the drawing to any chosen scale means that using various layer combinations and very few drawing files a comprehensive set of contract drawings can be produced. The clarity of these drawings are often far better than their hand drawn equivalent thereby avoiding site misunderstandings and their associated costs. The inherent efficiency in drawing production is obvious, this extends into the production of maintenance manuals, reports, articles and sales information, where existing drawings can be adapted easily for these purposes.

4.15 Auto dimensioning

The use of auto-dimensioning can save significant drawing office time. Where care is taken to size and locate building elements during the early stages of a scheme, auto-dimensioning can be added confidently in a very short time. If, as is more likely, the size and shape of the building evolves through the early stages, then the wall sizes and opening locations can be edited individually. The auto-dimensioning will adjust accordingly, and for those still committed to the use of imperial measurements, conversion is available via a simple selection from the basic settings dialogue box.

4.16 Drawing transfer

(DXF) output is useful in two main areas, both using CAD drawings produced by others. Firstly, the use of land survey drawings, which can be used in the same way as the scans at feasibility stage, only with the added accuracy necessary for contract drawings. Secondly the use of manufacturers pre-drawn details of their products can be brought direct into working drawings (Figure 12). The Royal Institute of British Architects compile and issue a vast collection of such drawings and their associated literature under the name of RIBACAD. Use of these drawings saves drawing time and ensures accurate details rather than general or diagrammatic details often produced when drawing by hand.

5 Summary

ArchiCAD is a professional tool and a sophisticated piece of software which presents itself simply and is easy to learn. This paper concentrates on the direct use of ArchiCAD however it keys in comfortably with many other Macintosh programs such as Word-processing, Desktop Publishing, Graphics, Spreadsheets and even more sophisticated 2D drawing and 3D animation programs.

The software is continually being updated and at the time of writing version 4.0 is due for release in the coming months. This will include a number of new features the most significant of which are:

1. The ability to assign up to 255 layers which can be named.
2. 20 identified undo and redo functions.
3. Editing in sectional view.
4. Import of 3D DXF and (Swivel 3D) files. Output to (Zoom).
5. Enhanced GDL to include spheres.
6. 3D surface hatching and realistic rendering including surface attributes, shadow casting, global light source with ambient light, smoother curved surfaces.
7. Anti-aliasing (allows close control of line width, placement and density); diagonal lines can appear virtually straight without the traditional jagged appearance.
8. 24 bit colour and 32 bit quickdraw.
9. Walkthrough facility.

6 References

Bird, R. (1989) **The Guide to CAD on the Mac. A Professional survey for architects and designers.** Richard Bird Associates, London.

Graphisoft (1988) **ArchiCAD Manuals—User's Guide and Quick Tour.** Graphisoft, California.
B.S.I. (1990) Construction drawing practice Part 5, Guide for structuring of computer graphic information B.S. 1192 Part 5. London.
North British Housing Association (1991) **Contract Documentation,** Manchester.
R.I.B.A (1990) **Survey of Computer Usage 1989.** R.I.B.A. Market Research Unit London.
R.I.B.A.S (1990) **RIBACAD,** R.I.B.A Services Ltd. London.

165
Expert system for resource smoothing in the building industry

D.VERMEIR and J.FASSIN

Abstract
The Expert Scheduling Advisor (ESA) is a prototype developed in the ESPRIT Project 2189. In view of the supplementary costs due to irregular use of the resources, ESA proposes specific actions in order to minimize these costs. Several simulations are possible. The project manager decides on the most appropriate simulation and can issue the workplan on these base.

Keywords: Expert System, Resource Smoothing, Prolog, Costs, Scheduling.

1 Introduction

The Expert Scheduling Advisor (ESA) is a prototype included in the ESPRIT Project 2189. ESA aims at minimizing the supplementary costs due to irregular use of resources.

A first prototype of the Expert System was written in May 1990, based on user's first specifications. These main specifications are:

– set of activities which are connected with Finish-Start (FS) relations;
– each activity has a duration in days, and uses per day a certain amount of resources;
– the schedule scheme has a required length L in days;
– the aim was to smooth the consumption of each resource, or to approach to the average consumption as much as possible.

This first version of ESA was demonstrated to a group of building contractors. They showed an interest in such an approach and defined the possible actions with a view to a better use of the resources. In order to estimate the benefit, and to measure the impact of any action, the contractors wanted to introduce the costs. The daily normal cost of each resource is defined. For each resource the manager defines a global normal availability level. If the daily cumulated use of a resource exceeds this level or falls under a minimum level, supplementary costs are calculated. The system aims at minimizing the extra-costs with respect to the constraints.

[1] UIA—University of Antwerp, BE
[2]BBRI—Belgian Building Research Institute, BE

2 ESA Concepts

The architecture shows the main parts of the system.

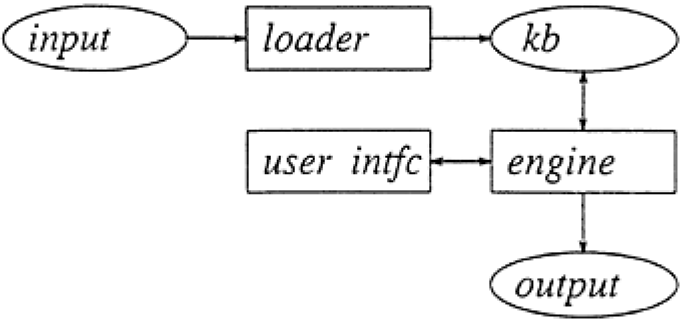


Fig.1.

The input defines:

1) the network with the set of activities and relations. The activities have a duration in days and an initial startdate. Each activity uses per day one or several resources. The relations are of two kinds: Start-Start (SS) or FinishStart (FS). Each relation has two attributes: early finish date and latest start date. These attributes are calculated by an external scheduling system and updated by the Expert System. Each relation may have a duration.
2) in percentage how much a SS relation can be shortened, or what part of the preceding activity can be unfinished in case of a FS relation.
3) the expansion and compression factor for the duration of one activity. The budget in resource days for each activity remains constant for any duration change.
4) the minimum, normal and maximum daily total uses of each resource. A maxmax level of availability is also defined. Under no circumstances is the consumption ever to exceed the maxmax level. Normal costs and extra costs are defined in relation to these levels.
5) multi-functional resources which can replace other resources.

The system satisfies all these constraints. For each instance of the schedule, the system assigns a start date and a duration to each activity.

The move of the start date of an activity, and the change of its duration are the two possible actions of ESA. At the end of the run, any overuse of resource may be moved to a multi-functional resource. The goal is to optimize the schedule, i.e. to keep the daily cumulated resource use within the minimum-normal interval. This with a maximum decrease of the extra costs.

3 Detailed description of the model

In this section, we extend the simple model to include start-start precedence relationships. In addition, relationships will themselves have a length as well as an early-finish date. Finally, we'll introduce the notion of extreme early start date, and the associated concept of extreme front margin, which will allow to relax the start date constraints in a controlled way, in order to enlarge the set of possible actions for ESA to choose from.

3.1 Start-start relationships

Besides finish-start relationships, we also allow start-start relationships. (For the time being, relationships for both kinds are assumed to have 0 duration). This will cause a change in the formulas for several parameters. In the following, we use $Succ_{SS}(A)$ and $Succ_{FS}(A)$ to denote the set of immediate successors, via a startstart relationship, of *A*, and the set of immediate successors via a finish-start relationship, respectively. The notations $Pred_{SS}(A)$ and $Pred_{FS}(A)$ are similar.

$$LF_A = \begin{cases} L & \text{if } Succ\,(A) = \varnothing \\ \min_{B \in Succ\,(A)} \{LF_B^A\} & \text{otherwise} \end{cases}$$

where

$$LF_B^A = \begin{cases} LF_B - D_B & \text{if } B \in Succ_{FS}(A) \\ LF_B - D_B + D_A & \text{if } B \in Succ_{SS}(A) \end{cases}$$

$$ES_A = \begin{cases} 1 & \text{if } Pred\,(A) = \varnothing \\ \max_{E \in Pred\,(A)} \{ES_E^A\} & \text{otherwise} \end{cases}$$

where

$$ES_E^A = \begin{cases} F_E + 1 & \text{if } B \in Pred_{FS}(A) \\ S_E & \text{if } B \in Pred_{SS}(A) \end{cases}$$

Finally,

$$FSLACK_A = \min_{B \in Succ\,(A)} \{FSLACK_A^B\}$$

where

$$FSLACK_A^B = \begin{cases} S_B - F_A - 1 & \text{if } B \in Succ_{FS}(A) \\ S_B - S_A & \text{if } B \in Succ_{SS}(A) \end{cases}$$

3.2 Relationship attributes

In practice, it is often useful to be able to specify a **duration** D_R for a relationship *R*, with the obvious meaning; e.g. if *A* is in a start-start relation of duration 3 with *B*, *B* being the predecessor of *A*, then any legal schedule must have *A* starting at least 3 days after the start of *B*. In addition, relationships will have an associated **early finish** attribute EF_R, and a **late start** date LS_R which will influence the early start date of the following activity or the late finish date of the preceeding activity, respectively.

EF_R and LS_R can be computed from the proceeding or following activities, denoted *Prec(R)* and *Fol(R)* respectively, as follows:

$$EF_R = \begin{cases} F_{Prec(R)} + D_R & \text{if } R \text{ is finish-start} \\ S_{Prec(R)} + D_R - 1 & \text{if } R \text{ is start-start} \end{cases}$$

and

$$LS_R = LF_{Fol(R)} - D_{Fol(R)} - D_R$$

A special case occurs when *Prec(R)* or *Fol(R)* is not part of the scheme. In this case, the initial values of EF_R and LS_R *are* to be taken as fixed, thus constraining the attributes of the proceeding or following activities. This feature allows for the optimization of subschedules (schemes) as activities in a schedule that are left out of the subschedule to optimize will nevertheless influence the subschedule through their relationships (which are included in it). In this way, it is ensured that the modified partial schedule constructed by ESA will fit with the rest of the schedule that has not been modified.

It is then possible to rephrase the previous formulas in terms of EF_R and LS_R:

$$LF_A = \begin{cases} L & \text{if } Succ(A) = \emptyset \\ \min_{A \in Prec(R)} \{LF_A^R\} & \text{otherwise} \end{cases}$$

where

$$LF_A^R = \begin{cases} LS_R - 1 & \text{if } R \text{ is finish-start} \\ LS_R + D_A - 1 & \text{if } R \text{ is start-start} \end{cases}$$

$$ES_A = \begin{cases} 1 & \text{if } Pred(A) = \emptyset \\ \max_{A \in Fol(R)} EF_R + 1 & \text{otherwise} \end{cases}$$

Finally,

$$FSLACK_A = \min_{A \in Prec(R)} \{FSLACK_A^R\}$$

where

$$FSLACK_A^R = \begin{cases} S_{Fol(R)} - D_R - F_A - 1 & \text{if } R \text{ is finish-start} \\ S_{Fol(R)} - D_R - S_A & \text{if } R \text{ is start-start} \end{cases}$$

As a final remark, it should be noted that, although, the extension of relationships with attributes can be simulated by introducing "dummy" activities A_R with duration D_R, appropriately constrained by additional conventional relations, it is felt that this would be less convenient for the user.

3.3 Extreme early start date

In practice, constraints following from the duration of a relationship are often not to be taken too strictly. E.g., if an activity *B* is to start at least 5 days after the start date of *A*, then it is often possible to relax this condition and let *B* start earlier, e.g. after 3 days past the start of *A*. In order to incorporate this heuristic, ESA assumes that it is possible to relax the required duration of a start-start relationship by 30 %. Similarly, the duration of a finish-start relation may be decreased by 20 % of the lentgh of the proceeding activity. Both these numbers can be specified as part of an input schedule schema.

The above then gives rise to the notion of **extreme early finish** date XEF_R of a relationship *R* and, by propagating this to the preceeding activity, to the **extreme early start** date XES_A for an activity *A*.

Formally, we have

$$XEF_R = \begin{cases} F_{Prec(R)} + D_R - 0.2 \times D_{Prec(R)} & \text{if } R \text{ is finish-start} \\ S_{Prec(R)} + D_R \times (1 - 0.3) & \text{if } R \text{ is start-start} \end{cases}$$

It should be noted that all durations in the above formula refer to the original durations, as specified in the input schema. Substituting XEF_R for EF_R in the previous formula for ES_A yields the definition of the extreme early start date of an activity:

$$XES_A = \begin{cases} 1 & \text{if } Pred(A) = \varnothing \\ \max_{A \in Fol(R)} XEF_R + 1 & \text{otherwise} \end{cases}$$

The **extreme front margin** takes the extreme early start date into account:

$XMAV_A = S_A - XES_A$

In order not to propagate this relaxation, ESA will not use the actual start date *SA* of an activity *A* if this date is smaller than the early start date, i.e. $S_A < ES_A$. Rather, in this case, ES_A is used instead. Also, the front margin MAV_A cannot be negative. Formally, we have the following (final) set of definitions:

$$\bar{S}_A = \max\{S_A, ES_A\}$$

$$F_A = S_A + D_A - 1$$

$$\bar{F}_A = \bar{S}_A + D_A$$

$$EF_R = \begin{cases} \bar{F}_{Prec(R)} + D_R & \text{if } R \text{ is finish-start} \\ \bar{S}_{Prec(R)} + D_R - 1 & \text{if } R \text{ is start-start} \end{cases}$$

$$LS_R = LF_{Fol(R)} - D_{Fol(R)} - D_R$$

$$ES_A = \begin{cases} 1 & \text{if } Pred(A) = \varnothing \\ \max_{A \in Fol(R)}\{EF_R\} + 1 & \text{otherwise} \end{cases}$$

$$XEF_R = \begin{cases} F_{Prec(R)} + D_R - 0.2 \times D_{Prec(R)} & \text{if } R \text{ is finish-start} \\ S_{Prec(R)} + 0.5 \times D_R & \text{if } R \text{ is start-start} \end{cases}$$

$$XES_A = \begin{cases} 1 & \text{if } Pred(A) = \varnothing \\ \max_{A \in Fol(R)} XEF_R + 1 & \text{otherwise} \end{cases}$$

$$LF_A = \begin{cases} L & \text{if } Succ(A) = \varnothing \\ \min_{A \in Prec(R)}\{LF_A^R\} & \text{otherwise} \end{cases}$$

where

$$LF_A^R = \begin{cases} LS_R - 1 & \text{if } R \text{ is finish-start} \\ LS_R + D_A - 1 & \text{if } R \text{ is start-start} \end{cases}$$

$$FSLACK_A = \min_{A \in Prec(R)}\{FSLACK_A^R\}$$

where

$$FSLACK_A^R = \begin{cases} S_{Fol(R)} - D_R - F_A - 1 & \text{if } R \text{ is finish-start} \\ S_{Fol(R)} - D_R - S_A & \text{if } R \text{ is start-start} \end{cases}$$

$$MAV_A = \bar{S}_A - ES_A$$

$$XMAV_A = S_A - XES_A$$

It should be noted that the introduction of extreme dates increases the number of possible actions to apply. However, it may be that a move-left operation by more than the front margin (but less than the extreme front margin) makes it necessary to recompute the network.

3.4 Net (re)computation

Part of the ESA knowledge base will consist of a constraint net representation of the above formulas, instantiated for the schedule scheme at hand. The effect of this is that it becomes straightforward, using a general net propagation module, to compute the effects of any action on the rest of the schedule.

4 The cost model

Resource smoothing is actually a rather naive and overly simplified view on “good” resource consumption functions. The present section develops a model for the costs associated with a resource function. It will then be the task of ESA to attempt an optimization of this cost.

The cost associated with the resource consumption function of a schedule is based on the “normal cost” associated with a resource type on the one hand and data on the resource availability, which may cause extra costs, on the other hand.

4.1 Normal cost

For each resource type *R,* the **normal cost** is computed from a given set of records that have the format

normalCostOfResource(R, unitCosts)

4.2 Extra costs

The duration of the scheme is divided into a number of **periods**. (In the present version, the input schedule is assumed to belong to a single period. This limitation does not significantly affect the goal of the prototype, which is to demonstrate the feasability of our approach). For each period and resource type *R,* a number of resource usage levels are given:

– The **normal** level is the amount of R that is available at normal cost. (Actually, there is no extra cost, if the consumption is between *minimum* and *normal,* see below).

– The **minimum** level is such that, if consumption falls below this level, there is an extra cost to be paid. This extra cost (per day) is given by

$$XC_{<\min}=(minimum-L)\times minXC\times NC$$

where *minXC* is a factor, e.g. 20 %, *L* is the consumption level and *NC* is the normal unit cost.

– A **maximum** level. A consumption between *normal and maximum* is allowed but carries an extra cost, which is computed in a similar fashion as above (but based on a different factor *maxXC).*

$$XC_{\{normal,\max\}}=(L-normal)\times maxXC\times NC$$

– Between the maximum and an extreme value maxmax the extra cost is given by:

$$XC\{max,maxmax\}=(L-maximum)\times maxmaxXC\times NC$$

Under no circumstances is the consumption ever to exceed the maxmax level.

It should be noted that “overconsumption” of resources may also imply a fixed extra “investment” cost. This cost is not taken into account in the present version of the model.

4.3 Multi-functional resources

ESA allows a scheme to specify so-called “replace” propositions *replace(R, S)*

that express that resource S can be replaced by the multi-functional resource *R* (there may be only one possible replacement for S).

This Information will be used by a new action that may be executed in an attempt to “normalize” the use of resources: if e.g. there is overuse of S but not of *R*, then it may be advisable to **replace** some units of S by units of *R*. The system will need to remember the makeup of any multi-functional resource usage.

In the present prototype, multi-functional resources will not be used during the main phase of the system’s computation. Rather, the third phase (see below) will attempt to remove some “over-use” of resources by (partially) replacing them with multi-functional resources.

5 ESA strategy

5.1 Initial phase

Obviously, one of the features of an optimal schedule is that the resource consumption is always below the normal available level. Hence, if the input scheme is such that the total resource usage for one or more types exceeds the total available amount, taking into account the available multi-functional resources, ESA will complain. In addition, ESA will suggest not considering some activities at the end of the schedule, in order to obtain an acceptable level of resource use. In any case, ESA will not apply any actions unless there are sufficient resources available. (In the worst case, the user will need to revise the availability levels).

5.2 Main phase

Given the cost model, optimizing a schedule amounts roughly to keeping the resource usage within the *{minimum, normal}* interval for each resource.

Several strategies to achieve this might be considered. The present system will adhere to the following strategy:

1. Do a left-to-right “sweep” over the schedule, applying promising moveleft en strengthen-left actions. Note that moving an activity to the left, may decrease the (extreme) early start date of its successors, yielding possibilities for performing a similar action on them. This effect, together with the fact that a “sweep” looks more like a consistent behavior of the system to the user, motivates the left-to-right sweep.
2. If step 1 is exhausted, the system will attempt to perform appropriate move-right or strengthen-right action in a right-to-left sweep. Such an action is likely to increase the free slack of preceeding activities, yielding more possibilities for similar actions on them, hence to right-to-left direction of the focus for this sweep.

   In each step, possible actions will be ranked according their predicted effect on the cost function, as well as their locality. E.g. a localized action will be prefered over a non-localized one if both promise the same improvement of the cost function. The exact weight of both factors remains to be determined.
3. During the final phase, resources usage peaks over the maximum (see above) level will be leveled by replacing appropriate amounts by the use of the corresponding multi-functional resource. Of course, this process is limited by the amount of multi-functional resources that is available.

6 User Interface

6.1 Output

Before each action is applied, the system displays its agenda, the selected action and a motivation for this action, consisting of the activity concerned and the resource consumption function for the resource involved.

In addition, the user has the option of asking for a global view of the schedule. This displays the timing of all activities as well as the resource usage by these activities and the resource consumption functions. This global view divides the screen in two windows, as is illustrated below.

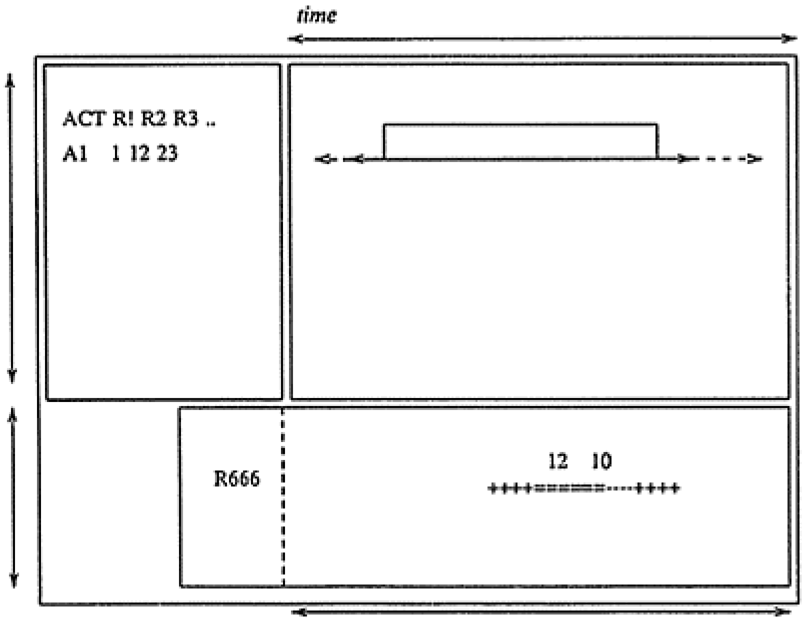
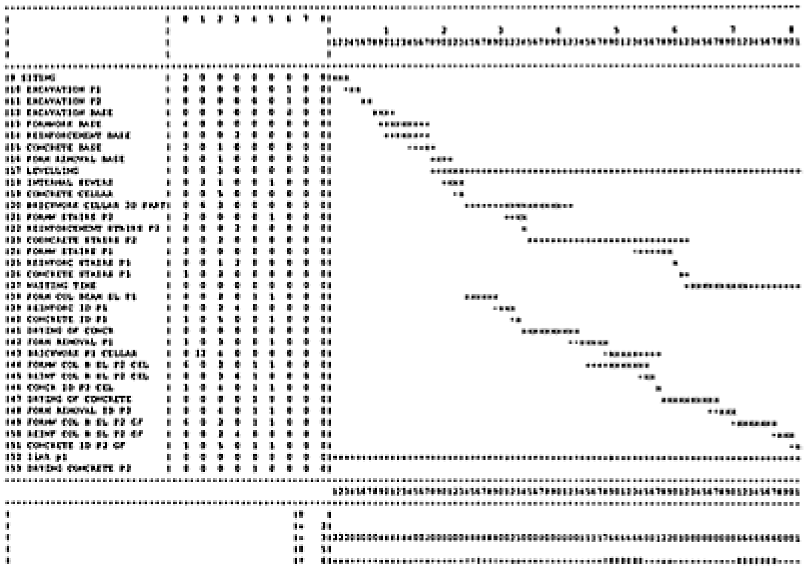


Fig.2.

The user can scroll horizontally (over time) in which case both windows are synchronized, or vertically, which is separate for both windows.

Output examples:



SAMPLE LOGFILE

```
Starting left sweep…
Checking rules at 8
Checking rules at 9
Rule MOVE-LEFT (Moving 13 from 9 to 8) can be applied
at 9 [Res. 0, Priority=4]
Rule WEAKEN-LEFT (Strengthening 13 from 6 to 7 days,
moving from 9 to 8) can be applied at 9 [Res. 0,
Best rule at 9: Strengthening 13 from 6 to 7 days,
moving from 9 to 8 [Priority=6]
Moving 13 (FORMWORK BASE) from 9 to 8
Strengthen 13 (FORMWORK BASE) from 6 to 7
TotalCost is 16955
Checking rules at 11
Rule MOVE-LEFT (Moving 14 from 11 to 8) can be applied
at 11 [Res. 3, Priority=6]
Rule WEAKEN-LEFT (Strengthening 14 from 4 to 6 days,
moving from 11 to 8) can be applied at 11 [Res. 3,
Best rule at 11: Moving 14 from 11 to 8 [Priority=6]
Moving 14 (REINFORCEMENT BASE) from 11 to 8
TotalCost is 16955
Undo
Moving 14 (REINFORCEMENT BASE) from 8 to 11
TotalCost is 16955
Best rule at 11: Strengthening 14 from 4 to 6 days,
moving from 11 to 8 [Priority=4]
Moving 14 (REINFORCEMENT BASE) from 11 to 8
Strengthen 14 (REINFORCEMENT BASE) from 4 to 6
TotalCost is 16887
```

```
Checking rules at 23
Rule MOVE-LEFT (Moving 17 from 20 to 19) can be applied
at 23 [Res. 2, Priority=3]
Best rule at 23: Moving 17 from 20 to 19 [Priority=3]
Moving 17 (LEVELLING) from 20 to 19
TotalCost is 16863
Checking rules at 24
Checking rules at 30
Rule MOVE-LEFT (Moving 20 from 30 to 23) can be applied
at 30 [Res. 1, Priority=42]
Rule WEAKEN-LEFT (Strengthening 20 from 10 to 15 days,
moving from 30 to 23) can be applied at 30 [Res. 1
```

7 Conclusions

7.1 This prototype has shown that we dispose of a feasible approach.

7.2 The prolog implementation allows fast development and is also available under Unix.

7.3 The prototype will be tested on real building projects and improved afterwards.

8 References

Davis, E.W. and Patterson, J.H. (1975) A comparison of heuristic and optimum solutions in resource-constrained project scheduling. Management Science, Vol. 21, n° 8.

Fox, M.S. and Smith, S.F. (1984) ISIS—a knowledge-based system for factory scheduling. Expert systems, Vol. 1, n° 1.

Kurtulus, I. and Davis, E.W. (1982) Multi-project scheduling : categorization of heuristic rules performance. Management Science, Vol. 28, n° 2.

Patterson, J.H. and Roth, G.W. (Dec. 1976) Scheduling a project under multiple resource constraints: a zero-one programming approach. AIIE Transactions.

Smith, S.F. (1988) A constraint-based framework for reactive management of factory schedules. Intelligent Manufacturing.

166
EMMY: an expert system for predicting maintenance for housing associations

I.D.WATSON, P.S.BRANDON and A.BASDEN

Abstract
There is an increasing need for the long term strategic planning of building maintenance. This is particularly so amongst Housing Associations due to recent changes in legislation. This paper argues that conventional Maintenance Management programs suffer from several problems: They require too much data input, they are too inflexible, they do not explain their results, and their users cannot easily explore potential alternatives. The application of Expert System's technology to this area directly addresses these problems. This paper examines the need for such systems, describes the implementation of one such system, and outlines its potential benefits.

Keywords: Expert Systems, Building Maintenance, Built Asset Management, Housing Associations

1 Introduction

Recent changes in legislation have made Housing Associations (HAs) more financially responsible for all aspects of the maintenance of their new housing stock. Because of the levels of funding within HAs and the need to provide accommodation at a "fair rent" the planning of maintenance, and the consequent planning of expenditure, has never before been so vital. Moreover, most literature on maintenance, be it government reports, research by professional bodies or academic institutions, identifies a need for improvement in decision making with respect to building maintenance [Briffett, 1989; Kennerley & Oxley, 1989].

The project under way at the University Salford aims to provide an Expert System (or decision support tool) that will assist Maintenance and Finance Officers in the strategic planning of maintenance. It is worthwhile emphasising that we are not constructing either a database for HAs building stock and their tenants, or a pro-gram that itemises maintenance jobs, handles invoices and performs various accounting tasks.

There are many programs in existence that estimate the Life-Cycle Costs of buildings or provide Maintenance Management; however they all share two major problems:

- □ They require voluminous data input to describe each building.
- □ They function as *"black boxes"* that is, data is put in and answers are given with little indication of how they were generated and what variables affected the results.

Storing all the relevant information in a database and selecting only that information required for the building under consideration is one method of reducing data input. In this way, one can construct a model of the building from prepackaged components, and calculations can then be performed using spreadsheets. This approach has the advantage of reducing data input and being relatively low cost [Tuts, 1989], but it still suffers from a lack of explanation.

Although there is a wide variety of computer software available to the industry, the technology with potentially the greatest benefits is still the least known and most rarely used—the Expert System [Cryos, 1989]. Expert Systems can directly address both of the problems outlined above: first, by reducing the need for data input, and second, by explaining how it arrived at its results as well as allowing users to explore different alternatives.

This paper first describes the history of HAs and explains why they would benefit from this technology. The architecture of the EMM Y system is then shown, detailing the advantages of EMMY over conventional software. The paper concludes by discussing the potential benefits of the system.

2 Housing Associations

Historically HAs have provided accommodation for the working class and those with special needs (*e.g.* the elderly). Early HAs were often established with the aid of wealthy benefactors, (*e.g.* the Bournville Trust, the Guinness Trust, and the Rowentree Trust [Aughton, 1981]). HAs continue to be non-profit making bodies providing housing and/or hostels. They mainly provide housing for rent and are managed by committees of members and have salaried officers to run their affairs. Some HAs are small and run on co-operative lines with part-time or voluntary staff, whilst others have large staffs and are managed as professional businesses (*e.g.* the North Housing Association is responsible for over 20,000 properties). Nationally they provide less than 7 percent of total rented accommodation [D.O.E, 1987] recently they have been the fastest expanding provider of housing for rent in the U.K.

The Housing Association movement in the United Kingdom increased markedly after the major housing reviews in the early 1960's. The government views the expansion of these organisations as a check on municipal housing and as a method of increasing home ownership. Initially, the financing methods were similar to those of local authorities; a central body, the Housing Corporation, was set up in 1964 to monitor all expenditure, its budget complementing the funding available to HAs from government.

Until 1989 the primary method of obtaining monies for maintenance was by a deductible allowance from rental incomes and this was increased by "Major Repair Capital Grants" from the Housing Corporation. However, this was viewed as penalising the more financially responsible HAs who would be told that their surplus funds or reserves should be used to finance major repair works, whilst less prudent HAs would obtain the money from the Housing Corporation.

This situation changed with the publication of the final circular of the Housing Corporation in Scotland [1989] which stated that all new submissions for development funds would be subjected to an annual provision to be laid aside for major repairs, replacements and renewals. This policy was subsequently implemented in England, whereby all major new schemes would require the establishment of sinking funds [Institute of Housing, 1989]. Consequently, for the first time HAs were forced to calculate the likely maintenance costs of buildings in order to estimate accurately provisions for the sinking fund.

A study conducted at Salford University on the potential for Expert Systems within HAs [Stafford & Brandon, 1988] identified strategic maintenance planning as joint highest priority along with the formulation of alternative schemes at the briefing stage. Thus, the HAs themselves view strategic maintenance planning as essential in the future.

3 An Overview of EMM Y

Ease of use was an initial design constraint upon EMMY because it is intended to be operated by people who are not computer experts. EMMY uses a graphical user interface and will be straightforward to operate. EMMY is being implemented using the Expert System Shell KAPPA™ to represent all the knowledge about buildings and maintenance. The life expectancy and cost information will be stored in a separate database to permit easy updating of this information.

EMMY is composed of three separate modules and a database as shown schematically in Figure 1. The first of these modules is the Building Description Module. This contains the knowledge about buildings which is represented in two different forms:

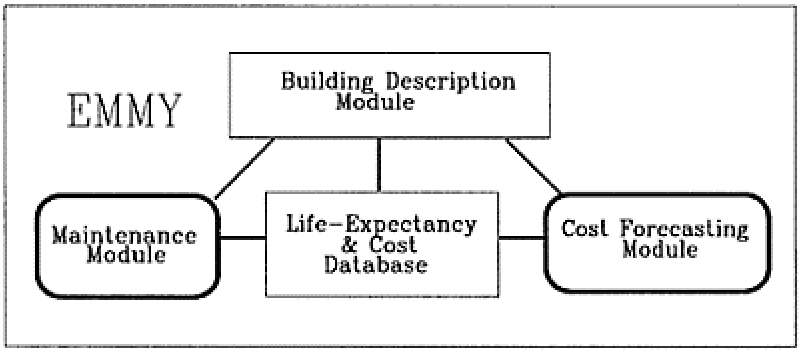


Fig. 1 A Schematic Overview of EMMY

- □ **Typical Descriptions.** These represent descriptions of a typical example of a particular building. These can be altered by the user to account for local differences in building design or construction.
- □ **Description Rule Base.** These store knowledge about building design and materials which can be applied to any hypothetical building within certain limits.

By providing both these forms of knowledge a user can either select a building from one of the typical buildings or construct a building from first principles. Figure 2 shows some of the building descriptions available to the user. (The number after each house type refers to its number of occupants.) The rule base is also used whenever the user changes a value of a typical building description. For example, the system knows that a pitched roof should not have an asphalt and gravel covering or that a six person house should not have twenty bedrooms.

The second module is the Maintenance Module. This contains a set of maintenance tasks which are only applicable under certain conditions; some of these tasks are shown in Figure 3. Hence, the task of restating the roof would not apply if the building does not have slates on its roof. However, the task of replacing windows would apply to all buildings. In the latter instance EMMY will then find out what type of windows the building has and from this it will calculate their life expectancy. This figure will take into account the materials and various environmental factors (*e.g.* climate, pollution). From this information an inspection, repair, and renewal plan can be prepared for the windows. This process can be repeated for all the elements in a building that require maintenance, thereby generating a complete maintenance profile for the life of the building and for all the buildings within a housing scheme.

The Cost Forecasting Module takes each elemental maintenance plan, costs it at current prices (adjusting for regional price variations and other factors such as

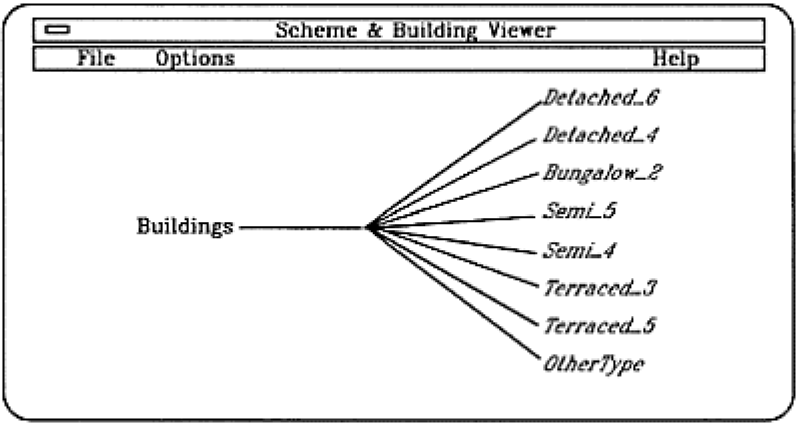


Fig. 2 A Screen dump from EMMY showing building templates

using contractors vs. in-house workers, discounting for economies of scale etc.). This module will enable the results to be analysed in a variety of different ways:

□ Costs per individual building over any given period.
□ Costs per individual maintenance job for a group of buildings over any period.
□ Costs per maintenance job for a group of buildings over any period.
□ Costs per group of maintenance jobs for a group of buildings over any period.

4 Differences to Conventional Software

EMMY's knowledge about houses enables it to construct a detailed model of a dwelling from general rules. Just as most people when asked to visualize a three bedroom house will envisage similar, but not identical, houses, so can EMMY. Currently, EMMY contains information on terraced houses, detached houses, semis, and bungalows, and it is intended that its knowledge will be extended to cover sheltered accommodation and communal dwellings.

To initiate a consultation with EMM Y a user merely needs to indicate that the building under consideration is, for example, a five person terraced house (by selecting Terraced_5 in Figure 2), and EMMY immediately produces a model description from the template of the property. This description will not be perfect, but it will be reasonable. The user can then view all the assumptions made and if necessary make alterations. This feature reduces the data input requirement of the system dramatically. (Some of the information available on a building is shown in Figure 4.)

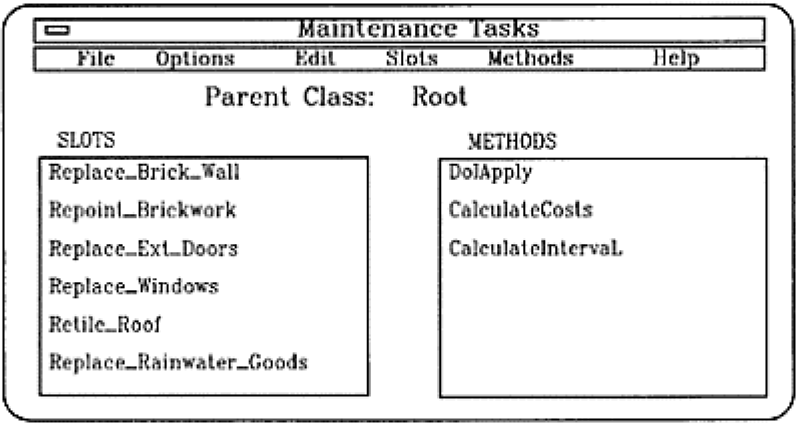


Fig. 3 A Screen dump from EMMY showing maintenance tasks

This is of particular importance at the present time; when a HA commissions a new scheme it possesses the architects' plans and the Bills of Quantity, and it can therefore at any time in the future determine the materials that are in the buildings and their quantities without having to inspect the property. However, increasingly HAs are buying buildings from speculative private developers or are taking over local authority building stocks. In these instances the HAs may have less detailed information about the design and construction of the properties.

Because, reasoning with uncertainty or incomplete knowledge [Alty & Coombs, 1984] is one of the strengths of Expert Systems. EMMY will make a reasoned assumption where specific information is unavailable. Thus, EMMY could be used to assess the probable maintenance costs of buildings before a stock transfer took place between a local authority and a HA.

In addition to knowledge about the design of buildings, EMMY also contains knowledge about the maintenance implications of certain designs. As well as the obvious facts such as “hardwood windows usually last longer than softwood windows,” EMMY knows that such design features as valley gutters or flat tops to bay windows neccessitate regular inspection. EMMY will also consider the building’s national location, with regard both to climate and differences in costs, and the location of the buildings with regard to vegetation, pollution, and vandalism.

All of these factors, including the design of the buildings and the materials, are used to estimate the likely lifespan of elements and to plan inspection, repair and renewal intervals. This information can then be costed over the life of the buildings, thus enabling sinking funds to be calculated.

As was mentioned above, EMMY will allow the user to alter all of the system’s basic assumptions. This *“what if”* facility is central to the use of Expert Systems as decision support tools. It enables the user of EMMY to consider different options such as “What if we replace the windows with hardwood rather than soft-

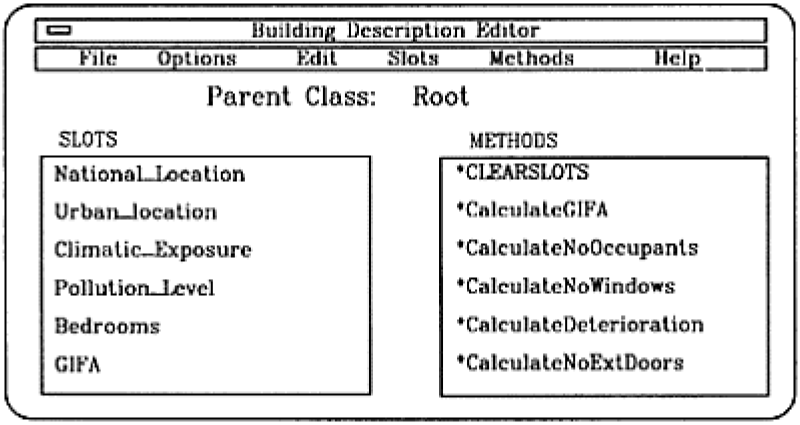


Fig. 4 A screen dump from EMMY showing some of the slots describing a building

wood”, “what if we lay quarry tiles rather than carpet”, “what if the heating systems fail after only 10 years”.

In this way the user can explore the full range of possibilities, and how they effect the results as well as how the results were obtained. This improves user confidence in the system's results since its functions are no longer obscure.

5 Potential Benefits

In addition to performing annual maintenance, it is vital that medium to long-term plans are made to generate financial estimates for sinking funds. However, maintenance managers are often presented with a standardised plan rather than one tailored to meet their local needs, and traditionally users of computerised systems have often relied blindly on the results without realising that the system has only been programmed with standard prices and statistical averages of life span. Moreover, these programs cannot take into account individual variables such as climate or quality [Bos, 1989].

EMMY these problems and will therefore enable strategic decisions regarding maintenance to be made with greater confidence. Several advantages will accrue:

- The system will run on comparatively low cost hardware (PCs) and will be stand alone; (*i.e.* there is no requirement for it to link into any existing systems). However, EMMY will be able to link into some of the market leaders in spreadsheets and databases for PCs which will make the technology particularly useful to the smaller HAs.
- The user will not need to be the HA's "computer expert" since the system is designed to be very easy to use.
- A HA officer will not have to spend many hours entering data in order to obtain results.
- The methods by which results will be obtained will be accessible to the user, thereby increasing confidence in the results.
- Information can be easily tailored to individual buildings and to local conditions and practices
- The user will be able to ask *"what if"* so as different alternatives can be considered.

In addition to the benefits stated above, use of development prototypes of EMMY has shown that the system will also have a role in costing design alternatives with regard to maintenance. This approach overcomes the problems inherent in traditional cost modelling techniques which are inappropriate for realistic building design evaluation over the life cycle of a scheme [Bowen & Erwin, 1989]. However, since the users are not simply provided with "the results" but instead are encouraged to explore various possibilities, they must take responsibility for the decisions. Hence, EMMY is a decision support tool, not a decision maker.

6 Conclusion

EMMY is in its second year of development and it is expected that a "usable" prototype will be ready in a few months. A further period of work will then be required to bring the system to a "saleable" state. In the long term it is intended that EMMY will be linked to another Expert System which will budget the cost of residential schemes, advise on the time it may take to build them and on procurement methods, and consider the overall financial returns on a scheme. This will then provide a powerful set of tools that will enable strategic decisions concerning many aspects of housing to be supported. This will be of particular benefit to the smaller HAs who may lack specific professional expertise and will ensure a more rapid spread of good practice throughout the sector.

7 References

Alty J.L, & Coombs, M.J. (1984). **Expert Systems: Concepts and Examples.** NCC Publications, Manchester, UK.

Aughton, M. (1981). **Housing Finance A Basic Guide.** Shelter, London, UK.

Bos, C.W.J. (1989). Classified Maintenance Inspection, in **Building Maintenance & Modernisation Worldwide,** Vol. 2, pp. 641–649. Longman, Singapore Publishers (Pte) Ltd.

Bowen, P.A., & Erwin, G.J. (1989). Cost Modelling of Design Alternatives Using Expert Systems, in **Building Maintenance & Modernisation Worldwide,** Vol. 2, pp. 1125–1134. Longman, Singapore Publishers (Pte) Ltd.

Briffett, C. (1989). Balancing Design and Maintenance Issues, in **Building Maintenance & Modernisation Worldwide,** Vol. 2, pp. 1097–1105 Longman, Singapore Publishers (Pte) Ltd.

Cryos, K.L. (1989). Computer-Aided Facilities Management and Maintenance Systems (CAFM).in **Building Maintenance & Modernisation Worldwide** Vol. 2, pp. 1097–1105 Longman, Singapore Publishers (Pte) Ltd.

Department of the Environment, Scottish Development Department & Welsh Office, (1987). **Housing and Housing Construction Statistics 1976–1986 Great Britain.** HMSO, London, UK.

Housing Corporation (Scotland) (1989). New **Financial Regime for Housing Associations in Scotland,** Circular 3/89, Jan. 1989.

Institute of Housing (1989). **The 1988 Housing Act Explained.** Institute of Housing, London, UK.

Kennerley, W.J., & Oxley, M.J. (1989). Economic Analysis and Property Maintenance, in **Building Maintenance & Modernisation Worldwide,** Longman, Singapore Publishers (Pte) Ltd.

Stafford, B., & Brandon, P. (1988). **The Potential for Expert Systems Within Housing Associations.** University of Salford, UK.

Tuts, R. (1989). Evaluation of Design Alternatives Through Computer-Aided Life Cycle Costing for Low-Cost Housing Projects in Nairobi, in **Building Maintenance & Modernisation Worldwide,** Vol. 2, pp. 1097–1105 Longman, Singapore Publishers (Pte) Ltd.

167
Information technology in housebuilding management

W.D.WOODHEAD

Abstract
Housebuilders face increased expectations in respect of quality and performance, environmental design, health and safety, and working conditions. This paper describes how computer-based management tools are being used to improve technical performance, administration, and operational functions as well as financial management. The importance of taking an integrated approach to ensure maximum effectiveness is emphasised, because this ensures that functions are complementary and data transfer is possible not only within a company but to and from external organisations. The nature of information is described and the functions of some specialist computer packages developed for the building industry are outlined.

Keywords: Housebuilding, Computer Software, Integration, Management, Videotext, PCs, Electronic Data.

1 Introduction

Housebuilders face increased expectations from buyers in respect of quality and performance, from the community in respect of environmental design, and from unions and workers in respect of health and safety and working conditions. At the same time, competition limits the opportunity to increase prices to cover additional costs. However, greater efficiency is being achieved with builders using computer-based tools to better manage their businesses and so overcome these impediments to profitability.

Computers have become smaller, cheaper and more powerful and have the capability to access information-based services provided by external organisations with great accuracy and economy. Now the thrust of purchasing choice has shifted from computer hardware to the software and to the means whereby it can increase personal and company productivity and profitability.

It is now being more generally realised that different software packages must link together in an harmonious manner, not only in terms of what they do and how, but also in the electronic transfer of information. The workings should be easily understood and practical, the technology blending with work practices to resulting in the quality and quantity of output being enhanced. The terms 'electronic data interchange' and 'user friendliness' are not just buzz words but are factors vital for successfully integrating computer systems.

This paper outlines the development of computing software for building, defines the operational and financial functions of housebuilders, identifies the nature of some of the information which is transferred, emphasises the areas where compatibility is needed and outlines the bases of software including some building-specific software packages.

2 Impact of computers in building

Computers have been used by large and medium size companies for years, but in Australia the software industry has made only limited attempts to meet the needs of small builders. The market is relatively small and this has been accentuated by a tendency for larger companies to have custom software written and to maintain confidentiality as to its nature, in order to maintain a competitive edge. This was rather curious given the considerable movement of personnel between companies. Specialised packages now exist to cover most facets of building activity, but there is some way to go yet before all functions are satisfied at different depths of complexity.

It is only recently that smaller builders have become aware of the benefits which can accrue from appropriate software in the running of their businesses. They are now realising it is not 'if they are to get a computer, but 'when'.

A brave move to introduce computers to small housebuilders was made in 1986 when the Housing Industry Association in Victoria became a participant in a national, privately run videotext network. For a monthly fee, members of the Association could gain access to a range of building industry services provided by the HIATEX system. The subscription fee included provision of a terminal which the user could plug into the television set and link via a modem to the telephone. The system did not meet expectations mainly because the providers of the system were waiting for an increased number of subscribers, and vice versa. Nevertheless, HIATEX has survived and it has become clear that videotext is an excellent medium where current information is sought and where access time is short.

3 The nature of software

Software falls into a range of types, from the general which includes word processing, spreadsheets and databases, to the generic, such as accounting, scheduling and personal contact management, to industry-specific, in which, for example, accounting and scheduling packages include features associated with building. A fourth category is software for particular functions, such as energy, acoustic and structural analysis. Fortunately consulting services are arising and, together with the increasing participation of industry associations, are providing builders with a source of information which is less biased than obtainable from software producers themselves.

Initial selection of software is of the greatest importance because of the enormous commitment which ensues in training and setting up the practices which the software requires. Choice is influenced by the size of the company and its philosophy of use, with larger companies with specialist staff having specific and sophisticated requirements for a wide array of functions at a high level of complexity. Smaller companies which are feeling their way with computers may have similar needs, but at a much lower level of complexity, or they may contemplate only a limited range of functions, at least initially.

One of the most important aspects of choice is to ensure that there is a matching in complexity level between packages which address different functions, for example an elementary low-level CAD system would best be matched to simple estimating, scheduling and accounting systems, not complex ones.

It is desirable to have only one word processing, accounting or CAD package in a working group, so the more intricate features of a package become familiar and files can be transferred easily. Having several in operation reduces productivity and promote errors, notwithstanding that some individuals may hold strong preferences for the desirable features in particular packages. Some features may have to be sacrificed in the interest of uniformity.

By way of contrast, packages for specialised functions, such as energy use analysis, feasibility and cost estimating, have a more restricted use and it is often valuable to have a range of packages which may have individual features available to handle particular tasks. Whatever packages are in use, it is important that there is access to detailed knowledge of the basis of calculations and output specifications.

4 Tasks in the housebuilding process

Whilst the housebuilding process involves a wide range of professions, trades and skills with diverse activities, most functions fall into fairly well-defined areas, such as administration, operational, technical and financial.

Administrative activities include engaging subcontractors, preparing time sheets and ordering materials. Operational activities include marketing, scheduling and quality assurance. Technical areas may be included within a large company or carried out by consultants for smaller firms and encompass general architectural design, specific design for items such as windows, and structural design, including wind loading, and seismic and thermal analysis.

Financial functions include feasibility studies, cash flow forecasting, estimating, tendering and budgeting, preparation of payrolls and calculation of various taxation obligations, as well as mandatory accounting procedures.

A representation of some of these functions is shown in Fig. 1.

There have been only limited attempts on the part of the software industry in Australia to get an understanding of the real needs of the building industry and of the features which make it different to other industries. Some of the unique features make general packages unsuitable, for example most building companies do not need the comprehensive inventory and stock control which often feature prominently in accounting packages.

The availability of building software has improved in recent years but it is often difficult for a builder to determine the suitability of generic packages for his requirements. Small builders tend to seek software packages which reflect their current practices and are needful of sound and unbiassed advice as to the best approach they

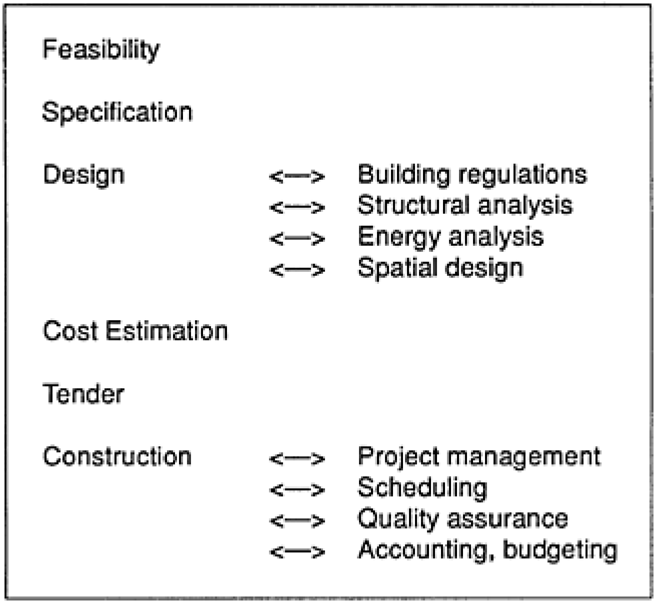


Fig. 1. Linked functions in the building process.

should adopt. Whilst the more generally applicable functions usually have an extensive choice of packages, builders rarely know the right questions to ask of a salesman and frequently the salesman is ignorant of a builder's needs. Knowledgeably exploring the detail differences with a consultant, enables a potential user to select the package best suited to the particular circumstances.

5 Electronic transfer of information

Given the extent of software development, it is not surprising that the structure and operation of different programs vary widely. However, from a user's viewpoint it is helpful if there are similarities in the structure and operation of packages to be used in conjunction. However, what is even more important in terms of overall effectiveness, is the compatibility of the parameters and functions of packages so that the output of their integrated use will have a high level of integrity.

For example, an estimating package may produce from input dimensions an output value of calculated area. If this is to be used subsequently as input for another software package, it is important that the two forms of measurement are the same—does the area refer to the dimensions inside or outside the wall? Prospective buyers of software need to know such facts and are urged to look for areas of possible inconsistency before purchase. Similar concerns arises in respect of calculations: because of their often complex nature it is often hard to know whether they are done in the anticipated manner. Attempts to check the output should be made wherever possible when the software is first acquired, using simple values and a calculator.

The transfer of information between groups involved in different industries poses major problems in terms of both the nature and the form. Definitions and standards are needed to ensure that data can be transferred in an accurate and error-free manner. Definitions of the data include its nature, form, sequence and layout. The nature refers to the nominally similar parameters being identical, as noted above in respect to floor measurers. The form refers to the alpha, numeric, binary or some abbreviated representation. The sequence refers to the order in which parameters are listed and the layout refers to the grouping of the data with defined separators and line delineators.

In some building software packages, data have been transferred electronically for some time. Price files of materials and labour may be updated by the user reading in a disk which contains latest prices as a file. At least one 'buying guide' is available, in which three-monthly updates are provided of the products and services required for house construction and which includes government fees and charges for licences and permits. In such instances the format of the parameters comprising the items must be compatible and so the use of the files is limited to particular software.

A summary of the sort of data which are used at different stages in the building process is given in Figure 2. At this stage there is need for the establishment of standard forms for data transfer in the building industry, as most of the development is currently being carried out on an individual basis by trading partners, such as material suppliers and large clients. There is a growing realisation that industry wide coordination is required, as reflected in the creation of EDICA, the Electronic Data Interchange Council of Australia, which is supported significantly by the automotive, transport, banking and retail sectors.

6 Videotext communications

The HIATEX system previously referred to has provided a communication medium which links clients, builders and their subcontractors. Videotext is costly when long connection times are involved, and programs involving large amounts of input, output and calculation are best performed on individual computers or networks. However, it is ideal for accessing current information. Services provided included: ordering of materials and services, job cost estimating and a housebuilding industry news service. The system also enables access to more general services provided by other commercial interests such as banking and travel.

Especially popular features are the listing of jobs and labour available, whereby members of the public can advertise for a builder to do a job, and builders who require tradesmen can place an advertisement directly on the system through their terminal, as can tradesmen who are seeking work from builders.

The Cash Book feature provides an easy method of recording payments and receipts in a simple and accurate manner. It enables examination of expenses by type, by date or by job. The Cash Book also allows tracking of costs and income and thus the cash flow of a job and a comparison of the actual costs against the budget. The facility enables a small builder to keep his eye on costs in a systematic way and greatly assists the accountant in the preparation of accounts and tax returns.

Stage	**Input**	**Output**
Project feasibility	Specification Building form Building size Cost structure	Building functions Proportions Dimensions $ Required
CAD design	Structural analysis Energy analysis Architectural design	Loads, dimensions Fabric, use, location Dimensions, number
Bill of quantities	Dimensions Numbers Materials Trade labour input	Quantities of items
Cost estimate	Quantities of materials Labour, equipment, consultants	Costs of above
Tender procedure	Cost estimate Market factors Company factors	Bid
Schedule	Building elements Construction method	Dates of stages Earliest start, latest finish
Management	Document tracking Personal contacts Quality assurance Reporting	Identification, location Details Checks Progress details
Accounts	Cost centres	Labour, material Overhead, margin Budget, profitability

Fig. 2. Data evolution in the building process

A novel approach to the ordering of materials was incorporated in the videotext system when it was originally introduced. This enabled a subscriber to order items directly through the videotext terminal. Access was available to a range of supplier subscribers who had their product ranges listed and a purchaser could place an order together with instructions for delivery. Whilst the procedure was good in theory there were several shortcomings in practice. It proved difficult to get suppliers to use the system as they maintained there were insufficient subscribers, whilst the subscribers complained of the lack of suppliers. More importantly, there were complaints that the suppliers failed to service orders quickly and that the communication was inferior to telephone orders which ensured that a message got across precisely. This related primarily to delivery instructions and was evidenced by several loads of bricks being delivered onto wrong sites, costly errors indeed. In fact, both the suppliers and the builders valued the personal nature of the conventional telephone system whereby the supplier can take the opportunity to pass on other relevant information which he believes may be valuable to a particular customer. Whilst none of the problems seemed insurmountable, the videotext ordering service never became popular and was eventually dropped.

The videotext network has proved a useful facility in giving small builders some experience with computers without going to a lot of expense, at a time when PCs were very costly and the technology was advancing rapidly.

7 Specialist software produced by the Division of Building, Construction and Engineering

7.1 The application of research

The Division has, over the years, developed software for a wide range of areas which embody, in a practical manner, its research expertise. It has avoided areas in which commercial software developers are active and has attempted to fill gaps in building software availability. In some areas, for example critical path scheduling, the Division contributed substantially in the pioneering stages but explored other areas when commercialisation became established. However, as a result of a perceived need it has recently produced a simplified scheduling system for housebuilders.

Considerable research effort has been directed to the development of expert or knowledge-based systems which embody particular areas of expertise in such a manner that it can be tapped by users in a logical interrogative manner. Brief descriptions of some of the Divisional software are given below:

7.2 Feasibility studies

The economic feasibility of a sizeable building, for example a block of flats, can be determined with the FINFEAS program developed by CSIRO (Tucker, 1986). Construction cost and time can be estimated using different interest rates, taxation scales, and profiles of income, maintenance and other life cycle costs.

7.3 Housebuilding scheduling

The many scheduling packages with critical path evaluation and resource levelling are unnecessarily complex for the small housebuilder. MASTERPLAN has been developed by Woodhead (1990) to identify the completion date of 15 stages in a job from a brief specification, the to identify the details of the trade teams. The package can also schedule together a work program of 8 separate jobs and indicate the resource requirements required during the ensuing 8 weeks.

7.4 Cash flow forecasting

FINCASH, which has been described by Tucker (1987), enables developers, builders and quantity surveyors to plan the construction process with different scenarios. It embodies a generalised form of the S-curve relationship between expenditure and time and enables assessment of features such as rise and fall, budget revisions, local holidays, differing cash flow profiles and payment schedules. Input parameters include interest rates, construction costs, rental circumstances and access to occupancy.

7.5 Job cost estimating

Some accounting packages have cost estimating modules based on the use of rates which have been derived from other jobs, combined with quantities taken off a plan. The QUOTE cost estimating system for housebuilders operates rather differently (Woodhead *et al.,* 1987). The builder inputs some basic dimensions from a plan and answers questions which effectively provide a specification of the construction method. Quantitative information of different materials and trade labour is then generated by the program and this is linked to a price file. The output comprises lists of materials and trade labour input for a series of cost centres based on the trade segments of work.

The system enables costing of the most commonly used building systems in Australia and has been in use for about four years on the HIATEX videotext network.

7.6 Energy use evaluation

A cooling and heating energy package, CHEETAH, has been developed (Delsante, 1988) to assist in the design for small buildings such as houses, schools or low-rise offices. It predicts hourly temperatures and heating and cooling energy requirements in up to ten zones of a building, using real climatic data for periods ranging from one day to a full year. A library of commonly used building sections (i.e. walls, floors, etc.) is available for describing the building, and the behaviour of the occupant in using curtains and moveable shading devices can be taken into account, and the building can be rotated relative to the compass by any amount.

7.7 Wind loading calculations

WINDLOADER is used by engineers and builders to calculate the wind loads on houses and buildings including building shape, terrain, shielding, topography, location and other factors (Sharpe and Marksjo, 1989).

7.8 Building regulations

BCAider is an expert system, described by Sharpe *et al.* (1990), which enables easy interrogation by users when applying the Building Code of Australia, and explains aspects of the regulations and how they apply to the user's building.

7.9 Window design

WATERPEN is an expert system which assists in the design of leak proof windows and uses graphical techniques to explore alternatives. It has been described by Thomson *et al.* (1987).

8 Conclusions

A wide variety of software tools are now available to assist builders to better run their businesses, and consulting services are becoming available to assist builders in selecting suitable software for their circumstances. When selecting, it is important to consider not only how adequate are the functions provided but also to envisage how the packages will be linked together to achieve the most effective use in line with company objectives. It is important to ensure, before purchase, compatability of electronic output if it is intended to transfer data files from one program to another. It is relevant also to consider the software used by associated organisations so that transfer of information to them may be by telephone modem or disk. The development of standards for the transfer of electronic data is proceeding and is likely to prove especially important to the building industry because of the large number of participants in the building process. The Division of Building, Construction and Engineering has produced a range of specialised software packages which have incorporated the results of research into building and which have filled gaps left by the major producers of computer software.

9 References

Delsante, A. (1988) CHEETAH: A thermal design tool for building energy management, in **Desktop Planning** (eds P.W.Newton, M.A.P.Taylor and R. Sharpe), Hargreen Publishing Company, Melbourne, Ch. 36, pp. 354–363.

Sharpe, R. and Marksjo, B.S. (1989) Expert systems for engineering codes. Proc. IABSE Colloquium, 'Expert Systems in Civil Engineering', Italy, Oct. 1989, pp. 383–391.

Sharpe, R., Marksjo, B.S., Oakes, S., Cao, Z., Guo, W. and Mashford, J. (1990) BCAider—PC software to help building code users and developers. World Building Official's Congress, Sydney, Oct. 1990.

Thomson, J.V., Marksjo, B.S. and Sharpe, R. (1987) A knowledge-representation language for engineering design codes. **Environment and Planning B, 14,** 293–304.

Tucker, S.N. (1986) A life cycle costing model for large buildings. **Australian Institute of Building Papers,** 1, 51–66.

Tucker, S.N. (1987) Modelling time-dependent building cash flows, in **Building Cost Modelling and Computers** (ed. P.S.Brandon), Spon, London, pp. 619–626

Woodhead, W.D. (1990) Improving housebuilders’ scheduling. Proc. CIB 90, ‘Building Economics & Construction Management’, Sydney, March 1990, 6, pp. 597–604.

Woodhead, W.D., Rahilly, M., Salomonsson, G.D. and Tait, R. (1987) An integrated cost estimating system for housebuilders. Proc. CIB Fourth International Symposium on Building Economics, Copenhagen, pp. 142–151.

PART FIVE
POLICY

168
Dynamics of investment in new housing and other new construction work

A.AKINTOYE and R.M.SKITMORE

Abstract
Economic theory suggests that construction investment varies directly with business and consumer confidence in national economic situation and inversely with price changes and interest rate. Studies of public and private sectors new housing and other new construction works using OLS regression analysis on UK data reveal the time lags and dynamics of these relationships. The time lags reveal the question of how rapid the construction investment could respond to changes in these underlying economic factors, as this may substantially determine private and public sector construction investment policies.

Keywords: Construction Investment, GNP, Interest Rates, Unemployment, Tender Price Level, Seasonal Variations.

1 Introduction

It is largely accepted that there are changes in construction investment and the type of construction work available to construction contractors at every point in time. Contractors are faced with the uncertainty of workload levels and are limited by the inability to identify specific construction markets for future engagement in expansion. According to Groak and Ive (1986), this situation affects the amount of cost-reduction innovation that contractors may be willing to undertake.

On the other hand, policy-makers both in the private and public sectors, and property developers, need technical and economic information to make construction investment decisions that will optimise their cost-benefit analyses. Most of the time they are involved in, and have to cope with, making decisions based on intuition and limited knowledge of the working of economy as it affects the construction industry. There is no doubt that the industry is characterised by fluctuating investment perhaps due to this intuitive decision making. The industry lacks decision support systems for construction investment. The generally poor understanding of construction investment is perhaps an indication of a continuing lack of interest in the construction sector.

The unusual pattern of investment in construction work needs a thorough examination on basis of the different construction types. It is accepted in modern economics theory that corporation tax, level of inflation, interest rate, business and consumer confidence, capital goods prices, etc., have strong links with general investment spending. Our knowledge of the interaction of these variables, with respect to investment on the basis of construction type, appears to be limited.

Accurate modelling of construction investment on the basis of construction types is expected to bring a better understanding of the interacting variables to assist in providing decision support needed by contractors, policy makers and property developers alike. For example, a better knowledge of the construction investment determining variables on the part of contractors may actually assist in timing of future fluctuations in investment on a construction type basis so that contractors can rationally plan the utilisation of construction production resources in response to expectations.

This paper, examines UK construction investment trends on a construction type basis and considers alternative explanations for fluctuations using ordinary least square regression method of analysis on a variety of indicators.

2 Investment in construction

The products of the construction industry are usually regarded as investment goods and part of fixed capital formation, which is essential for a rapid or continuous economic growth. Investment in construction work averaged between 8% and 12% of the U.K Gross National Product within the past two decades indicating the importance of construction products even in a developed economy.

The needs for investment spending can be generally classified as (1) expansion (to create additional capacity) and (2) rationalisation (to reduce cost, so that the profit margin could be maintained). When investment is undertaken primarily on the basis of the need for expansion it lead to economic growth. Construction investment for expansion may be either “growth-initiating” and “growth-dependent” (Drewer, 1980). When investment expenditure influences the trend and cyclical components of economic growth, such investment could be regarded as “growth-initiating”. Construction brings about growth, particularly in developing industry, due to its multiplier effect on the economy. In developed countries, however, most of the investment in construction is growth-dependent, which makes construction investment a derived demand.

According to Wells (1985), construction is generally used to describe the activity of the creation of physical infrastructure, superstructure and related activities. Construction investment can, therefore, be classified into five broad categories as follows (HMSO, 1989):

2.1 Public sector—new housing

Public sector new housing comprises investment in dwellings commissioned by governmental institutions/departments. This includes local authority housing schemes, hostels, quarters for the services and police, old people’s homes, orphanages and children’s remand homes, and the provision within housing sites of roads and services for gas, water electricity, sewage and drainage.

2.2 Private sector—new housing

This encompasses all privately-owned buildings for residential use, such as houses, flats, maisonettes, bungalows, cottages, and provision of services to new development. Also included is speculative work where no contract or order is recorded.

2.3 Public sector—other new work

This relates to any other construction work undertaken by governmental institutions apart from public sector housing. This includes construction work with respect to education, transportation, health, social services, commerce, agriculture, etc., provided from public funds.

2.4 Private sector—industrial work

Construction investment in private sector industrial work is diversified, and includes industrial production and processing, the oil and power generating industries, etc., provided by the private sector. Examples of this include factories, warehouses, electricity and gas installation, and in recent times construction works commissioned by privatised establishments such as British Telecom and British Gas.

2.5 Private sector—commercial work

This relates to private sector construction investment into the field of commerce. It includes the construction investment in office blocks, entertainments, schools and colleges, agriculture, health, churches, garages, etc.

3 Trends in construction investment

UK Department of Environment (DoE) data (Figures 1, 2, and 3) show clearly the fluctuation in the construction investment between 1974 and 1988. Figures 1 and 2 show the investment by construction type at current and real prices (1974 rebased) respectively. Figure 3 shows the shares of the construction type in the total quarterly construction investment within this period.

With the exception of private sector industrial work to some extent, none of these investment types have been stable over the years. There have been large fluctuations in the share of individual construction types, notably the rising share of private sector commercial work and housing, and drastic falling in share of public sector housing.

The 1970's witnessed low emphasis in private sector construction investment and were characterised by large scale public sector construction investment both in housing (10%-25% share) and other new works (25%-35% share). Contrarily, private sector construction investment was dominant in the 1980s, with 20%-35% investment shares in both private sector housing and commercial work.

The trough in construction investment between 1980 to 1984 was

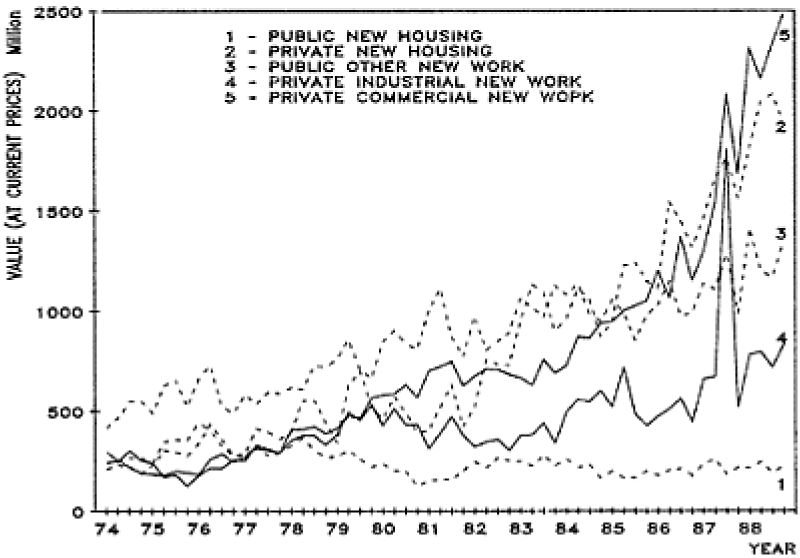


Figure 1 Sectorial investment in new construction works at current prices.

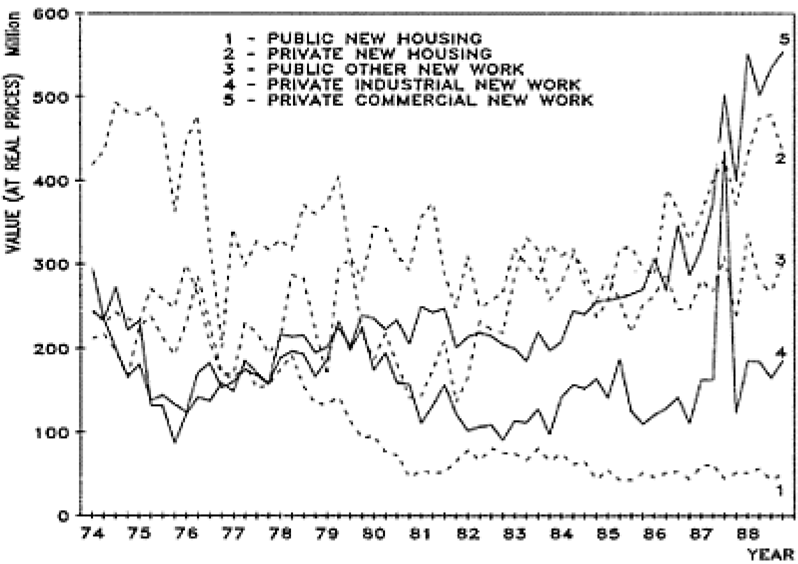


Figure 2 Sectorial investment in new construction works at 1974 price

probably due to the recession of early 1980's. However, these years coincided with the beginning of an acceleration in private sector investment in housing. The spontaneous rise in private sector industrial work in 1987, second quarter, is due to an element of European Channel Tunnel investment that is included in the value of industrial work. Otherwise, private sector industrial work had a stable share of 10%-20% of total construction investment.

Changes in the pattern of investment in construction types over the period is, perhaps, associated with changes in government policies and the rapid changes in the determinants of fixed investment in construction and manufacturing. Recent government policies place more emphasis on a freer market economy, while both individuals and firms are being encouraged to invest more in construction work. For example, the reduction in corporation tax has a tremendous impact on establishment of new private establishments. The increase in the stock of owner-occupied, at a considerably faster rate than the stock of renter-occupied residential buildings, in 1980's is perhaps as a result of government policies on low mortgage interest rates relative to the inflation rate and the tax savings available to home-owners, which grew in importance as marginal tax rate rose. These inducements led to boom in the private sector housing investment. However, there is slump in private sector construction investment at present, most probably due to the high inflationary level and rise in interest rates.

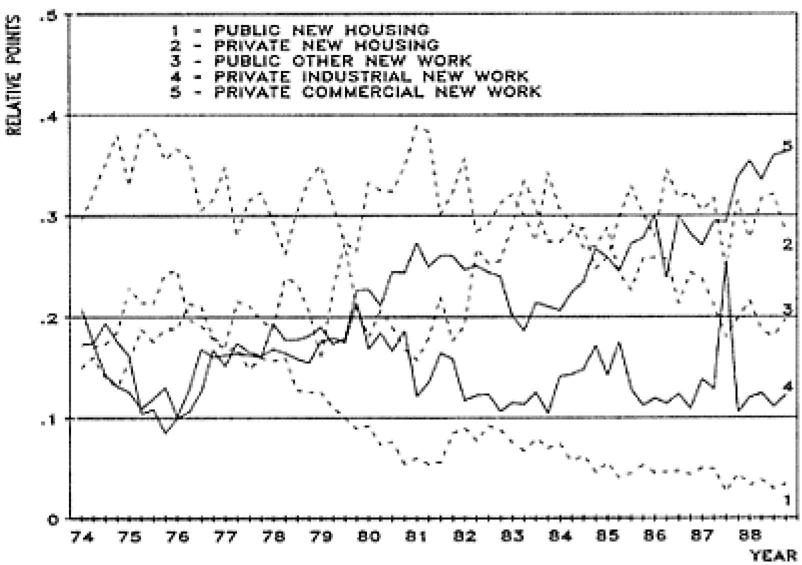


Figure 3 Relative sectorial investment in new construction works

4 Determinants of construction investment

The factors determining general investment have been classified into (1) changes in expected sales (accelerator effects) and (2) the cost of capital (Kahn, 1985).

The impact of expected sales is directly related to investment. As expected sales accelerate it may be expected that general investment should equally increase. In essence, the desired capital stock depends on the expected sales. The expected sales react with varied responses to business and consumer confidence. Business and consumer confidence, on the other hand is governed by factors such as the timing of governmental spending and consumer income. Since increases in expected sales growth are often associated with increases in real Gross National Product (GNP), it follows that GNP determines the desired capital stock and consequently, the amount of investment spending. GNP can therefore serve as a good proxy for expected sales growth and could be considered as one of the determinants of investment into construction work (Akintoye and Skitmore, 1990a).

Investors do make investment decisions based on comparisons of marginal return on capital invested and the user cost of capital. Rational investment decisions are made when expected returns exceed the cost, as it becomes profitable to invest under such conditions. Kahn (1985) identified three determinants of the user cost of capital—interest cost which has a negative impact on the investment, depreciation cost and inflation.

Depreciation cost relates to the cost of replacing the wearing out of capital items. In this case, the faster capital item depreciates, the faster the need to replace it in order to maintain capital stock at a constant level of productivity at current prices. Though it is usually claimed that construction products appreciate rather than depreciate, the emphasis here is on current price, which suggests that price is an important factor in investment decisions.

Inflation provides a capital gain that lowers the user cost of capital as it tends to raise the cost of existing construction. Since interest and inflation rates determine the user cost of capital, it follows, therefore, that they both have an impact on credit market conditions and consequently the level of general investment. The difference between interest and inflation rates (real interest rates) is a good measure of credit market condition (Hess 1977, Lombra 1984).

Other factors which afffect construction investment are unemployment and seasonality. A reduction in the rate of growth of employment and the resulting increase in unemployment may discourage investment in construction, as this has a direct link to the total purchasing power of the population.

The volume of construction investment tends to vary with the seasons of the year. Although seasonal fluctuations can vary with geographical location and type of construction, summer is usually regarded the peak season and winter a slack season for construction activity. This is most probably due to the effects on productivity of inclement weather and low temperature in winter. These tend to have direct influence on clients' preferences for certain periods of the year to place new construction orders. Russell and Pilot (1969) for example, found that the summer period of the year brings complaints of labour shortages from contractors, as this period is usually associated with larger construction investment.

5 An econometric specification and analysis

The models of investment in construction on work type basis (public sector new housing, private sector new housing, public sector other new work, private sector industrial work, and private sector commercial work) were estimated based on OLS regression analysis.. This analysis used GNP; real interest rate (RIR); construction price level (TPI); unemployment (UNEMP); and seasonal dummies for spring (D_1), summer (D_2) and autumn (D_3) as the explanatory variables. The monetary variables (dependent and independent) value were rebased to 1974 to remove the impact of inflationary effects on the analysis. So also, with the exception of the real interest rate (which may have a negative value) and seasonal dummies, the variables (dependent and independent) were expressed in natural logarithms, so that the coefficients of the independent variables represent their elasticities.

The lead relationships between the dependent and independent variables were estimated using a multiple regression program (after Akintoye and Skitmore, 1990b). The choice of appropriate lead relationships out of the 6561 separate regression models produced by the program for each of the construction investment types was based on models that (a) minimize the mean square error, (b) maximise the number of cases or the set of observations on which the regression is based, and (c) consistently produced a lead period for each variable in relation to the other models.

The results and the analyses of the choice of models based on the simultaneous entry of the explanatory variables into the construction investment function on work type basis are as follows:

5.1 Public sector new housing

The estimated investment function for public sector new housing is shown in Table 1. This investment function has the expected sign for construction price and unemployment. The price elasticity of demand is elastic and the lead period of two quarters suggests that public sector investment in housing responds fast to price changes. The model also supports the hypothesis that large scale unemployment (beta coefficient=−1.35) could lead to low investment in housing. Positive relationships are expected with respect to GNP; spring and summer dummies; and a negative relationship with real interest rate. Though, the results of these four variables are not statistically significant, these unexpected signs tend to have important implications for governmental investment in housing in suggesting that government provision of residential building is less motivated by economical gains or situations. This lends credence to the notion that government investment in housing is influenced more by public needs, political gains and the need for government to reduce the seasonality of construction work in view of the industry impact on general economic growth.

Table 1 Public sector new housing investment function

	CONSTANT	TPI	GNP	UNEMP	RIR	D_1	D_2	D_3
Coeff.	18.383	−2.494	−0.145*	−0.896	0.009*	−0.010*	−0.072*	−0.145
Beta		−1.073	-0.271	−1.346	0.213	−0.017	−0.124	–0.248
t-value	8.611	−6.945	−1.087	−5.689	1.196	−0.175	–1.262	−2.500
Lead		2	8	0	4	0	0	0

* Not significant t-value (at 5% level)

R	0.85	R^2 Adj	0.67
RMSE	0.15	DW	1.33

5.2 Private sector new housing

Table 2 shows the investment function for private sector housing. The variables have the expected signs with the exception of real interest rate. The construction price and the GNP responses are elastic. This suggests that an increasing income with two quarters lead stimulates the investment for private sector housing at an even greater level. Other things being equal, construction price has a reduction effect on private sector housing. With price elasticity of 2.384, an increase in construction price with two quarters lead, will bring down the investment in private sector housing investment by more than that proportion. Unemployment produced an inelastic negative relationship. There is seasonal variation in the private sector housing development, such that the spring and summer periods are associated with increasing investment and autumn with low investment. The real interest rate, with an unexpected sign, produced little effect on the investment when compared with other variables in the investment function (beta=0.245).

Table 2 Private sector new housing investment function

	CONSTANT	TPI	GNP	UNEMP	RIR	D_1	D_2	D_3
Coeff.	3.428	−2.284	1.263	–0.888	0.024	0.19	0.221	–0.05
Beta		–0.481	0.930	–0.597	0.245	0.136	0.163	−0.037
t-value	2.108	–9.780	12.382	–8.264	4.767	4.018	4.760	−1.072
Lead		2	2	0	6	0	0	0

* Not significant t-value (at 5% level)

R	0.98	R^2 Adj	0.96
RMSE	0.12	DW	1.41

5.3 Public sector other new work

The estimated investment function for public sector investment in other new work is shown in Table 3. Construction price is negatively correlated with public sector investment though not statistically significant. National income has a positive inelastic relationship with the highest beta coefficient (beta=1.147). The lead period of seven quarters with respect to GNP tends to suggest that it takes a some time for the impact of the national income to be felt. The lack of seasonal variation tends to support the role of the government in stabilizing construction industry workload against seasonal fluctuations. Credit market conditions do not seem to adversely affect government investment in construction work. This tends to support the notion that the government has a duty to boost the economy in the times of national financial hardship through the public investment spending.

Table 3 Public sector other new work investment function

	CONSTANT	TPI	GNP	UNEMP	RIR	D_1	D_2	D_3
Coeff.	0.770*	−0 .164*	0.638	–0.261	0.008	−0.007*	−0.100	−0.125
Beta		−0 .082	1.147	−0.486	0.200	−0.013	−0.171	−0.213
t-value	0.528	−0.700	4.348	−1.758	1.956	−0.196	−2.620	−3.309
Lead		6	7	5	8	0	0	0

* Not significant t-value (at 5% level)

R	0.94	R^2 Adj	0.86
RMSE	0.09	DW	1.62

5.4 Private sector industrial new work

Table 4 shows the private sector investment in industrial construction work. All the variables in the investment function have the expected signs. Price, with a lead period of two quarters, and income are elastic. Responses to unemployment are negatively inelastic. The highest beta coefficient (1.42) with respect to the GNP suggests that income level is very important in industrial construction investment and the effect seems to be noticeable very early (lead period=2). Real interest rates have a negative relationship with a lead period of eight quarters, though not statistically significant. There are seasonal variations in Table 4 Private sector industrial construction investment function

Table 4 Private sector industrial construction investment function

	CONSTANT	TPI	GNP	UNEMP	RIR	D_1	D_2	D_3
Coeff.	−3.49	−1.349	1.349	−0.852	−0.008*	0.103*	0.175	−0.056*
Beta		−0.362	1.423	−0.889	−0.125	0.115	0.194	−0.062
t-value	−1.13	−3.423	6.236	−5.278	−0.953	1.359	2.280	−0.733
Lead		6	2	2	8	0	0	0

* Not significant t-value (at 5% level)

R	0.89	R^2 Adj	0.76
RMSE	0.19	DW	1.97

industrial construction investment. Spring and summer are associated with increasing investment and autumn period with declining investment.

5.5 Private sector commercial new work

The investment function with respect to private sector construction investment in commercial new work is shown in Table 5. This shows that all the variables have the theoretically expected signs. The price, income and unemployment are elastic. However, the response of the investment function with respect to GNP is more for commercial work than industrial construction work and this suggests that income or the national economic situation has an impact on commercial construction work. The income lead period tends to suggest a two quarter waiting period to build up investors' confidence in what may appear to be a booming economy, or to exhaust an existing excess of construction stocks before more is desired. The negative impact of real interest rates may not be fully felt until about six quarters thereafter, while the impact of increasing construction price seems to come very early. Seasonal variations in commercial construction seem to exist, though these results are not statistically significant.

Table 5 Private sector commercial construction investment function

	CONSTANT	TPI	GNP	UNEMP	RIR	D_1	D_2	D_3
Coeff.	−15.78	−1.107	2.531	−1.170	−0.014	0.026*	0.067*	−0.086
Beta		−0.183	1.685	−0.788	−0.130	0.017	0.045	−0.058
t-value	−10.70	−3.024	15.071	−6.190	−2.747	0.549	1.465	−1.847
Lead		1	2	2	6	0	0	0

* Not significant t-value (at 5% level)

R	0.99	R^2 Adj	0.97
RMSE	0.12	DW	1.33

6 Summary and conclusion

Using quarterly data, we estimate construction investment with respect to public sector housing, private sector housing, public sector other new work, private sector industrial work and private sector commercial work.

The models produced for the five different construction investment seem to be satisfactory in several counts, (1) they are statistically significant, (2) they have some theoretical basis, and (3) they are based on comparative variables. The models have R^2 adjusted values of between 0.67 and 0.97 for the deflated data with acceptable Durbin-Watson statistics by Stewart (1984) criteria. The results indicate that:

(a) The construction investment types respond negatively to construction price, though the degrees of the response vary. The high price response of public sector investment in housing is perhaps due to the fact that most public housing schemes are undertaken by local authorities rather than central government. Local authorities are limited in terms of funds available, are usually more accountable than central government, and perhaps more price sensitive. Central government is more involved in public sector other construction work, which shows a least response to construction price. In the private sector, investment decisions are most likely to be based on a cost-benefit analysis. With respect to private sector industrial, commercial and housing work, the elasticities and/or beta values of GNP exceed those of construction price which tends to support the use of rational investment decisions in the private sector.

(b) Private sector construction investments have a positively elastic relationship with GNP. This tends to support the importance of national income or economic conditions to private sector construction investment. However, public sector investment in construction is, perhaps, attributable to other factors than national income. Governments have social and welfare obligations to the people being governed. Also, it is not unlikely that the public sector proceeds in the opposite direction to the general economic situation such that the government acts to increase construction investment spending in times of economic recession and reduce investment spending in times of economic boom so as to stabilize the national economic condition.

(c) Unemployment is negatively and inelastically related to construction investment, with the exception of private sector commercial construction work which has an elastic response. This has two implications (1) an increasing unemployment rate has a declining effect on construction investment generally and (2) changes in the unemployment level in an economy is good indicator of the trend in construction investment.

(d) The lack of an expected negative relationship between public sector construction investment and real interest rates tends to suggest that credit market conditions have little or no impact on government construction investment. The positive relationships found in these cases tends to support the obligatory role of the government to increase it's spending in times of unfavourable credit market conditions, in order to revamp the economy.

(e) The seasonality in construction investment is only peculiar to the private sector and particularly to housing development. This seasonal variation in private sector construction investment has a drastic impact on the industry workload, which is perhaps responsible for the seasonal pattern in construction industry unemployment and tender price levels. Public sector construction investment does not exhibit this seasonal pattern.

From a practical viewpoint, understanding these relationships is likely to help in the management of construction firms through the development of investment forecasts for the types of construction work studied. Construction firms that are able to foresee future changes in the share of construction investment on type basis may be able to plan their resources in a better way to maximise the outcome from these resources. It also anticipated that policy-makers (both in public sector and private sector) and the property developer will be more aware of the variables to investigate in their construction investment decisions and the impact these variables may have in their overall construction investment.

7 References

Akintoye, S.A. and Skitmore, R.M. (1990a) Structural comparison of sectorial construction demand, **Technical paper,** University of Salford, Dept of Surveying.

Akintoye, S.A. and Skitmore, R.M. (1990b) Analysis of UK tender price level, **Transactions,** 34th Annual Meeting of American Association of Cost Engineers, Boston, Massachusetts, pp. K7.1–7.7

Drewer, S. (1980) Construction and development: A new perspective, **Habitat International,** 9, 55–70.

Groak, S. and Ive, G. (1986) Economics and technological changes: Some implications for the study of the Building Industry, **Habitat International,** 10, 115–132.

Hess, C.A. (1977) A Comparison of automobile demand equation, **Econometrica,** 45, 683–701.

H.M.S.O. (1989) Definition and explanatory notes, 1989 Edt. **Housing and Construction Statistics Annual Supplement.**

Kahn, A.G. (1985) Investment in recession and recovery lessons from the 1980s, **Economic Review,** November, 25–39.

Lombra, R.E. (1984) The changing role of real and nominal interest rates. **Economic Review,** February, 12–25.

Russell, L.J. and Pilot, J.M. (1969) Seasonality in construction: A continuing problem, **Monthly Labour Review,** December, 3–8.

Wells, J. (1985) The Role of construction in economic growth and development, **Habitat International,** 9, 55–70.

8 Data appendix

Construction Price—Quarterly Tender Price Index. This measures the trends of contractors' pricing levels in accepted tenders for new works.

Source: **Building Cost Information Service, 1990,** "Indices—introduction" Building Cost Information Manual, Section ABb6, June.

Quarterly construction investment on work type basis—Quarterly construction new orders.

Source: **Housing and construction statistics, HMSO 1974–1989,** "Value at current prices of New-order obtained" pp.4

Real rate of interest—This is calculated as the difference between the nominal interest rate and the rate of inflation. Source: (for quarterly nominal interest rate and inflation rate) **Datastream International Ltd On-line,** A company of Dun and Bradstreet Corporation.

Gross national product—This is the most comprehensive measure of aggregate economic output. It represents the market value of total output and services produced by a nation's economy before deduction of depreciation charges and allowance for business and institutional consumption of fixed capital goods. This in essence represents the national income in the market economies.

Source: **Economic Trend Annual Supplement,** 1989 Edt, pp.12.

Unemployment—Unemployment figures refer to numbers claiming unemployment-related benefit at Unemployment Benefit Offices.

Source: **Economic Trend Annual Supplement,** 1990 Edt., pp. 112–114.

Seasonal dummy variables—These variables equal to 1 in the relevant quarter and zero otherwise.

169
The housing sector in the Portuguese speaking countries in Africa

J.BARREIRO

Abstract
This paper intends to give some ideas about the major trends of the Housing Sector in the Portuguese Speeking Countries in Africa (PALOP's). In fact we think that, giving the fundamental caracteristics of the actual situation, is more than theoretically interesting, stimulating from the practical point of view. It is important to note that the housing models in this countries and in Portugal, have gone through fundamental changes, due to the political mutations occured fifteen years ago, producing panoramas and especific interventions, due to the new realities of the brandly new social and political spaces.

1. General References

From the beginning, there are several conclusions that can be set up:

– although the growth recorded, the PALOP's still reveal a global economic fragility with consequences in the overall amount of investment made in the social sectors;
– the economic fragility also reproduces a low level of the families income, part of which complemented by an important activicty of the paralell market;
– the housing needs are high (including those related to infrastrutures of all kinds, especially in the urban areas)—, in result of the extremilly augmentation of the demografic pressures;
– for the disruption of the housing models no new suitable formulas have been found yet, making possible an efficient and self sustained functioning of the market. To the pressures of the housing demand, it can be seen an offer, in all terms inconsistent, in volume and logic.

More generally, all these facts deal with the difficulty to have (or not) an institutional support, lack of funds in a regular basis and no defined framework for the intervention of the multiple agents acting in the sector.

2. The Housing Market

Before the analisys of the market, some references to the housing stock:

– it is natural that the housing stock in these countries as grown in number, in particular, in the suburbs of the most important urbun centers. Some of these centers show however symptoms of decline, due to the loss of relevance of their urbun functions after the independence, or by reasons of the instability arrised from the war;
– if in some countries there was an improvement in the housing conditions (especially in terms of the basic infrastrutures), in others this was not the case;
– although the increasing of the housing stock, the housing needs have also increased. The construction levels did not followed the housing demand in centers where the population arrived in larger numbers. Nevertheless, it is important to note that, in these countries, the housing market must be seen (at least, methodogically) in compliance with the especific caracteristics of local habitat: rural, transition areas (urbun suburbs) and urbun areas, properlly speeking;
– the maintainance of the housing stock has declined, some times till his total ruin.

2.1 Housing Demand

As expressed before, the housing Needs can be forseen at a high level while the Demand (materialized in terms of the capability to pay a certain price) does not find ways to comply itself with the formal market. Whether by the low incomes of the families or by the difficulties to get alternative solutions in the credit market.

Looking inside the renting market, we can find different situations. While the old stock has very low rents, the shortage of the housing supply offers the opportunity to the pratice of very high and speculative ones, placing the domestic families in competitive difficulties against the foreign demand, payed in foreign exchange.

In the other side, there are the units rented by the State to the upper levels of the civil servents scale, among others, where the rents are also very low and only occasionally brought up-to-date. In some cases, this houses are not “professional units” but a kind of income complement.

The impossibility to pay has risen the number of the families that have choosed hazardous housing solutions.

These informal ways can be seen by near 50%in Cape Vert or 90%in Luanda, and in all Mozambique, and quietly similar in Guine-Bissau and S.Tome e Principe.

Note that the options through the home-owner occupied market are not an easy way to go. Besides the fact that this market does not exist in all the countries or areas, there are other factors that turns this solution obviouslly difficult: low incomes, lack of funds, high rates of interest, and even the inexistance of especific credit systems,

It is in fact in these domains of the market that it appears more clear the need for the stablishement of a framework of intervention.

Given these topics, we can display the basic points of the housing Demand as follows:

– low-income families, recently arrived to the urbun areas or in the lowest places of the remuneratory scale, generally surching a house for the first time;

– medium-class families (civil servants, young couples, etc.), looking for their first unit or wishing to improve their actual housing status;
– a third component (where can be also included the foreign demand) envolves the families having some one working in the upper level of the administration or in the public companies, with aceptable financial capability.

2.2 Housing Supply

The predisposition to invest in housing is not one of the most interesting and common situation, whether by the private or the public sectors. The first one had in the past a more coherent behaviour. Instead, the public investment, has suffered from the inconvenience of deep intermittences.

As we have already said, the economic evolution has transfered the available resources to other sectors (especially to the agriculture and industrial ones, to satisfy the public debt or the war expenditures), even those generated by the banking sector. These were the main factors that rose the difficulties of the public sector in the housing market, in some cases paralising it totally.

Due to the the restritions of the public budget and the limited funds available in the credit market—even so subjected to extremilly severe conditions—, the possibilities of intervention of the supply side become narrowed, turning the few entrepreneurs into fragile and inconsistent allies, or determining their vanishing.

Then, the inexistence of an alternative coherent model has resulted from:

– the idea of the individual landlord as promoter, exhausted for years, appears in some circunstances to be the most important actor in the supply side;
– there is a need for a capital reprodution spirit, associated to an (also) inexistent financial market;
– difficulties in the acess to credit;
– a non-coherent legal framework; or
– the almost inexistent intervention of public sector;

leaving the supply in a very contradictory situation, where the few agents had (or have) to take the maximum profit from their resources, besides their speculative posture.

The overall image is an individualist and non-organized behaviour, looking to answer to the market stimulus, without sufficient legal or institutional references.

But there are other factors. The Land is an important and preoccupier element, bloking the development of the housing sector, whether in what concerns its disponibility, forms of appropriation or yielding.

The building materials branche is another area of concern, because the local capacity of production is irrelevant, its exploitation as been abandoned or ignored as an important potential; there is a lack of local skills or entrepreneurial iniciatives in the building sector; the levels of produtivity are small due to the irrelevant professional qualifications of the workers. It remains the solution to import almost everything. The lack of foreign exchange leads to important blokages in the industrial sector and to unbearable prices, even in cases of self-help schemes.

2.3 Housing Demand and Supply Compatibility

The known main lines of the Demand and Supply tend, anyway, to establish a compatibility in the market:

– the low-income families does not find solutions in the market. The addoption of informal and spontaneous ways are usual. These become well adapted to their saving ritms and cultural patterns, although rejected by the other income classes or regulations. It is allways difficult to find institutional support for these cases;
– the midle-income families only marginally find satisfaction in the market, because this group is the one where the difficulties to pay the demanded prices are more notorious. Rejecting the informal solutions in the spontaneous and peripherical neighbourhoods, this group makes the most important pressures in the public promotion and aid schemes (when existing);
– the supply of rental units as grown, due to the high and especulativ rental levels, as an individual and private basis (its non-relevent the organized promotion for rental or to the home-owner occupied market); Note that the suplly has found a limited but sufficiently solvent market in the high-income classes, foreign experts and international agencies.

3. The Housing Finance

We can say that there are no strutured housing financing schemes in the PALOP's, and when they legally exist, their resources are scarces and they do not compatibilize their financial objectives with the social and economic interests of the beneficiares. [Their critics say that the existing schemes are used solelly by those who have allready the financials capabilities…].

Where they exist—with their basic parameters caracterized by very high interest rates and very short terms—, they provide conditions not aceptable or possible to assume by the majority of the families.

For that reason, these credit systems are mainly used in the building period, generaly by those having intentions to rent afterwords to the most affordable market (foreign consultants), through wich they can rapidly recover their capital.

Facing this situation, the main problem is how to find suitable financial produts, sufficiently addapted to the profile of the demand (most of which is, in what concerns to standards, tipically european), the cost inflation, the global financial capabilities and the expetation of the domestic and (even) foreign investors (see international agencies).

4. Institutional Framework

In general, the main challange that put to test the sectorial institutions or departments in the PALOP's are not the methods beeing used or even the policies followed but, the ways through which they are carried out into the housing market.

The diagnosis is known, local experts know how to act but, or the organizations are blocked by operative reasons or are marginalized in their decision making process.

Nevertheless, what we see is the general claim for more especialized sectorial institutions, when anyone can con-clude from the experience that, afterwords, nothing or only few things change.

From what we have seen, the lack of financial means is one of the most important reasons for so few observed results. But there other factors contributing to their failure or inefficiency: the inter-sectorial relations, the social and political pressures and impacts, dificult to deal with, and the goodwill to incorporate the housing sector into the national priorities package.

But it is not only a problem of functionality, since one of the most relevant action of the public sector is to regulate the market. In fact it is in this area where things faill for real. The truth is that no steps or only some shy ones have been made to regulate, actualize or create the majority of the sectorial instruments, with the urgency to transform the public instituions in housing promoting agencies or maintain them as landlords. The consequences are known and the exemples are, for the majority of the cases, not wise to follow.

5. Summary and Conclusions

The Housing Sector in the African Portuguese Speeking Countries is today an open problem.

The followed methodologies have been sistematicaly addopted in a centralized manner, the solutions and the means employed scarces, to much beyond the necessary or expected levels, but worse, were the reasons why the strutural functioning condictions of the Housing Market were forgoten, specially because were thought unnecessary the participation of other agents (the private) in the sector.

The existing picture of the housing sector in the PALOP indicats its own limitations, given as follows:

– there is a need to establish a managing set of instruments, taking into account the housing needs, in particular, the effective and potencial demands;

  [In these cases, the quantification of the housing needs is a pure logist mater, since what it is really important is to know whom demand, what, where, when and how much is intending (has) to pay for.]

– modification or implementation of new sectorial instruments, such as: the rental law; the update of cadastral register; the tax structure and incentives for housing and land; saving and credit schemes for construction and housing; new construction codes and standards, etc;

  [Note that the existing regulamentory specifications are in general not addapted to local conditions, where the majority of the population has no possibilities to comply it self with them. “Informal” solutions are not allowed, in cases where sites and services programs could solve and frame, in most cases, the situations. The image will be better than the one given by all those peripherical neigbourhoods, where the families inhabit but never live].

– the supply side needs also to be structured because, more than the dimension of the demand potencialities, is important to cope with the disconnections of its own agents.

In particular, the behaviour of the public sector should be seen, more than as a promoter, in the sence of its capabilities to mobilize the society towards the final sectorial objectives. [There is a need to prove if its action should not only be suppletive, if social and economically justified. Nevertheless, when necessary, its structure should be established in an entrepreneurial and decentralized way, to whom should be given the appropriate human and financial resources and the indispensable legal basis to act, facts that in the past did never occour or only very often.]

– built a physico-financial input output table of action,

[In fact, the needs are extremilly high and the resources scarces. Mobilize and know how to allocate those resources will make possible an organized and supported attitude towards the sector.]

Meanwhile, a final comment about the lack of financial resources, assumptiun that is in most cases advanced as the real barrier. What we think about it is—although there are in fact defficiencies at this level—, that the most important question is forgotten or hiden: the unefficiency of the managing and organising aspects.

We are, nevertheless, side by side those who think that there is alloways a hope and the capability to fullfill the desirable targets, that is, to reduce the quantitative and qualitative housing needs, in the basis of the existing conditions.

6. Final Remark—The Housing Market in Portugal

6.1 The existing situation

From what we have said and comment about the housing situation in the PALOP's, we shall not conclude that these problems have been solved in Portugal.

In fact, after 1974 (as in the other new african countries), the Housing Model was totally disrupted as the overall economy was it self sunked by the political situation (among other motives) and by the artificial increase of the population (near 15%), due to the return of the families leaving the ex-colonies.

Since 1976 till today, the housing sector has seen "moments of joy and others of trouble", in the course of its tipical (and notoriouslly, ciclical) production and comercialization processes.

We are facing housing needs forecasted in 1990 in about 400 000 units, mainly due to families sharing their homes with others, new families entering into the market and those leaving in slum areas.

The housing sector lives from the promoting and building capabilities of the private sector (near 95% of the total production, 50% of it in an individual basis), almost exclusivly to home-owners (more than 98% of the total production) .

This situation appeared due from the fact that the rents were frosen for almost 50 years and, when the inflation rate start to grow in the early 70% the profit margin of the invested capital start it self to loose importance, till levels, in average, bellow 1%. Taking into account the residual value (the land), it is easy to understand what rapidly occoured: a slow death of this market and model, till then based (also) in a individual landlord—

having no more than one to three rented units—, and the deterioration of the housing rented stock.

As we all know, it is easy to distroy an economic model, but very hard to bielt a new one! This is specially true in this area when other more interesting and liquid alternatives of investment appeares in the financial market.

The housing sector lives then from the available resources that the Administration can dispose to subsidize the credit system, used till now as the “unique” instrument to support the building and the housing sectors and obviously, through that, the flexibility of the the market (thus meaning, to support the families to buy their own houses…). Nevertheless, the growth of the selling prices tends to increase faster then the families incomes (note that the especulation on urban land rised rapidly, mainly after Portugal joined the EEC in 1986).

Another important factor is that the main options onto the main parameters of the credit system are taken aside the housing sector, puting the sector excessivly vulnerable to market cycles and to external decision making.

The fundamental conclusion is that in the latest 80’s, the amount of anual family incomes necessary to buy a house grown till seven (7) times the anual amount a family can got from its normal revenue. It is then easy to understand that, as in other spaces or countries, the housing demand of the middle and low-income classes have encountered dificulties from diferent sources.

6.2 The main problems

The housing model has been almost solelly sustained since 1976 by a credit system supporting the home-owner occupier market—“vocationally dedicated” to the middle and high-income classes—covering the majority of the housing production, despite the costs with interest subsidies, of doutfull economic and social efficiency.

The economic and financial managing of the system shows that the implemented credit scheme (although several adpta-tions) suffers from conjuncture strugles, simply translated into declines of credit contracts, housing production and sectorial expectations.

In the other hand, the modifications introduced into the national rental law in 1985 did not change the structural and old filled defaults, because the credit system continously tend to stimulate the families to buy.

The reabilitation of the housing stock remains something to wonder because, although the efford made, their technical and economic complexities turned the job particularly difficult, especially due to the external pressures into the real estate sector.

The housing production beeing currently subsidized by the Administration (controled price units) tend to be today not well accepted by the private promoters, since their parameters creates difficulties to the recent developments in the real estate sector: with an increasing (foreign) and (internal and directelly) sustained demand. For that reason, it is not strange that in the last few years some specific programs for the middle and low-income families had not found encouragement from the promoters.

6.3 The main objectives and mesures to adopte

The perspective, but also the main objective, to change the actual situation in the housing sector, is related to the capability of the Administration to bild and adopt an adequate and effective policy, taking into in account how much the scarce resources disponibilized to the sector showld be efficient, in social and economical terms.

This will mean the reform of several politics, mesures, instruments and sectorial programs, implemented in some particular moments, without relations to the overall frame-work and, in particular, to the specific conditions of the most needed families.

Nevertheless, there is an aspect that is important not to forguet. In fact, the Housing Policy is not neutral, does meaning that there is a need to articulate it with other areas of the political spectrum, namelly with the urban, tax, income and prices policies. If not, there will be allways a lack of coherence and efficiency.

After all this observations, we can then establish a set of general and operational objectifs to be reached:

– reduce the housing needs, in particular, those of the low-income families;
– raise the potencialities of intervention of the different agents (municipalities, cooperatives and private sector) in the housing market, reserving to the (central) Administration the role of the definition of the housing policy and the managing of the national resources and incentives to the housing sector;
– produce a more “neutral” model in the housing sector, through the establishement of a new and operative rental market, adapted to the national conditions;
– implement a strategy of costs-control (or more appropriatly, costs/prices reduction), through building materials normalization or standardization, project modeling efficiency and urbanization regulamentation and coherence; and
– last, but not the least, improve a sectiorial effective scheme, in economic and social termes, giving the possibility to manage, with racionalism, the resources afected to the housing sector.

The situation registered till now—where every one transfers to the State the entirely “social” cost of their housing schemes—, has become a political problem and, much more than that, an economic and financial dilema. We think it is time for each part to take its hown responsabilities in this area. Much more than that, turned crucial a discussion of two fundamental points:

– who decides about what in the housing sector, especially the financial resources needed for its development;
– shall the housing sector be it self a strategic domain or mearly an area where the strategies of the other sectors needs to be digested, with all the costs.

170
Housing and property management—research and development in Sweden

L.BENTON

Abstract
This paper is a describtion of research in the field of Housing and Property Management in Sweden. Research is mainly carried out at six research centres, two of these in the capital Stockholm and the rest in four major towns in Sweden. Each of the present six centres has a special profile in its research and in this way the centres complement each other. In addition a number of research projects have been encouraged and carried out at an empirical level on the demand from national organizations of housing managers in Sweden.

BACKGROUND

Research on housing and property management became an established subject for research in the 70's when the Swedish Council for Building Research initiated a number of projects. In the beginning the focus of interest was mainly on building techniques for the reconstruction of single buildings. Later the subject included the entire process of reconstruction and upgrading of housing areas and town centres. New demands in the 70's made it obvious that comparitively young houses had become "old" and needed attention. New important requirements concerning environmental issues such as waste products and their potential for recycling and treatment, accessibility in housing areas, and energy conservation in the build environment. The investigations of the housing stock were made in order to estimate the need for reconstruction. Knowledge of factors like the age, type and ownership of the building were important in order to estimate the amount of management work needed and the possibilities for reconstruction.

In the beginning of the 80's the day to day management problems came into focus along with the tenants influence on management. In 1979 SABO, the Swedish Association of Municipal Housing Companies, and the Swedish Union of Tenants adopted a joint recommendation to their members to sign special Tenant Influence Agreements. In the private sector there has been little progress in formal terms, i.e. the signing of Tenant Influence Agreements. In Sweden the housing stock during the 80's can be devided into four major types:

– one-dwelling house where the owner lives (40%)
– multi-dwelling house with tenant-ownership (15%)
– multi-dwell ing house with private rental (18%)
– multi-dwelling house with tenancy (22%)

Three of four dwellings with tenant-ownership are organized by the tenant owner cooperatives HSB (Tenants' Savings and Building Societies) and Riksbyggen (The Cooperative Building Organization of the Swedish Trade Unions). The main goal for cooperative housing was initially, in the 50's and 60's, to build and help to organize the management of the cooperative associations responsible for 50 or fewer dwellings. In the 70's the number of dwellings in each Society increased and some of the bigger associations included more than 1000 dwellings. "Large scale" was a way to get economic benefits from the management. It was difficult to influence the capital cost of the production while the management costs which had increased were the target for a more professional management. Research and development work started from the interest for cost analysis and cost relations. As a result of these studies the importance of management for the quality of living and social security was noted. The problem in the 80's was how the influence of the local association of tenants or the society could be combined with a professional management provided by the regional interest organizations, HSB and Riksbyggen.

The Swedish Federation of Rental Property Owners (SFRPO) represents a very heterogenous group of owners, from big insurance companies and other corporations with vast housing and office stocks to physical persons owning just one house. Some owners have their own management organizations and others buy these services from specialized management companies. Physical persons with one or a few houses often do the management jobs themselves. In the 80's the SFRPO initiated surveys of the housing stock, ownership structure and economy of the privately owned multi-dwelling houses for tenants. What makes the management of this type of housing different from the public or cooperative management is that these houses can quite easily be subject to selling and buying on the open market. Publicly or cooperatively owned houses rarely reach the open market. The private owner of a multi-dwelling house often regards the ownership as an investment in order to secure his capital. During the 80's the turn-over of the private housing was around 6% per year, and the houses on the market were mainly old ones. The general period of ownership lasted for ten years (Lundström-Gustavsson 1985). But almost one of three houses do not change ownership during these ten years while a small number is out on the market frequently. The interest for economic control devices in housing administration was very strong in the middle of the 80's and research and development work was followed by implementation in companies and organizations (B Ljung & A Stark 1985).

In the national housing policy in Sweden after the Second World War, Municipal Housing Companies (MHC) played a very important role in producing new dwellings. In 1945 MHCs provided 9 % of new dwellings in multi-dwell ing houses and increased this to 40% during the 50's and increased this further to 70% in the "one milion-programme" 1965–74. The MHCs in general provide their own management of the housing stock. In the 80's research has focused on three problem areas for the publicly owned housing, namely segregation, cost analysis and user's influence on management.

PROPERTY MANAGEMENT—RESEARCH AND DEVELOPMENT WORK

In the 80's Birger Ljung provided a general definition of property mangement as all actions made to a building during the time it is used, including larger reconstruction and administrative work carried out by the owner. (B Ljung 1985) The time a building is used can be regarded as the time after the building production and the major part of a building's life time. (See ill 1) More generally everything that happens after the planning and production and before demolition. Management is using the building and management includes renovation, additional- and re-construction.

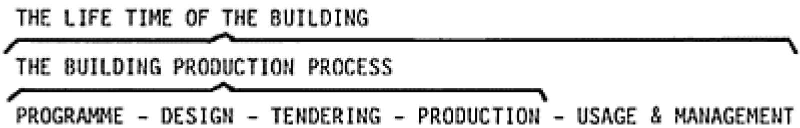


Illustration 1.

To illustrate the state of the art in Sweden regarding research and development in housing and property management I will take you on a tour round Sweden to five major towns. The research centres in these five towns have been supported by the Swedish Council for Building Research, the Swedish Association of Municipal Housing Companies, HSB (Tenants Savings and Building Societies), Riksbyggen (The Cooperative Building Organization of the Swedish Trade Unions) and the Swedish Federation of Rental Property Owner and other organizations and funds.

Many of the research projects at the research centres focusing on research on housing and property management are supported totally or partly by the Swedish Council for Building Research (SCBR-BFR). This National Council has 200 million Swedish kronor every year to allocate to research and development work and 6 of these millions are reserved for housing and property management research. In theory anybody—universities, technical institutes, research centres, consultants, corporations—can apply for these funds and the applications account for well over 20 million Skr. Many projects are funded by SCBR-BFR in combination with another institution—for instance SABO—and this is regulated in an agreement with the national associations concerned.

GÄVLE

The National Swedish Institute for Building Research together with The Central Board for Real Estate Data and The National Land Survey of Sweden, was moved in 1976 in accordance with a decision of the Parliament from Stockholm to Gävle, a town two hours drive north of Stockholm. Before the move the Institute had four subdivisions located outside Stockholm, and of these two are still situated in Lund and Gothenburg, where the research is carried out in cooperation with the University of Technology in Lund and with the Chalmers in Gothenburg.

As a tradition The Institute in Gävle has to complement the research carried out at other research centres and so far this has included evaluations of national regulations and programs such as tax reforms and subsidies for environmental improvements. (Bengt Turner, Tommy Berger SIB-Gävle and Thomas Schlyter SIB-Lund). What causes auction under a writ of execution has been the subject of a project carried out by sociologists and economists. (M Björk and L Eriksson)

SIB has established a department for research on Housing and Property management with researchers from both technical, humanistic and social science disciplines. Projects with published reports are:

The Crises of Public Housing in Sweden—Economic Reality or Organizational Myth? This notion is discussed in terms of objective and subjective crises. (B Bengtsson) Housing Cooperatives in Sweden—The economic and political progress of housing cooperatives in Sweden is described historically and analyzed in organizational, institutional and ideological terms. (B Bengtsson)

Mixing different tenancy and tenant-ownership in the same residencial area. The studies follows the effects of the economies and the social networks of the families. (L Hjärne) How to decentralize and change the management work in residencial areas in order to combine traditional services with new is in the focus of a number of projects. (A Fendell) At SIB-Gothenburg one project has accessibility as a theme and it is an evaluation of the implementation of new regulations. (K Strömberg 1987)

STOCKHOLM: ROYAL INSTITUTE OF TECHNOLOGY—STOCKHOLM UNIVERSITY

The Department of Real Estate Economics at The Royal Institute of Technology (KTH) has the responsibility at the School of Surveying to educate and train engineers for property management. This research focuses on the companies providing property management including their structure and the services provided. Important subjects are how to establish a solid stock of housing and the relationship to the owners of the companies when the politicians consider selling out or are negotiating for expanding management responsibility. (S Lundström)

Studies of management from a user perspective are carried out at a unit for Residential Management at the KTH. Residence management work was studied from the point of view of different strategies for management. (A L Högberg 84)

The research at the Department of Business Administration at University of Stockholm focuses on the company or the organization that manages the property and the purpose is to find “the theory of this type of firm”—the theory defined by an economist. Three main areas have, up to 1990, been of special interest:

– the art of property management
– effects of implementing regulations on the property management
– capital costs

Theories and ideas come from the fields of Business Administration and are applied to the property management sector, so the results of the studies can influence the theories of the subject. In the future three themes will have priority:

– new forms of ownership and management
– effects of regulations on property management
– efficiency in public property management

KARLSTAD: SERVICE RESEARCH CENTER, UNIVERSITY OF KARLSTAD

Contacts between the Department for Business Administration at Stockholm University and the Service Research Center at the University of Karlstad have resulted in a research project on quality in rental residence. (M Ericson)

GOTHENBURG: CHALMERS UNIVERSITY OF TECHNOLOGY—UNIVERSITY OF GOTHENBURG

The University of Technology and the University cooperate in a research project together with a Municipal Housing Company. The object is to produce a hand-book for the tenants and make the tenant resposible for managing his or her own flat, for example how to change the lamp in the stove, clear the sewerage system and fix a pipe fitting. Via intervues the wishes and the needs of the tenants will be described.

The Department for Social Work at the University of Gothenburg studies four housing areas in four municipalities. The aim is to find out how the municipality can actively support tenants' participation in the residential area (M Mattsson).

LUND: LUNDS UNIVERSITY

The Department of Sociology at the Lunds University was one of the first institutions in Sweden to start research projects in the field of housing management. One project was management development in Municipal Housing Companies in terms of decentralized management, tenants' influence or participation and energy conservation. A more recent interest is the functioning of local housing markets especially in regard to the housing needs of the population. Important is the role of public or social housing.

Göran Lindberg and Anna-lisa Linden have introduced sedimentation as a complementary word to segmentation in describing what is happening in Swedish residential areas today. Sedimentation describes the social differences between the different forms of tenure and this occurs in the same housing area. People in rental dwellings are less healthy and have a shorter lifetime than people in tenant-ownership.

OTHER RESEARCH PROJECTS

There are many more projects than the ones I have shortly described here on my Swedish tour, and many have financial support from one or a number of the national organizations presented initially. SABO, the Swedish Association of Municipal Housing Companies, funds research and development projects for 2, 5 million Skr per year and have so far spent 5, 7 M Skr. SABO cooperates with other national organizations such as The Swedish Federation of Rental Property Owners (SFRPO) and The Swedish Association of Local Authorities.

SUMMARY

There are quite a number of research and development projects in the field of Housing and Property Management which have as their main purpose to feed back knowledge and information to the building process. With my chosen defintion I have to concentrate on projects concerning the phase of using the building and not including the other phases of planing and production in this report.

Research on housing and property managment in Sweden can be found in many fields of studies, such as Business Administration, Sociology, Civil Engineering, Political Studies. Some research centres such as The National Swedish Institute for Building Research in Gävle and The Chalmers University of Technology and University of Gothenburg have tried to establish research over the boundaries of different fields of studies. Other centres such as Stockholm University work within one field of study.

The companies providing management are of different types, mainly because of ownership structure and are organized in different national associations. These associations support research and development as described previously. Initially these associations supported research at one or two of the research centres described here, and also a number of more practical projects in cooperation with management companies. Today the cooperation between the associations and the research centres can be described as a network which results in a number of projects which complement and support each other.

REFERENCES

The Swedish Council for Building Research S:t Göransgatan 66, S-112 33 STOCKHOLM, Sweden: **Stefan Strid**

HSB (Tenants' Savings and Building Societies) HSB National Federation Box 8310, S-104 20 STOCKHOLM, Sweden: **Stefan Svensson**

Riksbyggen (The Cooperative Building Organization of the Swedish Trade Unions) S-116 81 STOCKHOLM, Sweden: **Rune Blomquist**

The Swedish Federation of Rental Property Owners (SFRPO) P O Box 1701, S-111 87 STOCKHOLM, Sweden: **Göran Ekblad**

SABO (The Swedish Association of Municipal Housing Companies P O Box 474, S-101 26 STOCKHOLM, Sweden: **Claes Engerstam**

National Swedish Institute for Building Research P O Box 785, S-801 29 GÄVLE, Sweden: **Tommy Berger, Mia Björk, Leif Eriksson Bengt Turner,** Housing and Property Management Research Department: **Bo Bengtsson, Lil Benton, Astrid Fendell, Lars Hjärne, Peter Lidehäll, Birger Ljung, Eva Sandstedt**

SIB-Gothenburg Landalagatan 36, S-411 30 GÖTEBORG, Sweden **Knut Strömberg**

SIB-Lund Finngatan 16, S-223 62 LUND, Sweden: **Thomas Schlyter**

The Royal Institute of Technology (KTH) Department of Real Estate Economics S-100 44 STOCKHOLM, Sweden: **Stellan Lundström**

Royal Institute of Technology (KTH) Residential Management Group S-100 44 STOCKHOLM, Sweden: **Anna-Lena Högberg**

University of Stockholm Department of Business Administration S-106 91 STOCKHOLM, Sweden: **Agneta Stark, Paulsson Frenckner, Anette Gröjer, Claes Hägg, Li Malmström**

University of Karlstad Service Research Center: P O Box 9501, S-650 09 KARLSTAD, Sweden: **Mona Ericson**

Chalmers University of Technology Department of Consumer Technology S-412 96 GÖTEBORG, Sweden: **Helena Åberg, Margareta Dahlberg**

University of Gothenburg Department for Social Work P O Box 5048, S-40221 GÖTEBORG, Sweden: **Matts Mattsson**

Lunds University Department of Sociology Research Group on Housing and Community P O Box 114, S-221 00 LUND, Sweden: **Göran Lindberg, Anna-Lisa Linden, Marianne Liedholm**

171

Supply and demand analysis in the housing market: a case study in Turkey as a developing country

E.BOCUTOĞLU and Z.ERTÜRK

Abstract

In this paper, Turkish housing market is investigated. Turkish economy is characterized by variables which are the high rate of population growth, rapid urbanisation and industrialisation, and also relatively high rate of inflation. These variables which affect housing supply and demand are identified and the present situation of the housing stock will be discussed in detail. As a natural consequence of the lack of housing unit caused by the inefficient housing supply is the cronical problem of the housing market in Turkey. In this paper, the housing market and strategies are investigated and new estimations related to the housing market mentioned.

Keywords: Turkish Housing Market, Demand for Housing, Supply of Housing, Housing Stock, Shortage of Housing, Housing Policies, Squatter Housing (in Turkish Gecekondu).

1 Introduction

Turkey is a country which has some characteristics of its own from the point of view of its geographical location, socio-economic and cultural structure. One of the most interesting areas in the world to be analysed as a housing environment is perhaps Turkey, since it is the land of many civilisations and cultures. Anatolia is a cultural melting pot, and therefore its housing reflects its mixed cultural structure.

On the other hand, as in many other developing countries the most serious problem in Turkey is housing. Today the rapid change of the man-made environment is staggering. In most developing countries all over the world, rapid change in society, the rate of urbanisation, the growth in population, growing mechanisation, and industrialisation have resulted in most people spending by far the greater part of their lives in a housing environment which is insufficient.

The dynamics of population growth in developing countries poses a great challenge to human settlements, and eradication of squatter settelements and improvement of rural habitant have to be tackled on a priority basis (Ertürk, 1989).

During the period of the new Turkish Republic, which has been over 65 years, the most remarkable socio-economic changes listed below:

High rate of population growth.
High rate of urbanisation.
Transition from the import substitution strategy to the export leading growth strategy.

This period is the evidence of transition of Turkey from being underdeveloped country to the developing country. Macro economic structural features of the Turkish economy are characterised by the relatively high development rate, high rate of unemployment, high rate of inflation, and being open to challenge to outside world.

The high rate of population growth and rapid urbanisation in the structural changes are remarkable. In the economic and social structure, together with the housing market considerable developments take place.

The most important factor which affects the accuracy of the analysis of the conditions of the demand and supply in the housing market is the lack of the statistical data of the different dimensions of them. First of all, we should emphasize the fact that we do not have a reliable statistical data on the existing housing stock in Turkey and all estimations are relied on the methods which are subject to discussion. Second, information on housing demand can be provided by rough estimations which rely only on the basic factors such as population growth rate, and housing density, but we still do not have information related to the new changes have been occured by the time. Another important point is that we do have officially recorded statistical data; however, squatter houses are not officially recorded and not taken into consideration. Therefore, only this point is an important clue for the relaibility of the degree of the information. It is very obvious that all estimations rely on those unreliable data and they will be subject of further criticism by the academicians and practicians in the field of housing research. Turkish housing market has interesting structural characteristics with all those constraints.

The authors of this paper believe that; it will be unique and premier step to present recent situation of the housing supply, housing demand, and housing policies of Turkey as a developing country with her unique features and local motivies for discussion.

Two major issues which are the housing market and the housing policies will be discussed in length. Under the heading of the housing policies which were set up in order to solve housing problem during the period of Turkish Republic will be eveluated and some estimations will be put forward for the future of the Turkish housing market.

2 Housing Market in Turkey

2.1 Housing Demand

Housing demand of Turkey could be presented as below:

DH = f (POP, IU, SS, SOF, I, W, REN)

Where;

DH	;	Housing Demand
POP	;	Total Population
IU	;	Immigration and Urbanisation
SOF	;	Family Size
I	;	Income
W	;	Marriages
REN	;	The need of Renewing Housing
SS	;	The idea of taking house as a social security indicator

In the next part of the paper, those independent factors which have effects on the housing demand will be discussed. Although the total population in Turkey decreased very much in the period between First World War and The turkish Independence War, population increased to 57 million from 13 million in last six decades.

In this period the population growth rate has been 2.3% which is quite higher than the rest of the world especially than developed part of the world. It is obvious that the population growth is the most important independent variable which has affected the housing demand for last ten years. Total population increased one million each year, (DIE, 1990).

Rapid economic developments and industrialisation made urban centers and their immediate environments more atractive since 1950. This is the basic cause of the mass immigration of people who want better standarts of life and better income and new opportunity for a new job from rural areas of the country to the urban centers. In 1970 only 35% of total population were living in the urban environment but this figure increased to 59.1% in 1990. After 1970s this immigration flowed to cities which have the population of between 100.000 and one million. This made housing and infrastructure problems worse, (DIE, 1990).

As a peciluar feature of Turkish culture, housing is considered as a saving and therefore housing is counted much more different from other properties. Inflation rate has been mostly over 50% since 1980 and even this rate made housing very important saving. Since price increase at housing market have been below inflation rate for last couple of years the demand for housing as a saving started to decrease.

Everybody knows the positive correlation between housing and income and obviously an increase at income also increases quantity and quality of housing. During last ten years anti inflationary programs have been used by goverments and these applications made income distribution very peculiar in Turkey. We came such a point that increases at incomes of middle and low income group have been behind the increases at prices of housing. Obviouslys as a result of urbanisation and increases of the number of working household members, nucleus family type has been emerged. Changes of life style and strong inclination towords living in seperate from other family members causes family size decrease. Population growth rate was 2.3 per years between the years 1970 and 1980 and average household size was 5.6 in 1970, 5.4 in 1975 and 5 in 1980. Population growth and the decrease of family size increases housing demand. It is clear that marriage rate is larger than divorce rate and this also affects the demand for housing. The shortages of new housing for nonuseble old houses also effects the balence of the housing marked in a negative direction.

2.2 Housing Supply

The function of housing supply of Turkey can be as following:

SH = f (DH, FIN, TECH, L, ORG)

Where;

SH; Housing Supply

FIN; Financial Resources for Housing

TECH; Construction Technology and Construction materials

L; Living Areas and their Infrastructure

ORG; The level of Enterprise and Organisation Ability Housing supply is a function of housing demand. Even though other independent variables which affect housing supply are positive, housing can not be produced without enough demand of it. However, attention should be given to the difference between the demand of produced housing and the demand of shelters. The demand of built housing is low by middle and low income group who agglomerated in especially big cities in Turkey.

The main resources of financing of housing are savings, housing credits, and equity resources of constructors; however, basically savings and housing credits are used. Private sectors of housing market make the selling process before they complete the construction of housing, so they do not need to use their own equity resources.

There are two types of construction technology which are traditional and industrial used in Turkey. The main system of industrial technology is large panel systems which have very limited use. Traditional technology requires more labor work and time and this makes the system more expensive; however, it is the one commonly used. The construction-materials of the system needs are expensive, but produced enough in Turkey to meet the requirements. In housing construction, first lands should be divided into lots. Topographic maps, master plan, construction plans and appliques should be made and infrastructure should be constructed. In big cities, the supply of lots has decreased and state agencies which are responsible of supply of lots has not succeeded for their duties because of high price of land and the shortages of funds. So the cost of lands is sometimes more than half of the total cost of housing.

Housing market is dominated by small construction companies, which are not well organised, and so thay are unable to construct mass housing to meet the needs of the country.

2.3 Housing Stock

It is estimated that total housing stock is 11.5 million units in Turkey and the housing stock is 7 million units including squatters in urban areas. In rural areas, it is around 4.5 million units. If average family size which is 5 persons is taken into account, it seems there is no shortage of housing, but it is misleading. First there is a difference between the number of househould members living in rural and urban areas and this difference hides the real need of housing demand. Second, the difference between housing supply and demand is met by squatters which is about 1.5 million units. It can be claimed that squatter type of housing is not real housing, in fact the number of squatters is the need of housing.

Seventy precent of the population of the capital city of Turkey live in squatters today. This rate is over 50 percent in other metropolitian cities.

Even though it is estimated that the need of housing of Turkey is 300.000 units per year, production is just 75 percent of it. It will take a long time to come to meet the need and it is clear that; unfortunately low quality and also illegally built squatters will close the gap.

3 The Politics of Housing

The constitution founded in 1961 with the five-year plan made the economic development for the state sector mandatory, since, it has had quiding and encouraging effects for private sector. The politics of housing could be discussed in two periods; the period before the planned economic development between the years of 1923 and 1962 and the period during the planned economic development from 1963 to 1991.

During the years between 1923 and 1945 infact before the planned economic development; Turkish economy was basically based on agriculture and immigration to the cities and urbanisation were low and there was no politics of housing. After 1945, industrial movement started and this made urbanisation start. So it created a demand of housing and it was the time of building squatters. In this period a ministry was set up to take care of planning of housing, and city plans. There was no tax at housing and first time housing credits made available; however, coordination among steps to increase production of housing was not set up yet.

During the planned economic development; six “five-year” plans were established. They had different approaches to housing. The first “five-year” plan which was between 1963 and 1967 did not take housing investment as a production investment and so housing investment fell from 30 percent to 20 percent. To increase the housing supply, the tax rate at housing decreased and housing credits supplied for the houses with the area of less than 100 square meters. During the second “five-year” plan which was from 1968 to 1972, as a result of shortages of housing the squattery tpye of housing was spread out all over the big cities. The increasing demand of housing was not met by housing supply and it was understood that squattery type of housing could not be prevented. Unfortunately; this is the reason to pass a law and this made this type of housing legal. The third “five-year” plan which took the place from 1973 to 1977 caused housing investment decrease. The fourth “five-year” plan which was from 1978 to 1983 did not have any new approaches different from others. The only new approach it carried the lands of squatters were rented to awners of them. Inverstment for housing fell to 15%. During this period there was a high rate of inflation and this caused saving of households flow from housing sector to banking sector. Consequently, this affected the supply of housing. The fifth “five-year” plan from 1984 to 1988 and the sixth “five-year” plan from

1989 to 1993 are basically for the purpose of privatisation of Turkish economy and open its markets to challange to outside world (DPT; 1963, 1968, 1973, 1978, 1984, 1989). During the last two planned terms, a law passed for construction of mass housing. A fund which named “Mas Housing Fund” (MHF) also was set up for the same purpose. With this law goverment help the private sector using funds from MHF to construct mass housing. Private sector makes 92% of total housing investment. MHF finances especially small size housing. With the mass production of housing during the last two planned terms, cities have been changed and lost their images and structure. Although the majority of housing in rural areas has traditionally been in the form of an independent family house with all its rural-vernacular characteristics and identity, with the rapid growth of urban areas, two or three storey small houses have decreased in number, and apartment blocks or so called “units” have instead dominated the housing environment in urban areas. In dwellings spaces are highly specialised with respect to function, such as study room, play room etc. (Ertürk, 1989).

During the planned terms, to encourage the housing investment, cheap and sufficient land were supplied but from time to time there were difficulties to supply them. Some agencies were founded to find a solution to this problem, however, they did not succeed.

Squattery type of housing closes the gap between the demand and the supply. It is estimated that shortages was 1.5 million units in 1985. People living in these houses is seventy percent of the population of the city of Ankara, 50% of the cities of Istanbul, Izmir and Adana, 40% of the cities of Erzurum and Samsun and 30% of the city of Bursa.

The politics of Turkey related to this type of housing have been always in transition from being illegal to becoming legal. Squatter housing is one of the most important fact of Turkish housing market which can not be ignored.

4 The Future of Housing problem in Turkey

In the past twenty five years more than 300 million people in the developing countries have moved to cities to find a better life. Unfortunately their living environments are still poor. Turkey is one of these countries, and there are still a lot of measures to be taken at the strategic and planning levels. In spite of the many attempts to reduce the environmental problems, there are no major directives to be found. The reason for this situation is quite obvious; governments have failed to realise that the issue they are faced with is not only the supply of more housing units, but it is the improvement of the process of squatter housing construction. They should realise that these people constitute a most important human resource that has not been comprehensively organised and utilised to improve their own living environment.

If this process is utilised and sufficient technical and planning aids are provided, the quality of the squatter housing environment will be improved, a great deal even in the short term, in Turkey (Ertürk, 1989).

It is claimed that the housing problem will take a long time because of Turkey’s high population growth, rapid immigration and urbanisation. In the near future, squatter type of housing will help greatly closing the gap between the supply and the need of housing.

Today, immigration is from rural areas to cities and from east part of Turkey to its west. It is clear that immigration direction can be reversed by two factors. First, it is becoming difficult to find land for squatters in cities and there is inadequate infrastructure and insufficient employment opportunities in cities. So these can change the direction of immigration. Second, there is a well known project (GAP) which is basically for watering the area of "South-East Anatolia" between the rivers of the Tigris and the Euphrates and make the land productive for agriculture. When the project is completed, there will be some employment opportunities and this can reverse the direction of immigration from the West to the East in Turkey.

Unless the variables related with population are in order, there is a fair income distribution, and the income of the household increase, the supply of housing will be lacking.

It is believed that the housing problem is not only solved by providing minimum size units but, more importantly, by the contribution given by local customs and values. This represents real force of production of great quantity and quality if support is given, which still would leave control and responsibility in the hands of the people. The form and support could provide good environmental and infrastructural provisions for people to exercise their need to build. This is the cardinal issue which is usually underestimated by public and private initiatives.

5 References

DPT. (1963) Birinci Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DPT. (1968) İkinci Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DPT. (1973) Üçüncü Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DPT. (1978) Dördüncü Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DPT. (1984) Beşinci Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DPT. (1989) Altinci Beş Yillik Kalkinma Plani, DPT Yayini, Ankara.
DİE. (1990) 1990 Census of Population: Preliminary Results, Publication No: 1437, Ankara.
Ertürk, Z. (1989) "Private and Public Responsibilities in the Quality of Housing Environment In Turkey", **Quality in the Built Environment, The Urban International Press, pp. 99–103.**
Keleş, R. (1989) Konut Politkalarimiz. **Ankara Üniversitesi Siyasal Bilgiler Fakültesi Dergisi, 1–2, 63–98.**

172
The Dutch building industry in the 1990s

J.J.de BRUIJN

Abstract

Developments in building production as a whole mirror the general economic trends in business. Today's less promising prospects (Gulf-war) will in the short term have a definite negative effect on building prospects. After that, in 1988 a continuously increasing scarcity in the labour market has already been clearly established. The supply of young tradesmen stagnated partly due to the image of the building industry and more particularly in relation to the working conditions. The danger is that the building production cannot be realised in the short term.

The market for contracting firms will switch from one which is capacity-oriented to one oriented towards products; the supply industry will force designers in the direction of industrial designs. This new way of thinking will have to be developed by many firms.

The application of information as a production factor has given a new priority to the information system functions within the firms, but also in another way, to how the participants in the building process operate together and how the product is achieved.

Changes in the present participant-model require changes in the mentality and behaviour of the building world in order to improve the atmosphere, co-operation and co-ordination needed for building projects to become prosperous.

Developments in building production

Before presenting my vision for the Dutch building industry in the 1990's it would be a good idea to first take a look backwards and review the 1980's. This will enable you to see my vision in perspective. In this way we can see that the developments in building production as a whole mirrors the general economic trends in business. After a few years of decline, building production grew in the second half of the 80's, reaching a peak in 1988. In that year the total building production was 11% higher than in the early years of the decade.

In 1989 a level of Dfl. 50.6 miljard was reached even without the addition of value added tax at 18.5%, based on 1987 prices.

This total was 2.6% higher than in 1988. The Netherlands, one has to say, was well placed, taking into consideration that the guilder, like the German mark, is “hard” currency.

The less promising present prospects, which must also be seen in the light of the Gulf War, will in the short term have a definite negative effect on building prospects. The relatively high growth in recent years will, I suppose, be certainly something of the past for which there will have to be some reckoning. What is certain is that there will be a fall in production in 1991 of about 3%.

Opportunities for work

The strong downturn at the beginning of the 80’s has had drastic effects on the opportunities for work. The labour force in the building industry fell from 400,000 to 285,000 man years in 1984. After this low point the figures recovered but only to a limited extent despite the strong growth in building production in the second half of the 80’s. The number of unemployed in the building industry remains, relatively speaking, high. Some of the unemployed apparently could not find work in the industry because of inadequate qualifications. The slight increase in the work force of 8,000 to 314,000 man years, which occurred from 1987 to 1988, was seemingly greater than the reduction in unemployment.

In 1988 a scarcity in the labour market was already clearly established and the indications were that it was increasing continuously. The supply of young tradesmen stagnated and the numbers leaving the industry continued at a high level. The poor supply was partly due to the image of the building industry particularly in relation to working conditions. This was reflected in the amount of sick leave and the considerable number unfit for work.

In 1989 the number of absentees due to ill-health in the building industry was about 300,000, 10.3% of the work force, and in that year the number declared unfit for work was never less than 8,300. This situation, in the building and other industries, led the Prime Minister of the Netherlands to proclaim that ‘The Netherlands is sick!’.

On account of labour shortage there is the danger that the building production cannot be realised in the short term. This negative image must change drastically, if the building industry is to attract young people in particular.

Modification to the building process.

Because of modifications to the design process traditional designs will change to become more industry-orientated.

As a result the market for contracting firms will switch from one which is capacity-orientated to one orientated towards products. That is to say, that the supply industry will force designers in the direction of industrial designs. In order to achieve building quality, the know-how gained by product experience and logistics will be extremely important in the new design process. Various (types of) performance bids will be expected in response to specifications.

Building education will become directed towards this new approach and completely new courses will be provided such as:

– industrial design in the building industry,
– functional quality determinants,
– selection of products by tender,
– assembly and logistics,
– etc.

In addition when the building industry arrives at a successful strategy for Electronic Data Interchange (EDI), that is, the computerized exchange of structured and standardized data between project participants, a new way of thinking will have to be developed for many firms. The methods employed at present for using data in project preparation will not be suitable. In one of the studies carried out by my institute (SBR), entitled 'Information transfer using drawings' it was established that the information database was, in fact, unsuitable for performing particular actions or fulfilling certain functions. The aim was to develop a theoretical model which would satisfy role-related criteria. This depended therefore on which functions had to be fulfilled and also on which data were involved.

An appeal may therefore be made to architects to play as active a role as possible in the establishment of the 'language' which we should use in the building planning process; this agreed 'language' should then be adhered to. The more so because, at present, interest is clearly switching from production-orientated 2D-drawings to 3D-packages. The possibilities presented by the newest generation of CAD software are very interesting, particularly for architects. One can certainly assume that this potential will have a stimulating effect on the creative process. The still frequently heard remark that it is not very interesting to even consider the use of computers in the Definitive Design Phase, will, in view of the facts, soon be no longer applicable. That the architect after consulting the principal is the one most able to produce the primary or basic data for a building plan seems to me to be a valuable point in the discussion on the division of roles in the building preparation process. These primary data will in the future be worked out and supplemented by other disciplines, assuming that the data are so structured that they can be used as reference points for further specifications.

Information transfer

I am now going to explore more deeply my starting points. As we know there are many different disciplines involved in the building preparation process. All are involved in their particular way in the same building project, using however, different types or groups of data. Each discipline uses different (computer) programs, each program having its own method of describing and storing data (internal data structure). The individual systems are thus, so to speak, sealed. As a result the 'output' from one program cannot be used directly as the input for another program. If this is the case communication can only be between programs of similar origin, or when there is a fortuitous 'marriage' between programmers.

Communication can then however only be on a one-to-one basis. We have assumed in my institute's (SBR's) study that in the future there must be open systems with modular interconnection. In this context we understand 'open systems' to be those which employ a standard database for data storage. The data structure is then determined separately outside the actual program. I can assure you that there are CAD packages available which do this satisfactorily.

Management of information

Within the framework of information transfer I would like to discuss another point. Both the application of information as a production factor and the structuring of the necessary information 'logistic' by progressive firms have greatly improved our understanding of information management. They have also given a new priority to the information system functions within firms, producing a shift in the responsibilities of the function managers. This has brought about an inter-relationship between management, organization and information which requires a specific level or expertise. I would like to suggest that it is only in this way that opportunities can be created for firms. The correct sequence for the phases in this process is: the building-up of the required qualifications, followed by planning and the precise contribution of information management in a new arrangement of the information system functions.

Information management must ensure that (internal) information services are a clear objective of company policy, both now and in the future. Information management should provide clear objectives and strategies for achieving this. Future target dates, for example, in the next five years, criteria and routes to be followed should all be established. The strategic planning of information system activities must lead to a better realization of company objectives and also to the sensible and economic use of available resources and the full exploitation of new technical opportunities.

"Trend-setting" market

I think it would now be interesting to consider how the new developments in the building process are undertaken by the participants in the process. We quickly perceive that a clear separation must be made from the market in which the individual builder of a house, small factory, office building or farm operates on the basis of the specific living or usage requirements. Often the "small investor" still plays a role here. This is clearly not a trend-setting market and is still in the world of the traditional architect and contractor, in which most participants operate only on a limited scale. We should adapt the line that in this market there is a hesitancy and often resistance towards development trends which arise in other markets. In the long run the project participants must still follow the trends found in large new building and renovation projects in particular. When, on the other hand, we speak about the large scale market(s) and turnovers of millions of guilders, or if you like, Portuguese escudos, then we clearly see trend-setting markets. Such markets will determine how the participants in the building process operate together and how the product is achieved.

These markets function in the power struggle between the investor/speculator and the hirer/user in which the initiator/developer is an important co-participant. Changes develop in responsibilities, prodedures and agencies. These developments will influence the contracting firms of the project partners considerably. It can be assumed that these markets will grow strongly in The Netherlands particularly through the influence of European integration in the mid-1990's.

There is still even a third situation in which we think of what is referred to as the environment and traffic market. In The Netherlands this is a developing market which still has no real form. In this area, also, investors and government must come together (public private partnership—PPP) under the strong initiative of project developers. In this respect we think of the construction of carparks, roads, bridges and dams. In addition, in the environmental sector, the construction and renovation of sewers is important particularly for regional and local governments; about 10% of the 50.000 km of Dutch sewers must be renovated in the next ten years. A minimum of 7 millard Dutch guilders is needed.

Almost all the material used for sewers after the second world war is unsound and therefore leaks. The cleaning up of contaminated building sites and polluted river and canal beds in the Dutch delta of the Maas and the Rhine near to the world's largest seaport, Rotterdam, represent another immense growth market. Many Dutch building firms are already busy here. In this repect The Netherlands is to some extent the "dustbin" of Western Europe.

Working conditions

I would now like to consider another point which is extremely important for The Netherlands: the working conditions. This is something we cannot boast about. Often good tradesmen leave the industry because in the first place, there is a lack of continuity, but also and particularly, because working conditions are less than adequate. Do not let us mince words: the work is often heavy and unsafe. If we want to retain and also to attract tradesmen in the 90's, the traditional unskilled labour (luckily) must disappear: this will not happen so quickly in the small scale markets where work and maintenance for individual small clients will remain. However, and this is a plus point, the tradesmen of the future will be, by preference, real specialists, for example, bricklayers and carpenters. I predict that soon these tradesmen will become highly regarded and they will then get a much better deal. In contrast the old-style building worker will disappear, particularly from larger building works, to be replaced by specialized workers well trained in the assembly of prefabricated components. These tradesmen will carry out highly mechanized work in carefully controlled conditions for which they will be very well paid.

An increase in building productivity of perhaps 10% per year and even higher is possible by the end of the 1990's using industrial design. As a consequence, wages will rise; we see this already. In addition, a considerable amount of money will be invested in training.

The building industry will then catch up with the rest of industry, working conditions will improve dramatically and the work will be highly regarded. A comparison can be made in this respect with the developments in the computer industry in the second half of the 1980's.

As a result of these encouraging developments, one could speak of a complete turnaround, the image of the building tradesman will be greatly improved and there will be an associated rapid reduction in absentesism. More young people will choose to work in such a building industry. I must say that I am very optimistic about what these improvements can lead to. And why not, if these predictions, which I infer are not so far from the truth, actually come into being?

Calculation of prices

Then the other side of the coin: the calculation of prices. Something else that I am also very happy about is that there are changes coming in the calculations, although these are not yet clearly apparent.

What do I mean here? The cost price will lose its significance as a basis for the tender price; the market price, based on specified performance, will be the determinant.

Costs will only be a means for guiding tender specifications. As a result calculation of prices will be less of a mystery to outsiders, and I would really like to emphasize this, these changes can only lead to great improvements in the image.

Changes in the present participant-model

Because of the opinions being formed about Dutch developments in the building industry in this decade, I think that it is important now to go more deeply into the changes in the present participant-model. I will begin with the (role of the) principal and then the architect-consultant-contractor-subcontractor-supplier and the occupier/ user in the function-model of the future.

This model is based on the new product development process activities which I can see as follows:

– instruction to proceed
– design
– advice
– build
– installation
– delivery
– exploitation.

The **product development process** will then be modified as follows:

	Traditional process	New process
Program	.Initiative .Planning .Specifications	.Initiative .Use specifications and draft plans .Project definitions and function requirement specifications
Design/advice	.Structure design	.Structure design (outline)

	(outline) .Preliminary design .Final or definitive design	.Preliminary design and value determination .Final or definitive design
Result	.Tender and drawings .Pricing cost estimates .Pricing	.Performance tender .Tender specification and drawings
Build, installation	.Work-preparation .Execution	.Work preparation and logistics plan, choice of materials and products .Process coordination and quality monitoring
Exploitation	.Delevery	.Transfer of user instructions, maintenance conditions and guarantee certificates

The following responsibilities, tasks and procedures will be important in this product development process:

a) – In the development and requirement performance phase the developer and the investor and/or user (if known) sign a contract in which the quality of the accommodation is defined and guaranteed.

– The “measuring instruments” required for the development can now be improved and refined.

– Other items will be set out in the performance specification. Participants in the design, execution and supply can all advise on the details of this specification.

– The performance specification describes the visual and functional quality and defines the related building and usage (operational) qualities.

b) – Participants in the execution and supply prepare tender specifications on the basis of the performance specifications. Once again these tender specifications are prepared taking into account the relationship between cost and quality.

– the tender specifications can be drawn up by a building sub-contractor but also by a supplier or an installation firm. A joint-venture of participants can also draw up the specifications.

– The participants involved guarantee the (building) quality within the framework of the performance specifications.

c) – At the start of the occupancy phase the usage quality is checked against what was defined at the beginning in the contract. The instruments required for this checking will be developed in the next few years.

Changes in mentality and behaviour

Finally I would like to discuss a subject with which the Dutch Foundation for Building Research has been very busy in recent years. A report has been produced entitled “It can be better in the building industry”. I would like to tell you something about this work particularly since I have been involved in it. We, as a foundation, have posed the following question to a number of researchers: “What changes are required in the mentality and behaviour of the building world in order to improve the atmosphere, cooperation and co-ordination needed for building projects to be brought to fruitions?”. From the answers it appears that the changes and developments question the distance to be taken from what is correctly referred to as the participant-model. That is, the developments should be those which, via codes of conduct, lead to a better balance between competition and collaboration. It appears that the methods we use at present to realise building projects, with all the risks and uncertainties, are among the most important sources of unrest. This applies both to the selection of partners and the negotiations about contract conditions. It is a self-perpetuating process; mutual distrust leads to great uncertainty in which everyone reacts in his own interests.

In the near future when project partners want to break through and understand the present situation in which they set each other conditions, they must be frank with each other. This will demand a different mentality and, if desired, different codes of conduct. A number of these codes are summarized below.

There are arguments for a number of less cynical types of relationships between project partners, from which no one would be excluded. It would also be an advantage if everyone with responsibility for design and execution is given their full rights to exercise their particular responsibility, beginning with the specifications. In addition a more open exchange of information between project partners is essential. The investigation has also pointed out that it is better to learn to live with uncertainty. This can be achieved by early discussions about unclear and/or possibly unforeseen events and developments before they even occur. Participants must have safeguards against unpredictable conduct by other participants. There is also a need for the presentation of a clear profile of the building industry to the government so that the industry can have a more constructive influence.

From the investigation it is clear that the individual partners in the building industry are barely able, in their own strength, to improve their viability. A relatively independent position in the market remains a basis for strategic co-operation. From such a position strategic space can be sought in which to develop new forms of co-operation. This can be found somewhere in-between the pure market mechanisms and the completely integrated organization. All of this points to networks involving co-operating organizations: more or less affiliated structures between relatively independent firms. These firms draw together on the possibilities presented in various areas. This we will refer to as “co-makership” or “strategic partnering”. Resourcefulness and wisdom are the key words in the search for workable solutions. A real blue-print for this cannot be given, therefore conditions in the building industry have to change accordingly. Changes will lead to the best results when they are implemented gradually. Learning by doing; in other words, the project partners must invite each other to experiment with different forms of co-operation. First with caution but where possible in the form of a challenge to each other to improve the present disrupted capacity and to strive for other forms of contracted relationships. To achieve this there must be a move away from pure competitive strategy. For some project partners this is perhaps a worrying thought, which nonetheless may be worth following up.

Fortunately I can quote good examples of collaboration from present building practice which are, eventually, going in the right direction.

Therefore, and I am convinced of this, in The Netherlands there will be many more instances of new associations and co-operatives and, during the 90's, the whole building industry will be in motion in this respect. And that is a fact.

I am convinced that it will be better in our Dutch and later on European building industry.

173
Household demography and the effective demand for new housing

I.E.CORNER

Abstract
The growth of households in a region can be shown to be closely related to the growth of its housing stock, and an understanding of household demography is of primary importance in assessing housing demand. Methods of analysing and forecasting household numbers are described. The general approach treats population change and house-hold formation patterns as separate components. At national level population projections introduce little error into household forecasts, but at a regional level migration is an important and uncertain factor. Most methods of analysing household formation patterns use either a headship rate method or a dynamic model based on a matrix of household transitions. An analysis is made of house-hold formation in England and Wales, showing the prospect of a decelerating rate of household growth in the 1990s.

Keywords: Housing need, Housing demand, Households, Population projections, Headship rates.

1 Introduction

Whilst shelter is one of man's most fundamental needs, it is only in the most extreme situation that he will be content with its provision at the most basic, life-sustaining level. In addition to seeking a roof over his head, he may aspire to a dwelling which satisfies his desire for comfort and privacy, is aesthetically pleasing to him, has a convenient or environmentally attractive location, and so on. However, these demands will be effective only to the extent to which he able and willing to commit resources, and herein lies a fundamental difference between the concepts of housing need and housing demand. 'Need' is a minimum level of provision which, according to common agreement, everyone has a right to expect. Its definition may not be explicit, and may vary from community to community and change over time, but it is a standard which is independent of the individual's means. 'Demand', on the other hand, is the expression of constrained choice, and can only be defined empirically, in terms of the balance between the means and desires of households.

In Britain, interest in household demography was stimulated by the 1945 Housing White Paper, which stated the priority of 'a separate dwelling for every family that wishes to have one', and planning the housing programme required to fulfil this need led the Government to investigate methods of projecting households. More recently, though, the emphasis on housing provision in Britain has moved towards the private owner-occupied sector, and whilst forecasts of household numbers have an obvious value in estimating future need, their worth is less clear in a market where the private sector speculative builder is the main supplier of new housing. In a free market the house-builder would decide what and where to build on the basis of profitability, and his decision would generally be made in terms of current relative house prices. However, the free market is not a good model for explaining the development of the housing stock, even in the private sector. In many areas land is a scarce resource, and house-building must be subject to some form of long term planning control which provides a balance between the allocation of land for housing, industry, agriculture and amenity. In this situation there is a need for relatively long term estimates of future housing demand.

The value of an understanding of household demography for the long term estimation of effective housing demand is illustrated by the strong relationship between the rates of growth of the dwelling stock and of household numbers in an area. For example, the increase in dwelling stock in the local authority areas of England and Wales over the period 1971–81 was correlated with the corresponding increase in household numbers, with an R^2 value of 0.97. Although it is true that the comparison does not suggest equal growth of household numbers and dwelling stock—the latter slightly exceeding the former, indicating an overall improvement in housing provision in numerical terms—the likely growth in households is nevertheless an important benchmark against which to measure housing provision, representing the target which will maintain the status quo.

Whilst the focus of this paper is the overall demand for housing, it may be noted that interest in housing demand, and the scope of household demography, extend further. The size and type of dwellings required in the future can be estimated with the aid of forecasts of the size and type, as well as the number, of households. The British Government, for example, makes forecasts for a number of household and family types, disaggregated by the age, sex and marital status of the household head (Corner, 1989). Other systems, such as that developed in Sweden (Holmberg, 1987) forecast the numbers of households of various sizes. Furthermore, households' tenure choices are strongly related to household type, and a change of tenure is often linked to the formation or dissolution of a household (Murphy, 1989).

2 Methods of analysing and forecasting household formation

2.1 Population projections

There is clearly a relationship between the population of an area and the number of households who live there, but population and household growth rates are often of very different magnitudes. Indeed, the recent experience of most developed countries is that household growth has greatly outstripped population growth. In England and Wales, for example, households increased by 163% between the 1901 and 1981 Censuses, compared with population growth of only 52%. Nearly all methods for forecasting households distinguish between population change and the pattern of household formation. The first step is to make a population projection—generally disaggregated by age and sex. In a recent paper Keilman (1990) compared the methods used to make national population projections in 30 industrialised countries, and found that every one used the cohort-component approach, albeit with a wide variety of practical implementations. This technique starts with an age/sex breakdown of the population in a base year t, and considers the demographic changes to each cohort during the time period t to t+t0. Predictions of losses through mortality and out-migration are subtracted from the cohort, and gains by in-migration are added. Forecasts of births during the period determine the estimated size of new cohorts. These calculations give a cross-sectional description of the population in the year t+t0, the process being repeated to extend the projection further into the future.

Assuming that a base population estimate is available, the method therefore reduces to forecasting fertility, mortality and migration. Of these, fertility is generally the major cause of error in national projections, but for lead times of up to about twenty years, the unreliability of fertility forecasts is unimportant. Children are born into existing households, and it is not until they reach adulthood and start to form households of their own that they affect household numbers. Thus, although a knowledge of historical fertility levels is important in determining the adult population, it is only for very long term projections that future rates are of interest to the household forecaster.

Methods for forecasting mortality rates have a long history, and have been widely discussed in the general demographic literature. Murphy (1990) reviews such methods as logarithmic extrapolation, life-table methods, cause-specific models, asymptotic approach to rates in ‘leader’ countries, and time series analysis of parameterised mortality schedules. Although mortality rates are not easy to forecast (Murphy, 1990), they do not usually introduce substantial error into population projections as the factor of importance is the survival rate rather than the mortality rate. As the latter is small for most age groups, its error can be quite large without greatly affecting the accuracy of the forecast survival rate. An exception is amongst the elderly where mortality is high, and here, as Field (1990) has demonstrated, substantial projection errors can occur. Nevertheless, the effect of errors in mortality forecasts on overall population—and therefore household—projections is small.

International migration, being heavily dependent on economic and political factors, is particularly uncertain. Many forecasts simply assume the continuation of currently observed rates or numbers at a constant level. Others use graphical extrapolation or expert opinions, or try to translate government plans and policies into future migration rates. However, in most countries, annual net international migration is only a very small percentage of the total population, and so it is not a major source of error in projections.

Migration flows across regional boundaries are greater, and can be an important source of error in sub-national projections. There is general agreement that the working of the labour market is an important determinant of sub-national migration. Differential rates of employment growth between areas are seen as important effects, and higher unemployment rates appear to reduce mobility generally, but there is less of a consensus on the magnitude of the effects, and on other factors such as differential wage levels. A useful discussion, in the context of migration between England and Scotland, is given by Ermisch (1990). There is disagreement on whether high housing costs discourage migration into an area, although moves within labour market areas may be motivated by considerations of housing satisfaction. Life-cycle effects are of acknowledged importance. People are most mobile as young adults, and there is often a 'bulge' in migratory behaviour around normal retirement age (Rogers and Castro, 1981).

Methods for forecasting sub-national migration often have problems of data availability. Whilst some countries—such as the Netherlands—maintain population registers which record all changes of address, many others have no regular, reliable and comprehensive source of migration data, and even where good migration data are available it is often difficult to quantify the variables which are perceived as explanatory factors. Methods include those based on labour market trends, such as the shift-share analysis of Tyler and Rhodes (1989), those based on migration age profiles (Armitage, 1986), and multiregional models, which estimate migrants' origin-destination matrices (Rogers, 1980).

If this assessment of population projections sounds discouraging, it may be re-emphasised that, particularly at the national level, the components of fertility, mortality and migration are all marginal effects. In any given year the large majority of people will not die or migrate, and new births do not have any direct effect on household forecasts until the children attain adulthood.

2.2 Patterns of household formation

To forecast household numbers it is necessary to estimate the extent to which people will group into households. There are many factors which affect the pattern of household formation, some of the most important being related to changes of marital status. First marriage has traditionally been associated with the formation of a new house-hold, and, investigations by Holmans et al. (1987) imply that in the long term, after allowing for remarriage, a divorce results in an average increase of 0.4 households.

Household formation or dissolution is not always related to change in marital status. Unmarried cohabitation is an important effect and, although this status may, in some ways be similar to marriage, it is not yet clear whether the duration of such relationships or the household formation behaviour on separation are comparable. Other important effects include the tendency of single people to leave the parental home at an increasingly early age, and the greater ages to which the elderly are maintaining an independent life style.

In contrast with population projections there is not a universally adopted method of forecasting household formation patterns, but the most common approach is the headship rate method. For each demographic subgroup the proportion of people who head households is forecast. These proportions—known as headship rates—are multiplied by suitably disaggregated population projections to give a forecast of the number of household heads, which can be equated to the number of households.

There are many variations on this basic framework. Methods differ according to the degree of disaggregation. For example, the method used to make forecasts for England and Wales (Corner, 1989.) takes account of the relationship between marital status and household formation, by estimating headship rates for demographic groups defined by marital status as well as age and sex. The same system defines headship as a multiple response variable determining the type of household headed, rather than simply a binary head/non-head distinction. Other variant methods include one by Kono (1987) which projects households according to their size, and Pitkin and Masnick (1987) have developed the concept of a headship/membership accommodation matrix to examine the effects of family structure on headship.

The crucial calculation of the headship model is the estimation of future headship rates, and various methods are used to do this. The most common is to fit past data, preferably using a curve which restricts estimates to the interval [0,1]. Expert opinion is often used to determine suitable asymptotes for such projection curves. The model used for England and Wales is a curve-fitting method, which models the cohort development of headship rates (Corner, 1989).

There have also been attempts to model headship rates in terms of economic and social variables, by means of both time series and cross-sectional analyses. The time series methods often suffer from inadequate series of data, both in terms of their length and their disaggregation, and these difficulties have often been compounded by failure to separate the time trends of headship rates and of the explanatory variables used, resulting in collinearity problems and improbable claims for the statistical significance of the results achieved. Cross-sectional studies examine either the headship of individuals—defined as a binary response variable—or headship rates in different areas, at a point in time. For an example of this approach see Carliner (1975). These have the advantage over the time series models in that they allow more disaggregated analysis and provide more data cases. They eliminate the problem of the time trends and suffer less from problems of collinearity, but they suggest that the explanation of headship rates in terms of economic and social variables is complex. Personal income is generally agreed to have a positive effect, although its importance varies over demographic groups. Some variables, such as dwelling availability in particular tenures, are more partial—affecting some groups but not others. Others, such as house prices, have a complicated relationship with headship rates, where cause and effect are intermingled and have not yet been satisfactorily analysed. The likelihood is that there are effects from numerous variables, many of which are difficult to define in terms of available data.

The main rivals to the headship rate method are the class of dynamic models, based on the philosophy that, to study household composition, it is only necessary to monitor individuals' changes of household affiliation. The primary aim is an understanding of the dynamics of household formation in terms of processes such as marriage, divorce and leaving the parental home. Such methods are usually based on a matrix of household transitions. Members of a cohort are partitioned into a number of 'states', defined in terms of their demographic and household membership characteristics. A transition matrix defines the probabilities of an individual moving between any pair of states, or of leaving the system, in a particular time period, so that if transition matrices and patterns of migration into cohorts can be estimated for the projection interval, future numbers of individuals within each state can be estimated.

Dynamic models are claimed to have the advantage that they marginalise the study to processes of household formation and dissolution. Their drawback is the requirement for data and forecasts of transitions between household states, which limits their effective use to those countries, such Sweden and the Netherlands, where suitable linked or longitudinal data are available. Keilman (1988) reviews a number of dynamic models.

3 Household trends and housing demand in England and Wales

To illustrate the importance of the various influences on household formation—and hence on the effective demand for additional housing - this section provides an overview of household formation in England and Wales, by examining estimates for the last thirty years and projections for the next twenty. The forecasts use population projections made by the cohort-components method and incorporate marital status projections made by a dynamic model (Daykin and Leete, 1979). Households are forecast by a headship rate method, the number of household heads in each age, sex and marital status group being projected by a life-cycle headship rate method (Corner, 1989).

The estimates and forecasts of annual growth in households during 1961 to 2011 are shown at the top of figure 1. There is positive growth for all years, of between about 100,000 and 200,000 households per year—about ½ to 1 per cent per year. Up to the early 1980s the growth rate varied about a fairly constant mean, but reached a peak during the 1980s, from which it is now forecast to fall until early next century, whereafter a modest increase is expected. In terms of housing demand this forecast reduction in the growth rate of house-holds is of considerable importance. There is concern amongst some housebuilders that after the boom years of the 1980s there are leaner times ahead, with a diminishing demand for net additions to the housing stock for the next decade.

To help explain this picture of household formation, figure 1 divides the total household growth into four components. The first describes the effect of change in the adult population, assuming that headship rates and the distribution of population by age, sex and marital status remain unchanged over each year. Subsequent components assume a constant total adult population. The second allows only the variation of the population distribution by age and sex, the third permits only marital status within each age and sex group to vary, and for the fourth all factors are fixed apart from the age, sex, and marital status specific headship rates. The four components thus represent the separate effects on household formation of total adult population size, population distribution by age and sex, marital status distribution and headship rates.

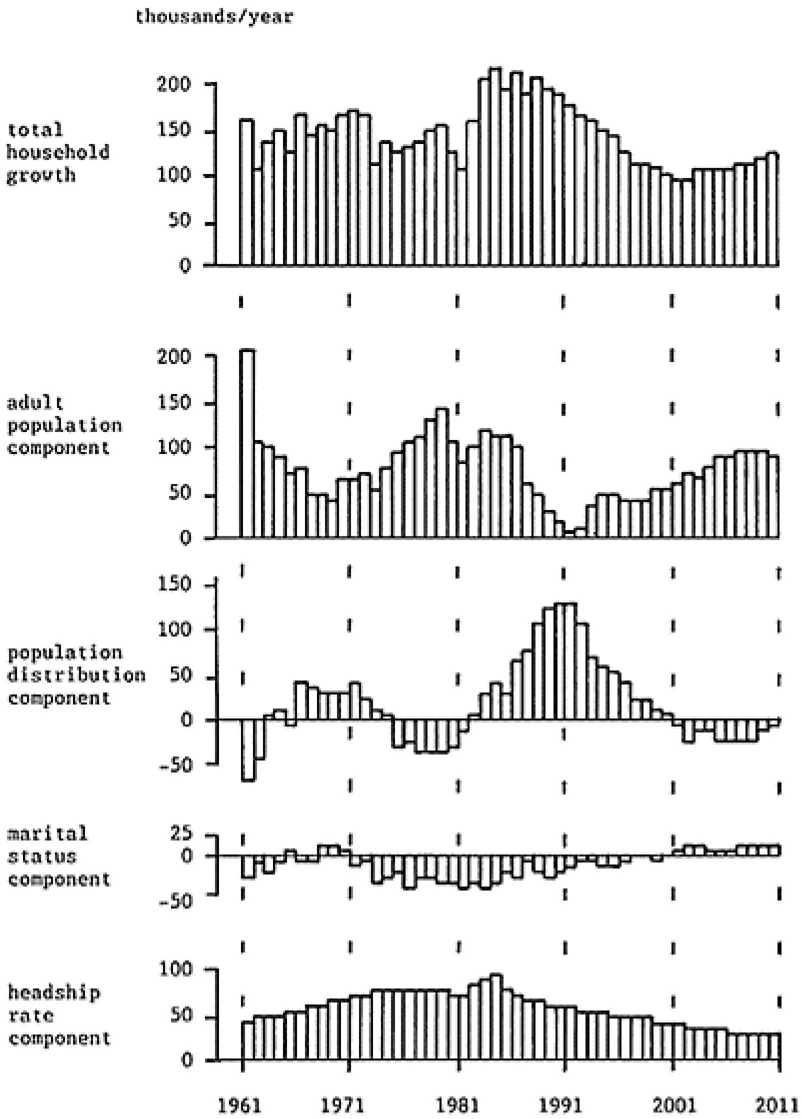


Fig. 1. Components of annual change of the total number of households in England and Wales, 1961–2011

The first component is proportional to the total adult population, and so reflects the combined effects of deaths, migration and the number of people reaching adulthood (defined as 15 years old) in each year. The latter figure is closely related to the number of births 15 years previously. Of these effects, deaths remain about constant at 550,000 to

600,000 per year throughout the 50 year period, the effects of increased life expectancy being counterbalanced by the general ageing of the population. Net migration, whilst erratic, is sufficiently small to affect the picture only exceptionally—most notably in the period 1980–83, when a net migrant inflow turned to a fairly substantial outflow and then back again. However, the predominant cause of variation is the fertility level 15 years previously. The first year considered illustrates the effect of the exceptionally large post-war 1946/47 cohort reaching adulthood. The 'baby boom', which peaked in 1964, has its effect on the adult population in the mid 1970s to the mid 1980s, and this is followed by a reduction in the growth rate to near stagnation just about now—the result of the 'baby bust' centred on 1977. The adult population is set to accelerate again into the next century, when the children of the baby-boomers reach adulthood.

The distribution of population is important because headship rates generally increase with age, so that the older a person is the more likely he or she is to head a household, the increase being particularly rapid up to the age of about 30. To an extent the population distribution component and the adult population component are counter-cyclical, as, when the cohorts reaching adulthood are small the average age of adults increases and the average headship rate is higher. Examination of the first two components suggests that they largely explain the high rates of household formation in the 1980s and are the main cause of the reduction in the 1990s. In the 1980s the baby-boom generation were reaching the age where they were forming their own households, whereas in the 1990s they will mostly have passed through this stage, and new household formation by the ensuing baby-bust generation will be on a smaller scale.

The effects of marital status on household numbers have been referred to earlier. At all ages, widowed or divorced people tend to have the highest headship rates. At younger ages, single (never-married) people have the lowest rate, but single and married headship rates are closer for older groups. The average age of first marriage has been falling for the past two decades. The percentage of 20–24 year olds who are married has fallen from nearly 50% in 1971 to under 20% now, and is forecast to decline to less than 15% by 2011. Part of this change is due to the growth in unmarried cohabitation but, as only 9% of people in this age range were cohabiting in 1987, most of the change is clearly due to people marrying later, or not at all. As single headship rates are low amongst the young this change has tended to reduce household growth. To some extent this effect has been offset by the higher number of divorces which, as was seen earlier, tends to increase headship rates. The marital status component shows no clear trend in the 1960s, when the marriage rate was fairly stable and the divorce rate was low. In the 1970s and 1980s it was negative, with the fall in the marriage rate of the young prevailing over the increasing divorce rate, but from now onwards the component is projected to move from being slightly negative to slightly positive, as the marriage rates level out and divorces decrease slightly.

Throughout the period headship rates have a positive effect on household growth. Important effects include a general increase in headship rates amongst young single people due to earlier departure from the parental home to live alone, to share with friends, to enter an unmarried cohabitational relationship or to form a lone-parent household. In addition, it is now comparatively rare for young married couples to live temporarily with parents after marrying. The proportion of people living alone has increased at all ages, but particularly amongst the elderly. Indeed, amongst elderly widowed and single women headship rates are approaching their maximum theoretical value of 1, so that little future increase can be expected for these groups. The proximity of headship rates to saturation level in some groups is largely responsible for the forecast decline of the headship effect in future years.

Are the expectations of a reduced demand for new dwellings in the 1990s justified? At face value it would seem so, with household growth falling steadily for the next decade—but how accurate are the forecasts? Regarding the population components, which are chiefly responsible for the future trend, there can be little doubt. There may be increased in-migration—from mainland Europe or Hong Kong for example—and there may be medical advances which will prolong life-expectancy, but there is little basis for forecasting sustained in-migration or reduced mortality on a scale sufficient to significantly change the picture. Headship rate growth amongst young single people may accelerate due to an ‘Easterlin’ effect whereby, because of the small cohorts of young people, demand in the first-time buyers housing market falls, resulting in lower house prices in this sector and easier entry into the market. However, as rates for the elderly, and for married people are close to saturation level, such growth would have to be at an unprecedented rate to have any significant overall effect. Similarly a reversal of the increasing age of first marriage is possible, but is unlikely to reach a magnitude sufficient to alter the general picture. All in all any realistic assessment must be that household growth in the 1990s will be substantially below that of the 1980s.

On a brighter note for the housebuilding industry, it must be borne in mind that total household growth is not the sole determinant of housing demand. It was pointed out earlier that during the 1970s the housing stock grew more quickly than the number of households, and there is the possibility of housebuilding to replace demolitions. Consideration should also be given to the characteristics of house-holds, as well as their numbers. For example, whilst the 1980s largely saw the assimilation of the baby boom generation into the housing market, the 1990s will see many of them seeking to move further up the housing ladder. To what extent does the present housing stock provide for their aspirations? Much will depend on government policy. How far will considerations of housing need reemerge, to what extent will demolition be required, and how great is the backlog of need and demand? Such questions are beyond the scope of this paper, but they set the framework in which the methods and results described here must be applied.

4 References

Armitage, R.I. (1986) Population projections for English local authority areas. **Population Trends,** 43, pp. 31–40.

Bongaarts, J. Burch, T.K. and Wachter, K.W. (eds) (1987) **Family Demography,** Clarendon Press, Oxford.

British Society for Population Studies (1990) **Population Projections: Trends, Methods and Uses,** Occasional Paper 38, HMSO, London.

Carliner, G. (1975) Determinants of household headship. **Journal of Marriage and the Family,** no. 37, pp. 28–38.

Congdon, P. and Batey, P. (eds) (1989) **Advances in Regional Demography,** Belhaven Press, London.

Corner, I. (1989) Developing centralised household projections for national and sub-national areas, in Congdon and Batey (1989), pp. 91–106.

Daykin, C. and Leete, R. (1979) Projections of the population by marital condition. **Statistics News,** 44, pp 17–24.

Ermisch, J. (1990) **Modelling the Income-Household Formation Relationship,** Scottish Homes, Edinburgh.

Field, J.L. (1990) Past projections: how successful?, in British Society for Population Studies (1990), pp. 23–30.

Holmans, A.E.Nandy, S. and Brown, A.C. (1987) Household formation and dissolution and housing tenure: a longitudinal study. **Social Trends,** 17, pp. 20–28.

Holmberg, I. (1987) Household change and housing needs: a forecasting model, in Bongaarts et al. (1987), pp. 327–342.

Keilman, N. (1988) Dynamic household models, in **Modelling Household Formation and Dissolution,** (eds N.Keilman, A.Kuijsten and A. Vossen), Clarendon Press, Oxford, pp. 123–138.

Keilman, N. (1990) National population projections in industrialized countries: a review of methodology and assumptions, in British Society for Population Studies (1990), pp. 31–42.

Kono, S. (1987) The headship rate method for projecting households, in Bongaarts et al. (1987), pp. 287–308.

Murphy, M.J. (1989) Housing the people: from shortage to surplus?, in **The Changing Population of Britain** (ed H.Joshi), Basil Blackwell Ltd., Oxford, pp. 90–109.

Murphy, M.J. (1990) Methods of forecasting mortality for population projections, in British Society for Population Studies (1990), pp. 87–102.

Pitkin, J.R. and Masnick, G.S. (1987) The relationship between heads and non-heads in the household population: an extension of the headship rate method, in Bongaarts et al. (1987), pp. 309–326.

Rogers, A. (1980) Introduction to multistate mathematical demography. **Environment and Planning A,** vol. 12, no. 5, pp. 489–498.

Rogers, A. and Castro, L.J. (1981) Model migration schedules. **IIASA Reports,** vol. 4, no. 2, pp. 125–159.

Tyler, P. and Rhodes, J. (1989) A model with which to forecast employment and population change at the regional and sub-regional level, in Congdon and Batey (1989), pp. 124–149.

174
Housing shortages in a rich country: the case of Germany

E.GLUCH

1
Introduction

Abstract
A housing shortage prevails once again in Germany. Rents, especially in the conurbations, have risen strongly in the past few years. The population in western Germany increased by more than two million, above all due to immigration. In 1988 a total of 209 thousand new housing units were constructed, the lowest number in the past four decades.

On the other hand, the government finances housing construction, directly or indirectly, at an annual rate of about DM 70 billion; nearly every second D-Mark in this area comes from the state.

Since reunification on October 3, 1990, enormous new needs for housing investment have arisen, since the housing supply of the some 16 million people in the eastern Länder is clearly worse than in the western part of Germany.

The situation could be alleviated in the short term by intensifying construction as much as possible in the coming years. For a long-term solution, housing construction must be liberated from the many subsidies now in effect. The major area will be the elimination or modification of fiscal regulations.

Keywords: Housing Shortage, Housing Supply, Home Ownership, Fiscal Regulations, Subsidies, Tax Relief, Quality of Construction, Federal Republic of Germany.

The housing shortage in Germany has once again become a topic of discussion in Germany. For many people this is a present reality, especially for the lower income groups and young families. How did this come to be, since there were still thousands of vacant housing units as late as the mid-1980s?—units consisting not only of luxury flats but also public housing.

2 The Housing Market since 1950

In the past 40 years in the Federal Republic of Germany approximately 19 million housing units have been constructed: 5.2 million in the 1950s, and 5.7, 5.0 and 3.1 million respectively in the following decades. The total number of housing units increased from 10 million in 1950 to 26.3 million in 1987. (Approximately 2.7 million units were torn down during this period or were removed from the housing stock in other ways.) Thus, a good two thirds of homes in use today were built in the past 40 years.

2.1 Development of Housing Supply

The housing supply has improved noticeably. The number of people per unit declined from an average of 5.1 in 1950 to 2.3 in 1987; at the same time the living space per person increased from an average of $14m^2$ to $36m^2$. In 1950 an average of 1.67 households had to share a housing unit. Today the number of housing units corresponds roughly to the number of households.

Table 1. Housing supply in West Germany, 1950 to 1987

Year	Housing units (million)	People per unit	House-holds per unit	M^2 per person
1950	10.0	5.1	1.67	14
1960	16.2	3.4	1.20	20
1970	20.8	2.9	1.06	26
1980	24.3	2.5	1.02	32
1987	26.3	2.3	1.02	36

2.2 Development of Housing Standard

The many newly constructed housing units have become not only larger from year to year; they are also better equipped. In 1960 only 11% of all housing units had central heating, only 47% had a bath and only 67% a WC. In 1987 the corresponding values were 73%, 96% and 98%. Since the beginning of the 1970s virtually all new homes have been built with baths, since the beginning of the 1980s only very few (especially holiday homes) units have been built without central heating.

Such a global look at the standard and quality of the housing units in the Federal Republic of Germany suggests the conclusion that it would be difficult to find any other country with such a high standard of housing.

Table 2. Housing standard in West Germany, 1950 to 1987

Year	Housing units with central heating	bath	WC
1950	7	20	n.a.
1960	11	47	67
1970	35	74	82
1980	67	90	93
1987	73	96	98

2.3 Development of Construction Activity

New housing starts in the last four decades have not been marked by a steady development. The number of units completed rose relatively rapidly—parallel to the rebuilding of the nearly totally destroyed construction capacities during the war—to ca. 550,000 units in the mid-1950s. Towards the end of the 1960s when nearly every household had a housing unit, the first weakening tendencies in housing demand emerged. High rates of inflation at the beginning of the 1970s brought about a great boom in housing construction in West Germany. Many attempted to escape the drop in the value of money by investing in “concrete capital”. In the three years from 1972 to 1974 nearly 2 million dwellings were constructed.

This led already in 1974, more than 15 years ago, to a housing surplus with large numbers of unsold or unrented units. Looking at the chart of housing construction in West Germany, the declining trend that already set in at the end of the 1960s is clearly noticeable. All the recovery trends in the twenty-year period of decline—with the exception of the above-mentioned excessive development at the beginning of the 1970s touched off by the strongly expanding inflation rate—were only possible by means of government interventions (programmes). Often the realized effects were only marginal, i.e., short recovery phases were followed by a continuation of the declining tendency.

A few examples of these government interventions were:

1971: Programme for the construction of 200,000 public housing units.

1978: Expansion of the fiscal incentives for owner-occupied housing units in second-hand dwellings.

1982: Tax relief up to a limited amount for loan interest in owner-occupied housing units, tax relief for construction based on number of children, interim financing of building society loans, etc.

These three promotional programmes led to the housing surplus of 1974, vacant housing in 1981 and several hundred thousand vacant housing units in 1984/85.

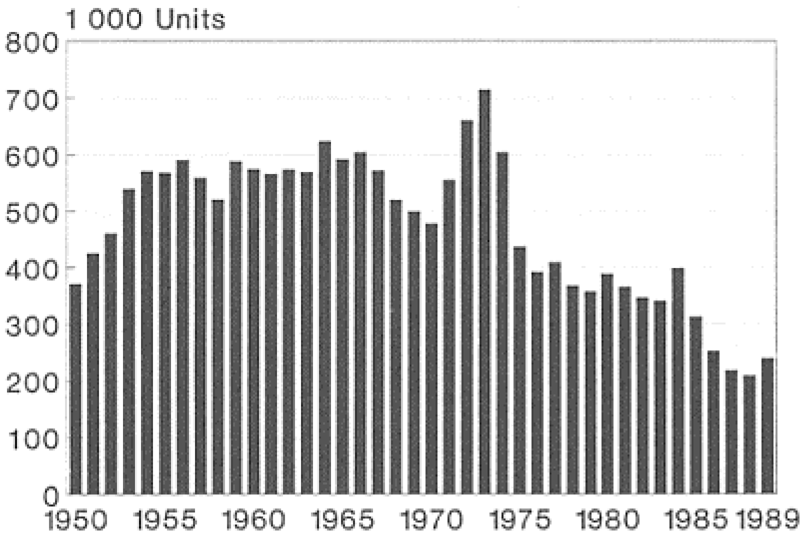


Fig. Housing completions in West Germay, 1950 to 1989

Often the impression was given that potential investors waited until either new or better promotional programmes were introduced.

Especially crass was the situation between 1986 and 1988. The number of housing completions sank during these three years from 251, 940 to 208,621. Not until the wave of immigrants from Eastern Europe and the former GDR set in and rents increased dramatically did the long-awaited government programmes come. Then a virtual cornucopia of old and new measures was poured out. Since 1989 housing construction has been operating under full steam.

3 The Housing Market in 1991

The present precarious situation in the housing market has a number of causes. The following influencial factors have overlapped to such an extent that the result was today's dreadful state in the housing sector:

– The number of completed housing units was reduced by half within only four years (1984:398, 373; 1988:208,621).
– The overall economic situation in the second half of the 1980s was extremely positive. This led, especially in conurbations, to the creation of many new jobs. The people that took these jobs in the cities were upper-income consumers, also with respect to housing.
– From 1986 to 1988 there was a noticeable increase in real income. An instrumental factor was the extremely low rate of inflation.

– Since 1987 the number of households increased rapidly. This is largely attributable to the baby-boomers having reaching the age of starting their own households.
– Finally, since 1988 the size of the population has risen drastically, caused primarily by immigration from Eastern Europe and the former GDR. This amounted to 250,000 persons in 1988 and 730,000 in 1989!

A particulary important role, however, was played by activities of the government which have clearly intensified in the past two decades. Presently, the volume of direct and indirect subsidies in the German housing market according to official statistics and experts' estimates amounts to DM 70 billion yearly. The direct subsidies listed in the subsidy report comprise only one fifth of the total amount:

– tax relief for owner-occupied housing	DM 6 billion
– government rent subsidies	DM 4 billion
– public housing (net amounts), subsidies for building loan contracts, etc.	DM 5 billion

The major portion (four fifths) does not appear in the official statistics but can only be roughly estimated. This consists of the following fiscal elements:

– tax relief for rental units	DM 20 billion
– tax exemption of gains on sales	DM 25 billion
– benefits in the net worth tax	DM 10 billion

Since the entire construction volume amounts to nearly DM 150 billion a year, direct and indirect subsidies have reached nearly half of this amount.

After October 3, 1990, the housing market took on an additional problem. As a result of German unification, the population increased overnight by 16 million for whom housing is to be made available in sufficient quantity and high quality. Presently in the new German Länder there are approximately 7.5 million households and some 7 million housing units. The average housing space per inhabitant is $27m^2$ ($36m^2$ in former West Germany). The quality of the dwellings is much more modest than in western Germany: only 82% of the units have a bath or shower, 76% a WC, and only 47% central heating.

These few statistics show the enormous pent-up demand in housing investment in the new Länder. If the average quality level of western Germany is to be achieved in 10 to 15 years, then, according to rough, initial estimates an annual average of DM 100 billion will be necessary.

4 The Housing Market in the 1990s

4.1 Suggestions for Changes in Government Subsidies

It is thus mandatory to rethink the present system for stimulating housing construction in order to finance this huge volume. In doing this the following basic questions must be addressed:

– Should a deliberate support of home ownership be continued?

If so:

Should—as currently—the assets be virtually disregarded and only the earnings situation be taken into consideration?
Should second-hand dwellings continue to be supported?
Should regional differentiations be made?

– Should the emphasis of support continue to be placed on tax effects?
(tax relief for owner-occupied housing according to §10e EStG, declining balance tax depreciation, tax exemptions of gains on sales, etc.)
– Should the quality of the construction measure continue to play no role for support?

4.2 Goals For a New Housing Policy

In the shortest possible period of time the following must be achieved:

– The level of subsidies (presently ca. DM 70 million annually) must be drastically reduced.
– The tax breaks must be rigorously cut back.
– The support programmes must take qualitative aspects into consideration.
– The housing supply for lower income groups and young households must be improved.

It is obvious that the implementation of these targets will affect privileges enjoyed by certain interest groups. With an annual subsidy volume of ca. DM 70 billion, each citizen pays more than DM 1000 per year into the subsidy fund, but only a few receive any benefits.

A very simply proposal was made in April 1991 by the French Nobel Prize winner in economics, Maurice Allais, in his presentation at the third European construction symposium in London. He proposed eliminating **all** subsidies in the housing markets, both direct and indirect. He is perfectly aware that the lower income groups—especially in conurbations—will have difficulties paying the higher rents. They would then receive supports, up to a certain income level. This would not be coupled to a particular housing unit. Every household should be able to decide the share of their income they are prepare to devote to housing.

It will take some time for such a liberal programme to be implemented. Returning to the German case, the following observations can be made.

In the coming years large capital flows must be diverted to housing construction—for new buildings and modernization in western and eastern Germany. To achieve this it is necessary to build as many dwellings as possible in the coming years. In the medium term, the entire housing market must be freed from the various forms of stimulating, government interventions. The present market is strongly influenced by speculative private investors with short-term goals. The reasons for this are the current fiscal regulations. These should be changed so that once again business enterprises can develop greater interest in housing investment; i.e., in the long term a satisfactory yield must be achievable. The quality of construction is not likely to worsen under these circumstances but will probably even improve.

175
The development of a European housebuilding industry

R.GROVER

Abstract
This paper examines the differences between the housing markets within the European Communities and examines the potential for cross-border expansion by housebuilders. It discusses the foreign activities of UK housebuilders, noting the relative unimportance of the EC. It considers the extent to which the harmonization policies of the EC may assist in the development of a European housebuilding industry. The major measures likely to have an effect are those concerned with public purchasing, the technical harmonization of construction products, and the harmonization of the regulation of credit institutions.

Keywords: Housebuilding, European Communities, Harmonization, Public purchasing, Construction products, Credit institutions.

1 Introduction

In 1982 the European Communities set themselves the goal of achieving the completion of the internal market by the end of 1992. The Commission proposed a series of measures in 1985 to eliminate non-tariff barriers, including measures to remove border controls, to harmonize indirect taxes, and to harmonize the national regulations and administrative controls governments' impose on a wide range of goods and services. Non-tariff barriers can cause similar effects to tariffs and quotas. They can cause the prices of imported goods and services to be raised, as a tariff does, or they can restrict access to the domestic market in the manner of a quota. Thus, domestic producers are given protection from foreign competition. The result may be higher prices for the consumer than would occur with free competition and a less efficient structure for industry than would otherwise be the case. One means by which a government can impose a non-tariff barrier is by means of regulations and administrative provisions. Separate regulations for different national markets can raise costs for importers, whilst the time taken to gain national product approvals or registrations can act as a quota. In the construction industry, regulations and administrative provisions of this nature are probably the major non-tariff barrier encountered.

Regulations can be imposed for a variety of reasons but a common justification, particularly in construction, is the need to protect the consumer. Governments impose regulations that govern who may produce certain goods and services, how the products are to be approved, and how it may be demonstrated that the products meet quality standards. This paper is concerned with those that have been imposed on the housebuilding industry and the extent to which national regulations are being removed under the Single Internal Market programme. The regulations and administrative provisions being harmonized impact on the industry at three points in the housebuilding process. Some are concerned with the building process itself and the products used in construction. The construction industry is one of the first industries to experience technical harmonization under the “new approach”. This will initially affect building products but will, in due course, affect design and workmanship. Others are concerned with the finance of housing, particularly the provision of mortgage finance for owner occupation. Yet others are concerned with the development process, in particular how public sector bodies should procure construction works. Many of the measures discussed in this paper also have a bearing on other areas of construction. However, the concentration on housebuilding is due to its economic significance. A single internal market is unlikely to develop where there is no economic rationale. Profitability is too low in much of the construction industry to encourage firms from one Member State to operate in others. This is not the case with housebuilding. The paper examines the extent to which housebuilders have begun to operate across national borders and how the development of a Single Internal Market may encourage this further.

2 The Housebuilding Market in the EC

2.1 Size of the Market

Table 1 sets out the dimensions of the housing market in the EC. The precise figures should be treated with caution, but the main patterns are clear. For example, it has been estimated that 20/000 houses per annum have been built illegally in Portugal over the past two decades (Housing Research Foundation, 1990b, 28–9). The EC contains five major housing markets, as measured in terms of housing completions/ namely the UK, Germany, France, Italy, and Spain, and two medium sized ones, the Netherlands and Greece. Activity within these markets, as measured in terms of completions per 1000 households, varies markedly with Germany having a ratio of only 19 per cent of that of Greece, 28 per cent of Spain’s, and 32 per cent of that of the Netherlands. Activity also varies within markets. For example, housing permits issued in Spain in 1988 varied from 30.30 per 1000 population in Baleares, 18.41 in Valencia, and 18.36 in Canarias to 3.38 in Pais Vasco and 3.96 in Extremadura (Housing Research Foundation, 1990c, 9). Similarly in Portugal, housing approvals in the Algarve run at 10.8 per 1000 population, compared with a national average of 3.8 (Housing Research Foundation, 1990c, 1). In both Spain and Portugal housebuilding has been proportionately more active in holiday centres than in other areas.

The pattern of tenure also varies within the EC. Countries like Spain, Greece, and Ireland have a relatively high proportion of owner occupation compared with Germany and the Netherlands. Belgium and Germany have relatively large private rented sectors, whilst the Netherlands and the UK have relatively large public rented sectors. In both these latter cases, the importance of the public sector is declining. In the Netherlands this is due to reduced government support for social housing and in the UK it is the result of the ability of public sector tenants since 1980 to be able to purchase their properties at substantial discounts to their market values.

Expenditure on housing as a proportion of consumer expenditure does not appear to vary markedly within the EC other than for Ireland and Denmark. However, there would appear to be marked discrepancies in the relative cost of purchasing a dwelling compared with incomes, with Germany, Greece, and Italy standing out as relatively expensive markets. The importance of external demand also varies between countries. It is estimated that 30 per cent of Spain's housing output is in the form of second homes for EC citizens, with second homes accounting for 13 per cent of its housing stock (Housing Research Foundation, 1990c, 7). In 1988 £2.25bn was invested in Spanish property by foreign residents and, perhaps, half of this went into housing (NEDC, 1990, 32).

The figures in table 1 suggest three potential opportunities for cross border activity in housebuilding. Firstly, one might expect to find foreign housebuilders

Table 1. The Housing Market in the EC

	UK	**Germ**	**Fran**	**Italy**	**Spain**	**Neth**	**Denm**	**Belg**	**Irel**	**Port**	**Greece**
Market Size Households (million)	21.3	26.4	19.6	19.9	10.8	5.5	2.2	3.7	1.0	3.4	3.0
New dwelling completions 1988 (000)	245	183	327	237	269	119	24	35	18	46	110
Completions per 1000 households	11.5	6.9	16.7	11.9	24.9	21.6	10.9	9.5	18.0	13.5	36.7
Tenure (%) owner occupied	62	37	51	59	75	14	52	61	74	60	70
private rented	8	60	26	}	23	13	20	32	14	}	}
				} 36						} 40	} 30
public rented	30	3	14	}	2	43	22	7	12	}	}
Housing Costs % consumer expenditure on housing (1988)	10.6	13.5	11.2	12.9	13.5	13.0	19.2	11.3	5.7	10.7	10.6
hours worked to purchase house (1984)	9165	20453	9928	14154		8839	6469	4477	7698		18533

Source: NEDC (1990) with additional information from Housing Research Foundation (1990b, 1990c) active in markets, such as Spain and Portugal, where there is a substantial external demand. Foreign firms can exploit the marketing advantages they enjoy in their home state, such as their reputation and established marketing structures, with which a firm in the host state is unlikely to be able to compete. A second possibility is that housebuilders will be attracted to those markets in which housing completions are proportionately high relative to their populations, since there should be some economic advantage that the local industry is exploiting in order to achieve such a level of activity. Such markets will appear particularly attractive if they have traditionally used different approaches to marketing houses than the foreign firm uses and it can see an opportunity for exploiting its own methods. For example, French housebuilders tend to develop small scale developments with sales of individual properties from catalogue designs. This market could offer opportunities for UK developers, who produce speculatively built estates of relatively low cost houses aimed at those with a lower disposable income than the customers of French developers (Housing Research Foundation, 1990a). The third possibility is that foreign firms will attempt to enter a market such as the German one, where the cost of housing is relatively high and there is a low proportion of owner occupation. There could be potential for selling low cost housing to groups whose limited effective demand has kept them out of the owner occupied sector. These opportunities are all in the owner occupied sector. The trend in the 1980s was for governments in the EC to reduce their support for social housing. The private rented sector calls for a long term commitment to the management of property which building for owner occupation does not require. Therefore, it is the owner occupied sector that is likely to be the most attractive for foreign housebuilders.

2.2 Profitability

The profitability of the housing market indicates that there is greater potential for cross border activity than is the case for other construction activities. Table 2 sets out the profit margins reported by some major UK companies who are active in housebuilding and general construction and civil engineering. The figures should be treated with caution as British company law and accounting practice permit differences in the treatment of particular items. However, the figures indicate that housebuilding is of the order of three to nine times more profitable than general construction work.

Table 2. Profit Margins in Housebuilding and Construction

Company Date	Housebuilding (%)	Construction (%)	Reporting
Barratt	16.2	–	June 1989
Costain	18.1	3.1	Dec 1989
Higgs & Hill	21.6	2.4	Dec 1989
John Laing	12.6	2.6	Dec 1989

Y J Lovell	7.4	2.6	Sept 1989
McCarthy & Stone	16.3	–	Aug 1989
Tarmac	19.9	3.3	Dec 1989
Taylor Woodrow	13.3	1.8	Dec 1989

Source: Annual Reports and Accounts
Notes: Profit margin is defined as profits before interest and tax/turnover. For Higgs & Hill, Lovell, and Taylor Woodrow, the profit margin has been computed as profit before tax/turnover.

For Costain housebuilding includes commercial property development and construction includes engineering.

2.3 EC Activities of UK Housebuilders

Table 3 illustrates the extent to which leading UK housebuilders are active elsewhere within the EC. It enables comparison to be drawn between the scale of this activity and their other overseas interests. As it has been derived from company accounts, it is subject to the same qualifications as table 2. British companies are required to identify the profits and turnover that come from different activities and markets, but the degree of detail to which this is done varies. As a result, it is not possible in many cases to identify the precise contribution being made by housebuilding or the EC. The scale and range of activity within the EC appears to be similar to that found in comparable economies (Building Material Producers, 1990a, appendix J;1990b, appendix F). A survey of Dutch companies (Buur,1989) found that 4 per cent of them have been active abroad in residential construction, mainly in Belgium and Germany.

Four main points emerge from table 3. The EC markets in which UK firms are most active in housebuilding tend to be those, such as Spain, Portugal, and France, which have relatively high levels of housing permits or completions relative to the population. Within these markets, UK housebuilders are attracted to those regions that exhibit this characteristic, such as Andalucia, Provence, and Faro.

Table 3. Activities of Some Leading UK Housebuilding Companies

Company	Year end	Turnover (£m)	Operating Profits (£m)	Activities (% turnover)	UK Activities	Other EC Activities	Other Overseas Activities
Barratt	June 1990	579.8	54.9	housebuilding property development	5950 units sold	subsidiary in S France leisure dev in Spain	18% turnover 22% profits from America
Costain	Dec 1989	1404.2	97.1	engineering & const 67% mining 19%	696 units sold 68% turn-	leisure dev in Spain	18% turnover from N

				commercial & res dev 14%	over		America, 6% from Australia
John Laing	Dec 1989	1363.2	63.9	const 73% housing 19% prop dev 2% trading & tech 6%	92% turn-over 64% profits	Spain 0.4%, rest Europe 0.7% turn-over; 15% shares in Laing SA Spain	America 5%, Mid East 2% turnover California 23% group house sales
Higgs & Hill	Dec 1989	419.1	27.8	const 84% housing 8% prop dev 8%	94% turnover	prop dev in France, Spain, Netherlands	
Y J Lovell	Sept 1990	394.6	33.8	const 45% housing 49% commercial dev 6%		2 housing devs in Spain	

Company	Year end	Turnover (£m)	Operating Profits (£m)	Activities (% turnover)	UK Activities	Other EC Activities	Other Overseas Activities
McCarthy & Stone	Aug 199C	B7.7	10.0	retirement homes in UK & France, second homes in France	85% turn-over, 84% profits, 74% units sold	France: 14% turnover, 11% profits, 26% units sold	
Tarmac	Dec 1989	3527.0	446.6	const 26% housing 26% quarries 17% products 18%	84% turn-over. Largest UK hse'builder	Europe 4% turnover, mainly products	USA 12% turnover, inc housebuilding
Taylor Woodrow	Dec 1989	1321.1	125.2	const 69% housing 15% prop dev 8%	75% turn-over, 21% housing completions	Europe 2% turnover Spain 2.4% housing completions	N America 19% turn-over, 62% housing completions
Trafalger House	Sept 1989	3228.6	290.5	const & eng 56% property 23% hotels & shipping	55% turn-over 71% housing completions	Europe 4% housing completions develops in Portugal	Americas 10% turnover USA 25% housing completions

				21%			
George Wimpey	Dec 1989	2065.0	171.2	contracting 44% housing 36% minerals 15% property 3%	74% turn-over 71% housing completions	France 3% housing completions also housing in Spain	N America 18% turnover housing in USA, Canada, Australia, Hong Kong

Secondly, the markets in which UK housebuilders have been most active are those in which there is a strong external demand element so that developments can be marketed to UK residents. The rise in house prices in the UK between 1982 and 1988 has produced equity that owner occupiers can release for other purchases, including second homes. These UK companies usually have active property development interests and have the capability to become involved in projects for which the marketing and financing of housing is only one part. In their home market, they are involved as developers, for example, of shopping complexes, and property development is an important contributor to their profits. A number of the developments have associated leisure elements, as may be expected with residential properties aimed at the second home or retirement markets. Several of the developments are joint ventures or are being managed from long established bases, such as Gibraltar. Thirdly, the German market has yet to emerge as a major one for these companies, in spite of some well-publicised investigations into its potential (eg Building, 3 Feb 1989, 15; 23 June 1989, 7). German sources suggest that this is because the market is unwilling to accept inferior British quality standards. However, it could also be because British style residential development requires British style housing finance to be effective, and this will have to wait until the liberalization of housing finance is complete. Perhaps the most significant point to emerge from table 3 is that the EC is not a major market for these firms. In all cases, the UK market is the dominant contributor to turnover, though the importance of the UK is least where the construction firm is part of a diversified business, such as Trafalgar House. British construction firms have traditionally looked to north America for their overseas activities and a number, such as Barratt, Laing, and Taylor Woodrow, have extensive American housebuilding operations. The EC operations come nowhere near to matching the contribution of these. For example, Wimpey have had a French housebuilding operation for approximately 16 years but it contributes only 3 per cent of house completions. For Taylor Woodrow, there were 12 times as many housing completions in Canada as Spain. Buur (1989) reached similar conclusions about the importance of EC markets for Dutch firms. He noted that they tended to use Dutch personnel and subcontractors when working abroad and concluded:

> "The frontiers are crossed but not very far."

At issue, therefore, is the extent to which the Single Internal Market policies are likely to cause this situation to change.

3 Housing Development

The main EC policy initiatives that influence the development process are those concerned with public purchasing. As was shown in table 1, a significant part of the housing stock has been built and managed by the public sector. An additional element has been financed by the public sector, although it was developed by private bodies, such as housing associations. Public purchasing can enable a government to favour domestic firms over importers so that part of the GDP becomes out of bounds for importers as effectively as if a quota was in place. Public purchasing accounts for a significant proportion of the GDP in the EC. W S Atkins (1988) estimated that it amounted to 15 per cent of the EC's GDP in 1986. of this, 7 to 10 per cent is put out to contract. Purchases are concentrated in certain industries, with the construction industry accounting for 29 per cent of public purchasing. W S Atkins estimated that only 2 per cent of public construction contracts went to firms from elsewhere in the EC and that US firms were more likely to gain such construction contracts than firms from other Member States.

The EC has had directives dealing with public works since 1971 and with public supplies since 1977. These provide for the advertising of contracts of above a minimum value, the methods of tendering to be employed, and the criteria for the selection of tenders. The evidence suggests that they have not been effective in opening up public purchasing to foreign competition. Two reasons can be put forward to explain this. It could be argued that the governments of the Member States have flouted the directives, in spirit if not in actual practice. For example, tenders may not have been properly advertised; exemptions from tendering or award rules may have been abused; contracts may have been split so as to take them below the threshold for advertisement; or contracts may have been biased towards domestic producers through the use of national standards or the ways in which the technical capacity or financial standing of bidders has been evaluated (87/C 319/17). Such accusations receive some support from cases that have been brought before the European Court (eg The Times, 20.10.1989 on Store Baelt Bridqe; Building Design, 7.10.1988 on Dundalk Council case). However, it is the case that many contracts have been properly advertised without attracting bidders from elsewhere in the EC (Wanstall, 1990). This could suggest that economic reasons could also have played a part. Profit margins may be insufficiently attractive for foreign contractors. Contracts may be too small to be worth bidding for (Federation of Civil Engineering Contractors, 1989, 17). Contractors need local knowledge of the market, including knowledge of procedures, contacts with sub-contractors, and an understanding of employment practices. This may discourage foreign bidders who do not have a subsidiary in the country or who cannot find a joint venture partner.

The EC's response has been to introduce new directives that seek to tighten up the procedures concerned with the award of public contracts. These involve directives in five main areas. They include new public works and public supplies directives; a utilities directive that is intended to extend the principles of open competition in purchasing into previously excluded public services, such as the supply of gas, water, electricity, and transport; services directives, that will extend controls over public purchasing into the supply of services, and remedies directives, designed to provide redress for those who believe that they have been discriminated against in the award of a public contract. of these measures, the new public works directive (89/440/EEC as amended by

90/380/EEC) is of most immediate relevance to housing, though the proposed services directive (COM (90) 372 final) relates to services purchased in connection with housing development, such as those concerned with building design.

The Public Works Directive of 1989 is concerned with public procurement of building and civil engineering works, including residential building. It amends the 1971 directive in a number of important respects by redefining which contracts and contracting bodies are to be covered by the directive, raising thresholds for the advertising of contracts in line with inflation, limiting the use of restricted tendering and national standards, and providing for publication of information on the award of a contract and for disappointed bidders to be given reasons for their rejection.

The directive covers purchasing by a variety of public bodies. They include state, regional, and local authorities and other public bodies, such as the UK's National Health Service. Also covered are the recipients of Community financial assistance and bodies for which the majority of finance comes from public sources or for whom the majority of the management is appointed by public bodies. The directive also covers public works concessions, where a contractor carries out public works, such as the building of a road, in return for the right to exploit them, for example by charging a toll. The 1971 threshold for advertising contracts has been raised in line with inflation to 5 million ECU (£3.31 million) and there are restrictions on splitting contracts so as to keep them below the threshold. Certain contracts are excluded from its provisions, for example on grounds of national security. Negotiated contracts can be used under certain circumstances, for example, where the works are carried out for the purposes of research, or where the risks do not permit overall pricing. Otherwise open procedures or restricted procedures, where there is bidding by prequalified contractors, are to be used.

A prior indicative notice warns potential contractors that a contract is to be advertised in the future. A contract notice advertises for bids and, after the award of the contract, the contract award notice identifies the successful contractor and the contract price. Where possible, European standards or technical approvals should be used, though the directive does permit these to be ignored in certain circumstances, for example, if their use would result in disproportionate costs or technical difficulties. Where such standards do not exist, the directive sets out a hierarchy of alternative standards in order of preferred use. Trademarks and patents should not be used unless qualified by "or equivalent." The selection of the contractor can either be by means of the lowest price or most economically advantageous tender. If the latter is to be used, this must be disclosed in the contract notice or documents, as well as the criteria by which this is to be determined. Contractors can be excluded on grounds of bankruptcy or professional misconduct and financial and technical proofs of standing can be required.

The revised public works directive changes the procedures for the award of contracts but whether it will change development practice in social housing is debatable. If economic factors rather than administrative restrictions have been responsible for the low level of contracts awarded to foreign firms, then the revised directive is unlikely to have a major impact. Moreover, many housing contracts are too small to require advertisement under the directive. As was noted above, the countries in which the public rented sector is strongest are reducing the support this is being given. In the UK this has resulted in severe reductions in the public sector housebuilding programme. There must therefore be reservations about the extent to which the public purchasing directives will have an effect on housebuilding.

4 Housebuilding

4.1 Harmonization of Building Products

A study of the costs of non-Europe in building products identified national systems of standards as a major barrier to free trade (BIPE, 1988). It found that 70 per cent of products have problems in obtaining approvals under foreign standards and 60 per cent do not conform to those standards in one way or another. This is due to the multiplicity and complexity of specific standards. The major measure to combat this problem is the Construction Products Directive (89/106/EEC). This was promulgated in 1988 and is due to come into effect in June 1991. It is one of a series of technical harmonization directives produced under the new approach resolution of 1985 (85/C 136/010). The aim of directives produced under this resolution is- to ensure that products can be marketed freely throughout the EC, providing that they satisfy certain essential safety requirements. They provide for the harmonization of these essential safety requirements and for a common system for attesting that products conform to these. Products that meet the essential safety requirements are entitled to bear the CE mark and Member States may not impede the free mobility of such products. Thus, national systems of regulation cannot act as a barrier to trade and producers can export freely throughout the EC without the necessity of complying with different national systems of product approval.

The Construction Products Directive is one of the most complex of the new approach directives produced to date. It attempts to regulate all the products of a major and broadly-based industry, rather than being concerned with products with a limited function or from a small industry, such as the directives concerned with simple pressure vessels, toys, or gas appliances. Construction products are defined by the directive as any product which is produced for permanent incorporation in construction works. Six essential requirements are defined: mechanical resistance and stability; safety in case of fire; hygiene, health and the environment; safety in use; protection against noise; and energy economy and heat retention. These must be satisfied for an economically reasonable working life. Construction products should have such characteristics that the works in which they are incorporated should meet the essential requirements, providing that they have been properly designed and built. The essential requirements are given concrete form by a series of documents known as the interpretative documents, one for each essential requirement.

Products are presumed to comply with the essential requirements if they satisfy the requirements of a harmonized European standard, a European technical approval, or a national specification that meets the essential requirements. There is likely to be an initial delay before the former two categories are present in appreciable numbers. Harmonized standards are to be produced by the European standards organizations, CEN and CENELEC under mandate from the Commission. A number of Member States have operated a system of agrement for a number of years, by which an innovatory product, for which there are no standards, can gain approval as being fit for its stated purpose.

This is embodied in the directive as European technical approval. The national agrement bodies of the Member States collectively form the European Organization for Technical Approvals for the granting of technical approvals.

The directive sets out how attestation that a product conforms to the essential requirements is to be demonstrated. The precise approach depends upon how vital a product is for the building in which it is incorporated to meet the essential requirements and the variability inherent in the product. Different methods for controlling conformity can be specified for different products but, in each case, producers must carry out "factory production control." This is the permanent internal control of production to ensure conformity with specifications. The approaches to attestation vary from factory production control and initial type testing by the manufacturer (ie the declaration of conformity by the manufacturer) to type testing and the approval and surveillance of the factory production control by an approved independent body (ie third party certification). Each approach is treated as equivalent and leads to the CE mark. No Member State can require a more onerous method of attesting conformity than that collectively agreed. In this way, a harmonized system of product approvals for building products will come into existence. A standing committee of representatives of the Member States has been created to advise the Commission on technical matters.

At the time of writing this paper, it looks unlikely that the system will come into full operation in June 1991. Some Member States may not have enacted domestic legislation to implement it by that date. The interpretative documents have still to be approved in their final form, as have the rules of the European Organization for Technical Approvals. Without the interpretative documents, mandates cannot be issued for the production of harmonized standards or European technical approvals. The infrastructure for achieving attestation of conformity appears not to be available evenly throughout the EC (90/C 10/01). Even in countries where this is relatively well developed, it has been suggested that there may be shortages of capacity (International Marketing and Economic Services, 1990). As a result, it may be difficult for new products to obtain the CE mark in the short term.

4.2 Harmonization of Building Control

A system for harmonizing building product approvals will not of itself produce free trade in building products if each Member State retains its own approach to building control. Products may enter the market but may then face restrictions on the ways in which they are used. Moreover, the essential requirements in the Construction Products Directive are not to be satisfied by building products themselves but by the buildings or civil engineering works in which the products are incorporated. These two factors suggest that controls over product approvals will be extended so as to create a harmonized system of building control. This has been recognised by the Commission in the guidelines it has drawn up for the preparation of standardization mandates (CONSTRUCT 90/049). These identify two types of standard: category B standards are to be concerned with construction products; but category A standards are to be concerned with the design and execution of construction works. The Commission has taken over responsibility for the production of Eurocodes and these could form the basis for category A standards, being concerned with design principles and how they are to be executed. In addition, the directives on the introduction of measures to encourage improvements in the safety and health of workers (89/391/EEC; 89/654/EEC) have building design implications. Although measures in this area are in their infancy, the steps that have been taken so far would seem to indicate an intention to create a harmonized system of building control.

5 Housing Finance

The development of a single market for housing finance within the EC has been limited by the impediments that have existed to the free movement of capital and over the freedom to offer financial services. Freedom for one's citizens to purchase real estate in another Member State and a willingness to permit residents from other Member States to purchase real estate within one's own territory cannot be readily be divorced from the liberalization of other capital movements. Nor can the freedom of firms from other Member States to offer one's citizens mortgage lending services, or for them to set up branches on your territory to do so, be separated from their ability to do the same for other financial services. Although the Treaty of Rome provided for the free mobility of capital, it is only recently that the EC has tackled restrictions on this, such as different national systems of regulating financial services firms and exchange controls.

5.1 Abolition of Exchange Controls

Limits on the free movement of capital are being removed by the abolition of exchange controls. The UK abolished them in 1979 and they have also been abolished by Germany, France, the Netherlands, and Denmark. The Capital Liberalisation Directive of 1988 (88/361/EEC) should ensure that the remaining controls disappear by the end of 1992, though Greece and Portugal may apply for an extension of up to three further years. Amongst the capital movements specifically covered by the directive are investment by non-residents in real estate on the national territory of any Member State and investment in real estate abroad by its residents. Thus, once the remaining restrictions on the movement of capital are abolished, a single market can develop for house purchase.

5.2 Regulation of Credit Institutions

With the ending of exchange controls, the main barriers to the free movement of capital and to competition within the financial services industry are the different national regulatory regimes for the control of financial institutions. The principal objective of these is to protect depositors, policyholders, and clients from the loss of their savings through fraud or mismanagement. A secondary objective may be to ensure that macroeconomic policy, pursued through the use of monetary instruments, is not rendered ineffective by the activities of financial institutions. The effect, though, can be to make it difficult and expensive for financial institutions from other Member States to compete on an equal footing with indigenous firms. Thus, regulations may confer a degree of monopoly power on domestic firms.

Price Waterhouse (1988), in a study of the costs of non-Europe in financial services, estimated that price reductions of 10 per cent might result from the completion of the internal market in financial services. The total reductions could amount to 0.7 per cent of the EC's GDP, though the impact would vary between countries. Their estimates were based on a study of 16 financial services products in eight countries. One of the products examined was the annual cost of a home loan of 25,000 ECU, expressed as the excess interest rate over money market rates. Table 4 shows the variations in cost in the seven countries for which data was obtained. It illustrates the extent to which the absence of a single market allows cost differences to be maintained.

Table 4. Percentage difference in the cost of a home loan compared with the average for the four lowest observations

Belgium	31%	Italy	−4%
Germany	57%	Netherlands	−6%
France	78%	UK	−20%
Spain	118%		

Source: Price Waterhouse (1988)

The EC has sought to establish a harmonized system for the regulation of credit, institutions and, thus, to eliminate restrictions on free competition between firms caused by different national regulatory regimes. Credit institutions are those whose business is to receive deposits from the public and to grant credits. Although the most important of these are banks, they also include institutions that specialise in providing housing finance, such as building societies and savings banks. The aim is to provide a passport for credit institutions so that, once they have been authorised by their home Member State, they will be able to establish branches in other Member States to conduct authorised activities, or to provide authorised financial services across national frontiers into another Member State. These activities would then be carried out without the need for further authorization from, or supervision by, the host Member State. The policy necessitates the establishment of harmonized minimum standards for the authorization and regulation of credit institutions throughout the EC so that host Member States have confidence in the prudential regulation of home Member States.

The starting point was the First Directive on Credit Institutions of 1977 (77/80/EEC). This established a system whereby a credit institution must be authorised by its home Member State before it can take deposits from the public. The directive set standards for authorization, including the institution having its own capital that is separate from that of its proprietors, having management of sufficient repute and expertise, and adhering to appropriate liquidity and solvency ratios set by competent authorities in each Member State. Member States could require that credit institutions from other Member States seek authorization from them before they conduct business on their territory, but could not refuse authorization on the sole grounds that the institution has a different legal form from that which would be required from one of its own credit institutions carrying on similar business. Thus, it established a common system within which regulation could take place, whilst permitting Member States to determine their own national details. It did not provide for the mutual recognition of authorization. In the UK it was implemented by the Banking Act 1979 and the Building Societies Act 1986, with the latter being the more important for housing finance.

Since 1977, the EC has taken several further steps towards the goal of a single market for credit institutions. The Consolidated Supervision Directive of 1983 (83/350/EEC) provides for supervision of credit institutions with subsidiaries to be undertaken by the Member State in which the head office is located. The Credit Institutions Branches Directive of 1989 (89/117/EEC) requires credit institutions with a branch in another Member State to publish their accounts in the host Member State. It gives the host Member State powers to require the publication of certain additional information relating to assets, liabilities, income, costs, and staff of the branch. These measures seek to reduce the duplication of regulation by Member States whilst increasing the confidence of host Member States in regulation by home ones.

In 1987, the EC proposed a directive on the freedom of establishment and of supply of services in mortgage credit (87/C 161/04). This would have permitted a home Member State to authorise designated credit institutions to undertake mortgage credit activities in other Member States. However, no discussions have taken place on this proposal since September 1989 and much of it has been overtaken by the Second Credit Institutions Directive. It is difficult to see how it would be possible to make progress on the liberalization of the provision of mortgage credit without also dealing with the other activities of mortgage lenders. Factors, such as equity withdrawal by home owners, make it difficult to treat the supply of mortgage credit in isolation.

Three directives passed in 1989 establish the basis for a harmonized system of prudential regulation on which a passport for credit institutions can be based. They are due to come into effect in 1993. The terminology that they use builds on that set out in the Bank Accounts Directive of 1986 (86/635/EEC). The Own Funds Directive (89/299/EEC) defines the capital base of credit institutions. It sets down what items can comprise the capital base, what must be deducted, and the limits on the contribution to capital that can be made by specific items. A common definition of the capital base is essential if there is to be agreement on the capital adequacy of credit institutions. The Solvency Ratio Directive (89/647/EEC) establishes a harmonized system of risk management for credit institutions and a common solvency ratio. The solvency ratio is set at 8 per cent and is computed by dividing the institution’s own funds by the sum of its total assets and off-balance sheet liabilities as weighted by appropriate risk adjustment factors. Thus, it defines when a credit institution’s capital may be considered adequate for its activities and when, by implication, the regulatory authorities should intervene to protect depositors. The Second Credit Institutions Directive (89/646/EEC) sets out the conditions under which a credit institution, authorised by one Member State to provide specified services, can provide those services to another Member State, either directly or from a branch established there’, without being subject to further authorization by the host Member State. It establishes minimum standards for authorization and prudential supervision by the home Member State, including a credit institution having a minimum of 5 million ECU capital, restricting their ability to engage non-financial activities, and the vetting of major shareholders. The three directives will not remove all the differences in authorization and regulation between Member States but should create the legal environment within which a single mortgage market can be created.

6 Conclusion

The differences between the housing markets of the Member States of the EC suggest that there may be potential for housebuilders from one Member State to develop activities in another. There are differences in the rate of housebuilding between different markets, differences in the cost of housing, and differences in marketing methods that could be exploited, and there is the potential of external sales of second homes located in certain areas. However, the scale of activity by foreign housebuilders within the EC is limited. For UK housebuilders, it is on a smaller scale than their activities in North America or Australia. A few have French subsidiaries and some have developments in Spain and Portugal, largely associated with leisure developments. Although the German market has attracted interest, it is not a major contributor to their profits.

The EC has produced a number of directives that may help to stimulate the development of a European housebuilding industry. Public sector housing development is subject to the revised Public Works Directive. However, this type of development has declined just as the revised directive has into effect and many housing schemes will be too small to be affected by it. Like all construction activities, housebuilding will be affected by the technical harmonization of construction products resulting from the Construction Products Directive. Although, initially, this will largely affect building products, there is the potential for technical harmonization to apply to design and workmanship standards. In the longer term, this could break down resistance to the acceptability of foreign construction firms and the buildings they produce. The development of a passport for credit institutions should lead to an integrated market for housing finance encouraged by differences in the price of mortgage credit. Lenders are unlikely to be prejudiced against the housebuilding firms they are used to lending to in their home markets.

Over the past two decades in the UK there have emerged national volume housebuilders and national mortgage financiers where once activities were once regional or local. The number of building societies, for example, has fallen from 481 in 1970 to 273 in 1980 and 126 in 1989. Activity within different markets in Europe could reduce risks by diversification. The emergence of national firms may be followed by the emergence of multi-national firms in Europe through the development of new markets and joint ventures. Housebuilding firms from Britain have already achieved this in relation to North America and Australia.

7 References

7.1 Books and articles

Atkins W S (1988) **The Cost of Non-Europe in Public Sector Procurement.** Commission of the European Communities.

BIPE (1988) **The Cost of Non-Europe in Building Products.** English edition, National Economic Development Office (1989).
Buur, A.P. (1988) The Dutch Construction Industry after 1992, in Euro-Construct, **The European Construction Industry in the Nineties,** Economisch Instituut voor de Bouwnijverheid.
Coopers & Lybrand Deloitte (1990a) **The NHBC Euro-Guide for France: a practical guide to housing development in France.** Housing Research Foundation.
Coopers & Lybrand Deloitte (1990b) **The NHBC Euro-Guide for Portugal: a practical guide to housing development in Portugal.** Housing Research Foundation.
Coopers & Lybrand Deloitte (1990c) **The NHBC Euro-Guide for Spain: a practical guide to housing development in Spain.** Housing Research Foundation.
Federation of Civil Engineering Contractors (1989) **Contractors Guide to the Single European Market.** FCEC.
International Marketing & Economic Services (1990) **A Study of UK Testing and Certification Resources for Construction Products.** Department of the Environment.
National Economic Development Council (1990) **Gateway to Europe: A manual for the construction industry.** National Economic Development Office.
Price Waterhouse (1988) **The Cost of Non-Europe in Financial Services.** Commission of the European Communities.
Stammers, J. (1990a) **The Federal Republic of Germany construction market.** National Council of Building Material Producers/Building
Stammers, J. (1990b) **The French construction market.** National Council of Building Materials Producers/Building
Wanstall, M. (1990) The Public Procurement Directives—a procurer's view. **Building Technical File,** 29, 37–44.

7.2 European Communities Documents

First Council Directive of 12 December 1977 on the coordination of the laws, regulations and administrative provisions relating to the taking up and pursuit of the business of credit institutions, 77/780/EEC. **Official Journal** L 322, 17 Dec 1977.
Council Directive of 13 June 1983 on the supervision of credit institutions on a consolidated basis, 83/349/EEC. **Official Journal** L 193, 18 July 1983.
Council Resolution of 7 May 1985 on a new approach to technical harmonization and standards, 85/C 136/01. **Official Journal** C 136, 4 June 1985.
Council Directive of 8 December 1986 on the annual accounts and consolidated accounts of banks and other financial institutions, 86/635/EEC. **Official Journal** L 372, 31 Dec 1986.
Amended proposal for a Council Directive on the freedom of establishment and the free supply of services in the field of mortgage credit, 87/C 161/04. **Official Journal** C 161, 19 June 1987.
Opinion of the Economic & Social Committee on the Proposal for a Council Directive amending 71/305/EEC, 87/C 319/17). **Official Journal** C 319, 30 Nov 1987.
Council Directive of 24 June 1988 for the implementation of Article 67 of the Treaty, 88/361/EEC. **Official Journal** L 178, 8 July 1988.
Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products, 89/106/EEC. **Official Journal** L 40, 11 Feb 1989.
Council Directive of 13 February 1989 on the obligations of branches established in a Member State of credit institutions and financial institutions having their head offices outside that Member State regarding the publication of annual accounting documents, 89/117/EEC. **Official Journal** L 44, 16 Feb 1989.
Council Directive of 17 April 1989 on the own funds of credit institutions, 89/299/EEC. **Official Journal** L 124, 5 May 1989.

Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, 89/391/EEC. **Official Journal** L 183, 29 June 1989.
Council Directive of 18 July 1989 amending Directive 71/305/EEC concerning coordination of procedures for the award of public works contracts, 89/440/EEC. **Official Journal** L 210, 21 July 1989.
Council Directive of 30 November 1989 concerning the minimum safety and health requirements for the workplace, 89/654/EEC. **Official Journal** L 393, 30 Dec 1989.
Second Council Directive of 15 December 1989 on the coordination of laws, regulations and administrative provisions relating to the taking up and pursuit of the business of credit institutions and amending Directive 77/780/EEC. **Official Journal** L 386, 30 December 1989.
Council Directive of 18 December 1989 on a solvency ratio for credit institutions, 89/647/EEC. **Official Journal** L 386, 30 Dec 1989.
Council Resolution of 21 December 1989 on a global approach to conformity assessment, 90/C 10/01). **Official Journal** C 10, 16 Jan 1990.
Guidelines for the Preparation of Standardization Mandates relating to the Council Directive 89/106/EEC on Construction Products, CONSTRUCT 90/049, 15 March 1990.
Council Decision of 13 July 1990 concerning the updating of annex i to Council Directive 89/440/EEC, 90/380/EEC. **Official Journal** L 187, 19 July 1990.
Proposal for a Council Directive relating to the coordination of procedures on the award of public service contracts. COM (90) 372 final, 6 Dec 1990.

176
Regulations, codes, standards and affordable housing

V.K.HANDA, C.LAGOS and R.OLIVEIRA

Abstract
The low-income housing policy in most developing countries has to be re-examined for a better housing solution. The lack of understanding about the actual situation and basic needs of the poor have prevented the authorities to deal with the problem efficiently.

This paper discusses government attitudes towards housing the poor and proposes basic parameters to provide solutions the poor can afford. Examples of how costs of land, infrastructure, and building elements can be reduced by adjusting codes are addressed.

Keywords: Affordability, Building Codes, Homeless, Low Cost Infrastructure, Low-Income Housing.

1 Introduction

The increasing number of people living in slums and squatter settlements in absolute poverty is a reality that affects the vast majority of the population in developing countries. This is a result of the lack of adequate measures by the authorities to accompany the rapid population growth. The necessity of an appropriate housing policy for improvement in the quality of life is essential and urgent.

The desire of housing ownership, according to the ability to afford, and within the law is inherent to all human families. To low-income families however, the desire to own a house can only be achieved if existing codes, standards, regulations, and zoning by-laws are reviewed in the reality of the poor.

2 Government attitudes towards urban poor

The actual situation of the homeless in many developing countries is a proof of the lack of adequate measures by the authorities to provide the needs of the rapid urban population growth. In response, the poor find their own ways to survive. By violating the law, they build shelters in any vacant land, generally near sources of employment, without minimum requirements for safety and health. As an illegal settlement they lack the basic infrastructure, like water and sewerage system.

In face of this problem, some governments have created housing programs for low-income families with the intention of improving their living conditions. These efforts however, have generally not been successful, because they have not met the low-income groups ability to pay. In most low-income housing programs the monthly instalments are so high that the poor families are often unable to pay and are then replaced by people with higher incomes. This occurs because most housing programmes are based on codes, standards, and regulations that are not aware to the real conditions of the poor people (Handa 1990).

Some governments have seen the illegal settlements as an obstacle for the development of their cities. Consequently many attitudes towards urban poverty are to destroy these communities, through clearance programs. Now, efforts are being directed to squatter upgrading and sites-and-services rather than in clearance programs.

Another common attitude that is being followed by many authorities now-a-days is to ignore the increased number of illegal settlements. This fact is well illustrated in Rio de Janeiro City, Brazil. With the lack of measures by the authorities to supply housing and land for the homeless, and the increasing real estate speculation in the well established favelas, the homeless is struggling for space in open public spaces, green areas, and vacant private property. Favela is not anymore the place where the poorest live. They now live on the streets and under viaducts. The omission by the governments in solving the homeless situation has stimulated these illegal occupancies.

The gap between resources available and the need of housing is far too big, creating the necessity of solutions that are affordable to the poor. Upgrading programmes preserve the already existing housing stock, employment sources and community organization. Thus, with the additional provision of basic services, security of tenure, access to loans and community participation by labour and savings, the physical and social improvement of these areas can be better achieved.

Sites-and-services programmes are often complementary to upgrading programmes, when people have to be relocated to give place to access roads, infrastructure and community services. The sites-and-services approach, however, has had little impact on housing for low-income groups, since the serviced plot is still too expensive for the poor to afford. This is due mostly to the unrealistically high standards for lot sizes and infrastructure and on the other hand to the availability of job opportunities near the new area.

As an example, in Sapang Palay Resettlement, in Manila, 40% of the resettled population had returned, a year and a half later, to squatting closer to their original homes in consequence of the lack of job opportunities on the new settlement area (Grimmes 1976).

3 Affordable building codes and regulations

To be successful any low-income housing programme has to be based on affordability. The affordability requirement is in respect to the capacity of the target group to pay. In this context, affordable house means not only the cost of the physical structure, but also the easy access to sources of employment. This basic requirement however, cannot be met without a significant change in the existing building codes, regulations, standards and zoning by-laws.

Existing building codes and regulations, in most developing countries, do not recognize the use of building practices being used by the majority of the population living in squatter settlements. Some building practices in these communities have been very successful in the use of available local construction materials and labour. Building codes should be based on performance criteria and be flexible to accept a continuous improvement from a semi-permanent house to a permanent one, when resources are available (Handa 1990).

In India, for example, approximately 50 per cent of houses built in medium and small cities and towns are considered substandard, due to the high standards imposed by building by-laws, standards, and specifications (Bhattacharya 1990). In contrast, the experience of Hong Kong can illustrate how standards can be consistent with income levels. In Hong Kong's early housing projects, standards for spaces and services were below the previously adopted minimum standards. Small rooms and shared water supply and sanitary facilities were adopted. Nonetheless, these buildings were designed for a future conversion to a higher standard as incomes rose (Grimmes 1976).

4 The supply of land for the urban poor

Land with access to employment, infrastructure and social services is indispensable for the improvement of all low-income families. The real estate speculation have restricted the supply of land for low-income developments. Zoning regulations have excluded the poor from living in areas with income earning opportunities, imposing heavy transportation costs on them.

Planning measures to obtain land more accessible for low-income developments are needed. Zoning changes in order to give the poor access to employment through decentralization of major sources of employment and services is one way to give the poor access to such facilities. The reduction of land taxes can be attractive to industries and services to locate near low-income developments. At the same time, an effective transportation system to serve the new area, should also be provided.

Another aspect with respect to land is the tenure regularization of existing settlements. The insecure tenure condition in squatter areas is one of the reasons for the precarious physical condition of dwellings and related services (UNCHS 1982).

Density is a key to the economical use of land. In this context, the choice of plot size and the structure type are very important in minimizing costs per household basis. High densities are a way to lower the housing costs. Nevertheless, the level of density should be based on the type of structure used to provide the most economical and affordable total cost when land costs and buildings costs are considered. High-rise buildings give the highest density indices, but construction and maintenance costs are very high, when compared with low-rise buildings.

The choice of the structure type has to be based on the potential for a future expansion and improvement of the housing unit by the low-income families. In this way they can use their own labour to improve and expand the house when they can afford. High-rise buildings are not appropriate to such expansions and improvements. High densities should be achieved with the adoption of one or two storey row houses with plots being almost completely occupied by the dwelling. The reduction of internal living spaces and the creation of semi-public spaces is one' way to arrive at an economical and affordable solution for the poor.

Present zoning requirements, that define lot frontage and size, are designed to provide low density which is contradictory to affordability. Planing developments are without regard the cost of transportation and infrastructure; it is as if zoning is not related to any of these parameters. It is done in isolation to provide isolation to the inhabitants from their neighbours.

As a basic need for the poor, land should be provided by the authorities in a systematic way, through leasehold or sale on an affordable basis. Some kind of restrictions for posterior sale should be established to avoid speculation, therefore the guarantee of tenure security is essential and indispensable.

Figure 1 presents a scheme showing factors affecting land for the urban poor. Housing policy, government subsidy, zoning by-laws (including codes, regulations, home size, and density), and location near employment and social services, have a great influence on land for low-income families. On the other hand, topography, soil, privacy, and health are less important costwise, although health has a great influence on infrastructure.

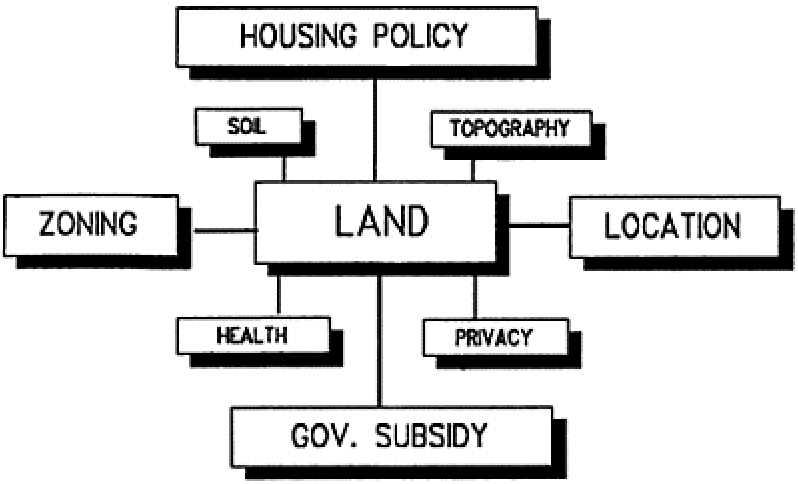


Fig.1. Land components

5 Affordable infrastructure

The main services needed to make land appropriate for housing are roads, water supply, sewerage, drainage and electricity. The choice of service level, though, must be based on the ability of low-income families to pay. For all these services, standards have to be reviewed in the light of the reality of the poor. In this context, roads can be narrower and in less proportion, water supply can be made available in communal water taps or in individual connections depending on the household capability to pay, and alternative sewerage systems can be adopted to minimize costs.

Infrastructure components, according to the level of influence, are showed in figure 2. Health and security are the basic requirements in the choice of any infrastructure system. Materials, technique, dimensions, service life, density, and design flexibility have a direct effect on infrastructure costs. Codes and regulations however, should be reviewed to accept alternative solutions that are affordable to poor families.

Subsidies for infrastructure should be kept at a minimal level through the provision of affordable systems. All alternatives should be analyzed to minimize costs of infrastructure assumed by the governments. In this way larger proportion of low-income families can have access to such facilities, minimizing the risk of a future replacement of the original target group by families with higher incomes.

The adoption of small bore sewer systems provides an economical way to give and/or to improve sanitation for low-income communities. The reduction of water requirements, excavation costs, material costs and treatment requirements are the principal advantages of this kind of sewer system. They are designed to receive only the liquid portion of the household wastewater which are separated from the solid portion in interceptor tanks. The solids which accumulate in the tanks are removed periodically. Local by-laws and national codes should recognize that small bore sewers are an economical alternative over conventional sewerage systems, providing a similar level of service with savings in construction costs of approximately 50% (Mara and Otis 1985).

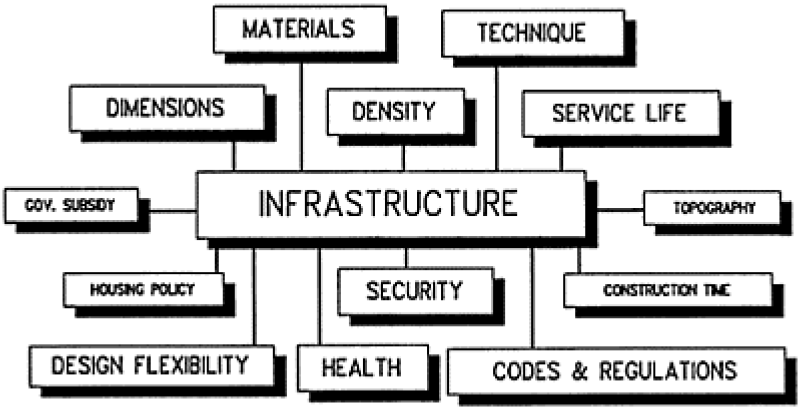


Fig.2. Infrastructure components

6 Step-by-step housing construction

The housing programmes have to meet the ability of the household to pay. To meet this constraint, some facilities like water and sewer systems could at first be communal, with the potential for a future improvement to individual facilities as income rises. In respect to the housing unit, it could be improved in a step-by-step basis as income increases. The building codes, standards, and regulations should accept this approach as a way to increase the access of the poor to better housing.

To illustrate how the step-by-step approach could be implemented in a low-income community, a staged housing construction is proposed. Lot size is an important component of the housing cost, with direct influence on the price of the house and infrastructure. Based on these assumptions, small plots of 5 metres wide and 10.60 metres deep are adopted.

The first step of the staged housing construction consists of a multipurpose room where the basic activities are developed, living, sleeping, cooking, and eating. People will live together in a small room, where all activities are developed, without any privacy. To be affordable to poor families, the house must be coherent with their reality. The difference between this approach and the present reality of the poor is only in terms of better sanitation, health, and safety and the potential for a future improvement and expansion.

To optimize space/cost more people are assigned to the multipurpose room. In this case, four people in a family share a common space. The area ratio in this first step is 5.1 square metres per person, including the sanitary unit. The provision of sanitary unit for each dwelling depends on the target group's capability to pay. Individual sanitary units, where provided, can be located in the front part of the plot, with two sanitary units sharing the same wall, minimizing the water and sewerage costs. In these sanitary units, a shower and a water-closet are provided. The sink is provided outside the dwelling, to be used initially, for all purposes, as washing the dishes, laundry, etc.

In the second step, it is possible to build one bedroom. At this stage a kitchen sink can be added, if the total cost of the added construction can still be met by the dweller. In step 3 it is possible to build a second bedroom. The new area ratio will increase to 9.91 square metres per person, including walls, and considering four people per dwelling (Fig.3.). In all these steps, the improvement of the finishing materials can be made.

It is also possible to transform the area outside the bathroom into an inside housing area. This area is defined by a dashed line in step 3, figure 3. Another possible expansion of the house can be made upwards. In this case, after step 2 is completed, step 3 would be the construction of two bedrooms in the second floor. The kitchen in this case has to be located close to the sanitary unit. This option will increase the total area to 64.30 square metres, with six inhabitants. In this way, the same area of land can provide increased housing space per inhabitant from 5.1 square metres per person to approximately 11 square metres or more per person. Furthermore, such an area, because of the semi-public space, will not lose its "friendly" neighbourhood atmosphere.

The front doors of the dwellings will open to a semi-private open space. Such open spaces are intended for recreational needs, encouraging social interaction.

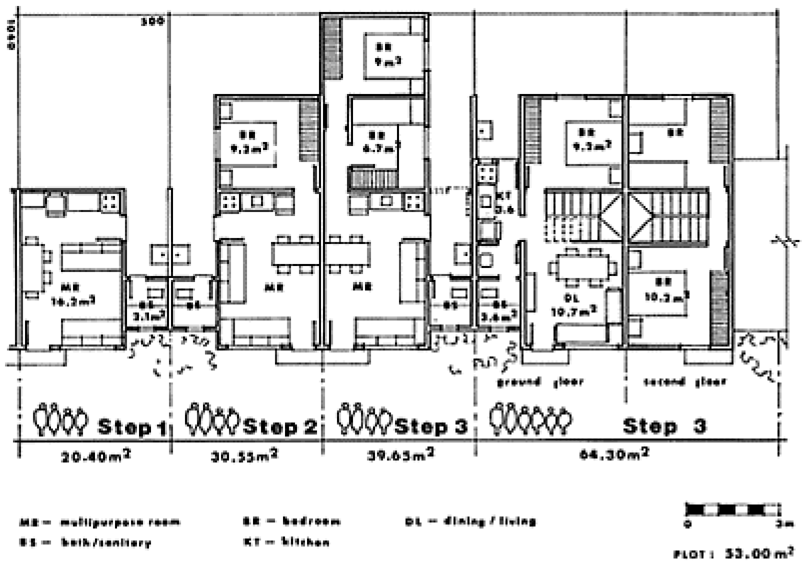


Fig. 3. Step-by-step house improvement

Sanitary and water systems will be installed here for those communities that cannot afford individual facilities in the first place, until such time that they can afford.

7 Affordable housing

Affordability, health and safety are the basic requirements for the success of any low-income housing program. The dimensions of the house, and the choice of materials, service life, and technology have a great influence on housing costs. Figure 4 shows the components of housing costs.

There is no reason why codes and regulations are not formulated to be appropriate for different levels of costs. There are many different kinds of materials for wall, roofing, and finishing, and codes could have performance requirement for each level. Combinations of mud for the top and normal bricks for the bottom, can decrease the wall costs substantially. Floors can be made equally well with soil lime at a very substantial reduction of costs. There are many kinds of material for roofing, going from thatch and other unconventional material through galvanized iron sheets to concrete and shingles (Handa 1989, 1990).

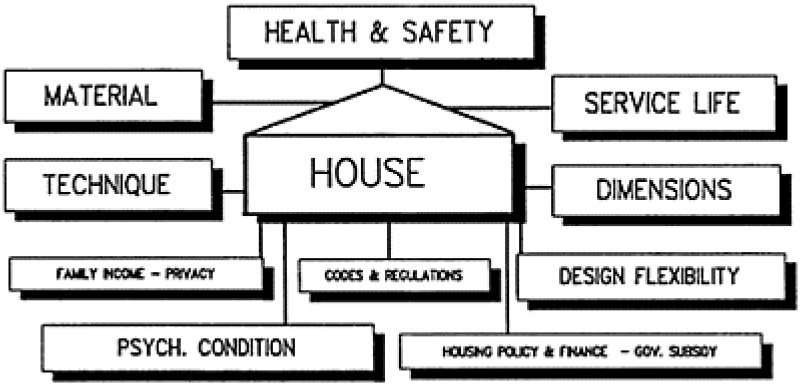


Fig.4. House components

The poor do not want a big house they cannot afford, they want instead a place that they can build for themselves with protection from the elements, safe, healthy, and close to job opportunities. Their demands are minimal, and technology should help them to achieve a better house. They really do not want government intervention and are quite capable of achieving it themselves, as confirmed by the existence of flourishing slums where the poorest can no longer afford to live.

8 Conclusion

The increasing number of dwellings erected without minimum health and security conditions makes urgent housing solutions affordable to the poor. Existing codes should be examined from the basic purpose for its existence, that is, to provide different performance standards for different costs and affordability.

As an analogy, both Volkswagen and Mercedes Benz provide the same level of required safety and transportation, but Mercedes Benz provides higher performance, comfort, and luxury to different standards. In this context, different levels of codes for different levels of affordability can put a low-income housing, with minimal health and safety guidelines, within the law and affordability.

Users and experts could jointly formulate codes that recognize different levels of services for different levels of costs. These experts could further look at successful innovative solutions for each building component in different parts of the world. They can also make these solutions available as part of a compendium relating them to appropriate code levels. This conference is in a unique position to lay the foundation for such an endeavour.

9 References

Bhattacharya, K.P. (1990) Housing in India—Observations on the Government's Intervention Policies, in **Housing Policy in Developing Countries** (ed. Gil Shidlo), Routledge, London, pp. 67–103.

Grimmes, O.F. (1976) **Housing for Low-Income Urban Families—Economics and Policy in Developing World.** World Bank Research Publication, John Hopkins University Press, Baltimore and London.

Handa, V.K. (1989) Affordable Shelter—A Challenge, in **Affordable Housing: A Challenge for Civil Engineers** (eds O.Ural and L.D.Shen), ASCE, New York, pp. 67–75.

Handa, V.K. (1990) Economic Life of Mass Housing. **Building Research and Practice,** 18, 2, 105–115.

Mara, D. and Otis, R. (1985) **The design of Small Bore Sewer System.** United Nations Development Programme, TAG technical note#14, World Bank, Washington.

UNCHS—United Nations Centre for Human Settlements (Habitat) (1982) **Survey of Slum and Squatter Settlements.** Tycooly International Publishing Ltd, Dublin, Ireland.

177
The influence of good design and standardisation on public sector housing in Northern Ireland

B.HARRIS

1 Introduction

The Northern Ireland Housing Executive was established by Act of Parliament in 1971 and is the largest single housing authority in the United Kingdom. Today it owns and manages 170,000 homes, commands an annual budget of £500 million, and employs 5,000 staff in a wide variety of professional, administrative and manual roles.

The Housing Executive Act 1971 established the Executive as a comprehensive housing authority with a remit to assist both the public and private housing sectors in Northern Ireland. It does this through building, managing and maintaining the public sector housing stock and by assisting the private housing sector through a rennovation grants scheme, by releasing land for private house building and by dispensing information and advice to the public on all aspects of housing policy. Since 1979, the Organisation has also helped to extend home ownership in the Province by selling almost 50,000 homes to former tenants under a voluntary purchase scheme.

An important dimension of the Executive's comprehensive role relates to the measurement of housing conditions in Northern Ireland, It does this through house condition surveys, normally undertaken at intervals of between 4 and 5 years.

When the Executive carried out Northern Ireland's first assessment of housing conditions in 1974, it found itself faced with an enormous task. The survey painted a very bleak picture and showed that around one fifth of all homes were unfit for habitation. The situation was even more critical in Belfast with almost one home in four requiring either demolition or major renovation.

The chronic housing problem identified by these surveys has been mainly alleviated by an ambitious programme of works on four fronts:

i. New House Building
ii. Improvements and Modernisation to existing stock
iii. Maintenance
iv. Grant Aid to the Private Sector

In 20 years, the Executive has completed some 71,000 new homes throughout Northern Ireland and to standards of design widely acknowledged as being the best in Europe. Several schemes have won prestigious design commendations from influential bodies such as the Civic Trust and the Royal Institute of British Architects. More importantly, people power has played an important part in the design process with architects keen to encourage community participation in the renewal of neighbourhoods. A major redevelopment programme was embarked upon which is nearing completion and has greatly enhanced the appearance of most urban settlements in Northern Ireland.

Whilst new house building has spearheaded the Executive's housing programme, the modernisation of older properties has also played an important role and today demands a greater share of the allocated funds as the need for new build diminishes.

Since the late 1970's, the Executive has established a roll-on programme of action for its total stock which is targeted to those estates in greatest need as determined by our ongoing surveys, organisational data base and financial availability. As with new-build, good design, high specification, standardisation and value for money concepts have remained paramount throughout the programme development.

During the 1980's—and now in the 1990's—the Executive has further developed its comprehensive role. It has encouraged the growth of Housing Associations as a complementary wing to the public housing sector, and has extended housing choice through its voluntary house sales scheme.

In 1989, the Executive took on statutory responsibility for housing homeless people. Once again, it has responded in an innovative fashion through the provision of short-stay hostel accommodation and by working in close co-operation with the Province's voluntary sector.

As it approaches its third decade, the Executive can look back upon its first 20 years with some satisfaction. Since 1974, when the Executive commissioned its first housing condition survey, the number of unfit houses has fallen from 19% to around 8% of the Province's homes. However, there is still much to be done and the problem of derelict, mainly owner occupied homes in remote rural districts, in one for which a new Rural Initiative Policy is currently being devised.

The Northern Ireland Housing Executive is controlled by a 10 person Board, three of whom are elected representatives and nominated by the Local Authorities, with the remaining 7, including the Chairman, appointed by the Secretary of State for Northern Ireland

2 Housing Policy

Northern Ireland is a province of the United Kingdom with a population of 1,583,000, 42% of which are under twentyfive. The total number of households in the Province is in the region of 533,000 of which 354,000 dwellings are privately owned. The Northern Ireland Housing Executive owns around 170,000 and Housing Associations account for the remaining 9000.

During the 1970's the Housing Executive was involved in a programme of substantial redevelopment and newbuild to meet the urgent needs of very large waiting lists and deal with high levels of housing unfit for human habitation. Following major advances in dealing with these issues the 1980's, represented a period of consolidition and redirection of policy, moving progressively from the provision of new build to a major refurbishment programme involving over 100,000 Housing Executive homes. Superimposed on the activity of maintaining and repairing Housing Executive stock was a policy to manage the improvement of thousands of substandard homes in the private sector through home renovation grants. The 1990's present no less a challenge. While the same magnitude of problems do not exist, there are many important issues, some new, which require the resources, management and expertise of the Housing Executive.

The Housing Executive's principal objectives centre on a requirement to measure and plan to cater for housing need directly and indirectly and on landlord responsibilities and functions. In order to ensure that good progress continues to be made in meeting the corporately agreed objectives, a number of new policies, initiatives and new activities have been pursued since 1989. These affect Homelessness activity, work on joint planning and community care, the drive to improve very poor housing conditions in rural areas, improvements to the repair and maintenance service, extending and development of the principles of good estate management through greater tenant participation which continues to enhance the profile in upgrading run-down and difficult-to-let estates. Additionally, the standards of service provided to customers must be seen to be to the highest level of Quality Assurance. In order to do this, a number of market research projects have been commissioned both relating to the views of tenants and the public in general, to establish a performance baseline for further monitoring purposes.

2.1 Strategic Objectives

The Policy Objectives are as follows:

1. To reduce dwelling unfitness (particularly individual unfit dwellings in rural areas) through a combination of replacement rehabilitation and appropriately targeted renovation grant activity, to priority groups.
2. To build in the public sector each year sufficient homes to reduce the gap between need as measured by a combination of new household formation and replacement needs and the likely supply from the private sector.
3. To jointly plan for housing for special needs groups with the local Health and Social Services Agencies, Voluntary Housing Associations and Voluntary Organisations.

To the forefront of Housing Executive activity since its inception in 1971, has been the reduction in sub-standard housing in Northern Ireland. The number of sub-standard homes has fallen faster in urban areas relative to rural areas since 1974 and although there has been an absolute decline in the number of unfit dwellings in both areas, unfit dwellings in rural areas has increased as a proportion of total unfit.

The Housing Executive builds its strategy from a sound and solid market research base, and the results from recently completed research commissioned both internally and externally.

Table 1. Urban and Rural Unfitness compared:

Urban Areas	1974		1987		% Decline
Unfit Dwellings	41,330	46%	14,900	35%	−64%
Rural Areas Unfit Dwellings	48,040	54%	28,000	65%	−42%
	89, 370	100%	42,900	100%	−52%

The Housing Executive is committed to building new homes where they are required and where projected local levels of urgent housing need justify the scale of the proposed scheme. An increasing proportion of the Housing Executive's new build programme has recently switched to the replacement of obsolete dwellings, the redevelopment of worn-out stock and general greenfield development where high priority need exists. The Housing Executive is most sensitive to local considerations, like Private Sector and Housing Associations activity. In policy terms the basis of the Housing Executive's New Build Programme stems from Government attitudes to "social" housing, that it should be a residual provider, that is, it must take account of housing supply from private developers and the Voluntary Housing Associations in coming to a conclusion about public sector provision.

A comprehensive data base is maintained by the Housing Executive which includes details of approximately 20,000 applicants for housing of which 9000 are deemed to be in urgent need.

The data base also includes a description of each dwelling in the public sector with details of type of construction, date of construction, size, number of rooms and amenities etc.

Periodically the Housing Executive surveys and measures the condition of all the dwellings in the Province by means of a sample survey. This information is used to estimate the overall number of dwellings which are obsolete and require to be replaced and the number of dwellings which require repairs or capital investment to improve them, and an estimate of the total cost.

It is this periodic survey for information which when coupled with the annual review of progress, provides the Housing Executive with the means to convince the Government of the necessity to continue to fund the public sector housing programmes.

3 Design Standards

3.1 New Build

The Northern Ireland Housing Executive provides all the general housing needs in the Province's public rented sector and has been increasingly acclaimed for the quality of its new build housing by both tenant groups and professional institutions. In 1986 a report by the N.B.A. Building Construction Consultancy Partnership showed that the actual cost of Executive dwellings was 34% less than the cost of Local Authority dwellings in England. This report concluded that although there were many contributing factors, standardisation was a major element. “In Northern Ireland there is a degree of standardisation not found in England. This standardisation applies not only to designs, but to elemental specification. Standardisation leads to lower costs”.

The degree of standardisation in the Northern Ireland Housing Executive is quite substantial. It uses standard housetypes, standard details, standard contract documentation which incorporates standard specification and standard Bills of Quantities. In-house architects, consultants and builders are all familiar with the system and a reasonably high level of consistency is achieved throughout the Province. Despite this policy of standardisation, the completed schemes are seldom boring and although one expects sameness from standardisation, there is much evidence of skilful variation in detail and finish. In urban settings the theme is likely to be facing brickwork complete with fine brickwork detailing at windows, doors, eaves and plinths which reflects the resurgence of a craftsmanship which many thought was irrevocably lost. Houses in a rural or coastal setting are likely to have a white rendered finish, dormer windows, sheeted doors and other features of a contextual nature.

The layouts and juxtaposition of the houses also varies enormously from straight terraces to semi-detached and from formal squares to small intimate groups of houses. Always the layouts and the houses appear indigenous to their setting and a sense of place is achieved. So what is standardisation and how does the system work?

At Executive Headquarters in Belfast, there is a relatively small Standards Group which has prepared all the design and technical information relating to the housetypes and put together the system. This information which is updated three times per year is issued to all Technical Staff in the Executive’s six Regions and also to all the consultants who use it when preparing design layouts and production information for individual schemes.

Housetypes

As the needs of the tenant change and redevelopment replaces greenfield sites, the housetypes are reviewed and/or replaced as necessary. Currently 31 types are required to meet housing management needs and site constraints. The space standards are shown in Table 2. Kitchen provision is based on shelf storage area, worktop lengths and space for electrical appliances. The number of socket outlets for electrical equipment throughout the dwelling are based on modern living requirements. All dwellings have full central heating and thermal insulation standards beyond the local Building Regulations requirements.

Standard Details

A set of sound constructional details have been produced which cover all the various standards of building work and finishes.

Specification

A standard description of materials and workmanship is a reference document for every contract and has been compiled to achieve quality and value for money in the end product and minimise future maintenance costs.

Mobility Housing

i. Single-storey Dwellings—all bungalows and around floor flats should be designed to full mobility standards. Mobility dwellings are based on normal space standards, but are designed to be convenient for all ambulant disabled people to live in, including those who use wheelchairs but are not chairbound.

ii. Two-Storey Dwellings—In suitable circumstances, two-storey dwellings may also be designed to full mobility standards provided there is a we with washbasin at entrance level (ie. normally dwellings of 5-person and over) and a straight flight staircase to facilitate installation of a stair lift.

iii. All Dwellings—All dwellings with ground floor accommodation, not designed to full mobility or wheelchair requirements should incorporate some features to facilitate disabled visitors.

Reference should be made to DOE (GB) HDD Occasional Paper 2/74 Mobility Housing and Part 8, Mobility Housing Supplement of DOE (GB) HDD Occasional Paper 2/75 Wheelchair Housing.

Space Standards for New Build Dwellings

Dwellings should be designed for the number of required bedspaces and the gross area as set out in the table on the following page:

Table 2. Number of People (ie bedspaces) per dwelling

		Number of people (ie bedspaces) per dwelling						
		1	2	3	4	5	6	7
		m^2	m^2	m^2	m^2	m^2	m^2	m^2
	N	31.5	44.5	57.0	67.0	75.5	84.0	–
	S	3.0	4.0	4.0	4.5	4.5	4.5	–
BUNGALOWS	G	34. 5	48.5	61.0	71.5	80.0	88.5	–
	N	–	–	62.0	74.5	85.0	92.5	108.0
	S	–	–	4.0	4.5	4.5	4.5	6.5
2 STOREY HOUSES	G	–	–	66.0	79.0	89.5	97.0	114.5
	N	–	–	–	–	94.0	98.0	112.0
	S	–	–	–	–	4.5	4.5	6.5
3 STOREY HOUSES	G	–	–	–	–	98.5	102.5	118.5
	N	31.5	44.5	57.0	70.0	79.0	86.5	–
	S	2.5	3.0	3.0	3.5	3.5	3.5	–
FLATS	G	34.0	47.5	60.0	73.5	82.5	90.0	–

N—Suggested net space
S—Suggested storage space

G—Gross Area *
* TOLERANCE—a $2\frac{1}{2}\%$ plus or minus tolerance on the gross area is considered acceptable

The gross area includes—the area measured to the internal unfinished face of the main containing walls on each floor of the dwelling and includes the space, on plan, taken up by any (Private) staircase; partitions; chimney breast, flues and heating appliance; storage space or spaces, including any external provision.

The gross area excludes—any space where the ceiling height is less than 1.5m; any porch or covered way, etc., open to the air; any communal space or facility; any staircase to a flat or flats; external bin and fuel enclosures.

3.2 Existing Dwellings

The design criteria applied to existing dwellings is also determined with a view to providing optimum solutions based on standardisation across the Province and detailed guidelines are provided against the following:

> Space standards with detailed requirements for the individual rooms and the linkage between rooms under the headings:

i. Kitchen
ii. Dining Area
iii. Living Area
iv. Bedrooms

Internal arrangements which specified circulation space, fire risk, means of escape and means of entrance through a circulation area or a lobby.
Access—The Executive aspires to the provision of individual access for all dwellings including flats and maisonettes unless the provision of such is impracticable for physical or financial reasons.
Structure—Dwellings should normally have a life expectancy of 30 years and be structurally sound, free from damp, weather tight, have adequate natural lighting, have adequate natural or mechanical ventilation, have thermal performance as close as practicable to new build standards and an effective drainage system.
Components—Materials and components must be from the Approved List and comply with current standard specifications and the Executive's Code of Practice. Account must be taken of the recommendations and instructions contained in the current relevant Policy, Practice and Procedure/Technical Information Directives.

Services

i. Heating should comply with current Executive policy,
ii. Heating, plumbing and electrical installations should be in accordance with the standards set down by Central M & E Services

Externals

i. Defensible spaces should be maintained or created around dwellings with adequate privacy to at least one side,
ii. Direct external access links between front and back gardens and consideration given to the provision of off-street/in-curtilage car parking spaces where necessary to alleviate road congestion.

3.3 The Environment

Over the years, the Executive have developed a concern for environmental issues and the social consequence of poor design in this respect. The main contributions from the research and development carried out by the Standards Group in this area has been in the minimising of atmospheric pollution by the development of smokeless heating systems and by the conservation of energy by utilisation of increasing insulation standards. Unlike the rest of Great Britain, Northern Ireland is heavily reliant on solid fuel as its main heating material, and by the strict application of Clean Air Regulations, almost two thirds of the public sector stock are heated by appliances using smokeless fuel. By careful design, component specification and high insulation standards, the Northern Ireland Housing Executive boasts a public sector home with an energy rating higher than any other Local Authority in Great Britain and the current insulation standards throughout the structure are not only greater than the current Building Regulations requirements, but also are beyond those about to be introduced in the proposed Building Regulations Energy Conservation.

The application of standardisation across both newbuild and existing dwellings has produced a 39%—40% reduction in the peak heat demand for the dwellings with a substantial cash benefit to the tenants.

3.4 Economics and Cost Control

In the early 1970's, the Government introduced the Housing Cost Yardstick as a means of controlling public sector housing costs following which the Executive developed a standard range of dwelling types which produced well-designed housing within the defined cost limits.

One of the parameters of the Housing Cost Yardstick was a density factor which was included to take account of low, medium and high rise dwellings. The 1980's saw a move away from high and to a lesser extent, medium rise dwellings, and a set of allowances based purely on construction costs and related to low rise dwellings was introduced. In 1988 costs were added to the building works already established for acquisition and professional fees resulting in what is now known as Total Indicative Cost Allowances. Consequently, by the use of these allowances the Northern Ireland Housing Executive now ensures that expenditure on housing projects represents value for money when these projects are consistent with agreed standards and the Total Indicative Cost is contained within the appropriate cost allowances.

The quality of design embodied in the Parker Morris Standards which were initially adopted by the Executive in 1971 and which with enhancements still apply, has attracted higher costs but these costs have been more than offset by the savings achieved by the policy of standardisation.

A recent comparability study of housing standards and costs between Northern Ireland and England showed that in public sector housing, standards were higher and costs were significantly lower in Northern Ireland. There is no doubt that the main contributing factor for these lower costs was the way in which the standard dwelling type range performed as it is infinitely easier at every stage of the design and building process to monitor and control costs when these costs are based on dwelling types of similar shape, size and specification. When schemes are built to comparable designs and costs, it is possible to apply the concept of project appraisal and elemental life cycle to ensure project viability. The Northern Ireland Housing Executive have adopted these techniques to satisfy Government that value for money is being attained without loss of quality and also to demonstrate the necessity to keep pace with the introduction of building methods, new materials and the rising expectations of the public sector tenant.

The cost control system was initially set up to take account of newbuild schemes, but has now been extended to facilitate control of rehabilitation and major improvement schemes. In operating the system, detailed cost information on each scheme is obtained and gathered in a cost data base which proves useful as an aid to planning and controlling future schemes.

4 Conclusion

The Mission Statement for the Northern Ireland Housing Executive states:

"As a comprehensive regional housing authority, the Housing Executive has three primary objectives

1. To assess housing need in Northern Ireland and progressively to meet that need by direct provision and by facilitating or enabling other individuals or agencies to do so.
2. To promote high standards of new building, repair, maintenance, housing management and general housing advice.
3. To be the best public housing authority in the United Kingdom, measured in terms of quality and value for money".

The influence of good design and standardisation as a continuing policy is essential if these objectives are to be sustained.

178
An investigation into the effect of ‘standard of living’ on the household sector of the Australian economy

C.A.LANGSTON

Abstract
Affordability is identified as an additional consideration to opportunity when making economic decisions about residential investment projects. Affordability is hypothesised as a function of changes in the standard of living and the corresponding ability of individuals to finance such changes. Using data collected from the household sector of the Australian economy, an index is developed to measure changes in affordability. The resultant rate of change, depicted by the *affordability rate,* can be combined with investment return, inflation, specific escalation and taxation rates and employed in traditional discounting applications.

Keywords: Affordability, Standard of Living, Time Value of Money, Affordability Rate, Discounting.

1 Introduction

When making informed judgements about the worth of an investment project spanning a number of years, the time value of money is an essential ingredient. Discounted present value is a measure of equivalence for time-phased costs and benefits derived from consideration or the theoretical investment return, preferably after tax. As it takes explicit account of the cost of finance, whether it be interest lost or interest payable, discounting can be described as leading to the determination of comparative value using an investment-based or *opportunity* approach.

It is hypothesised that the value of future costs and benefits is additionally susceptible to fluctuations in basic living standards that in turn will reflect changes in the worth of goods and services and the purchasing power of available income. If it can be shown in hindsight that costs and benefits are affected by living standards, then it must follow that such matters should be considered when making predictions about the future and that traditional opportunity approaches are an over-simplification. Making adjustments for changes in worth may thus be described as contributing to the determination of comparative value using an income-based or *affordability* approach.

This paper discusses the measurement of an affordability rate, based on changes in the standard of living of individuals, for the purpose of assessing the worth of residential investment projects. While the data employed herein is relevant only to the household sector of the Australian economy, the concept nevertheless has significant international application.

2 Standard of living

2.1 Objective and subjective aspects

The *standard of living* is traditionally used as a yardstick for assessing the level of comfort or lifestyle satisfaction experienced by individual members of the community. Manning (1984: p. 2) states that the standard of living is a subjective concept, and as such there is no single objective way of measuring its cost. Nevertheless, while *"there are those that are content to leave the standard of living as non-observable,* […others] *claim that the cost of a constant standard of living can be inferred by the application of an estimating technique to data on household expenditure patterns".*

The common difficulty found in measuring changes in the standard of living is due to the imponderables of social issues pertaining to the quality of life. Working hours and conditions, improvements in technology levels for manufactured goods and services, greater variety of choice in purchase, attainment of lifestyle objectives, law and order and environmental issues are just a few of the facets of living standards that will affect and defy meaningful assessment. Living standards can only be judged with reference to the individual, as the performance of governments and corporations is reflected by the benefit they ultimately provide to their citizens and shareholders. Final analysis must be based on the perception of individuals in comparison to the standards being achieved by others.

If lifestyle satisfaction is considered the global term and is divided into the components of "standard of living" and "quality of life", then the objective and subjective aspects can be conveniently isolated. The standard of living thus only encompasses matters of a monetary nature and can be measured by the ability of individuals to purchase goods and services. As the value of acquired goods and services grows in real terms per person, so does the resultant standard of living.

2.2 Standard of living measurement

Analysis of expenditure in the household sector of the Australian economy from 1950 to 1987 shows that individuals are spending approximately 2% p.a. more per person on goods and services in real terms than they have in the past. The standard of living is thus similarly increasing. Purchase of goods and services, rather than the accumulation of "paper" wealth, is considered to lead to tangible improvements in basic living standards that can be identified objectively. Figure 1 illustrates the acquisition growth of goods and services, subdivided into private final consumption expenditure, fixed capital expenditure on dwellings and consumer debt[1].

Clearly private final consumption expenditure is the most significant. Figure 2 shows the real level of each of me eight components of private final consumption expenditure from 1950 to 1987, per person in 1987 dollars. The identified categories are: (1) food, (2) cigarettes, tobacco and alcoholic drinks,

[1] It is arguable whether changes in the standard of living are best represented by consumption expenditure alone, or by the addition of capital expenditure, or by the further addition of consumer debt. The measured change in real terms per capita for the above three combinations of household expenditure from 1950 to 1987 is 2.02%, 2.05% and 2.11% respectively. While consumption expenditure, capital expenditure and consumer debt are relevant outlays on goods and services, it may be reasonable to exclude consumer debt from an analysis aimed at identifying changes in basic living standards.

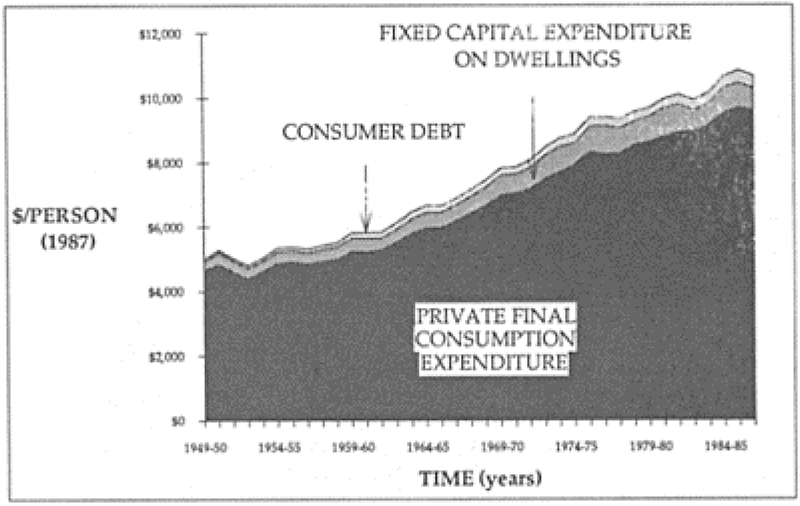


Fig.1. Household expenditure patterns 1950–1987

Source: Norton and Alymer (1988)

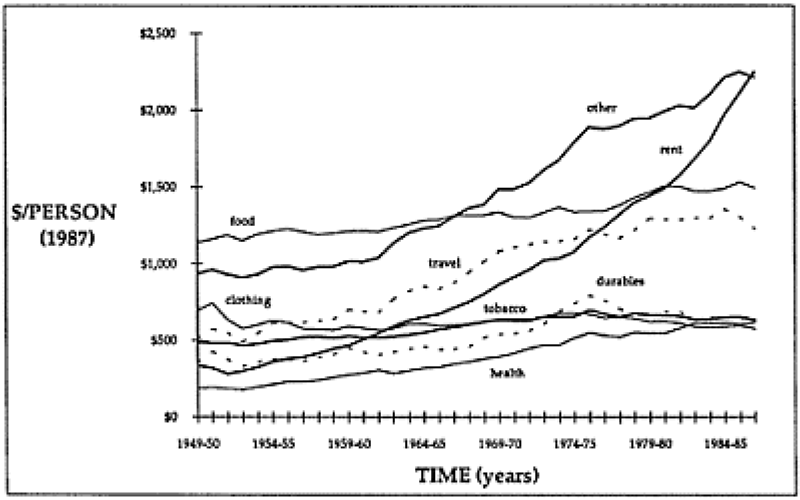


Fig.2. Private final consumption expenditure 1950–1987

Source: Norton and Alymer (1988)

(3) clothing, footwear and drapery, (4) rent, (5) household durables, (6) health, (7) travel and communication, and (8) other expenditure.

The rate of growth in expenditure is generally positive, but both rent and other expenditure have seen large real increases over a long time frame. Since 1950 the categories of rent, health, travel and other expenditure have risen above the average for private consumption; the remainder below. Clothing is the only category that has decreased in real terms over this period. "Other expenditure" includes entertainment, education and rates, amongst further miscellaneous costs.

Figure 3 expresses the rate of change per annum in total household expenditure (and hence standard of living) between 1950 and 1987. The maximum recorded change over the study period is 6.04% and the mean increase is 2.11%. Expenditure is susceptible to the overall economic performance of the nation and the level of wealth of individual citizens, and implicitly accounts for matters such as unemployment, interest rates and government monetary and fiscal policy (Jackson and McConnell, 1988). Interestingly, Gross Domestic Product (GDP)[2], which is commonly used as an indicator of national growth, has shown a mean increase of 2.43% over the same period.

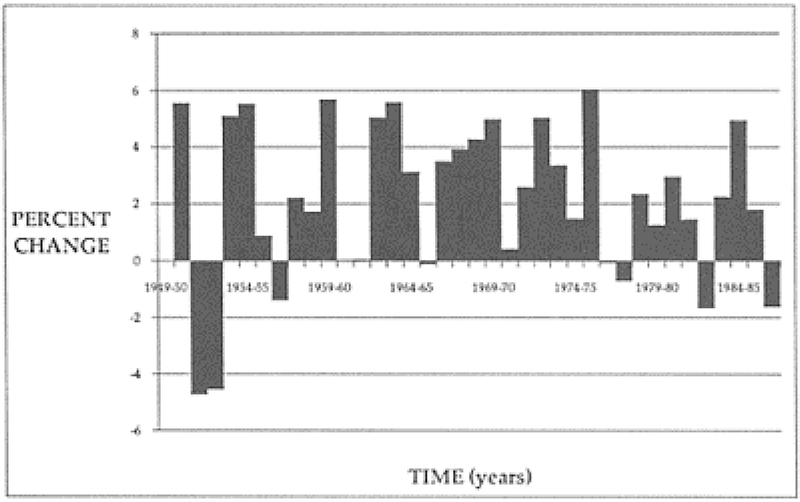


Fig.3. Changes in the standard of living 1950–1987

Source: Norton and Alymer (1988)

[2] GDP is the total market value of goods and services after deduction of the cost of goods and services used up in the process of production but before deducting allowances for the consumption of fixed capital. It is equivalent to gross national expenditure plus exports of goods and services less imports of goods and services (Australian Bureau of Statistics, 1989). Alternatively, GDP can be calculated using an income approach, involving the addition of wages, salaries and supplements, gross operating surplus and indirect taxes less subsidies. Gross national expenditure is composed of private and public final consumption expenditure, private and public fixed capital expenditure and increases in stocks.

2.3 Income considerations

While the standard of living has increased, along with the cost of maintaining this standard, affordability must ultimately be judged by the ability of individuals to finance such growth. Earning capacity is the measure employed herein to depict income levels from productive activities and is used to form a datum against which total expenditure can be compared. If earning capacity has grown at an equivalent rate to the standard of living then the ability to afford this increase in standard is unchanged. Total household expenditure can be expressed relative to the earning capacity datum, **to** derive an affordability index, indicating the real *cost of the standard of living*.

Future costs are the actual amounts of money expended for goods or services at some future time and will be greater than their equivalent today due to the effect of inflation. But the value of future costs may equal their value today provided that the cost of the standard of living remains constant. In other words, whilst the actual cost has changed, the affordability of the goods or services relative to base living standards is the same.

3 Affordability

3.1 Expenditure and income comparisons

Fluctuations in basic living standards affect an individual's perception of the real value of costs and benefits over time. The affordability of goods and services is thus another type of exchange rate between money now and money in the future. Investment decisions pertaining to the household sector must take account of changing affordability levels if the real value of future costs is to be objectively considered.

Table 1 summarises the developed method used to measure the cost of the standard of living. Total household expenditure on goods and services comprises actual private final consumption expenditure, fixed capital expenditure on dwellings and consumer debt for each year per person, converted into 1987 dollars using the CPI index. Earning capacity comprises wages, salaries and supplements and income from unincorporated enterprises after income tax. Interest received on savings is ignored, as the average after tax return approximates the loss in capital value of the investment due to inflation. Government transfers and benefits are non-productive sources of income and do not constitute earning capacity.

3.2 Affordability rate

It can be seen that the rate of increase in the cost of the standard of living is higher as the time frame is shorter and more recent. From this analysis, forecasts of future trends can be postulated. The future rate of increase in the cost of the standard of living is forecast as 2.10% p.a., but shows a tendency to reduce as the time horizon is lengthened. This rate is herein called the *affordability rate,* and can in theory be positive or negative. The choice of rate for projects involving long-term ownership is recommended to be near zero, since income and expenditure levels cannot continue to be increasingly disparate.

Figure 4 transposes the values given in Table 1 into a graphical form. It can be clearly seen that total household expenditure has risen in real terms, but earning capacity has fallen since 1975. The real cost of the standard of living has tended to rise after this time, thus indicating that purchase of goods and services is becoming relatively more difficult to afford. Individuals must therefore be financing the cost of the standard of living from accumulated savings, sale of assets, windfall or other form of wealth transfer.

Table 1. Forecasting household sector affordability

Year	Total household expenditure in real terms (1987)		Earning capacity in real terms (1987)		Affordability index in real terms (1987)	
	$/person	*% change*	*$/person*	*% change*	*$/person*	*% change*
1949–1950	5,008	–	4,537	–	7,207	–
1950–1951	5,286	5.55	5,111	12.66	6,753	−6.31

1951–1952	5,037	−4.71	4,293	-16.00	7,661	13.45
1952–1953	4,809	−4.54	4,344	1.18	7,228	−5.65
1953–1954	5,053	5.07	4,319	−0.57	7,638	5.68
1954–1955	5,331	5.51	4,532	4.94	7,680	0.55
1955–1956	5,377	0.86	4,626	2.06	7,589	−1.18
1956–1957	5,302	−1.39	4,593	−0.72	7,538	−0.67
1957–1958	5,419	2.19	4,302	−6.33	8,224	9.10
1958–1959	5,512	1.72	4,566	6.15	7,881	−4.18
1959–1960	5,824	5.67	4,756	4.14	7,996	1.46
1960–1961	5,825	0.01	4,722	−0.70	8,053	0.72
1961–1962	5,827	0.05	4,707	-0.33	8,084	0.38
1962–1963	6,120	5.02	4,940	4.97	8,088	0.05
1963–1964	6,461	5.57	5,286	7.00	7,980	−1.34
1964–1965	6,662	3.12	5,431	2.74	8,009	0.36
1965–1966	6,656	−0.10	5,326	−1.94	8,159	1.87
1966–1967	6,887	3.47	5,648	6.05	7,960	−2.43
1967–1968	7,156	3.92	5,530	−2.10	8,449	6.14
1968–1969	7,462	4.27	6,014	8.75	8,101	−4.12
1969–1970	7,832	4.96	6,169	2.58	8,289	2.32
1970–1971	7,865	0.41	6,324	2.51	8,120	−2.04

1971–1972	8,067	2.58	6,476	2.41	8,133	0.16
1972–1973	8,471	5.01	6,935	7.08	7,976	−1.93
1973–1974	8,755	3.34	7,351	6.01	7,776	−2.51
1974–1975	8,883	1.47	7,478	1.72	7,756	−0.25
1975–1976	9,420	6.04	7,466	−0.16	8,238	6.21
1976–1977	9,414	−0.06	7,213	−3.39	8,522	3.44
1977–1978	9,348	-0.70	7,064	−2.06	8,640	1.39
1978–1979	9,566	2.33	7,251	2.65	8,613	−0.31
1979–1980	9,686	1.25	7,124	−1.76	8,877	3.06
1980–1981	9,969	2.93	7,235	1.56	8,996	1.35
1981–1982	10,113	1.44	7,181	−0.76	9,196	2.22
1982–1983	9,944	−1.67	6,784	−5.52	9,570	4.07
1983–1984	10,166	2.24	6,894	1.62	9,629	0.61
1984–1985	10,666	4.92	6,969	1.10	9,992	3.77
1985–1986	10,856	1.78	6,844	−1.79	10,356	3.64
1986–1987	10,678	−1. 64	6,529	−4.61	10,678	3.11
Mean:	1950–87	2.11		1.11		1.14
	1965–87	2.19		0.91		1.35
	1976–87	1.16		−1.18		2.40
	1984–87	1.69		−1.77		3.51
Forecast:		1.79		−0.23		2.10

Source: Norton and Alymer (1988)

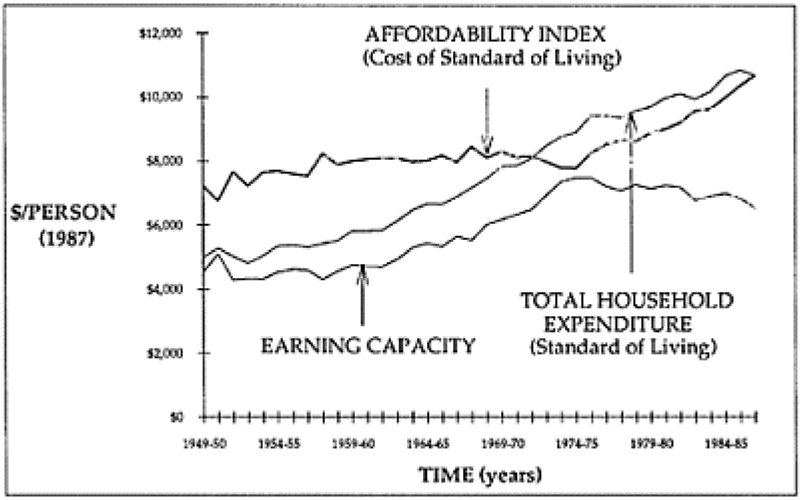


Fig.4. Changes in household sector affordability 1950–1987

Source: Norton and Alymer (1988)

Thus total household expenditure depicts the standard of living and the affordability index illustrates the cost of maintaining this standard in relation to the earning capacity of individuals within the community. It may be postulated that the rate of increase in the standard of living is an endemic condition of our current lifestyle objectives that is financed from sources other than productive income in times of diminished earning capacity.

Figure 5 illustrates the level of household savings, expressed in real terms (using 1987 dollars) from 1950 to 1987. Savings have shown significant decreases since 1974, supporting the view that the growth in the cost in the standard of living is being financed from accumulated reserves. Capital growth of property has dramatically exceeded inflation in the 1980's, further suggesting that profits from sale of property may also be a funding source. Nevertheless, property value growth in real terms over the last fifty years is approximately 2% p.a. (Waxman and Lenard, 1988), and thus corresponds closely to the general increase in the standard of living.

3.4 Application

Although previous expenditure and income data has been expressed in real terms per head of total national population, the derived affordability index shows identical rates of change to one that ignores adjustments for either inflation or population growth. This is because the affordability index is calculated on a yearly basis, and for any particular year the same comparative relationship between expenditure and income will occur. Thus the accuracy of both inflation and population growth data is irrelevant to affordability rate predictions. The affordability index is calculated as follows:

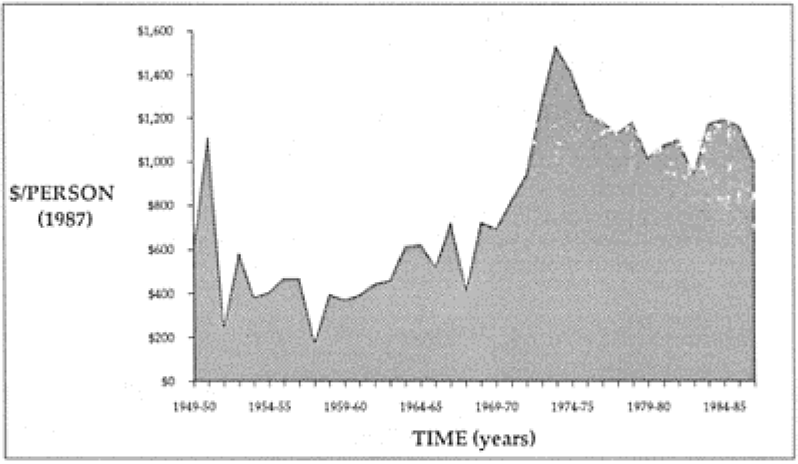


Fig.5. Real household savings 1950–1987

Source: Norton and Aylmer (1988)

$$\text{affordability index for Year X} = \frac{\text{total expenditure for Year X} \times \text{earning capacity for Year Y}}{\text{earning capacity for Year X}}.$$

where: X = year for which the affordability index required

Y = affordability index base year

The affordability index thus represents income-adjusted expenditure on goods and services, where income is defined as earning capacity rather than total revenue. Earning capacity is considered a more useful measure of the relative productiveness or various income-generating activities. The index base can be set at any date, but in the previous analysis the base used is 1987.

Economic information can be found in the Australian National Accounts, published annually by the Australian Bureau of Statistics. However, there is no reason why *person-specific* expenditure and income data can not be used in preference to *averaged* national information. “Person” in this context may be extended to include a group or class of individuals, perhaps separated according to occupation, geographic area or other relevant characteristic. Nevertheless, averaged national information can be calculated occasionally and used frequently, is readily available and avoids use of specific financial data which in many cases may be confidential.

4 Conclusions

Affordability changes can be identified by the analysis of national expenditure and income patterns in the household sector of the Australian economy. The approach taken is to interpret total expenditure on goods and services relative to a datum of productive earning capacity. The resultant index for affordability highlights the real cost of maintaining current expenditure levels. In the household sector the level of expenditure on goods and services can be considered representative of the standard of living within the community and the affordability index can be considered representative of the real cost or maintaining that standard. Although living standards can only apply to the individual, such an analogy can be theoretically extended to both the public and corporate sectors.

Discounting applications would need to incorporate the affordability rate along with investment return, inflation, specific escalation and taxation rates to adequately assess the changing time value of money.

5 References

Australian Bureau of Statistics (1989) **Australian National Accounts—National Income and Expenditure 1988–89,** Canberra.

Jackson, J. and McConnell, C.R. (1988) **Economics** (Second Australian Edition), McGraw-Hill, Sydney.

Manning, I. (1984) Measuring the Costs of Living of Australian Families in **SWRC Reports and Proceedings No. 43,** Social Welfare Research Centre, University of New South Wales, Kensington.

Norton, W.E. and Alymer, C.P. (1988) **Australian Economic Statistics (Occasional Paper No. 8A/8B),** Reserve Bank of Australia, Canberra.

Waxman, P. and Lenard, D.L. (1988) **Investing in Residential Property,** Alliance, Sydney.

179
Housing policy, building, needs for housing and tenure choice

B.LEFEBVRE and M.MOUILLART

Abstract
In most developed countries. the level of the housing building has been decreasing, while home ownership has been increasing for about fifteen years. But according to the housing policy, in some of these countries, the needs for housing are always satisfied and the liberty of tenure choice respected. In some others, the needs for housing are satisfied with many difficulties, the soaring of home ownership results from the decrease of the rental housing stock, and the tenure choice freedom can no longer be respected.

In this paper, we will study the consequences of the housing policies on the development of the housing market. First, we will examine the housing policies in the developed contries during the last ten or fifteen years. Second, we will compare the situations and draw up a typology.

Keywords: Needs for Housing, Occupation Status, Housing Policies.

1 Introduction

Since the early 70's, deep changes have taken place in the housing policies of EEC countries. Traditionally, sociological transformations have accounted for these evolutions: but they can also be explained by the effort of the major countries to reduce their public deficits and to modernize their economic and financial sectors, which, then, comes to mean less government intervention in the housing sector. But not all countries proceed alike, as some try to maintain a delicate balance between the rental and the home ownership sectors.

2 Transformations in housing policies

2.1 Reconstruction needs

In 1945, all the governments were forced to bring a lot of money in the housing and building sectors. Then this intervention was made necessary by the needs in reconstruction and reduction of insalubrious and temporary housing.

As a consequence, the effort in re-building the housing stock was remarkable in some countries, especially in West Germany, where it has been destroyed or seriously damaged, and also in the United Kingdom, France and Spain, which was just emerging from the civil war.

Up to the late 60's, this intervention also met needs due to a persisting shortage in housing. The situation was more difficult in the other countries, with the exception of F.R.Germany, Denmark, Luxembourg and the Netherlands, which all could use existing (and nonetheless still effective) financing systems that were able to attract private savings and to boost the public budgetary effort—in F.R.Germany, for reasons due to the situation of the housing stock, in the other three countries for reasons due to options in favour of social justice.

Indeed, the raising of budgetary as well as monetary and industrial resources was never sufficient to make up for the deficits accumulated in some countries for decades. That was the case of the United Kingdom, for one, even though she had a proper financing system, and also of France and Italy, where no such financing system exsited, and so had to be created almost from scratch.

As a consequence, since they could not increase the housing stock sufficiently, the governments tried to limit the consequences of the shortage. Thus, almost all countries set up a system of rent control in the private profit-seeking rental sector. This control was lifted in a very progressive way and still exists in many countries, in a milder form.

Contrary to the desired effect, these measures resulted in a reduction in the supply of good quality housing in the private rental sector and also in an increased strain on the rental sectors as a whole.

The only countries to avoid such consequences were those which lifted these measures early, namely the Northern European countries—F.R.Germany, Luxembourg, the Netherlands and Denmark. These last two countries also developed the rental housing stock with social purposes, so as to give households the widest range of housing services. As for Luxembourg and F.R.Germany, they have always encouraged private initiative by granting the necessary budget and tax advantages.

Other countries also managed to lessen some of the consequences for a while, by developing the rental housing stock for social purposes to compensate for the dullness or even the setback of the private rental housing stock market.

These countries directly interfered in the construction of social housing either through local councils (in the U.K.) or through non profit-seeking organisations (in Belgium or France).

With the 1974 crisis. many countries took the opportunity to start or to confirm changes in housing policies. Except for the Southern European nations (i.e. Greece. Italy, Spain and Portugal), almost all the other E.E.C. countries claimed that the housing needs were by now met, and consequently they reduced (or tried to reduce) the scope of government intervention in the sector.

2.2 Increase in household access to owner-occupied housing

Changes in housing policies took place in a difficult context in the 70's. After 25 years of state control, the governments "discovered" the advantages of a liberal system, in which private initiative was allowed freely to develop. But the private rental housing stock had shrunk dramatically in some countries -especially in the United Kingdom and in Ireland) or had been stagnating for a long time (as in France and in Belgium).

So. in the early 70's, most European countries stressed the importance of encouraging household access to owner-occupied housing. which they justified by the legitimate desire of people to own their homes and which they based on a system of credit facilities offered to the middle classes, and later to the lower middle classes., when an additional system of allowances backed the building activity which had been made possible by the economic development of the preceding years and was expected to go on by all the governments.

This way, they reckoned it would be possible to maintain the building activity with a smaller burden on the budget than when they developed the rental housing stock with social purposes. When needed, they set up counter cyclical strategies -as in the United Kingdom in the 70's, or in France and Spain in the early 80's- and were intent on sticking to a policy limiting government intervention in the building sector. From that point of view, they also tried to promote the improvement and maintenance of the existing housing stock in the early 80's first in order to prop up activity in the sector (as the increasing interest rates made household access to owner-occupied housing much more difficult for the middle classes) and second in order to counter the developing geographical segregation due to the discontinuation of new housing programs in the United Kingdom, Spain and France.

Table 1. Breakdown of owner-occupiers
(Percentage of owner-occupiers out of the global housing stock)

	Around 1950	Around 1960	Around 1970	Around 1980	Around 1990
Belgium	39 %	50 %	54 %	62 %	65 %
Denmark	–	45 %	47 %	52 %	58 %
Spain	50 %	51 %	64 %	69 %	75 %
France	36 %	42 %	45 %	50 %	56 %
United Kingdom	–	42 %	50 %	58 %	65 %
Greece	–	–	–	71 %	79 %
Ireland	–	–	71 %	73 %	76 %

Italy	40 %	46 %	51 %	59 %	68 %
Luxembourg	–	55 %	56 %	59 %	67 %
Netherlands	29 %	–	35 %	43 %	44 %
Portugal	–	45 %	48 %	52 %	58 %
F.R.Germany	–	35 %	36 %	40 %	42 %

3 Contrasting current situations

3.1 A typology of European housing policies

Today, the situation of the 12 EEC countries having been studied, three different groups can be distinguished:

– Northern Europe (Denmark. the Netherlands, F.R. Germany) is characterized by the fluidity of its rental sector and the good quality of the housing stock, which both guarantee the tenure choice. The development of the home ownership sector depends more on the individual choice than on a public strategy.

– In Southern Europe (Spain, Greece. Italy and Portugal), which is far less developed and traditionally rural, home ownership prevails and keeps increasing. In those countries, the public sector is indeed limited. As there are no developed and organized administrative structures, organisations in charge of a large and decentralized public rental housing stock cannot be set up. The private rental sector is under control (limits and rules are applied to rents) so as to reduce the risks of social tension and/or explosion, and which leads to the option of subsidizing household access to owner-occupied housing. This is made possible by a constantly high rate of inflation and a substantial public deficit.

– Western Europe (Belgium, France, United Kingdom and Ireland) is composed of countries whose governments are moving out of the housing sector while promoting household access to owner-occupied housing, after tackling (and sometimes solving) the problem of inflation and economic and budgetary modernization, either by selling part of the public rental housing stock (as in Belgium. United Kingdom and Ireland) or by letting the private rental housing stock disappear.

3.2 The risks of desequilibrium

The strategy chosen in Western Europe seems difficult to pursue because there are definite risks of social upheaval in these countries. especially due to an increasing geographical segregation that these countries try to stop. However. the governments are bent on their policy of developing household access to owner-occupied housing, and they encourage it by limiting the supply of the rental housing stock, among others.

Besides, deep sociological and demographic changes are taking place in all E.E.C. countries today. Except in the Southern European countries (but not in Italy) and in Ireland, where the fertility rate remains high and the demographic growth will hold steady until the year 2000, the purely demographic factor should not contribute as strongly as in the past to raising housing needs.

On the contrary, in all countries, the rise in the number of divorces and of single-parent families on the one hand, and the aging of the population and the increase in the needs of specific groups (handicapped people, students) on the other hand, should further the multiplication of new needs concerning the housing sector. This evolution is reinforced, in the Southern European countries and in Ireland, by a shortage in the housing stock (the number of housings per thousand). In the other countries, it goes along with the aging and deteriorating of the existing stock, due to inadequate maintenance. Such is the case, for example, of France and the United Kingdom.

Thus, even if the ways to calculate and assess vary a great deal among the E.E.C. countries, the housing needs still seem to remain fairly important.

Now, for 15 years, housing construction has indeed followed a similar evolution in all the E.E.C. countries. Until recently, a definite decline has been noted, situating the construction rate at an average level of half the maximum reached around 75, while, at the same time, household demand has not fallen by more than a third.

As a consequence, the increase in household access to owner-occupied housing only partly takes place in new housing programs, even if it accounts for half of the building programs in F.R.Germany and Denmark, two thirds in the Netherlands and in Belgium, 80 % in Italy and 90 % in Greece and in Portugal. Household access to owner-occupied housing has mostly benefited from the boom of the second-hand housing sector.

At first (in the 70’s), the boom profited the lower middle classes who could then afford a cheaper second-hand housing without having to borrow too much. But the rising costs of second-hand housing, especially in strained areas where land available for construction is scarce, bear on the market by barring the lower income households (or even the slightly better-off) from access, with the consequence that they find accomodation with an even greater difficulty. because, among others, of rental housing stocks.

4 Reinforcing differences

4.1 The boom in second-hand housing sectors

of course, these situations and their evolutions have had an impact on the respective shares of new housing programs and second-hand sectors in the market of household access to owner-occupied housing.

– Southern European countries encourage household access to owner-occupied housing in new housing programs, mostly through a system of subsidies to the housing industry, which prop up building activity and avoid mobilizing the existing housing stock that is generally dilapidated. This results in a low mobility rate and a dull second hand housing market.

– In Northern European countries. there has been no boom in the second-hand housing market. A balance between the two sectors still exists, except perhaps in the Netherlands where the lower income groups are encouraged to purchase second-hand housings through the sape of part of the public housing stock. It can even be remarked that in F.R.Germany. the granting of tax advantages for second-hand housing purchases has not led to a noticeable growth of that particular sector, at the expense of the new housing programs—as both the buyers and the government insist on quality and comfort housing.

– In Western European countries, the activity of second-hand housing markets has kept growing, mostly thanks to the re-seettling of the rental housing stock, which favours household access to owner-occupied housing. And in Belgium, today, this takes place more and more in the second-hand housing sector, despite the fact that the second-hand stock is composed of badly-designed housings and makes it necessary then for the buyer to carry out substantial improvement and transformation work.

4.2 Re-selling rental housing

Second-hand housing markets have indeed developed in the countries where governments have provided substantial supplies (stock effect), and increased purchasing facilities. Thus, in France, the growth in the second-hand housing sector that has been taking place since the early 70’s stands in sharp contrast with the decline in the new housing sector started in the early 80’s.

This boom has benefited from increased supplies as owners started selling property they had rented so far. This trend among landlords is recent, as it became of importance in the early 80’s only, and it has kept developing since then. It can be explained by the relative loss of profitability of real estate investments as compared to financial investments; this being due to a variety of reasons concerning taxation (reduction of the standard deduction and easing of taxation on savings), regulation (evolution of the respective roles of tenants and landlords and greater liberty for capital circulation), economy and finance (surge in housing prices and rise in real and nominal interest rates).

While the number of second-hand housings transferred every year rose by 100,000 units between 1964 and 1978 thanks to the opening of the second-hand sector to credit facilities, it rose by 120,000 between 1978 and 1988 as the landlords were selling out (with an estimate of 115,000 such sales between 1984 and 1988) and as the amount of government allowances (especially in the first years) increased.

In France, the increase in household access to owner-occupied housing has stepped up in the last ten years, and especially since 1984, no longer through a greater number of new housing programs (as in Denmark or in F.R.Germany between 1968 and 1978), but through a redistribution of the different sectors of the housing stock. As the importance of the private rental housing stock diminishes, household access takes place in the second-hand housing sector, thus changing the occupation status in housings.

From that point of view, the situation can be compared to that of Belgium and the United Kingdom at the same time. But in these two countries, and especially in the United Kingdom, the faster development of household access acted to the detriment of the public rental housing stock. Indeed, a long-term financing system had already permitted household access in the second-hand housing sector for a long time.

Thus, between 1979 and 1987, the number of owner occupiers increased by 2,300,000 units in the United Kingdom. In the meantime, 1,150,000 new housings were built for household access and over a million others were bought in the public housing stock.

Table 2. The "disappearing" of the rental housing stock (in percent of the total number of housings)

	Owner-occupier	Private rental	Social rental
United Kingdom			
1979	57 %	12 %	31 %
1987	65 %	8 %	27 %
France			
1978	47 %	38 %	15 %
1988	54 %	29 %	17 %

5 Conclusion

A certain number of conclusions concerning the evolution of housing policies can be drawn from the study of the situation in E.E.C. countries.

– The development of household access to owner-occupied housing, a common aim to all E.E.C. countries, hardly ever goes along with the respect of a balanced rental housing sector, as in F.R.Germany or Denmark. It takes place either entirely in new housing programs (the stock is built and extended as in Southern European countries, or in the re-sold rental housing stock as in Western European countries.

– Then in those two areas, the evolution goes somewhat against the aim of an increased residential and professional mobility, and especially in the Western European countries which are the most directly concerned by this necessity of increased mobility.

The current housing policies, devised in the early 70's when the governments had to reduce their budgetary efforts so as to make up their deficits, are no longer adapted to the new constraints they have to face. All the countries that now try again to redistribute the money granted in a more socially oriented direction (housing for the most underprivileged sections of the population) also seem to admit that previous policies failed.

Then, European prospects for 1993 might include a re-definition of housing policies that would balance the different sectors, while respecting a true liberty of tenure choice, and satisfying the housing needs.

6 References

Lefebvre, B. (1989) Le rendement de 1'immobilier résidentiel de rapport et des actifs financiers dans les pays de la C.E.E.: un essai de comparaison, in **L'observateur de l'Immobilier,** 14, 10–19.

Lefebvre, B. and Mouillart, M. (1990) Incidence des evolutions législatives et réglementaires sur le choix du mode d'occupation du logement par les ménages : la perspective des pays industrialisés. report for the French Assemblée Nationale.

Lefebvre, B. Mouillart, M. and Occhipinti S. (1990) Les perspectives du financement du logement en France et dans les pays de la C.E.E. (ed. CEREVE).

Mouillart, M. and Occhipinti, S. (1990) Le logement est-il un frein a la mobilité en Europe, in **Cahiers du Credit Mutuel,** 74, 22–33.

180
Building company failures

D.J.LENARD

Abstract
This study is essentially a discussion on the instability of residential demand for construction and its impact on company failures in Australia.

The variability in output of the sector is excessive with peaks and troughs occurring within a four year cycle. Such volatility impacts dramatically on the industry and causes hardship to both clients and builders. This paper specifically addresses the problems that arise during periods of boom. The 1988–89 property boom with an increased demand for residential property is chosen for a focus of the discussion.

Keywords: Company Failures, Liquidity, Residential Construction Instability, Building Insolvency.

1 Introduction

As Australia moves into the nineties there is general agreement that the rapid growth periods of the post-war era have passed. The energy crisis, the decline of natural population increase, the restricted immigration program in the early 70's and the shift of emphasis from production to financial services have all had their impact on the building industry.

Demand for residential building has always fluctuated, however since 1985 this fluctuation in demand has been extreme. In the immediate future the industry will face a shortage of available work in relation to its potential. During the next few years competition for work will be intense and builders will be forced to review their operations and incorporate sound financial management procedures.

Within the next four years there should be another boom in residential construction as supply catches up with the 'pent-up' demand (Lenard and Oluwoye J. 1990). The industry is familiar with fluctuations in supply and generally can cope with down-turns however, a booming market poses many unforeseen problems and causes many company failures.

1.1 Purpose and scope of the research

In the period since 30 June 1988, there have been a number of both voluntary and non-voluntary failures of building companies. Such failures have had a dramatic effect on the community and public perception of the industry at large.

The general aim of this research is to analyse the operation of building companies in a volatile market with a view to determining the causes of failure.

Whilst there are a number of individual and specific causes of failure it is hypothesised that common causes of insolvency are related to one or more of the following:

(a) The building market is volatile causing peaks and troughs of activity which impact adversely on the supply of labour and material resources.
(b) The estimating skill of builders is insufficient to cope with the volatility of the market.
(c) Cost control systems are deficient in a large number of companies.
(d) Operating capital is insufficient to cover the risk in the supply and cost of capital during peaks and troughs of activity.
(e) Profit margins are insufficient to allow for an adequate build-up of resources.

All of the causes listed above are analysed in a report (Lenard, Roberts and Willey 1990). The volatility and instability of the housing market is the underlying cause of building company failures. The effects of the volatility of the market are specifically addressed in this paper.

2 The residential building process

House construction is a short-term operation with materials and services moving from site to site. Some factory based production is included in the process but often not standardised. In essence the industry still relies on a substantial amount of on-site labour. Table 1 indicates the relative proportion of on-site work as represented by payments to sub-contractors.

Table 1 Breakdown of turnover of housing construction establishments by state 1984/85

	AUST	NSW		VIC	QLD	SA	WA
Payments to subcontractors	%	34	36	33	29	38	33
Materials, fuels, etc	%	45	43	44	47	42	46
Value added	%	21	21	23	20	19	17
Turnover	$M	5107	1424	1369	1005	439	578

Source: ABS(Cat 8771)
Note: Sums do not add to 100 because of exclusion of miscellaneous expenses category.

2.1 Builder/sub-contractor relationship

With builders largely adopting an entrepreneurial role there is no conventional employee-employer relationship. There is no permanent supervision on sites and consequently no check on the efficiency and performance of sub-contractors.

It is argued that the sub-contract system is efficient in that the sub-contractor only gets paid for work actually completed. The system often works when risk is minimal and sub-contractors agree rates to cover all costs including travel, tools, equipment and lack of production due to bad weather. In these situations most of the risk is carried by sub-contractors. In other situations the sub-contractor passes on the risk to the builders by working for day labour. This often happens when the work is complex.

Builders are generally convinced of the merits of the sub-contract system and argue that it is vital for low-cost housing production even though it is recognised that a major deficiency of the sub-contract system is in the area of training.

In 1988 builders took on more orders than the capacity of the industry to supply. This fact became evident in a study of major house builders undertaken by Lenard and Roberts (1990) in which it was found that average construction times for major builders increased 30% to 50% during 1988–89. Excessive periods of wet weather in Sydney aggravated the intense situation. Additionally shortages in material, caused by both lack of production and strikes, became acute in the period.

> "In summary, the basic problem that faced builders in 1988 was that as a whole they had taken on more orders than they could supply with the available resources."
>
> (Anderssen and McEvoy 1990)

In the study (Lenard, Roberts & Willey 1990) it was found that bricklaying rates increased by over 60% in the 1988 year. This is also confirmed by Anderssen and McEvoy (1990). Average take home pay for more productive bricklayers exceeded $A1500 per five-day week. In the same period carpenters were earning in excess of $A1200/week with concretors receiving up to $A400 per day. Builders were faced with liquidity problems due to pre-arranged contracts guaranteeing substantial losses.

3 The volatility of the market

Quarterly building commencements are used as an indication of the volatility in the production of new housing. After analysis it was found that the average difference between peaks and troughs represent a variation of 31% above or below the average level of production of 35, 877 between the 20 year period March 1958 to March 1986. In value terms the variation is 37% of the average of $1,647 million. An indication of the variation is given in Table 2.

Table 2 Peaks and Troughs in Residential Activity

	Quarterly Commencements (000)
September 66	29
September 69	36
September 73	45
September 75	27
September 76	36
September 78	28
September 81	37
September 82	25
September 85	37
September 87	29
September 88	45

In periods of decline builders cope by reducing overheads to minimal levels. Sub-contractors with specialist skills often leave the industry. Construction costs can often rise in these periods as both sub-contractor and builder overheads are re-evaluated during such periods based on the volume of production.

In periods of peak activity, such as the peak that occurred in 88–89, industry labour shortages present considerable problems. It is in these periods that the seeds for building company insolvency are sown.

The problems arise because of the lack of forecasting ability of the builders entering into fixed price contracts. Contracts can be signed up to six months in advance of construction with no allowance for possible cost increases during the course of construction.

In addition, quality becomes difficult to control as inexperienced sub-contractors are engaged to carry out the work in times of acute shortages of available skilled labour.

Disputes between owners and builders become common as some builders try to recover losses by resorting to contractual measures to improve probability and to hide non-performance. Clients and consumers become particularly distressed during the period and consumer protection bodies become inundated with complaints.

3.1 The effects of the 1988–89 boom and the resulting market instability

There were few winners during the period when builders struggled to complete projects and avoid the threat of insolvency. Table 3 (adapted from Anderssen and McEvoy 1990) sets out the experiences and the effects of the 1988–89 housing boom.

Table 3. Winners and losers from recent housing market instability

Experiences	Winners	Losers
Completion times for housing contracts increased from under 16 weeks to up to 10 months		purchasers
Lack of suitably skilled tradesmen and technical staff saw their income increase, in extreme cases by a factor of 2	subcontractors supervisors	builders
Delays in approval processes by local authorities frequently caused fixed-price contracts to be renegotiated, often at considerable unexpected additional costs to the purchaser	builders	purchaser
Due to the unanticipated rapid growth in labour costs and material prices (not allowed for in fixed-price contracts), coupled with the delays in completion times, many builders' return declined, despite substantially greater input of effort and increased turnover.	purchasers	builders
An abnormally high number of builders left the industry (largely due to cash flow problems brought about by increased costs).		bankrupt builders, their creditors & customers
In order to complete houses, builders used less experienced staff and sub-contractors which increased their costs (despite the sub-contract system) and reduced the quality of some homes	sub-contractors whose employment opportunities and pay increased	those builders forced to undertake expensive rectification of problems caused by sub-contractors buyers with lower quality homes than expected
Associated with the shortage in some building materials, there was a restriction in choice of building products available to consumers	suppliers as they could concentrate on more profitable product lines.	purchasers
As stocks of land were reduced, and prices of building sites increased, long queues developed for some "good value" land released by State government authorities. The expected shortage of land and higher future prices encourage "panic" and "speculative" purchases in both land and "spec" houses	land owners land developers state government specifically "Landcom".	land purchases during the period
State government instrument-alities that held land stocks—under land banking arrangements—made unexpectedly large capital gains on stock, enabling their continued profitable trading, albeit often with lower land	government authorities & departments	those purchasing the land at the higher prices

holdings		
Increased pressure for more public housing as price and interest rate changes put ownership out of the reach of low income wage earners. The response to this pressure differed across states	existing holders of lower cost public housing	low income households and government housing trusts

Experiences	Winners	Losers
There was considerable political pressure by those home purchasers who suffered unanticipated quality loss, cost increases, and/or completion delays	uncertain	the building industry
The number of building businesses failing increased, with the wages loss to their sub-contractors and bad debts to their material suppliers also increasing	liquidation parties accountants	all parties and the building industry,

7 Conclusions and recommendations

Not only is the housing industry dependent on a steady economic growth but also significant sections of commercial enterprise are dependent on the housing industry. House building can form up to 70% of the total building market and is sensitive to change in society and economic fluctuations. Despite its scale its sensitivity is heightened by the fact that its participants, both owners and builders, are asset poor and have limited resources to weather even short-term problems. Although the industry may be a major one it depends wholly on the resources of the individuals engaged.

That being so it is essential that owners be well informed and that builders be highly skilled. The knowledge level of owners is a serious matter and has already been adverted to on specific issues but is not addressed in this paper. The basic skills and knowledge required of builders, however, have been addressed in some detail by many (Lenard 1981, Lenard and Heathcoate 1990). It is not sufficient that a builder have only technical capability in actual construction, for there seems to be little or no relationship between this and business failure. This has been recognised by building groups such as the Master Builders Association and the Housing Industry Association who run short courses on business matters. The Building Services Corporation also provides resources in this area and, relevant to the issue of licences, has had a significant effect on courses run by the Department of Technical and Further Education. Instability in construction activity is an integral element in construction. The causes of instability are related to demand volatility. The two main participants in the housing market, both owners and builders, lose in periods of instability.

Governments need to lessen the profitability of instability by following stable and predictable policies in terms of provision of land and services, interest rates and general macroeconomic reform.

References

Anderssen, H. and McEvoy, J., (1990). Instability in the Australian residential construction industry. B.T.E. Research Paper 2. Australia Sept. 1990.

Lenard, D., (1981) A competitive tending strategy for the risk averse contractor, Master's Thesis, UTS, July 1981.

Lenard, D. and Heathcote, K., (1990) Profitability and risk in the australian residential construction industry, Land Economics Review, Vol.1, No.1, UTS, Sydney, 1990.

Lenard, D. and Oluwoye, J., (1990) The prediction of the short-term demand for new dwellings in NSW, Land Economics Review, Vol.1, No.2, UTS, Winter 1990.

Lenard, D. and Roberts, C., (1990). Unpublished report to the Trade Practices Commission.

Lenard, D., Roberts, C. and Willey. C., Liquidity of Organizations in the housing industry. School of Building Studies, UTS, Nov. 1990.

181
Methodology of residential building system design based on knowledge of the structure of housing community

S.MATSUMURA

Abstract
This paper proposes a regional autonomous way to design a residential building system, using adequately industrialized methods, instead of following the past industrialization of houses production, which had been developed in ignorance of regional context. The proposal will be shown after a short historical review of industrialization. Firstly, a new method to analyze the discrepancy between the change of dwellers' society and that of building society in a certain region is proposed. Secondly, a theoretical method to design a residential building system which is to be appropriate to the region, by means of the control of some variables related to building construction and its organization is proposed.
Keywords: Regional Identity, Industrialization, Building System Design, Housing Community, Detached Houses, Category of Work, Sphere of Occupation, Prefabrication.

1 Introduction

In Japan detached houses have been representing the majority of newly-built houses, although the ratio of the number of newly-built detached houses has gradually decreased recently. In the field of detached houses production, prefabricated houses manufactured and supplied by big companies have rapidly grown since the 1960's, however most of detached houses are still made by conventional wooden construction methods.

The production of conventional wooden houses had been maintained by regional networks of various types of artisans, where the carpenters play the main role. So, in comparison with the modern prefabricated houses production, these regional networks stood on a daily intense communication in each region, and embodied rich regional identities. But, since the 1960's the production system went out of order because of a passive and partial introduction of various industrialized materials and components, without autonomous judgment, though as a result the productivity of conventional wooden houses has been gradually improved.

Today, when there is no more problem of shortage of houses in Japan, it is imperative to find the happy marriage of autonomy in each region with a modern concept of rationalization in industrialized building. In order to do that, it is very important for each regional housing community to know which part and how much it must be Industrialized in regional houses production, based on the knowledge about the discrepancy between the change undergone by the dwellers’ society and that undergone by the building society.

2 Typology of conventional wooden houses

Though conventional wooden houses production looks individualized, scattered and uncontrollable, after careful surveys a useful typology could be found. Dr. Y.Fujisawa, Dr. K Ohno, Mr. M.Ando, Dr. S.Funo and Dr. S.Matsudome surveyed a great number of conventional wooden houses and builders in ten regions all over Japan, in 1982, and proposed a useful typology of conventional wooden houses which was mainly based on the style and the price per m^2. It was the most important conclusion of them was that in this typology the house type had strong relation to both the dweller’s attribute, such as income and occupation, and the ratio of distribution of construction expenses in each category of works. (Fig.1.)

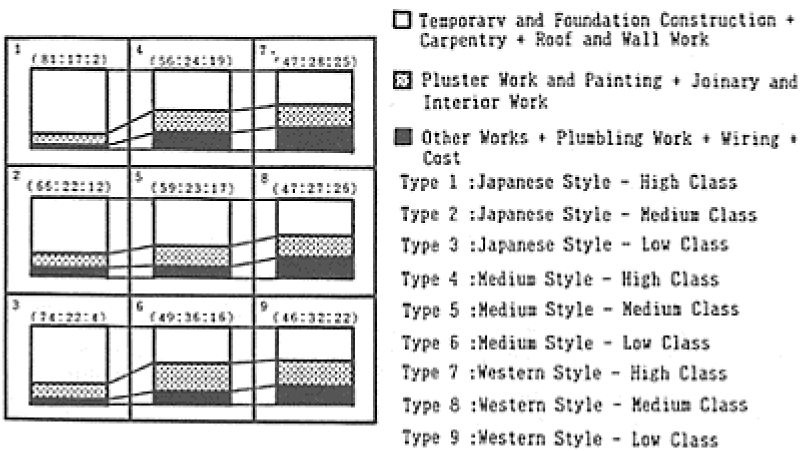


Fig.1. The example of the relation between the house type and the ratio of distribution of construction expenses in each category of works.

According to this conclusion two hypothesises of relations between the number of wooden house construction in each type and the structure of dwellers' society, and also between the house type and the ratio of distribution of construction expenses in each category of works have been formulated.

(a) There are strong mutual relations between the dweller's occupation and the style of the house, and between the dweller's income and the price per m^2. of course exceptions can be found when each construction is independently considered but these relations can be clearly recognized when a regional structure is totally considered.

(b) The ratio of distribution of construction expenses in each category of works changes regularly according to the house type.

3 Simulation process in the model region

Based on these hypothesises the quantitative evaluation method about the discrepancy between the change of regional dwellers' society and that of regional building society can be proposed. Firstly, in this method, the annual number of conventional wooden house construction in each type is calculated from both the structure of the dwellers' society, which is defined by the distribution of the dwellers' occupation and income, and the total annual number of conventional wooden house construction in a certain region. Secondly, the annual construction fee of each category of work in the total cost for the construction of all conventional wooden houses in a certain region is calculated based on the result of first calculation. Thirdly, the equality between the second calculation result and the total annual income of all workers, of each category in a region is instituted, from which the necessary number of workers of each category is calculated. Finally, in comparison with this necessary number of workers, excess or shortage of the existing number of workers of each category in the region is evaluated. That is to say, this evaluated excess or shortage can be the result of the quantitative evaluation about the discrepancy between the structure of dwellers' society and that of the building society in the region.

In this study the method has been applied in three numerical model regions—region A, region B and region C—which are regions with ten thousand population each. As these numerical model of regions are made on the basis of statistics of three groups of prefectures classified according to the degree of urbanization, region A is the most urbanized region of them and on the contrary, region C is the least urbanized one.

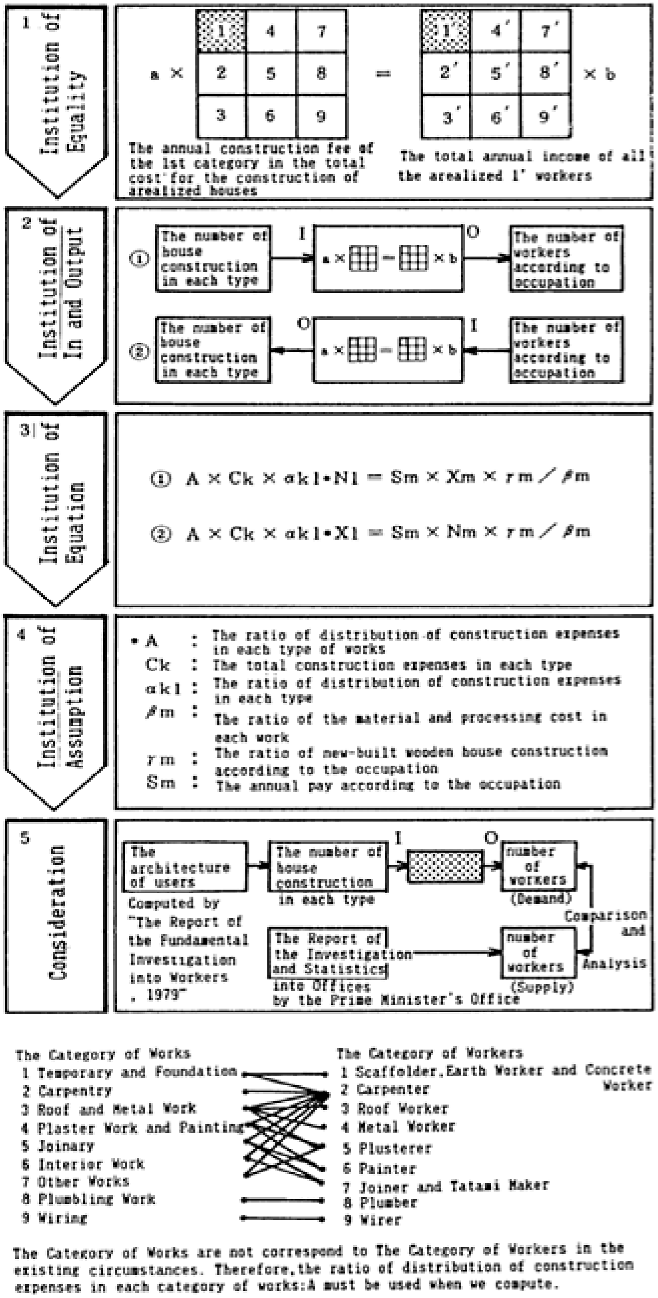


Fig.2 The simulation process in the model region

Fig.2 shows the simulation process in the model region. In the actual calculation, it is necessary to establish the value of coefficients, such as the ratio of the processing cost in each work, the annual pay according to the occupation and so on. Though in this study these coefficients values are established on the basis of government statistics and relative researches, some of them will possibly change according to the region. So when the result of the simulation is evaluated it is very important to judge how the values of these coefficients influence the result.

Fig.3 shows the result of the simulation. There are differences in the degree of excess(+) or shortage(−) of workers in each category, but the categories of workers which are in short supply are almost common among the three regions, because these numerical model regions are smoother than actual regions, as well as because these are made of averages of various statistical data of many prefectures. The categories of workers which are numerically in short supply in every three regions are carpenters, roof workers, metal workers, plasterers and painters and the degrees of shortage are commonly the biggest in the middle-urbanized B region. On the contrary rather excess in plumbers and wirers can be find. In this case the values of coeffi-

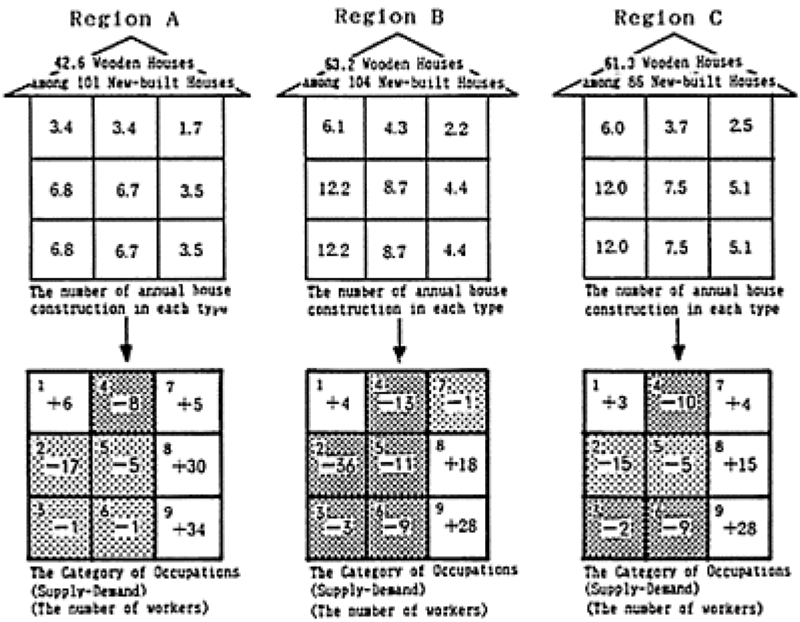


Fig. 3 The result of the simulation on regions A, B and C

cients γ had better be evaluated bigger than actual condition.

4 Building system design based on the result of the simula-tion

4.1 Controllable variables in building system design

When the quantitative evaluation about the regional discrepancy between the structure of the dwellers' society and that of the building society is done, the regional housing community should begin autonomous building system design based on the result. As far as the coefficients which are used in the simulation process are concerned, the annual number of conventional wooden house construction in each type(N1), the total construction expenses in each type(Ck), the ratio of distribution of construction expenses among categories of works in each type(αk1), the ratio of newly-built wooden house construction in annual sales according to the category of workers(γm) and the annual pay according to the category of workers(Sm) are uncontrollable coefficients in building system design. Controllable coefficients are only two, namely the ratio of distribution of construction expenses in each category of works among all the categories of workers(A) and the ratio of processing cost in each work(βm). (Fig.4) So it is necessary to consider how to balance the supply of each category of worker with the demand of them by manipulating these two variables in building system design.

As variable A represents the sphere of occupation in each category of workers, decrease of variables A results in decrease of the necessary number of the workers and increase of variable A results in increase of the necessary number. On the other hand, because variable β_m represents

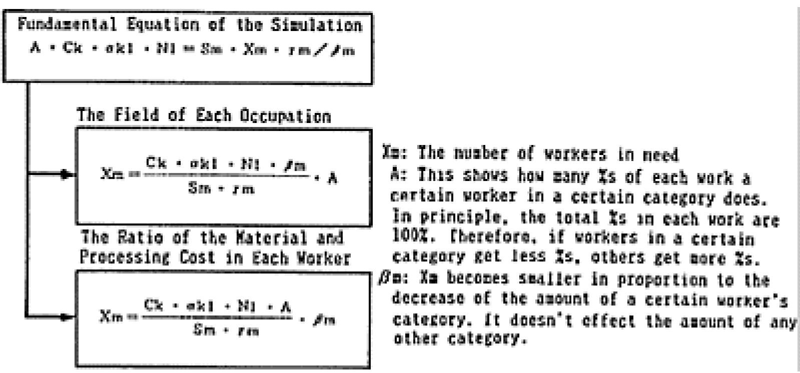


Fig.4 The controllable variables in residential building system design

the ratio of the processing cost in each work the result of manipulation of this β_m is the same as that of A. The concrete way to manipulate these two variables in order to balance supply with demand in a certain area is shown below. (Fig.5)

4.2 Control of variable A

Suppose the category "a" of worker, which is numerically in excessive supply and the category "b" of worker, which is numerically in short supply. The works of both consist of several elementary works and there is an interface of construction between them. In this case, supply and demand can be balanced transferring an elementary work "S", which is an interface work but belongs to the occupation of "b", into the sphere of occupation of "a". However, the transference is not easy when the elementary work "S" forms the essential part of the occupation of "b". Besides when both spheres of occupations are already well coordinated it is necessary to be careful so as not to confuse the existing construction system.

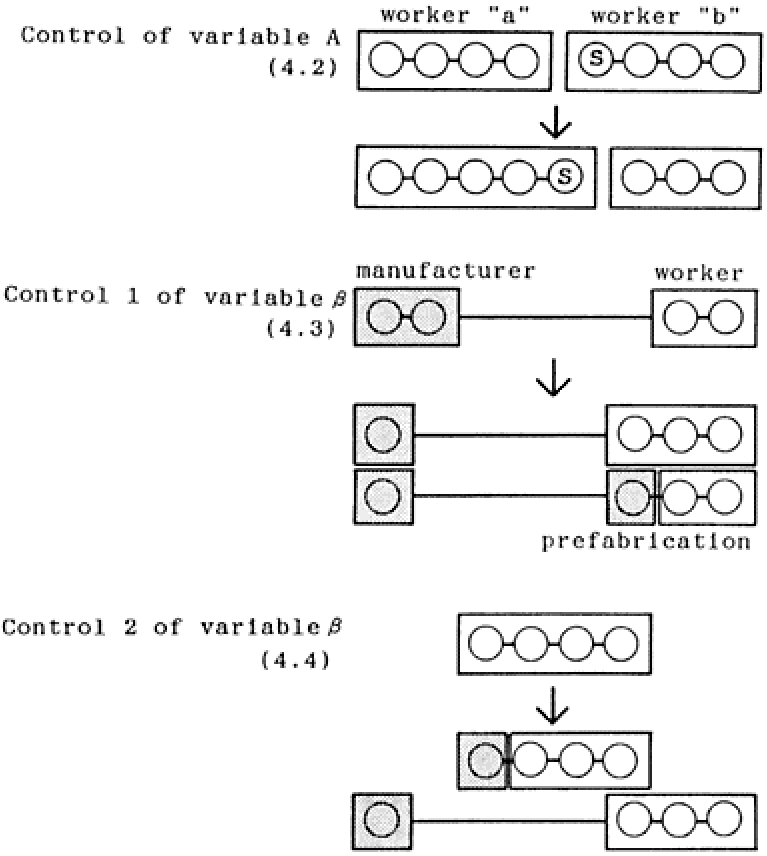


Fig.5 The control of variables A and β

4.3 Control 1 of variable β (Increase)

Suppose the category “a” of workers, which is numerically in excessive supply, does two elementary works on construction site and entrusts a building component manufacturer to do two other elementary works. In this case, an elementary work can be transferred from the manufacturer’s factory to the construction site or processing yard of workers of category “a” in order to increase variable β.

4.4 Control 2 of variable β (decrease)

Suppose the category “b” of workers, which is numerically in short supply, does four elementary works on construction site. In this case, two ways to decrease variable β can be found. One way is to transfer an elementary work from the construction site to its processing yard and increase its own productivity by the prefabrication effect. Another way is to entrust a building component manufacturer with an elementary work.

4.5 Needed knowledge in practice phase

When these controls are put into practice, we need to judge the rational relation between elementary works’ attribute and production scale, other than the coordination of sitework and transportation efficiency of components. For example in case an elementary work suits mass-production, the control 1 of variable β must result in reduction of productivity. On the contrary in case an elementary work has no possibility of increasing its productivity by massproduction and relative long circulation, the control 2 of variable β must result in reduction of productivity too. So it is necessary to gain knowledge about the rational relation between building elementary works’ productivity and production-circulation scale through careful studies.

5 Who applies these methods?

Anyway these proposals are for the autonomy of regional housing community. It means a kind of paradigm shift from the top-down uniform industrialization approach to bottom-up multiform industrialization approach. So it must be regional housing community that apply these methods. After collecting their regional data about houses, dwellers, building workers and so on, they must apply the simulation method and carefully design their own regional residential building system.

In practice phase, it is a serious problem that only few members can be expected to do so, because most of them are very small organizations and cannot afford the application of those methods. But, the recent appearance of new members in the regional housing community can be considered as a symptom which give us new hopes. The new members which are called “regional builders” have appeared In various regions all over Japan especially since the 1970’s, each of them construct hundreds of conventional wooden houses per year. So, on one hand in comparison with modern prefabricated houses manufacturers and suppliers some of which construct more than ten thousand houses all over Japan per year, they can be regional. On the other hand in comparison with conventional carpenters some of which construct less than ten conventional wooden houses per year, they can afford to research themselves and associate with most of building component manufacturers on equal terms.

In conclusion, it is necessary to continue careful studies about regional housing and make efforts to cooperate with regional builders, which are said to be several hundreds all over Japan.

182
Actual perspectives of habitational problems reduction in Latin America

C.F.A.da MOTTA

Abstract
The '80 decade showed a considerable aggravation in the habitational problem in Latin America, in particular, in Brazil. The new decade doesn't project great modifications in this dark scenery. In this article, we tried to discuss (in outline), the crisis in this sector and to analyse the actual habitational production, the future perspectives, the State and Civil Construction Industry functions under the trinominal: quantity, quality of the units and market pos sibilities.
Keywords: Mass Construction, Construction Quality, Civil Construction Industry, State.

1 Introduction

In the moment that we began to prepare this article, the Brazilian economy was attained again by "soi-disant" meliorative measures. For the second time, in less than ten months, violent rises in public tariffs occured (water 59%, gas 62%, electricity 57%, gasoline 49%) and the salaries and prices are "frozen". This is, unfortunately, the routine all over Latin America since 1980. This decade is called here "the lost decade", an extraordinary regression in the whole economic and social matters that took this continent to a poverty situation and made the Brazilian economy "be out" of other central economies reality.

Some informations about certain countries of Latin America will clear up this situation:

Country	Populat ion	% Living Cities	Per Capita Rent (US$)	Living Wage (US$)
Brazil	150.000.000	75%	1.800	60
Argentina	32.000.000	85%	2.200	120
Chile	13.000.000	80%	1.500	86
Colombia	30.000.000	67%	1.284	84
Ecuador	8.000.000	49%	600	55

Paraguay	4.600.000	46%	970	200
Peru	20.000.000	65%	−	30
Uruguay	3.000.000	84%	2.842	80

Looking at these numbers it is easy to understand why the habitational problem is so serious in Latin America. In terms of Brazil, it is estimated in twelve million the number of units that have to be constructed, aiming to give appropriate conditions of habitation to the primitive houses (favelas), slum-tenement-houses (cortiços), unsafe self-constructions and these places that risk the habitants health.

In this article we will try to comment only few pertinent aspects to such complex question, for instance, the situation of the Civil Construction Industry. The State position in the habitation supplying and the future perspectives under the trinominal: quantity of units to be produced, their quality and market possibilities.

2 The actual situation of the civil construction industry in Latin America

During the 1970's signs that, finally, there would have been a frontal attack to the habitational problem in almost all Latin America's countries appeared. The economic situation was relativelly favourable, there was an exporting market expanding and finally there was an obtainment possibility of interesting lendings in foreign countries.

In Brazil it was created an expression "the Brazilian miracle"—the country would be about to enter in the selected list of the developed countries, the economy was the 8th of the world, ahead of countless European countries. The "boom" progress was going through the country—it was the period of gigantic constructions: hidro-electric power stations, monumental bridges, pharaonic roads (Transamazônica is the biggest example of this period), railways connecting "nowhere to nothing". The civil construction industry and particularly the habitational construction industry prepared and equipped themselves to the new challenges. The construction industrialization and the prefabrications were the keywords to these new challenges. During three years a big habitational complex with aproximately 35.000 units (Itaquera) was built in the state of São Paulo.

As soon as the initial vainglory finished and the Government orders were becoming sporadic, if not disappearing, and with the crisis begining in 1979, the companies were bankrupting or leaving the innovated technologies quickly. However, it can not be affirmed that the Civil Construction industry is incapable of attending the challenges that eventually may expose. In terms of Brazil we can demonstrate the following situation:

− The constructive processes are many and they can be classified in the technology point of view into three different categories: traditional process, conventional process and industrialized process. In the first one, the main elements of the construction are obtained in the own brickwork plot through the utilization of nature materials with the manual work intensive usage. In the second one, the main elements are also obtained in plots, but through diversified materials and components furnished by the sum of construction industry elements, with the intensive use of labour, but also using many equipments. In the last one, the main fact in the mechanization and rationalization of construction with resultant reducing of the intensity labour force use to the same volume of work.

− In Brazil, conventional technics and handicraft arrangements of construction with mechanical methods are found out in which the Machine carries out the hard operations replacing the human being. It occurs because on one's hand the productive process specifications of the section, the work process discountinuance, the necessary worker's locomotion in the brick work plot and the temporary organization of it makes the mechanization a very difficult thing, comparing to transformation industries where the machinery and the work place are fined and stable. Otherwise, the prefab use changes the relations inside the plot profoundly, reducing the works duration, but raising the capital/work relation.
− Therein, the actual tendency within limits of technical advance, still is not for the industrialization itself, but for the alternative demands that permit productivity profts without violent modifications in the technical composition of capital and the continuous producing necessity forced by prefab. However, this tranformation is still weak, but there is an insufficient motivation for the constructive process or to improve rationalization. There is a reason to this lack of motivation: the fact that the construction cost in the property final price is just one of the components, observing that the derivative gains of commercialization of the land are very expressive. However, it is very important to stand out that the high investments claimed by industrialization (that passes by the prefab sector and construction elements industry) implied in an adequated volume necessity (and continuous) of production. Thus, on the law suit side limitations impose as industrialization opposer elements.

3 The State function in the habitational furnishing

Considering the bad situation of habitation in Latin America the State function would be fundamental either in the administration production or in the alternatives furnishing to finances.

Obviously, it does not happen. To each new Government in every countries, there are at the beginning purposes for the substantial changes to occur in that sector. However, after the initial moment, nothing happens and everything is unchanged.

In Brazil, the latest Government presented many purposes that were never made. We had the following programs:

– PROMORAR—that was seeking the construction of 2 mill ion of f habitations in a 5-year period by pre fab modules.
− JOÃO DE BARRO—mainly self-construction and it was intended to give 4 million and a half habitations also in a 5-year period.
− P.A.I.—of Collor's actual Government that includes many alternatives from the self-construction to industrialization. They want to conclude 6 million of habitations until 1994, but in the first 10 months of this Government anything was made.

This way, we can verify that the persistence of an insuficient offer for the lower levels of salaries causes infinite waiting-lines in the state-companies of habitation and due to this situation, anything that appears in the market is immediately sold. This fact leads us to another of the essential subjects of habitation in Latin America, among others, for instance: the quality problems The popular habitations in Latin America are financed by the state in the time limits from 25 to 30 years. A lot of them can not survive half of this period.

Talking about the quality of state, it reseals a total omission and it almost does not offer anything to the final consumer even though there are research institutes and universities in Latin America countries to furnish support to the big habitational opertions.

The State in the normalization and quality control view has two ways to follow: one is about the technological innovation and the other is for the conventional construtive process.

In relation to the technological innovations especially in the habitational area, it was observed in the last years that the new and constructive products introduction in industrialization and prefab program of construction are in front of the lack of the normative references, that could permit to estimate if these new products and systems that appeared in the market attended the minimal conditions of fulfilment.

The basic matter that is in the point of view of normalization and control is the following: to attend the habitational necessity program, it can be developed a constructive complex system, changing the project conception, the used components and the used materials.

The questions that could be asked in the point of view of the evaluation and the quality control are:

– what is demanded of the system.
– what answer is expected by the constructive system.
– what is expected in terms of termical isolation, acoustics isolation, of security, hability and durability in that systems of long duration?

The tendency that has been verified to the evaluation of these new systems is to compare to the traditional system, comparing it to the ceramic bricks house covered with mortar of cement and sand. This is a doubtful paradigm because the traditional system although it has proved empirically that it can work during the time it can be superdimensioned to some aspects and regions and can be sub-dimensioned to anothers.

In our opinion, there is an intrinsic relationship between the technical normalization matter and the quality control and integrated actions upon them are necessary.

The State, trying to avoid constructions problems that it finances, would try to actually act upon this reality in the following way:

– Trough effort concentration of technical normalization, seeking for identifying the normative “gaps” that exist and working in groups with manufacturers, builders, planners, universities, research institutes, public and consumer organs, that can “cure”, fill out these normative “gaps” and to review norms that are obsolete yet . Finally, to make this normalization structure stronger, either the prescriptive normalization or the fulfilment one;
– Aiming in accordance to these many segments that were identified, developing specific systems of quality control to the project phases, of elements and components fabrication, of execution and including the operation, use and maintenance of construction phases;

− Aiming to establish the confirmation systems to the technological innovations and the certification of agreement systems to the product that has been estabilished by the use.

These action of normalization, certification, confirmation and control being estabilished, will point to a future that may be coming, where a guarantee of quality exists in the civil construction section, where consenquently the user would have assured what he acquered.

4 Possible perspectives to the habitational need combat

Urgent measures must be adopted to the combat to so severe habitational problems, since the aspects mentioned before be considered in relation to the guarantee of quality.

We believe that a path we can follow to solve this problem is the construction rationalization. In this angle there are signals of the new enterprise strategies that include a orientation to reduce the costs production through rationalization. The “option” for the rationalization is due to the fact that this rationalization contrary to the industrialization does not involve big investiments in equipments. The rationalization permits gains of productivity and the minimalization of the costs and the time limit, without getting involved in a interruption of the productive bases, that characterize the sector. Through the rationalization, companies that used either the traditional system or the new technics, aimed to reducing the waste of time and materials, getting to some of the main points of “strangle” of the conventional construction, such as the disconnection among many projects and between project and work; lack of quality control; bad work conditions as low-productivity fact; plot disorganization, etc.

The technological modernization in the building sector can contribute to the equation system of a critical social problem—the habitational one—while it implies the costs reduction and the time limits that must mean also an improvement of quality of the product. The reduction of costs permits an increasing of the production, while it makes a market enlargement possible. The same way, the time limit reduction can also permit a bigger production volume, besides a reduction of financial costs.

In relation to quality, together with the obvious benefits to the consumers, there are advantages to the public power, in the case of the state-groups that, today, face the maintenance and recuperation problems, with the serious financial implications in front of the failures that happened during the last years in relation to this aspect.

In relation to the companies, the advance, known as the quality improvement, means, besides internal gains, a new standard in relation to the user, with the consumer, that begins to organize himself to claim for his rights in relation to the product that was offered.

An advance that directs itself to the rationalization presents series of advantages in relation to industrialization, in the actual angle:

– Adapting to the big disposition of manual work, when it maintains the technical bases that characterizes today’s sector;
– Flexibility in relation to the oscillations of lawsuit, while it does not involve big investiments in fixed capital;

– Viability, even in reduced scale, not depending on the big scales that only occur in Latin America, in the state-promotion segment (the ones that pressupose the continuity of “mass” programs by long periods relatively);
– Adapting to the sector composition—possible of being implemented in the range of small and medium companies, by not implicating big investiments;
– Adapting to local resources, either technological or material ones.

The effort for the advancement of the sector in the sence of rationalization, in an evolution in relation to the conventional construction did not exclude local initiatives more advanced, that point to parts of the building industrialization. Such initiatives may serve of experiences preparing the bases to more generalized advancement in the future (respected the specified in the Latin-american context), besides bringing contribution to the process of rationalization realized in a parallel and in a more exposed form.

When finishing this work, maybe the remaining image would be a pessimistic one in relation to the destinies of Latin America, especially due to its urban and habitational politics. In our comprehension it could not be different in these view, because after twenty years observing such matters, our image of this situation is one of a non-struggling backward process, in all senses. We are watching a lot of years of research and technological development being thrown away in the buildings section and worse, even though there are no resourses to the construction, we cannot see anyone planning things for the future. This future reserves towns such as São Paulo (Brazil) that will have almost 20 million citizens in the year 2000 and without concrete perspectives of its problems being solved or at least, min imalized.

We hope that the urban and habitational matters would be treated seriously again and not for momentaneous things only.

183
The changing condition of the English housing stock: measuring, modelling and managing it

A.O'DELL

Abstract
During the last few years a programme of research into the changing condition of the national housing stock has been undertaken jointly by the Building Research Establishment and the Department of Environment. The work relies heavily on data provided by the quinquennial English House Condition Survey. Attempts are being made to provide a basis for computer modelling of the stock as an aid to strategic planning.

Keywords: Housing Stock, Housing Condition, Survey Methods, Computer Modelling

1 Introduction

In both economic and social terms, a national housing stock can be regarded as a major asset which, like any other asset, needs to be managed. To do this effectively requires an understanding of the underlying processes at work on the stock. Governments differ in the control they exercise over the provision of housing, but there are few which do not seek to exert some influence. For the less directly interventionist government the particular need is for a strategic analysis.

The emphasis in this paper is on one particular aspect of the housing stock, its quality or physical condition. At the strategic level the sort of questions which can be asked include the following. What should be the magnitude of the annual investment on the stock?; how should this be split between demolition and rebuilding on the one hand and maintenance and upgrading on the other?; and what proportion of the investment needs to come from the public purse?

In order to tackle these questions, good information about what is going on within the housing stock is needed: but this alone is not sufficient. It is also necessary to examine what is likely to happen in the future, and more importantly, what changes to that future could be brought about by the adoption of alternative policies. And this means that we need theories of how the housing system operates, and ‘models’ of the system with which we may experiment.

In the UK we have been making basic measurements on the stock for the last 20 years, but we have only just begun to develop models. The purpose of this paper is to describe progress in this endeavour, and to outline the major findings to-date.

By way of background, we begin with a brief introduction to the English House Condition Survey (EHCS), from which our measurements of the condition of the stock derive.

2 The English House Condition Survey

Large scale sample surveys of the English housing stock have been undertaken by the United Kingdom Government every 5 years since 1971.

The first survey was simply a physical examination of a random sample of the housing stock. More recent surveys have included interviews with occupants to throw light on the social, economic, financial, institutional and personal factors which influence the way the stock changes, and to document the action being taken to maintain and improve homes.

The 1986 survey included physical inspections of 30000 dwellings (equivalent to 1 in 600 of the total stock), and interviews with 8000 occupants (selected on the basis of findings from the physical inspection).

A description of the most recent survey of 1986 and its findings is given in the official report (Department of Environment (1988)). An evaluation of the methods employed in that survey has been undertaken by O’Dell (1990).

3 The approach to modelling

3.1 The description of dwelling condition

Dwellings are such complex objects, and there is such a wide diversity in dwelling characteristics, that there are innumerable ways in which the condition of the stock might be described. However, since our interest is strategic, and since we are concerned primarily with financial investment programmes, a sensible initial approach is to allocate to each individual dwelling a single broad-based monetary measure representing the estimated cost of putting that property into good order—referred to in this paper as the ‘repair cost’. We may then describe the stock in terms of the overall frequency distribution of this measure. We are still left with the choice of how to define the repair cost—which elements of the building should be included and which left out; should it relate only to urgent work or should it take in future requirements—but this does not affect the general approach.

3.2 The relationship between dwelling age and condition

The simplest first step in modelling anything is to look for variables which seem to be correlated with the quantity of interest, and which are themselves possible to forecast; and to extrapolate into the future under the assumption of stability in the correlation.

Empirical evidence from EHCS suggests that the only variable capable of taking this role is the age of the dwelling. Although there is a wide spread in the condition of dwellings of a given age there is a strong relationship between, say, the median repair cost and dwelling age (Figure 1). For any given age, owner occupied dwellings tend to be in better condition than do local authority owned properties, and they in their turn are better than privately rented dwellings. So there is a possibility of using tenure as a secondary variable. There have been no other variables found which are unambiguously correlated with condition.

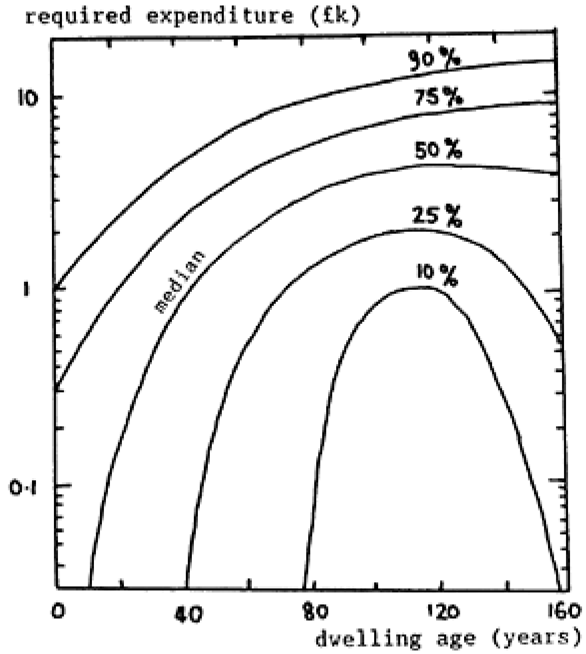


Figure 1. Variation of required expenditure with dwelling age

Both dwelling age and tenure are amenable to forecasting, and to some extent they are under the control of policy. The future age structure of the stock may be modified by demolition and new building; the tenure distribution may be changed by government action (and indeed this has been the policy of the UK government in recent years).

A further refinement may be added to the age—condition relationship by subdividing the stock according to whether (and when) a dwelling has undergone major refurbishment since it was built. Besides 'sharpening-up' the basic statistical relationship, this development allows the possibility of treating 'major refurbishment' as a policy instrument in the forecasting model.

3.3 The problem of 'net deterioration'

There is a major difficulty in using the age—condition relationship for modelling purposes. The change in the condition of a dwelling over time is a 'net effect', the product of two opposing underlying changes. These are 'deterioration' due to natural wear and tear of the fabric, and 'improvement' resulting from maintenance, repair and upgrading. Ideally we would wish to separate the underlying effects. We would like to measure the rate of natural deterioration, regarded as unalterable, and in the model set this against improvement which would be treated as under external control. It would then be possible to explore the impact of various levels of maintenance, repair and upgrading—a substantial advance on the use of two policy options, demolition and major refurbishment.

In principle EHCS offers the possibility of measuring the rate of natural deterioration. The use of a 'longitudinal survey' approach allows the condition of a dwelling to be assessed at two points in time 5 years apart, so that the change in condition may be calculated. During the interview with occupants which forms part of EHCS, information is collected on repairs and improvements undertaken during the 5 year period. Given the change in condition and the improvements carried out, the natural deterioration over the 5 years is obtained as a residual.

In practice there are two problems which can hinder this process. One of these is the difficulty in knowing that the change in condition is measured in the same units as the improvement works. Condition is recorded as the cost of the remedial works required, and although this is written as a monetary sum, the uncertainty in the calculation to obtain the cost means that the unit is a somewhat artificial, or 'notional' £. Improvement work, on the other hand, is measured in 'real' £, the expenditure reported by the household. The second obstacle is more fundamental: it is the presence of 'surveyor variability' in survey data.

3.4 The impact of 'surveyor variability'

In spite of careful training, surveyors can still vary considerably in their judgements. A typical distribution of estimated repair costs resulting from a large number of surveyors examining the same poor condition dwelling is shown in Figure 2. In this example one third of surveyors provided an assessment of disrepair the calculated cost of which differed from the mean value by more than 30%.

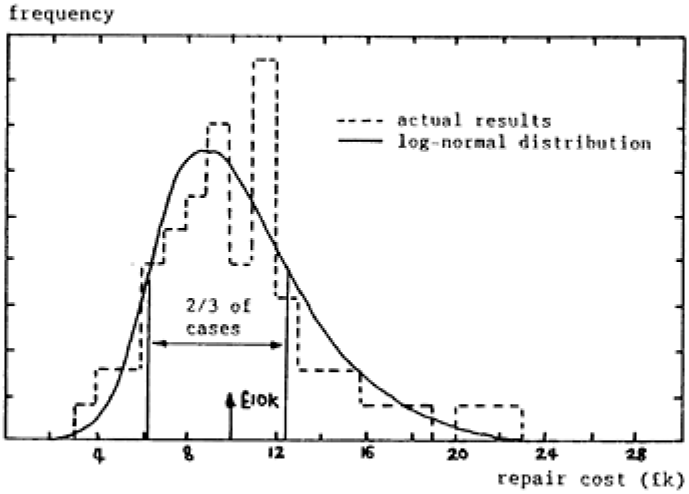


Figure 2. Surveyor variability

The impact of surveyor variability is diminished when large numbers of dwellings are treated in aggregate, as they are in the EHCS. However variability does make for particular difficulties in the measurement of changes in disrepair over time. It also has a distorting effect on the overall frequency distribution of repair costs within the stock.

Experiment has shown that surveyor variability can be reduced by introducing time into the concept of repair cost; and as a result 'whether a repair is urgent' and 'the estimated future time at which replacement of the element will be necessary' are questions now included in the survey.

Unfortunately variability cannot be eliminated altogether, so it is unlikely that data from EHCS can be used in a straight forward way to estimate deterioration rates. More complex procedures are required to deal with the problem as will be seen in Section 6.

4 A first attempt at building a model (1984)

The first model studied made use of the straightforward dwelling age—condition relationship and therefore implicitly accepted the limitation of working with 'net deterioration'.

The intention was to attempt to explain how the stock came to be as it is today, in terms of its age structure and its physical condition. If this could be done reasonably successfully then it would seem legitimate to extrapolate the process into the future, and to treat the model as a forecasting tool.

The model used official annual statistics on numbers of dwellings constructed, demolished and converted from the early part of this century to the present day, together with building cycle indicators from the last century, to plot the development of the stock over this period. The age—condition relationship was introduced in the form of a 'transition matrix' defining the probability of a dwelling of a given age and condition falling into a worse condition from one time period to the next.

In fact the age—condition relationship derived from the survey is not precisely the one needed in the model. The observed form is based upon those dwellings surviving demolition up to the time of the survey. Since buildings which get demolished tend to be in poor condition, the basic relationship, the one required in the model, should show a much more rapid deterioration with age than does the observed relationship. The problem was dealt with by including a parameterised adjustment factor, and varying the values of the parameters until the model reproduced reasonably well the age structure of the stock and the distribution of condition in 1981.

In no sense can it be argued that this model has been 'tested', but at least it did allow all the available data to be brought together into a self-consistent framework and it was able to reproduce remarkably well the changes in the proportion of the stock in poor condition between 1971 and 1976, and 1976 and 1981.

This is perhaps surprising in view of the magnitude of the assumptions. Although the basic statistics were available for the extended period, the only information on the age and condition of demolished buildings, and on the relationship between dwelling age and condition came from the EHCS survey carried out in 1981. So for modelling purposes it was necessary to assume that the underlying processes of deterioration and improvement which determined the development of the stock (or at least their combined effect) had remained relatively unchanging since 1850.

The model was never developed to a truly operational stage, but it was used to explore the likely impact of an increase in demolition rates in future years, and to enquire into the increases in annual investment needed to maintain the stock in a stable condition. The results obtained are not inconsistent with those from later studies.

5 An 'equilibrium' model

The 1986 EHCS provided another chance to examine the dwelling age—condition relationship, and remarkable consistency was found with the results from the 1981 survey.

This finding gives greater confidence in our accepting and interpreting the fine detail of the age—condition relationship plotted in Figure 1. There is a steep rise in the required expenditure with age up to about 100 years. Thereafter the median remedial cost remains constant, but the spread in condition increases as some buildings are abandoned to their fate while others undergo complete refurbishment.

The only changes detectable in the repair cost distribution of those properties surveyed in 1981 and still standing in 1986 were those associated with aging of the stock by 5 years. So we can say there was 'equilibrium' within the stock: individual dwellings might have been improved or or might have deteriorated, but the net effect for the stock as a whole was 'no change'.

We know from the interview survey that there is a considerable annual expenditure on the stock. During 1986 around £17B was spent in all, of which about 45% went on repair and maintenance and the remainder on upgrading. The conclusion to be drawn is that, for the stock as a whole, about £7.6B is sufficient to just counteract the annual deterioration.

Since the make-up of the stock can only change slowly this situation should persist for a few years, and could therefore be used to forecast in the short and medium term.

The conclusion can be taken a step further. The estimated total amount of disrepair identified during the 1986 survey was around £27B. An annual deterioration of £7.6B (25%–30% of the total disrepair) indicates a very dynamic situation; which implies that a relatively small proportionate change in the annual investment could have considerable effect in modifying the condition of the stock.

The 1986 EHCS draws a distinction between different categories of repair according to the relative urgency with which remedial action is needed. The reported total of £27.7B is made up of £10.9B of work needed immediately, £5.5B of work which should be done within 5 years, and £11.3B of additional work, mainly consisting of replacement of building elements which will come to the end of their life within 10 years. Implicit within these sums is some notion of the pattern of required expenditure over future years, which could perhaps be exploited in attempting to model the relationship between investment and deterioration/improvement of the stock.

Such an exercise has been tried. In the model, current disrepair in the stock is divided into three categories—urgent work, non-urgent work, and replacement of elements coming to the end of their life wihin 10 years. The processes acting to reduce disrepair are described by an overall financial input which is distributed between the different categories in some prescribed way. Those acting to increase disrepair are divided into two types, ‘transfers’, recording the deterioration from one urgency category to another, and ‘uplifts’, recording the average increase in repair cost within a category.

The procedure was to consider what is known about each process, and to propose in advance a likely range of values for each of the parameters used to describe the processes within the model. A computer was then used to search over the limited domain defined by these ranges for solutions which maintained stability in the overall pattern of disrepair from year to year (the ‘equilibrium’ referred to above). A number of solutions were found but they all exhibited the same qualitative behaviour, and a ‘central’ one was chosen to explore the impact of alternative investment patterns.

The results of these explorations are shown in Figure 3. It appears to be theoretically possible to make substantial inroads into the backlog of disrepair by marginally increasing the total investment (or at least by transferring some investment from upgrading to repair and maintenance). A more modest impact is achieved by concentrating the investment more heavily to urgent repairs.

In England about 75% of the housing stock is concentrated in private hands and the bulk of any investment must come from individual owner occupiers, so it might not be easy to secure the shift in behaviour which is required. Government can provide an incentive through the Renovation Grant System by which individual owners receive financial assistance with repairs and home improvements; and indeed the sort of shift in investment required is roughly comparable to the total amount spent on home Renovation Grants during 1986. Under new legislation there is improved ‘targetting’ of grant finance, with the intention that it does not merely replace private investment which would have been committed anyway. Whether this is effective in producing the required shift in investment remains to be seen.

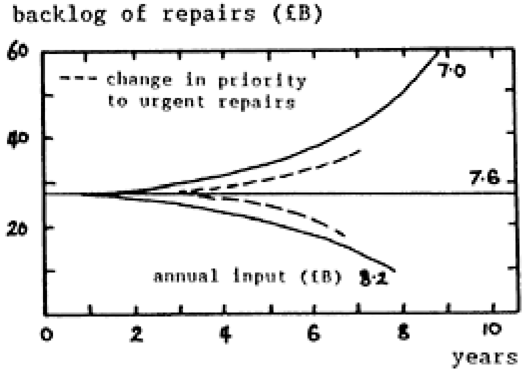


Figure 3. Equilibrium model—estimates of future backlog of repairs

6 Towards a 'complete' model

A 'complete' model of the stock requires a better understanding of what was referred to in section 3.3 as 'net deterioration'. In particular what is required is the determination the 'natural' rate of deterioration in the absence of any remedial action. Its quantification as a monetary measure, would allow it to be used as a benchmark against which future investment policies might be judged.

It was suggested earlier that a measurement of the change in the condition of an individual dwelling between 1981 and 1986 (C_6-C_1), together with information on the investment in repair over the same period (I_{1-6}) might be used to provide a picture of the 'natural' rate of deterioration of that dwelling (D_{1-6}) from the equation:

$$C_6-C_1=D_{1-6}-I_{1-6}. \tag{1}$$

However surveyor variability complicates matters and rules out the possibility of 'natural deterioration' being derived by a simple calculation. The equation becomes:

$$(C_6+S_6)-(C_1+S_1)=D_{1-6}-I_{1-6} \tag{2}$$

The S here represents the error due to surveyor variability: actual values of these in individual cases are not known but some information on the frequency distributions from which they are drawn is available from empirical studies.

Attempts are being made to 'unfold' the error terms in the above equation from the substantive relationship by means of a simulation model. A frequency distribution of (C_1-C_6) is derived under certain assumptions about the structure and magnitude of the quantities D_{1-6} and I_{1-6}; this is compared with the observed distribution from the survey, and D_{1-6} and I_{1-6} are varied until a good match is achieved. The sequence of steps is as follows:

1—A 'true' distribution of repair cost is obtained for the year 1981. This is achieved by trial and error, by taking a test form, and 'folding in' the effect of surveyor variability until a good match with the 'observed' distribution is obtained.

2—A repair cost, C_1, is selected randomly from the 'true' distribution.

3—The deterioration, D_{1-6}, appropriate to a dwelling with this repair cost is simulated.

> D_{1-6} is the quantity which is being investigated so there is no prior information on it. It is assumed that for dwellings with a repair cost C_1 the average deterioration will be given by the expression $\alpha_D+\beta_D.C_1$: individual dwellings will show a spread about this average which is represented by a log-normal distribution with a width defined by the parameter θ_D.

4—The investment in repairs, I_{1-6}, appropriate to the sampled dwelling is simulated.

The data for this operation are taken from the EHCS Interview Survey. Many households spend nothing on repairs in a 5 year period, the proportion varying between 35% and 50% according to the condition of the property. For modelling purposes the proportion, $F(C_1)$, is obtained by taking a smooth line through the data: some adjustment may be allowed within the model by introducing parameters to give $(\delta_I+\gamma_I.C_1).F(C_1)$. Amongst those properties in which repairs are undertaken, the average expenditure is found to vary with the repair cost C_1 according to the expression $\alpha_I+\beta_I.C_1$: the variation in the investment between individual dwellings with the same repair cost appears to follow a log-normal distribution about the average. (See Figure 4)

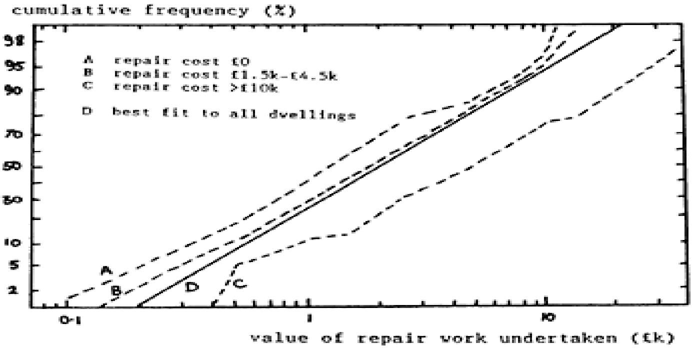


Figure 4. Frequency distribution of repairs undertaken 1981–86

5—The ‘true’ value of the repair cost in 1986, C_6, is calculated from equation 1 by using the simulated values of D_{1-6} and I_{1-6}.

6—The ‘observed’ values of C_1 and C_6 are simulated from the ‘true’ values.

> The information for this operation comes from (i) a training exercise, when each of 250 surveyors assessed the condition of 4 properties in poor condition (Figure 2), and (ii) the reinspections of a random sample of 4% of the properties in the survey by a second surveyor. The spread of ‘observed’ repair costs about the ‘true’ value follows closely the log-normal distribution, as is shown in Figure 2. The width of the distribution is determined from (ii) above to vary with the repair cost C_1: the form of this variation is represented by the expression $\log(\text{width})=\alpha_C+\beta_C\cdot\log(C_1)$ (See Figure 5).

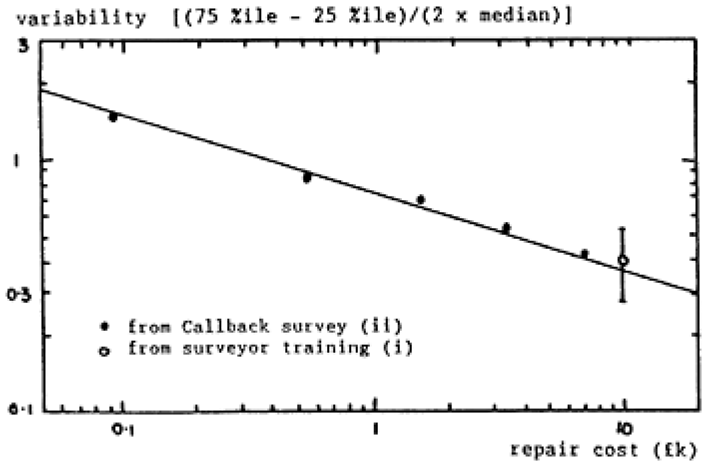


Figure 5. Variation of surveyor variability with repair cost

7—The ‘observed’ values of C_1 and C_6 are used to calculate the change in condition (C_1-C_6).

8—Steps 2–7 are repeated a large number of times (50000) to provide a frequency distribution of (C_1-C_6).

9—This distribution is compared with the equivalent distribution from the survey results.

10—The procedure is repeated with different parameters in the quantities used for D_{1-6} and I_{1-6} (α_D, β_D, α_I etc) until a good match with the survey results is obtained.

The form derived for D_{1-6} from this procedure is regarded as giving the ‘natural’ rate of deterioration; I_{1-6} may be manipulated to represent an alternative investment strategy; and together they may be used in a subsidiary model to examine the likely future impact of the changed pattern of spending on repair and maintenance.

Work on the model is not yet complete, but results so far are encouraging. Good fits to the data are obtained with properties which received no repairs during the 1981–86 period, and an average deterioration valued at around £350 is indicated. With properties in which repairs were undertaken, the shape of the frequency distribution of change in condition is reproduced, but the accuracy of the fit to the survey data is not yet acceptable. Some adjustment to the structure of some of the underlying relationships may be required.

7 References

Department of Environment (1988) **English House Condition Survey 1986** Her Majesty's Stationery Office, London

O'Dell, Alan (1990) Development of the English House Condition Survey in **Building Maintenance and Modernisation Worldwide Volume 2** (ed Lee Kiang Quah), Longman, pp 595–604.

184
Housing subsidies in Western Europe

M.OXLEY

Abstract
This paper will comment on the range of housing subsidies used in western Europe. It will show that there is a wide range of means by which governments seek to influence housing production and consumption. Certain points about the aims and characteristics of subsidies will be illustrated by reference to the situation in a limited number of countries. The illustrative material relates to West Germany, France, the Netherlands, Ireland, and the United Kingdom. Questions will be raised about the consequences of subsidies especially for housing production and tenure changes in the 1980s. Keywords: Housing, Subsidies, Policy, Europe, Housebuilding, Tenure.

1 Introduction

Governments in western Europe intervene in housing markets by means of a variety of expenditures, taxes and controls some of which involve subsidies. Whilst the illustrative statements in this paper refer to West Germany, France, the Netherlands and the U.K. the generalisations apply to many western European countries. The necessarily retrospective nature of the discussion accounts for the continuing reference to West Germany. A housing subsidy will be viewed as an explicit or implicit flow of funds initiated by government activity which reduces the cost of housing production or consumption below what it otherwise would have been. It might involve a direct payment by government or involve a concession which reduces the taxation that otherwise would have been payable to the government or reduces the payments on a government loan to below the market level.

This is a fairly broad definition and it provides the framework for the wide range of items that will be considered in this paper. However, it should be noted that the definition of subsidy could be extended to include several other considerations. For example, (i) the cost reductions that result from government loan guarantees on loans provided by various institutions and (ii) reductions resulting from rent controls in which case there is an implicit subsidy from the landlord to the tenant.

The concern here will be with measures which are intended to reduce housing costs rather than with actions that incidentally have this effect.

The relationship between public expenditure and subsidies is complex. Not all subsidies involve explicit public expenditure. Tax reliefs, for example, may be seen as income foregone but the treatment for expenditure purposes varies with the accounting conventions adopted. Not all public expenditure on housing constitutes a subsidy. Loans by government might only substitute for loans from other sources. Only to the extent that by virtue of the interest rate or the loan period they reduce costs do they involve subsidisation. A further set of complications relates to government expenditure which is not explicitly for housing purposes but reduces housing costs, e.g. some social security payments. All these points should lead one to be very cautious about the usefulness for comparative purposes of any figures which purport to measure the value of housing subsidies or public expenditure on housing.

2 Policy aims

Housing subsidies should be seen as part of housing policy and thus it will be helpful to consider the aims and objectives of policy. In general terms the stated aims of housing policy have been remarkably similar from country to country in the post-war period. Most western European governments have at some point declared somewhat blandly that they believe that all households should have a decent home at a price within their means.

More specifically, governments have argued that their objectives are more housebuilding, improvements in the quality of the stock, reductions in particular shortages defined by reference to certain locations or social groups, or more “affordable housing”. Increasingly, however, the aims have become explicitly tenure-specific and promoting an increase in home ownership has become a declared policy aim in many countries.

3 Objectives and perceptions

Perceptions of the causes of housing problems coloured by ideology, the political agenda, and the displayed “facts” on housing influence the housing policy objectives which get priority and the policy instruments that, are used.

In the 1950s and 1960s throughout Europe there was an acknowledgement that there was a housing shortage. Thus the key issue was housing production and policies geared to getting more houses built came to the fore. By the 1970s an increasing emphasis was being placed on the quality of the stock and the case for improvement policies. There was also a growing argument in favour of distributing subsidies according to the needs of individual households. By the 1980s the goal of increased owner-occupation which had been strong for many years in countries such as the U.K. and Ireland was high on the agenda in countries with lower home ownership levels such as West Germany and the Netherlands. Macroeconomic factors were an obvious constraint on what package of housing measures a country adopted. With a growing belief that government spending restraints were essential for the control of inflation many governments cut back on direct expenditures on housing.

Housing has shifted from being viewed primarily as a problem of production to being viewed more as a problem of distribution and tenure. Ideological motives have given prominence to the raising of home ownership levels.

Why should governments need to intervene in markets to promote housing objectives? One view is that action is necessary because of previous intervention, and current policies should undo the past and free up the market. Such was the view of some Conservative politicians in Britain in the 1980s.

A variant of this “intervene to help the market” theme emphasises the problems of adjustment to equilibrium, pointing not to the inability of markets to work but rather their ability to work only in a slow or erratic fashion because of the peculiar features of the housebuilding industry and factors which combine to create inelastic supply.

A rationale for policy can alternatively be based on the welfare economics analysis of market failure. This concentrates on the inability of markets, under certain conditions, to achieve social optima. Thus there are, for example, externality arguments based on the desire to promote the external benefits of decent housing which markets ignore and merit good arguments which take a paternalistic stance seeing the undervaluation of housing consumption by households as a justification for government promotion of one sector of consumption at the expense of others. A variant of this views only owner-occupied housing as a merit good (see, for example, Boelhouwer and Priemus, 1990).

Income distribution issues and the relationship between income levels and housing costs provide a further, most significant, set of arguments. The inability of low income groups to enter the market for housing of some minimum standard implies that incomes for certain households are too low, or costs are too high or both. This inevitably involves a value judgement about quality. The setting, at least implicitly, of minimum housing standards has to be coupled with distributional arguments to sustain this sort of rationale.

Another set of intervention arguments which are often used to complement one or more of the approaches above relates to the inevitable connection between housing markets and finance markets. These arguments stress the cost and availability of credit to housing consumers and suppliers and see prices and that are “too high” and/or production levels that are “too low” mainly as a consequence of money market factors.

We will not always be able to explain the use of a housing policy instrument by reference to housing policy aims. The aim might rather relate to engineering social or political change or to controlling the economy. Interventions related to promoting home ownership or influencing housebuilding activity may often be better explained by such analysis rather than by using a purer housing framework.

Not all instruments which influence housing production and consumption are necessarily housing policy instruments. They might be instruments of wider fiscal and monetary policy. Tax reliefs on mortgage interest, for example, have in some cases grown out of what would be better called taxation policy than housing policy.

4 Classification of subsidies

4.1 General taxonomy

It will be useful to identify four types of subsidy which, in principle, governments might use. Two are subsidies to suppliers and two are subsidies to consumers:

(a) Pure object subsidies. These are payments to housing suppliers that contribute to building, management, or interest costs. They are unrelated to the characteristics of the occupants of the dwellings.

(b) Conditional object subsidies. These are payments to housing suppliers that are given on the conditions that the occupants of the dwellings are in certain economic or social groups and/or the occupants are charged prices or rents within certain limits.

(c) Pure subject subsidies. These are payments to households in any tenure that depend only on household size and income. They are income supplements.

(d) Conditional subject subsidies. These are payments to households that are given on conditions tied to the consumption of housing.

Generally, any of these subsidies could take the form of a cash payment or “payment” by means of a tax concession or some other financial privilege such as a “soft” loan. Each type of subsidy will now be considered in turn.

4.2 Pure object subsidies

There are very few examples of property subsidies which strictly meet the criteria for pure object subsidies. Some tax concessions might be seen as general housebuilding subsidies; e.g. in West Germany land for house building has been exempt from the 7% land acquisition tax and in the U.K. housebuilding is subject to zero rate VAT. Several pure object subsides are related to the construction and improvement of private rented housing. Newly constructed dwellings are exempt from the annual land tax in Germany and generous depreciation and interest cost deductions can be set against income. Tax concessions apply to new investment in France, The Netherlands and Ireland. In France, A.N.A.H., the state agency for housing improvement, with a budget of 1.9 billion francs in 1988, gives grants for up to 40% of modernisation costs. Although with the top rate only payable mainly in low income areas the “pure” definition is called into question. In Ireland expenditure incurred in the construction of accommodation for renting is an allowable deduction against rental income.

Among the clearest examples of pure object subsidies are the measures that have been used in the U.K. and Ireland to support council housing. Exchequer subsidies in each case have not been tied to rules about who occupies the dwellings but the local authorities adopt their own allocation criteria. In Ireland the loan charges on the capital borrowed for the provision of dwellings by local authorities was until 1988 met in full by the central government. From 1988 a capital grant system has been used and existing loans written off.

4.3 Conditional object subsidies

West Germany, France and the Netherlands have made extensive use of assistance to non-profit housing organisations and to private sector suppliers as a method of supporting "social housing". This assistance has typically been provided on the condition that the housing is supplied to households on low incomes and at prices or rents below certain thresholds.

About one third of the social rented stock in West Germany is provided by private landlords and two thirds by housing associations (Tomann, 1990). The Lander and the Federal government have jointly been responsible for support which has included interest free loans and/or recurrent grants which have been, at least in part, non-repayable. Subsidy schemes have been designed to cover all costs not met by a predetermined social rent. In return, certain standards are guaranteed and tenancies are available only to certain income groups. The limits have been gradually extended so that, two thirds of households in the rented sector are eligible.

In France, grants to social housing organisations cover up to 12% of construction costs and subsidised loans up to 85% of project costs are available for a term of 34 years. The conditions for this assistance cover rent levels and rent increases as well as income limits for households. Similar subsidised loans, covering up to 75% of costs, are available from the state-controlled Crédit Foncier for housing for private renting which is subject to the same income and rent rules as those applying to the social housing organisations. A further source of funding comes from the requirement that employers with more than 10 employees (with some exceptions) have to pay a proportion of their wage bill to support housing. This has traditionally been 1% (and is thus characterised) although it is actually now 0.67%. The funds go as cheap loans to individuals or to social housing companies.

The social rented sector in the Netherlands comprises about 40% of the housing stock. It has been steadily increasing (1970:31%, 1980:36%). Over 80% of the social rented sector is managed by housing associations, about 15% by the municipalities and the remainder by other non-profit organisations. Generous production subsidies have supported this accommodation. Under the dynamic cost price system introduced in 1975, the authorities guaranteed to bridge the gap between a contract rent and a dynamic cost price rent for 50 years. As a result of the Government's Housing in the Nineties Memorandum, less generous property subsidies have been introduced which provide for fixed annual contributions and more significant rent increases.

An important point to make about West Germany, France and the Netherlands is that conditional object subsidies extend into the owner occupied sector. In each country, schemes for encouraging the supply of such housing within specified cost limits for low income households are an integral part of social housing policy.

There has, by comparison, been very little explicit use of conditional supply-side subsidies in Ireland and the United Kingdom where there has been a tradition of leaving the main suppliers of social housing, the local authorities, to have at least nominal freedom in setting rents and allocation criteria.

4.4 Pure subject subsidies

It is not possible to identify clear examples of pure subject subsidies which amount to income supplements that are not directly tied to housing (although some social security payments might approximate). Their explicit use for housing purposes would mean that a government had announced it would increase disposable incomes to assist housing consumption but would leave households free to spend the extra how they liked: for housing or non-housing purposes. This is a option that would appeal to welfare economists who equate utility maximisation with the greatest possible level of individual choice. It would, however, imply that income redistribution policy was paramount and not housing policy.

4.5 Conditional subject subsidies

There are two broad categories of conditional subject subsidies, each of which consists of measures which are designed to decrease the cost of housing consumption:

(a) housing allowances which are payments to households in any sector that depend on household size, household income and the price of the housing services consumed and

(b) financial concessions to owner-occupiers which reduce the cost of home ownership.

The significance of housing allowances has been increasing considerably in western Europe in the last two decades. In West Germany and France tenants and owner-occupiers are eligible; in the Netherlands, Ireland and the U.K. only tenants receive assistance.

The housing allowance system in West Germany has been geared to ensuring that not more than 15–25% of household income is needed to secure adequate accommodation. About 7% of households get allowances and 30% get income support from social benefits. Only about 10% of recipients are owner-occupiers. Despite the large increase in the total number of recipients in recent years only about 12% of tenants and 1% of owner-occupiers get a housing allowance.

In France, also, the number of households in receipt of housing allowances is increasing. In 1986 there were over 4.2 million recipients of whom 72% were tenants and 28% owner—occupiers (Kemp, 1990). Detailed formulae link the allowance to household size, income and housing costs.

In the Netherlands, where around 27% of tenants receive allowances and expenditure has risen from 965 million guilders at current prices in 1980 to 1665 million guilders in 1988, there has been considerable debate about how to restrict the growth of the housing allowance (Priemus, 1990).

Rent allowances for private sector tenants were introduced in Ireland in 1981 after the rent increases consequent on the decision of the Supreme Court to rule certain aspects of rent control unconstitutional. In the public sector there is an “indirect” form of housing allowance as a result of the differential rents scheme which relates individual rents to incomes. Additionally, rent payments to private landlords by persons aged 55 and over are eligible for tax relief.

The cost of housing benefits in Britain rose from £932 million in 1979–90 to £4, 131 million in 1989–90—considerably in excess of the rate of inflation. Around 75% of public sector tenants get benefits and over 40% of private and housing association tenants.

The significant methods of support for owner-occupation have not been geared to decreased support as household income increases. Although this has been a key feature of the design of housing allowances, the opposite effect is apparent in many of the consumer subsidies for home-ownership. The limitations on mortgage interest tax relief may have ameliorated this effect in West Germany. Until 1982 the loan interest deduction was limited to the very low imputed rental value of the property. From 1983 to 1986 debt interest was deductible up to DM10,000 for newly constructed buildings. From 1987, the emphasis has been on a depreciation allowance which amounts to 5% of the historic costs of purchase for 8 years. There is an annual limit on this deduction with additions for households with children but the concession can be claimed only once by each taxpayer. There is no longer tax on imputed rent nor an allowance for interest payments.

In France tax relief on interest payments is limited to a proportion of the cost of the interest for 5 years. More significant is the assistance provided through the Prêts à l'Accession à la Propriété (PAP). These loans, from the Crédit Foncier, are provided at preferential rates of interest for the purchase or construction of a new house or the improvement of an existing house. The loans are subject to cost and income limits which vary with household size.

Unlimited deductibility of mortgage interest is allowed in the Netherlands. There is, however a tax on a proportion of imputed rental income. In 1987 the cost of the tax relief was 5.75 billion guilders and the yield from the tax on imputed rental income 650 million guilders (Boelhouwer and Priemus, 1990).

In Ireland, in addition to mortgage interest tax relief, special mortgage interest subsidies and grants have been given to first time buyers of new houses. As in many other countries there are imputed rental income and capital gains tax exemptions.

Mortgage interest tax relief in the U.K. has. been subject to a £30,000 loan limit since 1983 and there are imputed rental income and capital gains tax exemptions. One might also include in the cases of Ireland and the U.K. the substantial concessions to tenants who buy their public rented dwelling.

5 Subsidy issues and consequences

Object subsidies have become increasingly unpopular with governments in all the countries considered. This is partly because housing is seen less as a production problem than it once was and because supply subsidies were a highly perceptible burden on state budgets. The distributional effects, even of conditional object subsidies, have been questioned and it has been argued subject subsidies target aid much better to where it is needed.

These points have often been set in the context of a wider debate about the achievements of social housing. In France it has been claimed that many low income households cannot enter the social rented sector because rents are too high, and because income eligibility limits in the 1980s increased at lower rates than did wages and so access has been reduced. One third of social housing in West Germany is let to tenants whose incomes exceed the required limits. Since the early 1980s it has been possible to levy a special fee on such tenants and several Lander have used it as a sort of negative housing allowance. In the Netherlands, the government's Housing Memorandum for the Nineties gave much attention to the distribution of the social rented stock and the notion that too many households on higher incomes were living too cheaply in subsidised housing. The German solution has been rejected but there are prospects for temporary tenancy arrangements in the future as a way of pursuing the distributional aims although this has met with much protest (Boelhouwer and Priemus, 1990).

Criticisms of object subsidies coupled with advocacy of more reliance on the market have led many governments to pursue rent-increasing policies and a shift in the balance of subsidies in favour of housing allowances (For a fuller exposition of the arguments about housing allowances see Oxley, 1987). Housing allowances are destined to become proportionally more significant still in future years. The dangers here are that there is a continuing supply problem that is not being tackled and that distributional issues are not being viewed in a wide enough fashion.

Housebuilding has been declining in most western European countries since the early 1970s. The decline has been clear throughout the 1980s in all the countries considered except the Netherlands, as Table 1 shows. These falls are the result of many factors and are partly offset by increasing investment in the existing stock but the shift away from object subsidies has played a part. In the case of the Netherlands, despite an increasing expenditure on allowances, an increase in property subsidies from 2,240 million guilders at current prices in 1980 to 6,190 in 1987 helped to maintain construction levels. There was in most countries a shift in favour of private sector production.

Table 1. Housing Production (Thousands of Dwellings Completed)

	1980	1988
West Germany (a)	389	209
France (b)	400	320 (1989)
Netherlands (a)	89 (1979)	123
Ireland (a)	28	16
U.K. (c)	242	212 (1989)

Sources: (a) United Nations Annual Bulletins of Housing and Building Statistics for Europe. (b), Council of Mortgage Lenders (1990), (c) Housing and Construction Statistics.

The shift away from production subsidies, and claims by governments that a more free-market approach is being pursued, does not mean in fact that there is less subsidisation of housing than in the past. There have been large increases in public expenditure and housing subsidies in several countries. In the Netherlands. there was a 'massive increase in government expenditure on housing' (Boelhouwer and Priemus, 1990). In West Germany while the sum of public expenditure on social housing and housing allowances decreased in real terms, 'Tax expenditure, which largely favours owner-occupation, increased in real terms' (Tomann, 1990). Calculations for Ireland suggest that total housing subsidies in 1987 were higher in real terms by 32% than in 1980 but subsidies to owner-occupiers for house purchase rose by 76% in real terms over the same period (Blackwell, 1989). In the U.K. between 1979–80 and 1989–90 public expenditure on housing on the Treasury definition fell by 43% in cash terms. Current housing subsidies to local authorities fell by 55% and net capital expenditure by 86%. However, the cost of housing benefits rose by 364% and mortgage interest tax relief by 327% in cash terms.

The common trend is clear. There is a movement towards subsidising consumption rather than production and, in particular, subsidising owner-occupier consumption mainly through tax reliefs. Both the efficiency and the equity of this trend is questionable. There is a good deal of evidence to suggest that 'housing tax expenditures are an inefficient policy measure in encouraging growth in home ownership' (Wood, 1990). A principal problem is that they fail to target marginal purchasers. In many cases they apply to purchases of both new and old housing and given an inelastic supply may have greater price than quantity effects. The distributional issues involve more significant benefits going to higher income groups. It might be possible to limit these consequences by using the sorts of restrictions that have been described for West Germany and France.

Subsidies will have played an important part over the years in producing the tenure distributions shown in Table 2. However if they are to be used to manipulate tenure change in the future, the efficiency of alternative means of achieving this needs to be considered alongside the distributional consequences of the measures adopted.

Table 2 Housing Tenure around 1987 (% of the housing stock)

	Owner-Occupation	Rented	of which non-profit	Other
West Germany	42	58	18	0
France	52	38	15	10 (i)
Netherlands	44	56	40	0
Ireland	79	21	15	0
U.K.	64	36	29	0

(i) mainly vacant and second homes
Estimates from a variety of sources.

The European Commission is showing a new interest in housing despite the fact that 'Housing does not fall within the direct competences of the European Commission. The right to housing is not embodied in Community Law. Nor does it appear in the European Charter of basic social rights. Nevertheless, housing is an important factor in social and economic integration' (European Commission, 1990).

The range and complexity of the subsidy systems illustrated here shows that if there is ever any serious concern with 'harmonisation' in housing policy the issues revealed will quickly show that efforts would be better channelled to more productive endeavours. Each country needs to understand better the instruments in use and adopt measures which are likely to achieve a more efficient and equitable production and consumption of housing. These means might well differ from country to country but there is evidence to suggest that the effective incidence of subsidies and the determinants of housing production and distribution are topics for more detailed investigation if policy makers are to be better informed.

6 References

Blackwell, J. (1989) Housing Finance and Subsidies in Ireland, Paper prepared for the Joseph Rowntree Memorial Trust International Conference on Housing Finance, York.

Boelhouwer, P. and Priemus, H. (1990) Dutch Housing Policy Realigned. **Netherlands Journal of Housing and Environmental Research,** Vol. 5, Number 1, 105–119.

Council of Mortgage Lenders (1990) **Housing Policy in Europe.** Council of Mortgage Lenders, London.

European Commission (1990) European Cities, Housing and Social Integration, Elise Project Profiles, Introduction. European Communities, Brussels.

Kemp, P. (1990) Income-Related Assistance With Housing Costs: A Cross National Comparison in **Housing Subsidies and the Market : An International Perspective** (eds. D.Maclennan and R.Williams) Joseph Rowntree Foundation, York, pp. 17–42.

Oxley, M. (1987) The Aims Effects of Housing Allowances in Western Europe, in **Housing Markets and Policies under Fiscal Austerity** (ed. W.van Vliet), Greenwood Press, Westport, pp. 165–178.

Priemus, H. (1990) The (Un)Controllability of the Housing Allowance. **Netherlands Journal of Housing and Environmental Research,** Vol. 5, Number 2, 169–180.

Tomann, H. (1990) Housing in West Germany in **Affordable Housing in Europe** (eds. D.Maclennan and R.Williams). Joseph Rowntree Foundation, York, pp. 55–73.

Wood, G.A. (1990) The Tax Treatment of Housing: Economic Issues and Reform Measures in **Housing Subsidies and the Market: An International Perspective** (eds. D.Maclennan and R.Williams). Joseph Rowntree Foundation, York, pp. 43–75.

185
The market and housing policy: identifying the target

E.H.ROBBINS

Abstract
This paper proposes the thesis that government policies in support of housing can only be effective if they are based on a careful analysis of local markets and the financial capacity of the target population. It suggests that by decentralizing control over the housing development process national and local programs will better respond to the dynamic processes of socio-economic change. In this way builders can better assess, and limit, the risk of investment in low and moderate cost housing, thereby increasing their interest in that market. It suggests, also, that in this way governments can stimulate housing production or improvement but avoid the financially disastrous experiences of so many countries that have launched housing programs without knowing exactly who they planned to serve.

Keywords: Housing, Market Analysis, Decentralization, Family Incomes, Financial Capacity, Housing Unit Pricing.

1 Introduction

The concern of this paper is the design of housing policies that stimulate the production of adequate housing for the mass of the world's population. It is not difficult to develop housing policies that stimulate production of housing for people with incomes that are large enough to absorb changes in economic or market conditions. The great challenge lies in generating policies that will assure production for income levels where there is little room for adjustment, and where the margins for builders are narrow.

In late April, 1990, the **Third International Shelter Conference** was held in Washington, D.C. This Conference was a result of the call by the United Nations for all of its members to develop a **Global Strategy for the Year 2000**. The Conference was sponsored by a wide range of public and private sector organizations from around the world. It became, happily, a forum for an unusually intensive and professional review of existing experiences that could help bring the public and private sectors together to achieve the goal set by the U.N.

Specific situations in such disparate environments as China, the United States of America, Portugal, Germany, Zimbabwe, India, Colom-bia and six other countries were used to orient the debates. The conclusions drawn from this meeting, and the proceedings, which will be made available in many languages during this year, may be obtained from the Department of International Affairs, National Association of Realtors, 777 14th Street, Washington, DC.

Three of the Conference Conclusions will serve as the basis for the thesis presented here.

Close the information gap on shelter data and indicators.

Empower and create public/private partnerships at the community level.

Recognize the central place of housing finance in shelter delivery.

2 The Thesis

Effective government housing policy requires accurate knowledge of the market. Government programs must be highly focused because the funds available are never adequate to deal with all housing needs and all types of housing production.

Public sector policy is far more effective over the long term if it explicitly recognizes that the private sector can react much more quickly to most expressions of need, leaving the public sector to deal with the toughest targets, the minority of situations where only special conditions will bring about the needed investment.

For housing policy to reflect this distribution of responsibility, as the Third International Shelter Conference concluded, **good data is critical**. In more commercial terms, market analysis is critical.

To make matters more complex, housing markets vary greatly by locality and region. This means that information is best gathered at the community level and best assessed at that level for use in shelter programs. The Conference participants reviewed a number of examples, and not only in Eastern Bloc countries, which made clear that when data analysis is applied to national programs without local adjustment, it usually prescribes solutions that are too inflexible to deal with reality.

The experience suggests that private developer, in collaboration with local authorities, have the best chance of accurately assessing markets and needs.

Last, but by no means least of the factors vital to effective policy development, are the prevailing financial circumstances. Precise knowledge of the end-user’s **capacity to pay** is critical to the efficient functioning of housing markets, and a “sine qua non” of this calculation is the pertinent financial market information. In sum, housing sector policy made without a close link to financial sector policy cannot work.

3 Restrained Government: Objectives

The experience gleaned for review at the Conference made crystal clear that private markets cope with bulk of the world's housing need. The information suggested that, whether in the world's most populous countries or in much smaller ones, even in periods of high levels of government investment, private production (not always of good standard) accounts for the largest percentage of total production.

3.1 Focus on the toughest cases

In fact, in case after case government-supported housing programs are underachievers. In their report to the Conference, experts from the Soviet Union estimated that 40 million people had an urgent need for housing, this in a country with a population of 279 million where the government assumed responsibility for virtually all housing production.

In Portugal the Government approved a housing plan in 1988 calling for the contracting, in 1989, of government-supported construction financing for over 11,000 units. The results were closer to 7,500 at a time when overall national production had never been higher.

Governments simply do not have, or chose to make available, the resources to solve the housing needs of the mass of the population. One could conclude that this is a result of poor political organization. In some respects it is because the process of converting household savings (money or materials) into housing investment is too dynamic, and dependent on too many variables, so that central government programs are always out of synchronization with reality.

The conclusion suggested by worldwide experience is that governments must, at a minimum, limit their direct support to the toughest cases, those cases where normally functioning markets cannot provide the services needed.

Indirect financial support programs, such as interest rate subsidies or tax relief, are more difficult to control. The most common negative experience is one of wasting government resources on targets that do not truly need the support. Indirect financial supports, for example, may, initially, provide the necessary stimulus to overcome market blockages, but all too often end up as permanent programs because they benefit a much larger, politically active class than was originally intended.

3.2 A little support goes a long way

Dr. Lauchlin Currie, whose career-long study of the impact of the housing sector on a national economy began before the Second World War, suggested in his presentations to the Conference that because the housing stock is such a large component of national wealth, governments can stimulate a large percentage rise in the magnitude of spending on new housing merely by encouraging a small change in effective demand for housing.

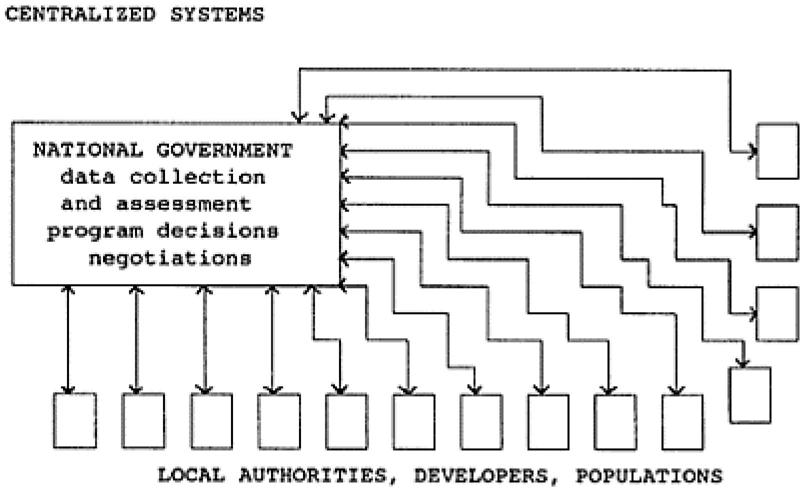
In sum, it is not necessary for governments to spread resources widely across the housing sector to get substantial positive (or negative) impact. In Portugal, once again, a combination of policies including inflation reduction and indirect financial support for roughly ten percent of the total number of units produced during the 1985–1989 period stimulated the highest annual national production of housing ever.

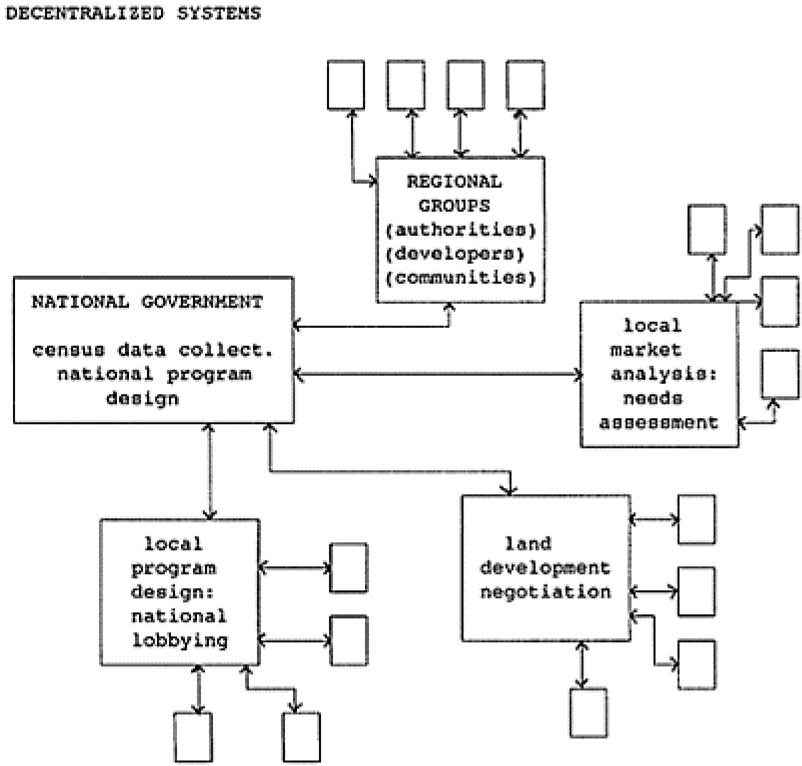
3.3 Give responsibility for housing to local authorities

National governments must avoid accepting or assuming responsibility for housing problems. This responsibility is best placed at local level, where the lines of communication between those searching for improved housing and government authorities are shortest, and the data is most specific. National governments are, in effect, too far removed to be sensitive to changes in the variables (demographic, economic, etc.) and their reaction time is too slow.

Placement of the principal responsibility for assessing housing needs and devising programs at local levels allows for more effective lobbying for national level resources. Local residents can be involved in the process, and local developers can better estimate risk and better define their own project objectives. National government planners can orient support programs more effectively when they are reacting to regional variations and pressures.

The following diagrams may help to make clear that when the data analysis and building program design are delegated to regional and local levels, the response time is cut, and the efficiency of the process of identifying need is improved. When central governments must process all information and requests for support, and then provide direction, the result is an over-concentration at the center, slowing response.





3.4 An effective data base is vital

To be realistic and achievable, government objectives should be based on **highly specific identification of the most acute needs,** and, therefore, on an effective data base.

Program funding over the long term will not be adequate if data collection does not pin down the different levels of financial capacity of those with housing need (in both rental and ownership markets).

Data related to the existing stock only sets the stage for housing programs. They combine with demographic information to give shape to the problem, but they do not provide for any action.

The data base must allow for identification of family income and investment capacity. This information is not only vital to an understanding of the type and volume of support required of government, it is also vital for any developer’s assessment of the risk.

The files are full of reports and articles about publicly-sup-ported housing programs whose cost to the developers (often the government itself) so greatly exceeded the funds allotted for production and maintenance that either drastic measures had to be taken, such as demolition, or funds were sucked away from other program initiatives, robbing governments of any flexibility in the orientation of housing programs.

This state of affairs is due to poor assessment of the risk. Often, no attempt is made to get information about the capacity of the beneficiaries to pay for the housing, or no effort is made to actualize information about the financial capacity of the beneficiaries over time.

In Portugal, for example, it was estimated in 1988 that the average rent for the approximately 30,000 apartment units owned by the government in the Lisbon area was 1000$00 (about U.S.$7.00) per month! Many other countries can claim comparably disastrous financial experience.

4 Finance is the key to effective housing sector operation and to effective government shelter policy

Often, housing policy is considered the exclusive domain of the building professions. In fact, if such policy is not designed with a very clear link to financial market conditions and policies, it is doomed to failure.

In Colombia, for example, the most effective part of national housing policy has been the link to financial markets. In this case, the value of savings deposited in the nation's housing finance institutions has been maintained, in spite of levels of inflation above 20% per annum, by an indexation process that is available only for the housing sector.

Housing policies carefully linked to financial markets have also resulted in positive experience in Chile, Singapore and Thailand and, in spite of the excitement generated by the collapse of the savings and loan system in the USA, it is very clear that the previous success of that nation's housing programs was founded on the tie financial sector policy.

4.1 Housing investment is dependent on long term financing.

Family incomes and savings cannot generate the cash required to buy a house or to quickly amortize investment in rental housing. Long term lending is the key. If too large a percentage of family incomes is devoted to solving basic housing needs, housing will absorb the savings that are vital to provide investment in other social development infrastructure (health, education).

In fact, housing is infrastructure, and not a consumer durable as so many economists seem to believe. Therefore, it requires the same type of long term investment as public utilities and other public facilities.

4.2 The financial capacity of lower income populations is very sensitive to financing terms.

Because lower income families cannot easily adjust to changes in the cost of financing for home purchase, housing sector policies that are not linked tightly to financial markets policies will have limited impact. They will be overshadowed quickly by financial market conditions.

The ease with which developers absorb changes in short term, construction financing costs should not be used as an indicator of response to changes in the cost of long term (purchase) financing. Builders, for example, can absorb a considerable change in financing costs by shaving other costs, or by cutting the time involved. There is less flexibility in the case of long term financing (pre-payment, refinancing). Furthermore, generalized estimates of future increases in family incomes may be well off the mark at certain points in time, thereby hiding the negative impact of graduated payments or variable interest rate changes on the borrower's capacity to pay.

5 Proper Orientation of Low or Moderate Cost Housing Project Design

In conclusion, how can one best combine effective market analysis with housing policy design?

5.1 Establish the financial capacity of the end-user.

This process lies at the very heart of the use of market analysis in support of housing policy design.

5.1.1 Determine target population income

The first step is to determine precisely the incomes of the target population. In cultures where it is difficult to do this accurately through census information, it is important to accept the challenge and carry out the sample surveys or precise analyses of related information (family expenditures, etc.).

It appears reasonable to say that if this step is not taken seriously, it is inevitable that government support programs will miss their mark and waste resources.

5.1.2 Analyze existing financial markets

The second step is to develop information about long term financing terms, including the effect on financing terms and costs of existing support programs (subsidies, etc.). These are then combined with income information to identify **the financial capacity of the potential beneficiaries**.

This information serves as the base for all discussion of the orientation of policy between public and private institutions. Decisions can be made about types of housing solutions: e.g. home improvement, new construction for purchase, new construction for rental, income support to offset rental obligations, etc. **If these two steps are not taken, however, policy designers are working in the dark.**

5.2 Establish unit: prices

With an accurate sense of financial capacity, developers can set the unit price required to reach a certain target population. It is particularly important that housing program design follow this order, for the financial capacity of the majority of beneficiaries in any housing market will not be flexible enough to allow for price increases above this level. The unit design process can then move forward.

This seems a very logical order for unit design, but it appears to be followed rarely in the case of publicly-supported programs, where the margins of error are narrowest and the challenge greatest.

In fact, in these programs unit design is often the result of too much amateur sociology, or the application of inappropriate cultural values. Unscientific generalizations of socio-economic conditions by well meaning professionals at national government levels lead to housing projects that remain uninhabited, or to large increases in government outlays to cover up mistakes.

For many years USAID, the World Bank and the UN have worked around the world to convince policy designers of the value of 20/30m^2 one or two-room houses that could be expanded as family incomes and savings improved. These officials often do not accept the suggestion that entire families would live in one room, and devote the remaining space to economic activity (building on a food stand, or weaving, for example), thereby providing a base for increased income and savings to be invested in improvement of the dwelling.

The authorities have insisted that an immediate objective of the beneficiaries was separation of the sleeping quarters of adults and children, when, in fact, field evidence made clear that this was not the first priority. The result, all too often, has been a long delay in the production of units priced at levels the target families could afford.

Reliance on local, not overly homogenized information, would have determined that access to land, water and sewer and a minimal, but expandable shelter sufficed to meet the needs of families living in shantytowns and would have kept the purchase price in range.

On the other hand, in more industrialized environments, the work of Alice Coleman in England (**Utopia on Trial: Vision and Reality in Planned Housing.** Hilary Shipman, London, 1985) and Oscar Newman in the USA (**Defensible Space.** Architectural Press, London, 1973), by detailed review of publicly-supported housing programs, support the argument that very careful market analysis is critical to the good performance of low-cost housing programs.

5.3 Negotiate Land Development Conditions with Land Use Authorities

Once the unit price is established, it is possible for developers to take the fourth step, and work with the appropriate authorities on the application or adjustment of norms and standards so as to minimize development costs, minimize the bureaucratic costs, and thereby, maximize the amount of dwelling unit that can be built for the target price.

Direct involvement of local authorities in project objectives is vital at this stage. Local authorities are far more sensitive to the local market, and, for that reason, will be more interested in the forward progress of any project that has been designed to improve housing conditions in their area.

National governments will be far more inclined to support a rigid application of regulations and processes since their objective will be the application of concepts, and since any adjustment would have to be applied uniformly throughout the nation.

Local authorities will be far better able to recognize that a family with a well identified financial capacity will only be able to afford a dwelling of a certain price, and they will be far more able to work with land developers and builders to keep within those limits.

6 Epilogue

This paper has emphasized the importance to those working in the shelter sector of the Conclusions drawn by the Third International Shelter Conference by linking the design of effective housing policy to

the availability of good data,
a central role for the financial sector, and
the use of private/public partnerships at the community level.

It has been suggested that such a design process implies **giving housing policy a market: orientation,** and that only through such an orientation can governments minimize the risk of wasting resources, make clear the risk for investors, in order to attract them, and stimulate improvements in housing conditions for the bulk of the population.

186
Market characteristics of housing sector in Turkey

Y.SEY, G.TOPÇU and A.KÖKSAL

Abstract
This paper aims to describe the characteristics of housing market in Turkey which is a country with a great housing deficit due to high population increase and urbanization rate. Following the brief explanation of the evolution of housing problem in Turkey the market is described by several indicators. The role of housing sector in general economy, the need and demand with references to population increase, income distribution and economic growth, the development of housing production are shown. The changes in need, demand and production are explained with the changes in housing policy and economical situation.

Keywords: Construction Sector, Housing Need, Housing Demand, Housing Production, Housing in Turkey.

1 Introduction

Housing is one of the major problems of Turkey which is a rapidly growing country with a population of approximately 60 million. Due to the high rate of population growth and limited resources the country is faced with a severe housing shortage. Although the housing problem has always been existed its amplitude and pressure has showed a steady increase since the beginning of the Republic. During the first decade of the new Republic the limited resources were allocated to other sector and little was done for housing. The government was faced with the task of rebuilding the devastations of the war; in addition refugees coming from the former provinces had to be resettled in Anatolia, On the other hand establishment of the new capital necessitated the building of housing for government personnel. In conformity with the economic policies formulated in 1923, the private sector was encouraged to participate in the building of cities as well as in providing housing for the exchanged population. Despite all measures the anticipated results could not be obtained due to the lack of both capital and construction materials. Thus the first decade of the Republic is marked on the one hand by the formulation of necessary legislation for the long term and by stop-gap measures for the immediate problem. In 1930's, following the preparation of a development plan a revitalization of the construction industry was observed. Although the activities were merely devoted to industrial and administrative investments, the housing of low-income people was introduced to the terminology of construction sector which remained in project stage. At this period construction of multi-storey apartment complexes for high-income bureacrats, merchants and industrialists was being undertaken at an accelerated pace. Due to land speculation, increases in the cost of basic construction materials, real estate values increased sharply. The attempts to introduce corrective measures such as price control and investments for factories to produce basic materials were made towards the ends of the decade. Starting from this date, land has become the major determinant of housing problem. During the second half of 1930's and beginning of 1940's a set of legislations had been introduced, also projects of several large scale housing projects were realized. The first cooperative housing project, workers' housing for the new established factories and dwellings for civil servants.

Following the Second World War, in 1950 a new era began for Turkey with political changes and liberalization in economy. In parallel with this new strategy due to rapid and unplanned urbanization, the housing shortage reached critical proportions. The aggregate growth in urban population led to the formation of uncontrolled housing settlements, the so-called "gecekondu"s in big cities. During this decade a state owned bank which provides long-term, low-interest credit had been established and several large scale housing projects were realized by this support. While this activity of publicly supported housing had constituted only small fraction of new housing production, a larger volume of production in cities were carried on by private sector, but all these attempt were for from fulfill the need.

In 1961, following another political change, the concept of housing has gained a new dimension in Turkish development policy. Since then many laws and regulation have been prepared. But due to economic and industrial growth and due to the insufficient conditions in rural areas, great masses if people still migrates to big cities and as a result housing shortage presents an ever increasing characteristics.

In this paper, the housing market in Turkey is introduced relying upon statistical data about need, demand and production.

2 Housing sector as an economic activity

The role of housing sector in the national economy is defined by several indicators which are:

Share of the sector in the gross national product (GNP) and in the gross fixed capital formation (GFCF),

Input-output relations of the sector with other sectors,

The effect of housing production on employement.

Construction sector's investments as the percentage of GNP has shown a steady state (approximately 8 percent) since 1975 while the nominal value of investments has increased (Fig. 1–2).

Housing investments constitute almost 80% of the construction activity. The share of housing investments in GFCF and GNP are shown in Figure 3–4.

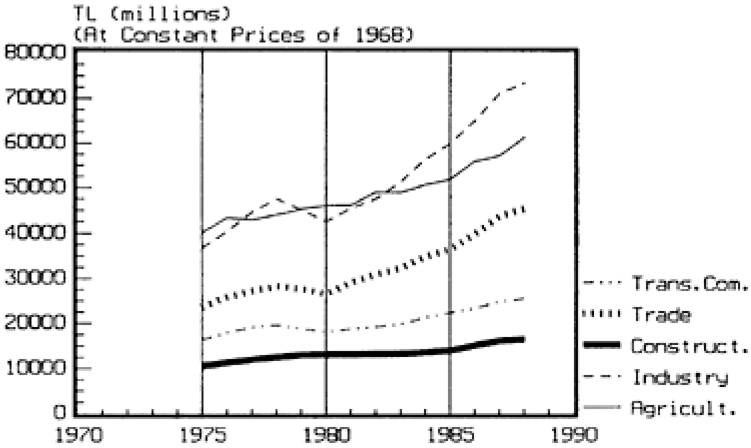


Fig. 1. Sectors in GNP.

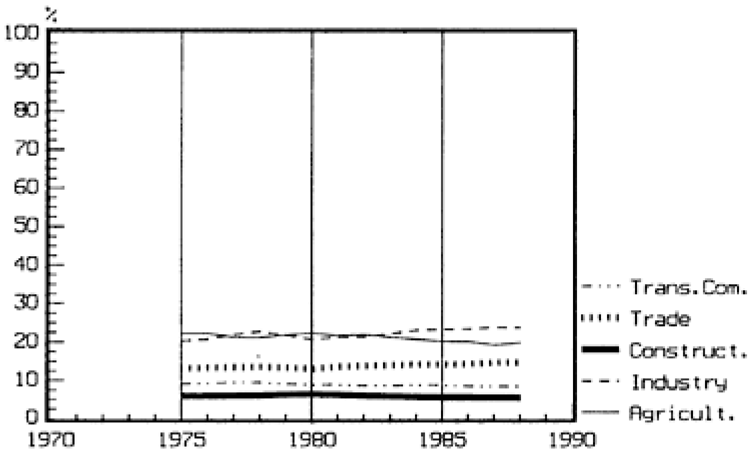


Fig. 2. Share of construction sector in GNP.

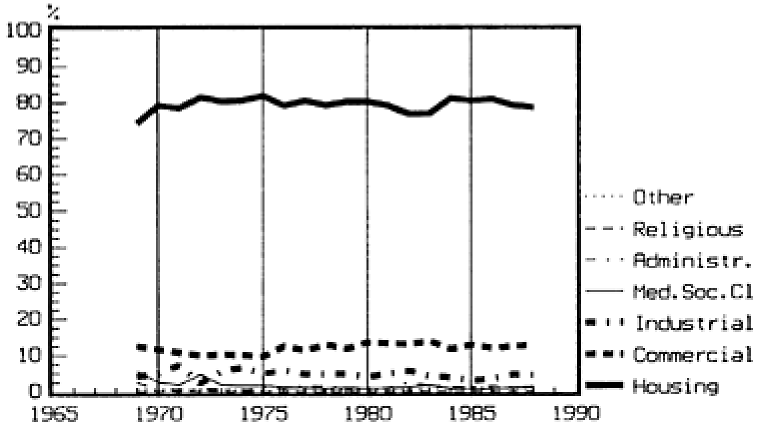


Fig. 3. Share of housing investments and other buildings in construction investments.

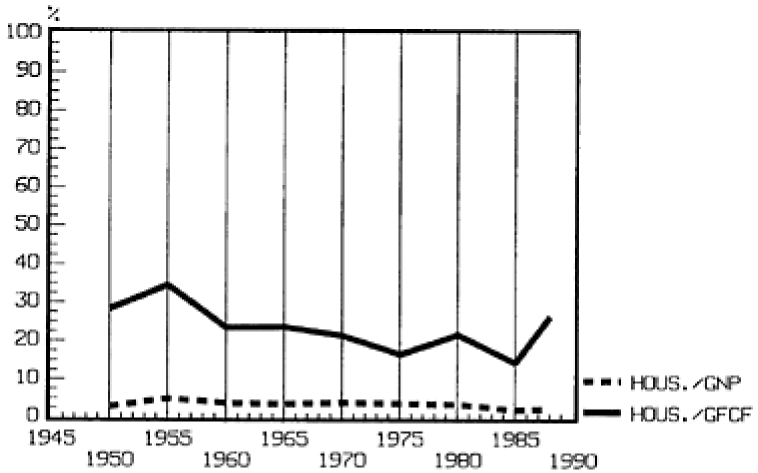


Fig. 4. Evolution of the Housing Investments.

Although the National Development Plans had been recommended the housing investments not to exceed 20% of GFCF, the realized figures are mostly higher. This situation is merely due to the high profit rates in housing production which has always attracted private investors to the housing sector. At times when more profitable investment areas are emerged, the preferences of clients are switched to those sectors, as it had been observed during 1978–82 when high interest rates are provided by brokers.

When the multiplier effect of housing sector is investigated, it is seen that it has an important impact on general economy. In order to find the effect of the increase in other sectors, a research has been carried on and Leontieff multiplier has been found between 2.99–2.45 which changes in accordance with technology. Also the increase in housing production necessitates an increase in employement. Beyond these positive impacts, it has been found that the increase in housing production has caused to increases dwelling prices.

3 Trends in housing market

The general trends in housing market is explaned from three dimensions point of view. These are clients, need/demand, production and resources.

3.1 Clients

In general two major modes of housing production can be classified in Turkey. The first mode belongs to the formel sector of housing which can be defined as the authorized production. The second mode is realized by the informel sector which is the clients of unauthorized “gecekondu” settlements.

The clients of formel sector are mainly public and private sectors. The number of houses produced by public and private clients are shown in Fig. 5.

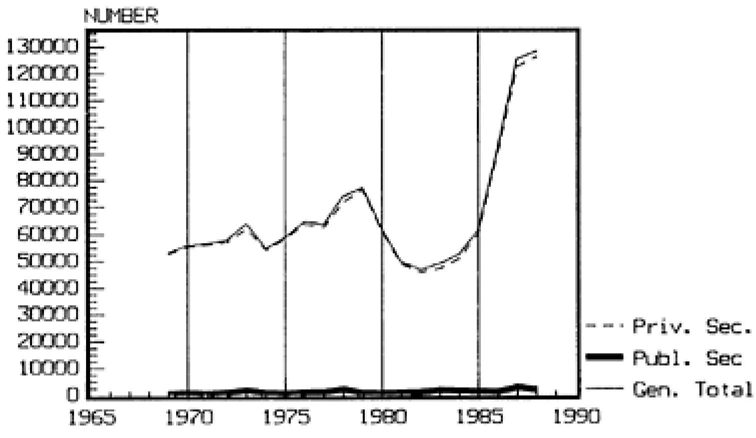


Fig. 5. The number of houses produced by public and private sector (According to building permits).

It is seen that the private sector’s share is approximately 95% of total investments.

The different types of formal housing production modes in Turkey are grouped as following:

– Production of single houses by individuals

– Production by housing cooperatives

– Production by private builders

– Production by private housing firms

– Production by private firm-public sector consortium

– Production by Public Authority of Housing.

In Turkey a great proportion of houses still are produced by individuals and private builders.

The general trend of number of housing units produced is shown in Fig. 6. The decrease between 1980–1985 is due to the economical crisis

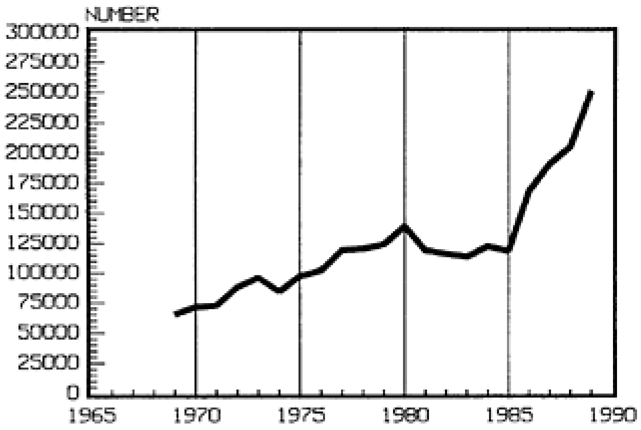


Fig. 6. Numbers of housing units produced between 1969–89 (according to occupancy permits)

in 1978–1979. Following the crisis, several legislations had been prepared and after the introduction of a new act for “mass housing” has been put into action the production have increased. This increase has especially been seen in number of houses produced by cooperatives (Fig. 7) due to the credits allocated.

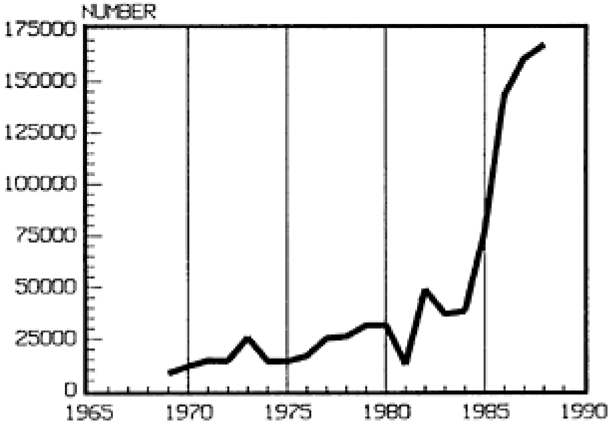


Fig. 7. Number of houses produced by cooperatives (according to building permits)

The number of squatters have shown a great increase since 1950 (Fig 8–9). This increase has been mainly influenced by political considerations.

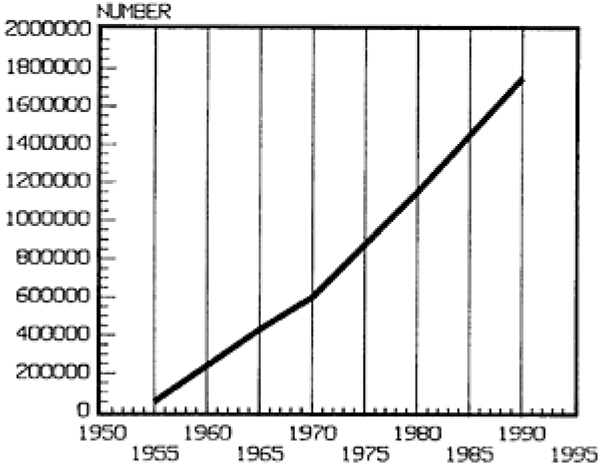


Fig. 8. Number of squatter housing.

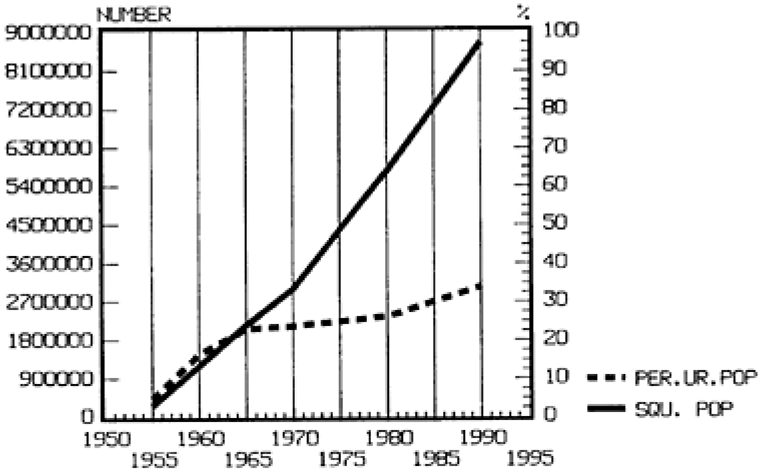


Fig. 9. Squatter population.

3.2 Housing need and demand

Since 1960 the production of housing has been discussed from two different points of view. The first approach has tended to consider housing as an unproductive investment. On the other hand housing sector has been accepted as the locomotive of the national economy and has been considered to be managed in the same way with other sectors. Due to the first approach which has emphasized in the development plans in 1960's housing deficit has grown rapidly. The production of new houses could not cope with the pace of high population increase and rate of urbanization. Now it is estimated that housing deficit will be around one million units in the year 2000. The yearly need of new houses is 400.000 units which is due to population increase, demolition increase, demolition and reneval of old stock.

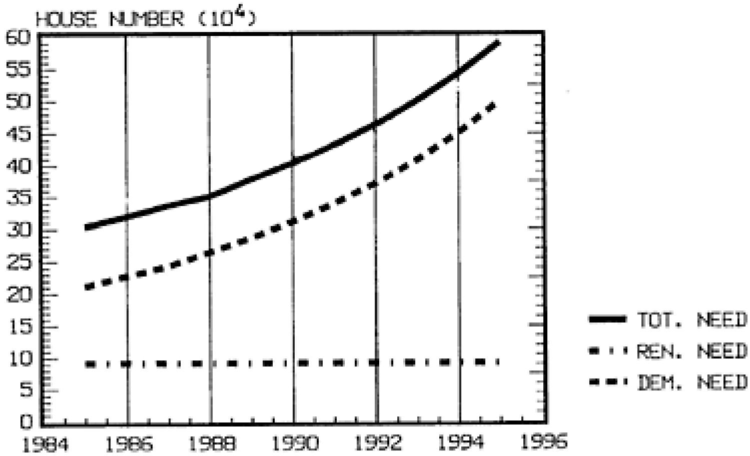


Fig. 10. Need of housing.

Economical factors such as inflation, income levels and building costs have negative effects on housing demand. Regarding the prevailing building costs and income levels, it is calculated that 20 percent of population could have no demand and 40 percent could afford only 15 sq.m of a dwelling.

The purchase power of low income groups show a gradual decrease every year. This situation is shown with the ratio of GNP to the cost of one sq.mt. dwelling unit and the ratio of average daily wage of worker to the cost of one sq.mt. dwelling unit.

4 Factors influencing housing production

Housing production is realized under the influence of demographic, economical and technological factors. These factors are briefly described.

4.1 Demographic factors

Population increase rate in Turkey has gained a greater pace after the second world war and reached to 13.25% in 1980–1985. The total population is approximately 60 million due to the latest census.

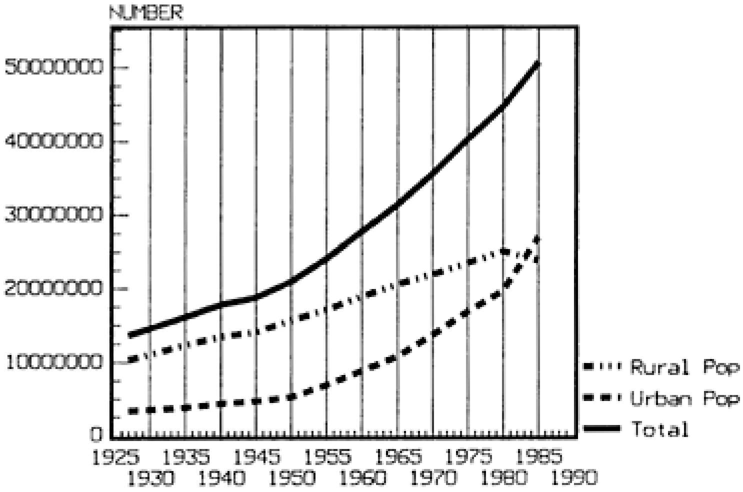


Fig. 11. Population increase.

The changes in the proportions of urban and rural population since 1925 is shown in Fig. 12. Urban population has increased four times in 25 years and reached to 53 percent of total population.

The rate of increase is 61% in cities and 1% in rural areas. Considering these rates Turkey is one of the countries which have the highest population increase.

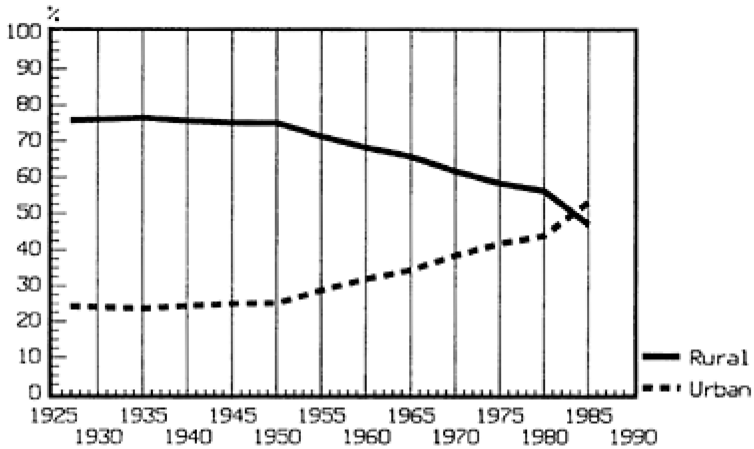


Fig. 12. Percentage in urban and rural population in total population.

4.2 Economical factors

Turkey has a developing economy with a growth rate of approximately 6% Due to political instability, external factors such as worldoil prices and balance of payments results in increased costs and higher inflation rates. Costs of building materials and buildings are higher than general cost index.

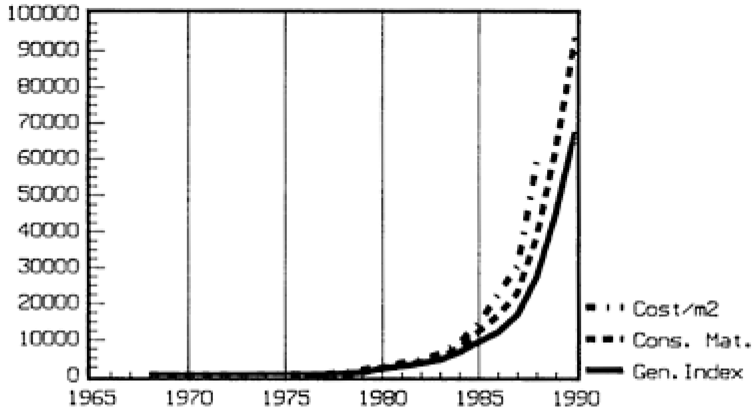


Fig. 13. Increases of inflation, prices of construction materials and housing cost per sq. mt. (1968=100)

This situation together with an uneven income distribution, influences the purchase power negatively the lower 40 percent of population is unable to make an effective demand for dwelling. This fact explains the increase in the demand for luxury dwellings and the growth of the gap between needs and demands.

4.3 Technological factors

In Turkey building sector had used conventional technology until early 70's. Following the establishment of large scale housing projects, new technologies with higher production rates have been started to be used Several closed prefabrication systems were imported but advanced moulding systems for reinforced concrete buildings have been more favorable for most of the contractors due to their relatively lower investment needs and project sizes.

5 Conclusions

The housing problem of Turkey to-day seems to be the aggregated result of the housing policies and socio-economical situation. The increasing gap between needs and production brings forward a pessimistic view. Almost one half of the population can not afford a proper dwelling and as a result unauthorized squatters surround all big cities. The established legislation is not sufficient to support low-income groups.

Under these circumstances it is obvious that a radical approach is necessary in housing policy. In order to provide housing for low-income groups long term credits with low-interest rates, low-cost land availability, rental housing systems must be studied Migration from rural areas has to be decreases by creating new attraction areas or by economical and social improvement of rural areas. On the other hand all ways of cost reduction has to be investigated.

6 References

Keleş, R. (1990) **Kentleşme Politikasi.** İmge Kitabevi, Ankara.

Sey, Y. (1989) Toplu Konut Yapiminda Ekonomik Sorunlar. **Çeşitli Yönleriyle Toplu Konut.** Tokyad, İstanbul.

DİE, **Statistical Yearbooks of Turkey** (1974, 1982, 1989), Ankara.

Tekeli, İ. (1982) Türkiye'de Konut Sorununun Davranişsal Nitelikleri ve Konut Kesiminde Bunalim. **Konut'81.** Kent-Koop Yayinlari, Ankara.

Geray, C. (1987) Toplumsal Boyutlariyla Toplu Konut Uygulamalari, **Dünya Konut Yilinda Türkiye Sempozyumu,** İnşaat Mühendisleri Odasi, İzmir.

187
The construction and housing sectors in four Nordic countries 1966–1989—some aspects

K.SWÄRD

Abstract
The purpose of this paper is to compare the development of the construction sector in the four largest Nordic countries over a 20-year period. In this context, the structure and growth rates of the national economies of these countries are important. The sector classification is mainly based on the use of building capital as a factor of production. Construction is defined as gross production, i. e. value added plus intermediate consumption.

Special attention is paid to the housing sector as receiving up to 50 % of the gross fixed capital formation in buildings and construction. The development of the stock of dwellings since the 1960’s is described. The paper concludes with a short discussion of housing production prospects.

Keywords: Construction Sector, Sectoral Share in GDP, Dwellings, Nordic Countries.

1 Five sectors

In a study presented in Sydney, Swärd (1990), demand for construction was estimated by classifying the economy into sectors. A crucial characteristic of the sector classification is that the use of building capital as a factor of production varies between sectors. Thus the distribution of sectoral demand for gross fixed capital formation, GFCF, in building is radically different from the distribution of value added.

The market sector includes agriculture, manufacturing industries, trade and private services. The market sector’ s contribution to the GDP is much larger than its share of GFCF in building and construction. Thus, building capital is a minor factor of production. Building investments in the market sector depend on profit expectations of firms and on the relative price of the production factor building capital versus other factors of production.

Part of the production of the market sector is used as intermediate consumption by the construction sector. Analogously, some of the building investments in the market sector are used in the production of deliveries to the Construction sector.

The housing sector basically represents household demand for building capital. In this sector building capital is **the** factor of production. The housing sector contributes less than 10% of the GDP, but roughly half the demand for building investments. Crucial for demand is the development of household incomes and population.

The welfare sector comprises health services, education, defence and judicial institutions, the consumption of which is almost totally financed out of taxation revenue in the Nordic countries. The welfare sector's contribution to the GDP is larger than its share of building investments. Investments in the welfare sector are to a large extent attributable to population changes.

The infrastructural sector consists of transport and communication. Building capital is an important factor of production in the infrastructural sector, as its share of building investments is much larger than the corresponding share of GDP. Investments in this sector are determined by investment decisions in other sectors. Roads and sewerage etc. are prerequisites for new housing projects and industrial developments.

The construction sector itself also demands investments in building capital. This is in the range of 1/2–1% of total building investments. More important is the derived demand for building investments in the market and infrastructural sectors needed in the production of deliveries to the construction sector.

The classification criteria also basically reflect how construction is financed in the Nordic countries. The public sector consists of the welfare sector and the infrastructural sector. In the Nordic countries, and especially in Sweden, the public sector is also involved in the housing sector.

2 Some basic concepts

The construction sector is defined as the sum of gross fixed capital formation, GFCF, and maintenance and repair, or as the gross output of this sector. Thus it includes intermediate consumption, which is excluded from the delivering sectors. The contribution from other sectors is estimated with the aid of input-output analysis.

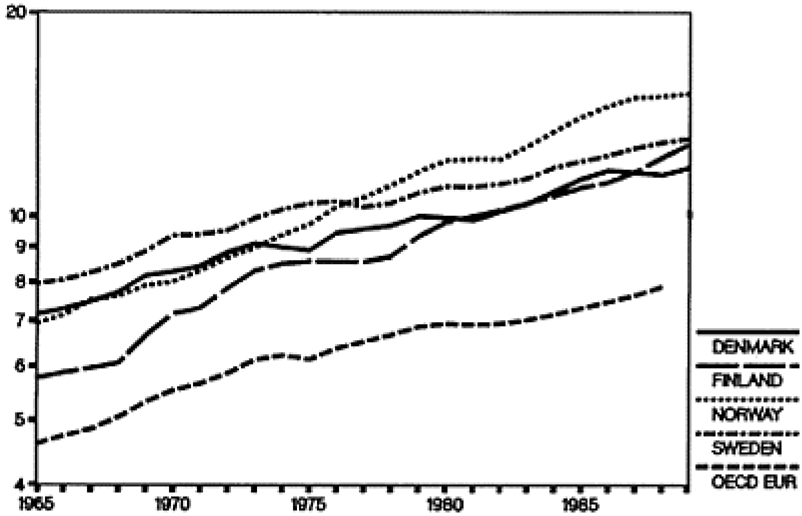


Fig. 1. Per capita GDP in the Nordic countries and OECD Europe at the price levels and exchange rates of 1985. (1,000 USD), 1966–1989. Logarithmic scale.

3 Economic development

The Nordic countries are small; their combined population is less than 25 million. They are comparatively rich countries. Figure 1 illustrates the development of GDP per capita in the Nordic countries since the mid-sixties. The unit is 1,000 USD at 1985 price levels and exchange rates. As a reference, a weighted average for the European OECD-countries is included.

Per capita GDP in the Nordic countries is well above the average of the continental OECD countries. By the mid-sixties Sweden had the highest per capita GDP, almost 8,000 USD. Norway and Denmark both had a GDP per capita of about 7,000, whereas Finland had less than 6,000. Since the late seventies the highest GDP per capita is found in Norway.

In the late eighties, the average GDP per capita in Norway exceeded 15,000 USD. Sweden and Finland shared the second place, with an income of 13,000 whereas in Denmark the average GDP per capita was approximately 12,000 USD.

4 Sectoral share of GDP

Characteristic of the Nordic countries is the small share of the market sector. This is especially the case with Sweden, where this sector ranges between 43 and 45% of GDP. In Norway it is larger, between 44 and 52%. In Finland, it contributes just under 50% of GDP.

The share of the housing sector is much higher in Denmark and Sweden. Except for the late sixties, it varied between 8 and 9% of GDP, as against 4% in Norway. This may partly be explained by differences in national income accounting conventions. Housing consumption in Sweden and Denmark, however, is higher in terms of headship rates etc. This will be discussed later.

The welfare sector, comprising health services, child care, education, defence etc., is much larger in Sweden and Denmark than in Finland and Norway. In the latter two countries the contribution of this sector to GDP ranges between 13 and 18%. In Sweden, by contrast, since the mid-seventies roughly 25% of GDP has been produced by the welfare sector, and slightly less in Denmark.

The infrastructural sector in Sweden and Finland is of approximately the same size, 8–9% of GDP. In Norway, this sector is more important, although it has decreased. The sectoral share ranges between 18 and 11%, reflecting the fact that Norway is a maritime nation.

It is to be noted that the construction sector is defined as the gross output of this sector, thus including intermediate consumption which has been deducted from, mainly, the market sector.

In Denmark, the sectoral share of the construction sector decreased from 22% in the late sixties to 13% in the late eighties. The same development took place in Sweden, although the decline started from a lower level, 19%, in the late sixties. In Finland, the share of the construction sector has been roughly 20%, except for a peak of 22% in the early seventies. In Norway, finally, the construction sector has varied between 19 and 20%, except in the early eighties, when it was only 17%.

Table 1. Sectoral share of GDP. Four Nordic countries 1966–1988,

Country	1966–70	1971–75	1976–80	1981–85	1986–88
Market sector (%)					
Denmark	48	45	44	45	48
Finland	49	48	48	49	49
Norway	46	44	47	52	48
Sweden	47	46	43	43	45
Housing sector (%)					
Denmark	6	8	9	9	9
Finland	8	7	7	6	6

Norway	4	5	4	4	4
Sweden	9	8	8	9	9
Welfare sector (%)					
Denmark	15	19	22	24	23
Finland	14	14	15	16	18
Norway	13	15	17	17	18
Sweden	17	20	24	25	24
Infrastructural sector (%)					
Denmark	9	8	8	8	8
Finland	9	9	9	9	9
Norway	18	17	12	11	11
Sweden	8	9	8	9	9
Construction sector (%)					
Denmark	22	20	17	14	13
Finland	20	22	20	19	19
Norway	19	20	20	17	19
Sweden	19	17	17	14	13

5 The construction sector

5.1 Gross output of the construction sector

Figure 2 shows the per capita gross output of the construction sector since 1966 in the four countries studied. The measurement unit is 1,000 USD at the price levels and exchange rates of 1985. (The USD exchange rate was very high in 1985). At the exchange rates chosen, figure 2 also gives an idea of the ranking between the countries. Had the exchange rate of january 1991 been used, Finland, not Norway, would have had the highest output except for 1986 and 1987. Thus, the choice of exchange rate date will influence the levels but not the slopes of the curves.

Danish construction output was highest of all in the mid-sixties. After a peak value of 2,200 USD per capita in the early seventies it decreased gradually until the mid-eighties, when there was a slight upturn. By the late eighties, however, the production value was no higher than in the mid-sixties. In Finland there was also a peak value of 2,200 USD per capita in 1975. Following a few years of decline, production has increased steadily.

Norway had the lowest level of construction output in the mid-sixties, 1,200 USD per capita. In the late eighties production was more than twice as high. Per capita production has dropped from the 1987 peak value of 2,600 USD to 2,200 in 1989. In Sweden, the output of the construction sector can be described as stable, or stagnant. The production value was 1,400 USD per capita in 1966 and 1,700 in the late eighties.

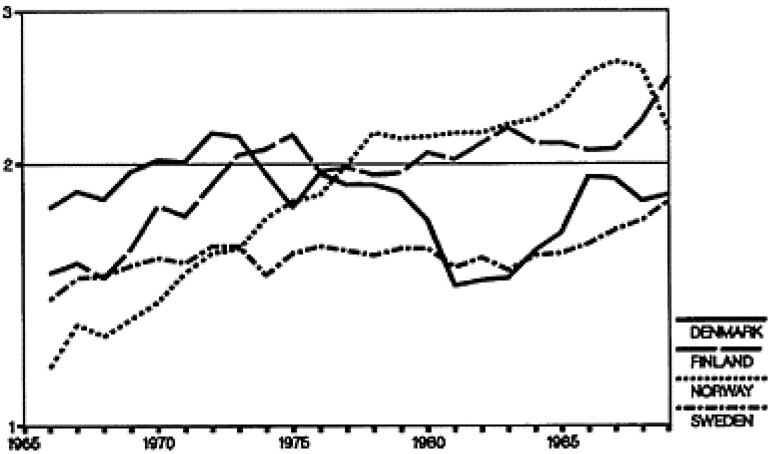


Fig. 2. Per capita gross output of construction. Four Nordic countries 1966–89. 1,000 USD at the price levels and exchange rates of 1985. Logarithmic scale.

5.2 Building investments

Sectoral shares of GFCF in buildings for the period 1980–88 are shown in table 2. The market sector demanded less than 20% in Denmark, slightly more in Sweden, 24% in Finland and Norway.

In Norway, 36 % of building investments were on permanent housing, in Sweden 40% and in Denmark and Finland 44%.

A time series for 1966–1987 is available in Swärd (1990). In the same paper sectoral incremental building capital output ratios are presented, linking building investment to GDP growth.

Table 2. Sectoral shares of building investments 1980–88

Sectoral shares of building investments 1980–88,	Denmark	Finland	Norway	Sweden
Market sector	19	24	24	21
Housing sector	44	44	36	40
Welfare sector	11	14	13	16

Infrastructural sector	23	14	22	19
Construction sector	3	4	4	4
Total	**100**	**100**	**100**	**100**

5.3 Growth rates of GDP and construction

Since the mid-sixties, GDP growth rates have been higher in Finland and Norway than in Sweden and Denmark. The same pattern pertains to construction. During the whole period 1966–89, average annual growth rates of construction output have been higher in Norway, 3.2%, and Finland, 2.5%, than in Denmark and Sweden (0.4 and 1.4% respectively).

In table 3 c) historical values of elasticities for construction are shown. An elasticity of 1 implies that construction output increases at the same rate as the GDP during the defined period of time. Since the mid-sixties, construction grew at almost the same rate as GDP in Norway, while in Finland and Sweden, construction output increased by just over half as much as GDP. In Denmark, construction output has increased at a much slower rate than GDP, thus reducing the sectoral share of construction. This was also demonstrated in table 1.

Table 3. Average annual growth rates of GDP and construction 1966–1989.

Period	Denmark	Finland	Norway	Sweden
a) GDP, average annual growth rates (%)				
1966/70	3.9	5.2	3.7	4.5
1971/75	2.0	4.0	4.5	2.6
1976/80	2.4	3.1	4.7	1.3
1981/89	2.1	3.4	2.7	2.1
1966/89	**2.4**	**3.8**	**3.7**	**2.4**
b) Construction output, average annual growth rates (%)				
1966/70	3.8	4.1	5.2	3.4
1971/75	−1.9	4.3	5.9	0.6
1976/80	−0.4	−0.7	3.8	0.5
1981/89	0.8	2.6	0.6	1.6
1966/89	**0.4**	**2.5**	**3.2**	**1.4**
c) Ratio (b/a=elasticity)				
1966/70	1.0	0.8	1.4	0.8
1971/75	−1.0	1.1	1.3	0.2

1976/80	−0.1	−0.2	0.8	0.4
1981/89	0.4	0.8	0.2	0.8
1966/89	**0.2**	**0.7**	**0.9**	**0.6**

5.4 Saturated markets?

There are several reasons for the different development of the construction sector in the Nordic countries. One obvious reason is differences in "economic maturity". Sweden and Denmark became urbanized and industrialized earlier than Norway and Finland. Thus, the share of employment in agriculture is much higher in Finland and slightly higher in Norway than in Denmark and Sweden. In 1960, the percentage of economically active population in agriculture and forestry was 14% in Sweden, 18 in Denmark, 20 in Norway.

In Finland, between 1960 and 1985, the share of the workforce employed in the agricultural sector decreased from 36 to 11%. This rapid urbanization implies the construction of dwellings and workplaces.

6 The Housing sector

6.1 Dwelling stock

Since the 1960's, due to construction of new dwellings and upgrading of the the existing stock, substandard housing has virtually disappeared from the Nordic countries. Table 4a) shows that in 1960 roughly half of the dwelling stock was equipped with a bathroom, except in Finland where only one dwelling out of seven had this amenity. By the mid- or late eighties 85 to 96% of dwellings had bathrooms, and 82% in Norway (1980).

Swedish and Finnish dwellings are smaller than in Denmark and Norway. In 1970 the average dwelling in Finland had just over 2 rooms and a kitchen, in Sweden less than 3 rooms. In Denmark and Norway the average dwelling size was 3.4. This pattern did not change over time. Although the average dwelling size has grown, Swedish and, in particular, Finnish dwellings are smaller.

Table 4. Dwelling stock. Four Nordic countries 1960–1990

Year	Denmark	Finland	Norway	Sweden
a) Dwellings with bathroom (% of dwelling stock)				
1960	48	16	45	54
1985	88	85	82	96
b) Average size of dwellings (rooms)				

1970	3.4	2.1	3.4	2.8
1985	3.8	2.5	3.4	3.2
c) One-person households (% of all households)				
1960	17	14	14	20
1980	29	26	28	33
1990	31	28	..	36

Note: Data for 1990 refer to 1989 (Denmark), 1987 (Finland) and 1985 (Sweden); data for 1985 refer to 1980 (Norway)

6.2 Diminishing households

What is perhaps more interesting is the development of headship rates. Figure 3 shows the number of dwellings per 1,000 inhabitants. In 1960 there were were roughly 270 dwellings per inhabitants in Finland, corresponding to an average household size of just under 4 persons. In Norway there were approximately 300 dwellings to 1,000 inhabitants. Denmark and Sweden both had more than 300 dwellings per 1,000 inhabitants, Sweden almost 360.

No census was taken in Norway in 1985, but in the other countries there were more than 400 dwellings per 1,000 inhabitants, in Sweden more than 460. This implies that there is almost one dwelling for every second Swede.

Could each Swede have his (or her) own dwelling? Table 4c) gives the percentage of one- person households. While there are comparatively few such households in Norway and Finland, they are frequent in Sweden, viz one in five households in 1960, more than one in three in 1985. Denmark comes somewhere in between.

6.3 Housing construction

Bearing in mind the high headship rates of the Nordic countries it is natural to ask if dwellings are still being constructed. In Denmark and Sweden the number of completed dwellings per 1,000 inhabitants has dwindled. During the late sixties and early seventies annual production was close to 10 in Denmark and between 12 and 14 in Sweden. In the eighties annual production never exceeded 6 dwellings per 1,000 inhabitants in Denmark, 7 in Sweden.

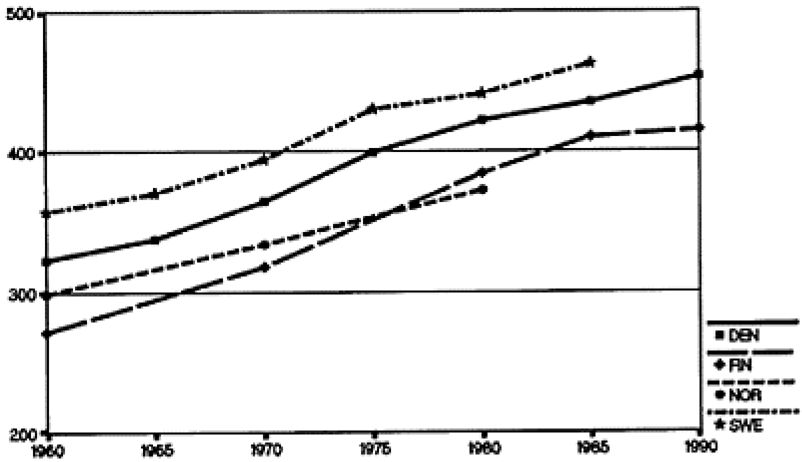


Fig. 3. Dwellings per 1,000 inhabitants. Four Nordic countries 1960–1990

In Norway, production has been quite stable, only occasionally exceeding 10 dwellings per 1,000 inhabitants, whereas in Finland there was a peak level at 15 dwellings per 1,000 inhabitants by the mid-seventies. Production has since remained at a higher level in Finland than in the other countries. Then, as pointed out earlier, urbanization took place later in Finland than in the other countries and headship rates are lower. Moreover, Finnish dwellings are smaller.

At the Nordic seminar “The future of construction and housing”, Spring 1990, different scenarios regarding future dwelling construction were presented, Mäntylä, (1990). The key factor was whether urbanization will continue. The population projection used, from the Central Statistical Office of Finland, predicts a heavy population decline, starting by the end of the century. A diminution of the present population by 8–9% is foreseen by the year 2030.

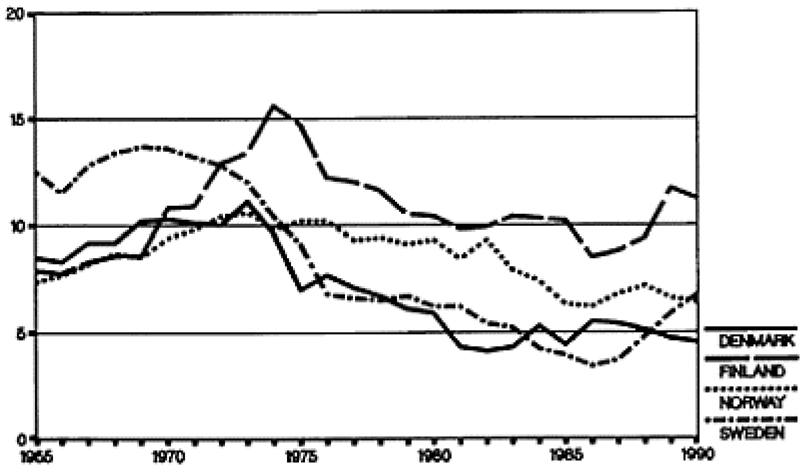


Fig. 4. Completed dwellings per 1,000 inhabitants. Four Nordic countries 1965–1990

Table 5. Dwelling stock by period of construction, latest census.

Country, year of census Dwellings by period of construction,	Denmark 1989	Finland 1987	Norway 1980	Sweden 1985
−1939	39	12	29	26
1940–59	17	20	26	26
1960–69	17	17	20	23
1970–79	18	29	24	20
1980	9	23	..	6
Total, (%)	**100**	**100**	**100**	**100**
Total (1,000 dwellings)	2328	2055	1524	3863

The view was also expressed that the housing standard of Finland lagged 15 years behind that of Sweden, Lankinen (1990), with large, often overcrowded households. Thus the construction of new dwellings should give priority to large dwellings. On the other hand, the average household size is diminishing, and in the future a dwelling stock consisting of small dwellings might match the composition of households.

Sweden faces the reverse problem. The number of small households, with only one occupant, has increased by more than 800,000 since 1960. During the same period, the number of small dwellings, with 1 or 2 rooms, decreased by 170,000. This topic was raised by Heinstedt, (1990) at Statistics Sweden. Heinstedt pointed out the disparity between the dwelling stock, with too many large dwellings, and the composition of households; 2/3 of all households have less than three occupants.

At the Economic department of Oslo University in collaboration with the Norwegian Building Research Institute a model, BUMOD, to forecast the annual construction of new dwellings has been developed, Barlindhaug (1990). Household incomes and demographic variables are used to estimate demand. BUMOD is an equi librium model, where prices are determined by supply and demand. The ratio between the equilibrium price and production costs is used to estimate the number of new dwellings to be constructed.

In several papers, the topic of renovation and upgrading was raised. The Danish dwelling stock is quite old. Almost 40 % of the stock was produced before 1940, as against only 12% in Finland. Thus there is a need for upgrading of the dwelling stock in Denmark, Vestergaard, (1990).

7 References

Barlindhaug, R. Om den norske boligmarkedsmodellen BUMOD, in **Byggandets och boendets framtid i Norden** (eds K.Swärd and L.J.Waldén), Nordiska Ministerrådet, Köpenhamn 1990, Nord 1990:105, p. 36, pp. 219–223.

Heinstedt, L.Bostadsmarknaden 1960–1985 med en utblick mot år 2010, in **Byggandets och boendets framtid i Norden** (eds K.Swärd and L.J.Waldén), Nordiska Ministerrådet, Köpenhamn 1990, Nord 1990:105, p. 34, pp. 179–189.

Lankinen, M. (1990) Att förutse bostadsbehovet i huvudstadsregionen, in **Byggandets och boendets framtid i Norden** (eds K.Swärd and L.J.Waldén), Nordiska Ministerrådet, Köpenhamn 1990, Nord 1990:105, p. 34, pp. 162–178.

Mäntylä, K. (1990) Finland 2030-scenarierna—sammanfattning av delstudier, in **Byggandets och boendets framtid i Norden** (eds K.Swärd and L.J.Waldén), Nordiska Ministerrådet, Köpenhamn 1990, Nord 1990:105, pp. 35–36, 206–218.

National Accounts (1990) **National Accounts 1988.** Danmarks Statistik, Copenhagen.

National Accounts (1982) **National Accounts 1982.** Danmarks Statistik, Copenhagen.

National Accounts 1989:12 (1989) **National Accounts 1979–88.** Central Statistical Office of Finland, Helsinki.

National Accounts N:o 59 (1977) **Input-output Study 1970.** Central Statistical Office of Finland, Helsinki.

National Accounts 1983:9 (1983) **Input-output Study 1980.** Central Statistical Office of Finland, Helsinki.

National Accounts 1985:4 (1985) **Input-output 1982.** Central Statistical Office of Finland, Helsinki.

National Accounts 1988:1 (1988) **Input-output 1985.** Central Statistical Office of Finland, Helsinki.

National Accounts (1970) **Input-output tables for Sweden 1964** Statistical Reports N 1970:13, Statistics Sweden, Stockholm.

National Accounts (1972) **Input-output tables for Sweden 1968** Statistical Reports N 1972:44, Statistics Sweden, Stockholm.

National Accounts (1980) **Input-output tables for Sweden 1975** Statistical Reports N 1980:3, Statistics Sweden, Stockholm.

National Accounts (1990) **Capital formation.** Appendix 2–3, N 10 SM8901, Statistics Sweden, Stockholm.

National Accounts (1990) **Production and factor income.** Appendix 4, N 10 SM8901, Statistics Sweden, Stockholm.

NORD 1990:5 (1990) **Yearbook of Nordic Statistics 1989/90.** Volume 28, Nordic Council of Ministers, Stockholm.

NOS B 934 (1990) **National Accounts Statistics 1988.** Oslo.

NU 24/73 (1974) **Yearbook of Nordic Statistics 1973.** Volume 12, Nordic Council of Ministers, Stockholm.

NU A 1977:18 (1978) **Yearbook of Nordic Statistics 1977.** Volume 16, Nordic Council of Ministers, Stockholm.

NU 1984:16 (1985) **Yearbook of Nordic Statistics 1984.** Volume 23, Nordic Council of Ministers, Stockholm.

OECD (1990) **National Accounts 1960–88.** Main Aggregates. Volume 1. OECD, Paris.

Statistisk Sentralbyrå (1988) Reviderte nasjonalregnskapstall, **Økonomiske analyser** nr 3 1988, Oslo.

Statistiska meddelanden nr 75 (1984) **National Accounts, Timeseries 1960–81.** Central Statistical Office of Finland, Helsinki.

Swärd. K. (1990) The construction sector in four Nordic countries 1966–1987. An analysis of demand and supply, in **Building economics and construction management,** Volume 1, The building market (ed V.Ireland), W55/W65 Joint Symposium Papers, Sydney, p. 291–302.

Unpublished input-output tables, Statistics Norway.

Vestergaard, H (1990) Reinvestering i boligmassen i en lille åben økonomi, in **Byggandets och boendets framtid i Norden** (eds K.Swärd and L.J.Waldén), Nordiska Ministerrådet, Köpenhamn 1990, Nord 1990:105, p. 30, pp. 140–150.

188
Classification of housing policies with regard to aims

L.J.WALDÉN

Abstract
This paper indicates a way to classify housing policy with regard to their aims. Economic stability, equitable distribution and efficient allocation are to be regarded as paramount goals. In the analysis references are made to various countries, such as France, Norway, Singapore, Sweden and the United Kingdom. The purpose of the classification is to facilitate international comparisons of housing policies.

Keywords: Housing policy, Stabilisation, Distribution, Allocation, Public Housing, Inflation-adapted finance.

1 What is specific about housing?

1.1 Immobility and durability

Housing, in an economic sense, stands for services yielded by residential capital. The housing market differs from markets for most other goods and services in two ways.

First, residential capital is immobile. The services rendered can be enjoyed only in the vicinity of the buildings. A major economic principle says that commodities shall be made where the relative production costs are the lowest, but this bears little relevance to residential construction. Dwellings must be erected where there exists a demand, regardless of the production costs on the local market.

Second, residential capital is extremely durable, in parts 30–50 years. Therefore, in the short run, new residential construction adds little to the available housing stock. As a consequence, the housing investment market is sensitive even to slight changes in total demand for housing services.

This may be displayed by the development of completed dwellings in European countries between 1958 and 1984. The number of completed dwellings per 1000 inhabitants in the six countries in the diagram on the next page was twice as high in the boom around 1975 than during the recession a couple of years later, Waldén, (1986), Urien (1987).

1.2 Equity

The factors mentioned refer to the supply of housing, and may explain why house prices and rents differ between local markets, as well as, why sudden shifts occur on markets for residential investment. This, however, does not give grounds for, specific policies for housing.

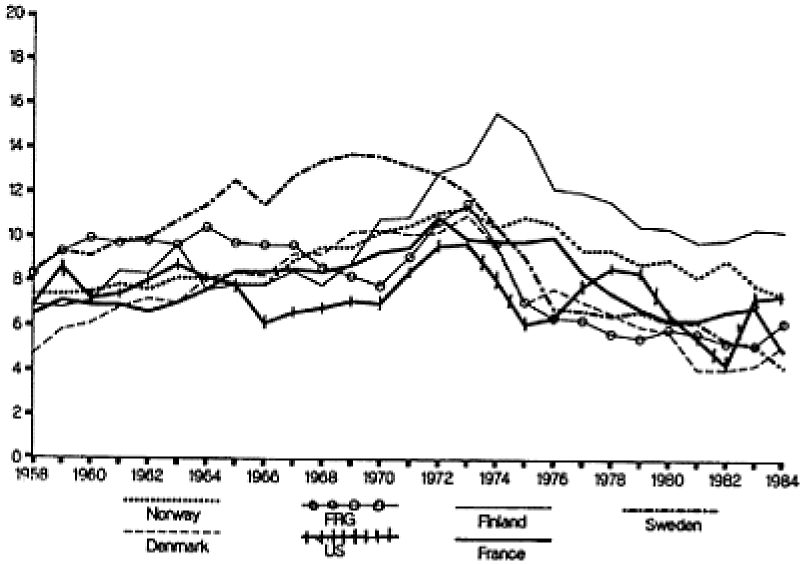


Fig.1. Dwellings completed per 1,000 inhabitants in six European countries 1958–84.

The rationale of housing policies is to be found on the demand side. Thus, for certain utilities, consumption is guided by legislative norms, based on the notion of "equity". This indicates that, up to a certain level, all citizens shall be granted equal access to the services in question. Services such as education, health care and housing are embraced by this notion.

Equity must be distinguished from egalitarism. Equity indicates that every citizens is entitled to a minimum consumption of certain items. It says nothing of the distribution of consumption above that level.

2 Musgrave's three branches

The paradigm that will be adopted in the following for classifying housing policies originates from "The theory of public finance" by the American economists Richard

Musgrave (1959). Considering the goals of financial policy, he distinguishes between three different branches, namely:

The Stabilization Branch, for counter-cyclical policy.
The Distribution Branch, for household transfers.
The Allocation Branch, for investments to fulfill public wants.

The scheme is developed in the following, and the reasoning will be exemplified with some countries. The approach is being adopted in a project, the purpose of which is to elucidate housing policies in various countries. The project is funded by Swedish Council for Building Research and The National Swedish Institute for Building Research.

3 Housing policy as part of the Stabilization Branch

The extreme durability of dwellings makes residential investment a risky business. The outlays for constructing a house or an apartment block take place during, say, a year. The period to repay the mortgage spans over a much longer time, in some countries up to 30–40 years or more.

The demand for dwellings may fluctuate considerably within a few years, due to varying prospects. Households are unwilling to get indebted when a slump is imminent, but may turn over-optimistic when “prosperity is around the corner”.

When the main target of the housing policy is to dampen the fluctuations on the market for residential investment, the Stabilization Branch of Musgrave’ s classification becomes relevant. The emergence of Swedish housing policy in the early 1940’s may illustrate this, Johansson (1966).

In 1939, 57,000 dwellings were completed, nearly 10 per 1,000 of the population. After the outbreak of World War II (September 1939) house-building declined sharply, down to 12,000 completed dwellings in 1941. Various measures were initiated in 1941–42 to stabilize the fluctuating market for housing investment. Thus, terms for obtaining State financed mortgages were facilitated and the interest rate was pegged at 3½%.

During the 1950’s the stabilizing aspect prevailed as well. This time, however, the labour market was basically over-heated, and residential investment was restrained by building permits and other means of physical control.

Stabilization policy may also concern capital formation, as a means to ensure a high, long-term economic growth rate. This can be demonstrated by the housing policy of Singapore.

The Singapore Government has set a goal to establish a long-term household saving ratio of 40%. Hence, the wage-earners of Singapore are forced to save nearly 25% of their salaries (the employers stand for the rest) to be paid as fees to pension funds. Wage-earners, however, are allowed to draw on their pension funds to finance dwelling purchases. Amortisation terms are favourable and the principal is repaid by future pension fees, Waldén and Swärd (1991).

It is worth noticing that this has not resulted in a stable housing investment market in the short run. The number of completed dwellings has varied considerably in the eighties, between 33 (1984) and 6 (1989) per 1,000 inhabitants of the Singapore population.

4 Housing policy as part of the Distribution Branch

4.1 Low price housing

Low price housing for certain households signifies a distributional housing policy. These households are selected on criteria of ability-to-pay. Thus the support to housing demand in this case is **house-hold related**.

4.2 Social/public housing

A crucial instrument in this context has been to provide dwellings of a minimum standard, the administration of which is under public control. This part of the housing stock is often referred to as the “Social Sector” or **social housing**. The term emphasises the aim: Homes for the poor.

Another term, **public housing,** puts forward the management aspect of these dwellings, i.e. that they are supervised by the public. The organisation of this kind of housing varies between countries. In Britain it is usually controlled by the local (municipal) councils; hence, the term **council housing** is often used.

The United Kingdom, and Scotland in particular, was the first country to develop a large public housing sector. When the servicemen returned from the trenches after World War I, they were to be provided with “Homes fit for Heroes”. The aims, however, were successively extended to embrace a general rise the housing standard of the British working classes, Merrett (1979).

In 1947 the British public housing stock accounted for 13% of all dwellings, Murie et al (1976). Its share increased steadily to over 30% in 1970 (60% in Scotland). This expansion had, as early as in the fifties resulted in an extension of the goals for public housing. It was no longer solely for “the poor” or workers but for middle-class families as well.

The public dwellings were mainly rental but could be bought by tenants who had lived there for a long time. Up to 1970 the rate of sales of council housing was about the same during both Labour and Conservative Governments. Altogether about 100,000 dwellings were sold by local authorities and New Towns in England and Wales up to 1970, Murie (1975). This corresponded to 2% of the current public housing stock.

The conservative Government that was elected in 1970 facilitated the purchase of public dwellings, and another 100,000 were sold in the next five years. Nonetheless, the public housing stock continued to be augmented and accounted for 34% of all British dwellings in 1981.

The policy of the eighties has differed from that of previous decades. Few new council houses have been built, and by various Acts, privatisation of the existing stock has been encouraged. Nonetheless, in 1987 public housing still accounted for 26% of all dwellings, Office of Population…(1987). The future will show whether the past decade represents a new era or only a historical parenthesis in British housing policy.

The size of the British public housing sector is some ¼ of the total dwelling stock. This is above the European average. A more “normal” figure is 15%, as in Denmark and France. The French HLM (Habitation a loyer moderé) has existed for nearly a century and is organised, as independent companies. Rental dwellings prevail in the stock, but about half of the new dwellings are for owner-occupancy. Priority is given to households with low ability-to-pay, Waldén (1985)

In Sweden public housing is also administered by independent companies, most of them affiliated to the central organisation of the public utility enterprises, SABO. This accounts for 1/5 of the Swedish dwelling stock.

The policy of SABO companies deviates from the pattern of the public housing sector delineated above, as the rents are not set below those in the private rental sector. Moreover, the social incentive is weak. Statistical surveys show that for most types of households incomes differ only slightly from those in owner-occupied housing, Waldén (1990).

4.3 Housing allowances

Housing allowances, based on the households' ability-to-pay represent a more straight-forward way of supporting the housing demand of the poor. Vital criteria are low income and household size. In practice, this means that housing allowances are, in essence, issued to families with children and retired people.

France is a country which, by tradition, has a well developed family allowance network. The Barre Commission suggested that the distribution aspect of the support to housing should be reinforced, Reforme (1975). A reconsideration of the French housing policy along this line was also decided in 1977, mainly by the introduction of the household-related support APL (Aide Personnalisée au Logement). The share of APL of total housing support increased rapidly during the eighties.

A crucial argument in favour of housing allowances is that they reduce the risks of poor people being gathered together in certain blocks. Moreover, in the thorough "supply experiment" directed by the RAND corporation in the early eighties, housing allowances turned out to be the most efficient way to stimulate housing demand, Lowry (1983).

5 Housing policy as part of the Allocation Branch

5.1 Low housing price

Whereas the Distribution Branch redistributes household incomes, the purpose of the Allocation Branch is to redistribute, by fiscal means, the allocation of resources of production. The attitude is ambiguous among economists towards such intervention in the price mechanism.

Hence, tax financed consumption is accepted for public goods, i.e. goods for which any individual may increase his/her consumption without anyone else having to lessen his/hers, Samuelson (1955).

It is also considered feasible to use discriminatory taxes to reduce the consumption of items that have injurious health effects, such as liquor and tobacco. But most economists are fiercely reluctant to the use of subsidies in order to increase demand for certain utilities.

Political judgement, however, does not always conform with economic wisdom. Housing policy as part of the Allocation Branch is a common phenomenon in European countries.

The aim of Housing Policy, when part of the Allocation Branch, is to establish a **low housing price,** for all households, not only for selected ones. The support to housing demand is then **product-related,** i.e. determined by dwelling attributes, such as year of production, unit of production costs, and dwelling size. There may be historical reasons for such a policy.

5.2 Reconstruction

One example is Norway after World War II, when the country had been damaged on two occasions (1940 and 1944–45) and no house-building took place. It became a major political task to offer the homeless new dwellings. This might have been resolved by the development of a non-profit public housing sector, but Norway chose another path.

The Government offered utterly favourable amortisation terms for new, owner-occupied dwellings. The principal covered only part of the building costs (75%), and it was assumed that the home-owners provided a down-payment and also did part of the work themselves, Hoffmann (1958).

In recent decades Norway has altered forms of housing subsidies which now amount to 800 NKK (=140 USD) per inhabitant (tax reliefs not included). The results achieved are, however, impressive. More than 80% of the Norwegians live in owner-occupied housing. According to a study of the living conditions in the five Nordic countries, Norway has the highest housing standard, as well as the most evenly distributed, Vogel (1990).

5.3 Inflation

Accelerating inflation and subsequently augmented interest rates in the sixties and seventies necessitated a reconsideration of housing finance systems in several European countries. A basic principle of inflation-adapted housing finance system is that the amortisation scheme is adjusted to the household’ s ability-to-pay, as this develops with inflation. In essence, they can be outlined in two ways.

One is to let outlays for housing, total rent, or capital costs, keep pace with inflation. Normally this implies that the interest paid is below the market interest rate during the first years after completion.

Hence, say the initial interest rate paid on the principal is 5%, whereas the market rate of interest is 10%. The difference, 5%, is added as an additional debt on the principal. If the rate of inflation is 10%, the following year the capital costs will be 5.5% (=1.1×5%) and another 4.5% (10%–5.5%) will be added to the principal.

After some years the capital costs exceeds the market interest rate, and the repayment of the principal commences. Such amortisation schemes were developed in Sweden, the Netherlands and Norway, for instance, around 1970.

The other form of inflation adapted housing finance is to adjust the principal in pace with inflation, i.e. indexed loans. In addition, the mortgage is charged with a (low) real interest rate.

In Denmark indexed-loans were introduced around 1980. In practice these have come to cover only a very small part of the Danish credit market. One reason is that credit terms and taxes must be coordinated; they both must be issued either in “real” or in “nominal” terms. And in Denmark nominal income taxation has been maintained, NORD 1987:40 (1987).

5.4 Overt and covert subsidies

It is, theoretically, easy to outline inflation-adapted housing finance systems that are neutral with regard to the effects on the State budget. It is quite another matter, that is the historical evidence, to make politicians follow the rules of the game so that inflation-adapted housing finance systems also remain neutral.

Thus, a scheme for housing that was meant to be neutral may develops into subsidies. To examine the actual outcome it is necessary to distinguish between **overt and covert subsidies**. Overt subsidies, such as interest subsidies emerge as outlays on the State budget. Covert subsidies are more sophisticated.

As long as landlords and owner-occupants presume that the inflation-adapted mortgage, with initially low capital costs, eventually will be repaid, the effect on the State budget may be neutral as intended. However, if there is reason to believe that the principal (not to mention the additional debt), is never to be repaid, housing will, in effect, be subsidised. But this does not show as an outlay, but as a loss of public income. This can be depicted as a **covert subsidy**.

Tax reliefs to home-owners as a result of deductible interest costs are sometimes also regarded as a housing subsidy. This statement requires an exhaustive comment.

If deductible interest costs are matched by imputed, taxable income from the dwellings the net effect may very well be neutral at low inflation and interest rates.

However, if inflation and interest rates are high, and output of new owner-occupied dwellings is large, then subsidiary effects are likely to occur. Provided the tax level is augmented to compensate for tax losses, the magnitude of these subsidiary effects, however, will be extremely difficult to estimate, Swärd et al (1978).

5.5 A rule of thumb

Housing subsidies may be justified as being part of a welfare distribution policy, while in fact, they are part of Allocation policy. A simple rule-of-thumb to monitor the tendency of housing policy, is to look at the distribution of the financial support (overt & covert) with regard to whether it is product-related or household-related. The product-related support basically has perverse income effects, as people are likely to demand more housing the better off they are. Consequently they also receive larger subsidies.

Sweden, for instance, has mainly pursued an allocational housing policy since interest subsidies were enacted in 1974. The Ministry of Housing and Physical Planning has estimated the gross support to the housing sector to be 40 billion SEK in 1989 (tax relief from deducted interest costs included). That means 5000 SEK (=800 USD) for every Swede. 80% of this support was product-related, Waldén (1991).

6 Are housing policies necessary?

This paper must not be read as a kind of General Theory for Housing Policies, but rather as a tentative first step towards international comparisons in this field. Classifications of this kind are adequate for certain countries at certain times, but not for all countries at all times.

Thus, for instance, rent control has been omitted in this paper. Rent control has been a major tool to keep rents down in the State economies in Post-War Eastern Europe. The rationale of such a policy has been the notion that return on capital is regarded as Surplus Value and, as such, unearned income, in accordance with the Marxist paradigm. It is obvious that such an approach does not agree with the one adopted here.

A crucial question that emerges from the argumentation in this paper is whether Housing Policies are necessary. Alternatively, one may ask whether they are redundant, in the sense that housing questions are handled better when subordinated to a more general policy such as those represented by the three Branches.

Not all countries find it necessary to have a separate Ministry of Housing. In Britain the Department of environment deals with housing policy errands, and Finland has a similar solution.

In Norway the former Ministry of Local Government and Labour, has been responsible for housing issues; this has now become the Ministry of Local Government only. In Sweden in the sixties the Ministry of Interior dealt with housing investments and labour market policy, whereas, during the fifties the Minister of Social Affairs was in charge of housing questions.

The advantage of passing on housing policy matters to a department in some other Ministry is that greater coordination is facilitated. The Ministry of Social Affairs seems a suitable place when distribution aspects prevail in housing policy. The Ministry of Environment or Municipalities may be adequate when emphasis is placed on allocation aspects. When the stability aspects are considered the most important, the Ministry of the Labour Market is a feasible solution.

However, if the crucial problem is to coordinate various aspects of Housing Policy itself, the best solution seems an independent Ministry of Housing.

References

Hoffmann, J. (1958) “Boligbygging og boligpolitikk”. Oslo (Memo).

Johansson, A. (1966) Promemoria rörande bostadsfinansiering och hyresbildning, bilaga 2, in SOU 1966:44 **Bostadspolitiskt kreditstöd**. **Betänkande avgivet av bostadspolitiska kommittén,** Stockholm.

Lowry, I.S. (1983) **Experiment with Housing Allowances.** The Final Report of the Housing Assistance Supply Experiment. The RAND-Corporation, Cambridge.

Merrett, S. (1979) **State housing in Britain.** Routledge & Kegan Paul, London.

Murie, A. (1975) **The Sale of Council Houses. A Study in Social Policy.** Occasional paper no. 35. University of Birmingham, Birmingham.

Murie, A., et al. (1976) **Housing Policy and the Housing System.** London George Allen & Unwin Ltd, London.

Musgrave, R.A. (1959) **The Theory of Public Finance.** Mc Graw-Hill Book Company.

NORD 1987:40 (1987) **Bolig, inflation og skat.** Rapport afgivet av nordisk arbejdsgruppe om realfinanciering og realbeskatning. Nordisk Ministerråd, Köpenhamn.
Office of Population Censuses and Surveys (1987) **General Household Survey 1987,** London.
Reforme du financement du logement (1975) **Rapport de la commission d' étude présidée par M Raymond Barre.** La Documentation française.
Samuelson, P.A. (1955) Diagrammatic exposition of a theory of public expenditure. **Review of Economics and Statistics, 40,** 350–356.
Swärd, K., et al. (1978) **En metod för bestämning av effekter på samhällsekonomisk nivå av avdragsrätten for egnahemsägare.** M78:20, The National Swedish Insitute for Building Research, Gävle.
Urien, R. (1987) Reflections on the determining factors and the macroeconomic effects of construction market evolutions, in **Building Economics**. **CIB Proceedings of the Fourth International Symposium on Building Economics** (eds D.O.Pedersen and K.Szöke), Danish Building Research Institute, Copenhagen, pp 111–143.
Vogel, J. (1990) **Leva i Norden.** Nordisk statistisk skriftserie 54, Nordic Statistical Secretariat, Copenhagen.
Waldén, LJ. (1985) **Reflexioner kring fransk bostadsmarknad och fransk bostadspolitik m m.** M85:21, The National Swedish Institute for Building Reserach, Gävle.
Waldén, L J. (1986) "The research project: The construction sector and the national economy". CIB-group W82 meeting in Gävle. (Memo).
Waldén, L J. (1991) "What are Housing Policies for?—The Case of Sweden", in **Investment and Utilities Assessment in the Housing Sector** (eds B.Lefebvre and L.Westerlund), Almqvist & Wicksell International, Stockholm (French edition, Economica, Paris).
Waldén, L J. and Swärd, K. (1991) **Reflexioner kring Singapores bostadsmarknad och bostadspolitik.** The National Swedish Institute for Building Research, Gävle.

189
Housing system rationalization model

M. ŽAJA and P.ĐUKAN

Abstract
The issue of rationalization in the field of housing, i.e. in the sector that is now being completely reconstructed using economic principles and market-oriented methods, can not be solved as a separate subsystem. The efficiency of this subsystem depends on the efficiency of the entire new political and economic system. The process of transforming the current housing system structure into a new structure is a very complex project whose complex goals and multiple activities are in functional, time and spatial interaction.

This paper focuses on the goals and resources, conception and regulation of the “new housing policy” system in the Republic of Croatia.

Keywords: Housing, Rationalization, Political-economic System, Structure

1 Analysis of the existing state

The results of the housing policy applied to this date in the Republic of Croatia can not be considered satisfactory. Non-economic relationships, loose capital links, monopolized organization of construction activities and an inadequate system of “self-management” organization, all these factors explain the necessity for making significant changes in this sensitive area. One of the greater weaknesses of the former and present housing organization system is the very frequent change of construction methods (first, only market oriented construction of apartments and then, only socially oriented construction etc.).

The basic characteristics of the present situation in the field of housing and the observed deficiencies in the implementation of the housing policy and in apartment construction can briefly be described as follows:

a) State of the current housing stock

– The housing stock in Croatia does not correspond to the existing needs (it is estimated that approx. 146,000 apartments are lacking, that housing stock is poorly equipped and is, on average, relatively old),
– The development level and the state of housing stock greatly varies by individual counties, which also points to the inadequacy of the general development policy of Croatia applied to this date,
– Very poor maintenance of the existing housing stock and great number of the completely depreciated buildings.

b) Policy of the housing stock use

– The non-economic relationships still prevail in the use of apartments belonging to the social sector (the surplus of apartment space is inadequately taxed, various manipulations are possible regarding the inheritance of the former tenant's rights or in the apartment exchange operations, etc.),
– Administrative distribution of apartments is the main cause of a great number of illogicalities. Thus, the structure of tenants indicates that the persons with higher incomes had the advantage in the process of apartment distribution (due to the unclear social policy, social subsidies have been given to all tenants, rather than to only those with lower incomes),
– Because of the inflation rate and the fact that the annuities were not reappraised, the users of credits given for construction or renewal of family houses paid back only 20 to 30 percent of the real value of the funds allocated,
– Low rents (in 1987, the cost of the apartment rent, heating and electricity together amounted to 10.9% of the personal consumption, while the rent amounted to less than 2%),
– Great difference between the real value of the housing stock and that applied in the rent payment calculation (insufficient means were thus collected for maintenance of the existing stock and for construction of the new stock),
– Undefined service life of buildings and constant changes in the depreciation rate,
– The owners of social apartments do not sufficiently participate in the management and use of funds and apartments,
– Huge funds have been attributed to the socially and privately owned housing stock that does not reproduce itself.

c) Housing construction

– Because of the steep downward trend in the housing construction and the fact that it is practically impossible to obtain housing credits, those households that do not have an apartment are put in a very difficult and discriminatory position (this particularly affects younger persons),
– Widening of the gap between the ever increasing apartment prices and the salaries brings the entire housing policy into a hopeless position,
– High cost of preparation of land destined for housing construction which accounts for as much as 40–50% of the total price of the square meter of the constructed apartment (almost entire infrastructure development costs are borne by new investors, although such costs should be distributed among all those that will benefit from the infrastructural development),

– Great increase in the price of construction is due to the increase in the cost of materials,
– Long construction times make the construction even more expensive and the current inflation rate further contributes to the increase in the price of apartments,
– Inadequate organization and poor adjustment of construction companies to market conditions (poor utilization of capacities, narrow production range, long construction periods, high overhead costs),
– Inadequate and insufficiently defined land, spatial and urban development policy (complicated and time-consuming procedures for obtaining the building permit, lack of urbanized lots for individual housing construction in urban centers),
– insufficiently developed housing cooperatives.

d) Housing construction stimulation and financing

– For many companies, the housing issue is an element of their social policy (when social apartments are distributed among workers of such companies, the financial contribution of apartment users is insignificant) and thus these workers are privileged if we compare them to other citizens who are forced to use market mechanisms when solving their housing problem,
– Unfavorable credit terms for housing construction (high interest rates, short repayment period),
– Insufficiently selective and non-stimulating measures of the tax policy which do not favor a flexible commodity circulation,
– Funds accumulated through the payment of different utility fees, contributions and taxes are not used for the improvement of housing, but rather for various other purposes (county budgets).

2 Basic guidelines for rationalization in the field of housing

The required changes should lead towards implementation of the market-oriented relations in the field of housing but this also assumes introduction of such relations in all spheres of the social system. At the same time, the necessary social protection measures must be introduced particularly for the most endangered population categories. In any case, it should be understood that the success in the sphere of housing and infrastructure is closely related with the overall socioeconomic and political situation both in the economy and in the society.

It is proposed that the following issues be given particular attention in the scope of the housinginfrastructural reform:

– introduction of market mechanisms in managing the existing housing stock through application of economic (cost-based) rents,
– Abandoning the exclusive predominance of social policy in the housing problem solving and transferring the issue of buying apartments (considered as the lasting consumer goods) in the sphere of the private initiative (this would reduce that part of the general consumption in the overall social product and would simultaneously increase that part in the personal consumption and, hence, a positive step forward in

the population consumption scheme would be made in the favor of the lasting consumer goods),
- The real reappraised values of the housing stock and of the optimum service life of buildings should be determined. These values should serve as a basis for calculating economic rents,
- The selective social policy measures should be implemented in the sphere of purchasing and using the living space,
- The selling price of the newly constructed apartments should be reduced by cutting out most land preparation costs (which now participate with as much as 50% in the overall construction costs),
- Housing & infrastructure bank should be formed in order to finance the housing construction by allocating credits for which the lowest possible interest rates would be paid,
- Specific-purpose savings under favorable conditions should be stimulated,
- Stricter obligatory relations should be introduced to define rights and obligations of the apartment owner and user (co-owner), which should ultimately result in the more rational use of the housing stock,
- Urban construction costs should be borne to the much greater extent by the users of urban advantages, rather than by new investors (this latter case is currently the most often applied),
- The process of adapting to market requirements must lead to the restructuring and rationalization of the construction industry,
- Conditions should be created for the housing cooperative intensification.

The buying-off of the socially owned apartments is an activity that holds a prominent place among various actions aimed at the reform implementation. The value of apartments should be assessed by determining the reappraised construction value from which depreciation costs, land use costs and rent are deducted. Repayment period must be longer than the currently applied crediting periods (up to 35 years) including the mortgage credit possibility. An average instalment for the apartment buy-off should exceed the economic rent by max. 20–30% in order to stimulate tenants to buy such apartments. The funds acquired by the sale of the socially owned apartments should completely be allocated to the construction of new apartments.

3 Model of the housing industry and housing construction rationalization

Economic principles can not be implemented and the open-market conditions can not be created by the structural changes that would affect only this segment of economy since it is closely linked with other fields. It the housing and infrastructural reform is to be successful, it is necessary to make a complete reform of the overall political and economic system.

Here we start from the assumption that the new social and economic relationships will be established and that other fields of social and economic activities will also be positively affected. Only then will it be possible to incorporate the housing industry into the concept of the global socioeconomic development of Croatia as one of significant factors of this development.

Although it could be assumed that the problem will be solved by the creation of such new relationships, it still must be noted that the proposed model can not easily be applied to the apartment market. This is mainly due to the fact that the market is often affected by some disturbances and malformations (such as the rapid changes in demand, monopolistic behavior, financing problems, discontinuities in the process of preparation etc.) and, on the other hand, the apartment viewed as a merchandise is characterized by some specific features.

When apartment is defined as a merchandise, then its following features are usually considered: the need for the long lasting quality and constancy, its location or the influence of the surrounding zone upon its value, durability (“long consumption time”), slow reaction of market to the changes in demand because of the long construction time and, finally, its social character.

Changes in the apartment demand can influence supply only after a longer period of time so that the action of public authorities (governments) aimed at the user protection is needed in order to eliminate possible negative effects.

In addition, the apartment market is characterized by great quality variations. One of mechanisms for achieving the balanced state of the market is to base the apartment price on quality requirements and to classify the different-quality apartments into separate market categories. When the supply and demand at the level of different market categories become balanced, then the price differences reflect the quality differences accepted by users. On the market, the apartments will be bought by different types of end users depending on their quality requirements, personal preferences and buying capacity.

However, even if the housing industry could function by following only the open-market principles, i.e. disregarding the market differentiation, some population categories would still find themselves unable to adequately solve their housing problem or even to solve this problem in accordance with some minimum requirements. In such a case, the intervention of public authorities (governments) and their interference with market mechanisms is equally necessary.

This means that even in the open-market conditions it is indispensable to create a system of the programmed meeting of housing needs and to enable the public to influence the housing industry system. The housing policy reform in Croatia should also be viewed from this aspect.

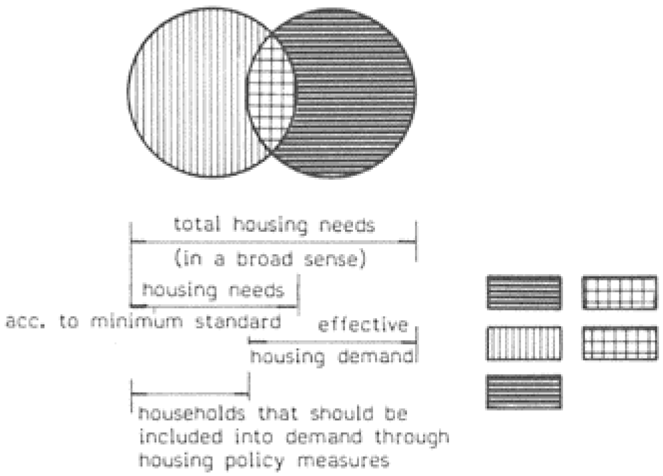


Figure 1

Consequently, the system whereby the housing needs within the observed period should be met must be formed in the scope of the housing policy programming activities.

The relationship between the housing requirements (i.e., standard apartments) and the market demand is presented in figure 1.

It is evident that the housing needs can not be met without making some normative decisions. It is therefore essential to prepare some alternative programs and to look for optimum solutions and standards by applying iterative methods.

Another important precondition for the reform implementation is the increase in the real personal incomes and the faster overall development rate in the Republic of Croatia. One of the basic assumptions for implementing market mechanisms in this field consists in the fact that the households should be financially stable enough to become an independent subject in the sphere of demand, so that they can replace in this sense companies, counties etc. through which many apartments are currently distributed to households. It is evident that the society will have to assume the obligation to assist individual households through different crediting and monetary policies, so that the households can effectively assume this new role and be able to meet their housing needs in the open-market conditions. Households will also have to attribute a greater part of their income (much greater than the part currently allocated for that purpose) for the housing and will, by such restructuring of consumption, contribute to the success of the economic reform.

When discussing the apartment market and consumption restructuring including much greater contributions for housing, we do not refer only to those households that do not have their own apartments or do not live in the social-sector apartments, since they represent only a smaller part of the population and, if only this part of population is affected by the increase in housing cost, that would not greatly contribute to the change in the consumption structure. In fact, all households and all apartments must be submitted to market mechanisms and affected by the increase in the housing cost. It is therefore necessary to implement a set of measures regarding the use of both socially and privately owned apartments. These measures would include modification of the taxing system and adequate valorization of the utility fees and the location rent.

In the open-market conditions applied to the field of housing, it is essential to make a distinction between economic activities and the social policy and, at the same time, to implement an adequate social policy and to provide realistic sources for its financing.

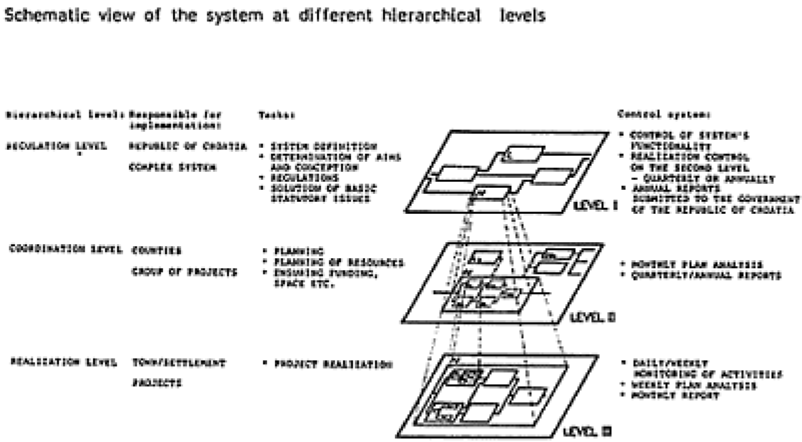


Figure 2

The housing reform constitutes a process in which the existing situation should be changed, i.e. reformed. When stating that this is a process, our intention is to stress the fact that the transformation from the existing situation into some new and better situation can not be performed in a single step. The entire set of measures and activities form a very complex project whose objectives and activities are grouped by fields and by the anticipated realization periods.

This is a process in which partial goals are realized through the execution of individual but closely interconnected activities and where the final objective is obtained by further linking of such activities.

The systematic approach enables segmentation of the housing reform process into several abstraction levels as shown in figure 2. It is evident that the real structure of the project is far more complex, but it is also quite clear that, on the level of the system regulation, it is necessary to define aims and conception, to determine the regulation model, to establish the program and to organize the project for the stage of design and realization.

In the dynamic sense, each project contains the following stages: conception, design, realization and exploitation. Rationalization is possible in all stages of this process, although it is known that the possible effects are greatest in the earliest stage. Figure 3 shows relationship between possible rationalization effects (R—possibility of cost reduction in individual stages) and the total cost of all stages (T).

Great creativity is required In the conception stage and it is in this stage that the most significant decisions, having the greatest impact on the final result of rationalization and construction progress, are made.

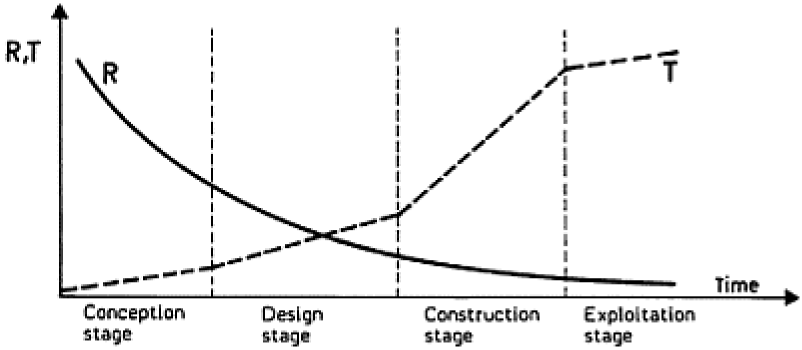


Figure 3

Rationalization in the housing management is based on a complex system of projects, subprojects and activities to be performed on different abstraction levels. Programming and realization should be organized in accordance with the principles of the projects theory. System of measures by which the progress is regulated in order to successfully realize the defined objectives in fact represents this new housing policy.

When we consider the new housing policy system in the light of the above mentioned theory, then the process is regulated at the highest possible hierarchical level. This very complex structure indicates that the regulation model should very carefully be defined by iterative procedures and by simulation of numerous activities. It is very important to stress the need to keep the system balanced at all times and to constantly maintain this balance, using the defined model, by corrective actions.

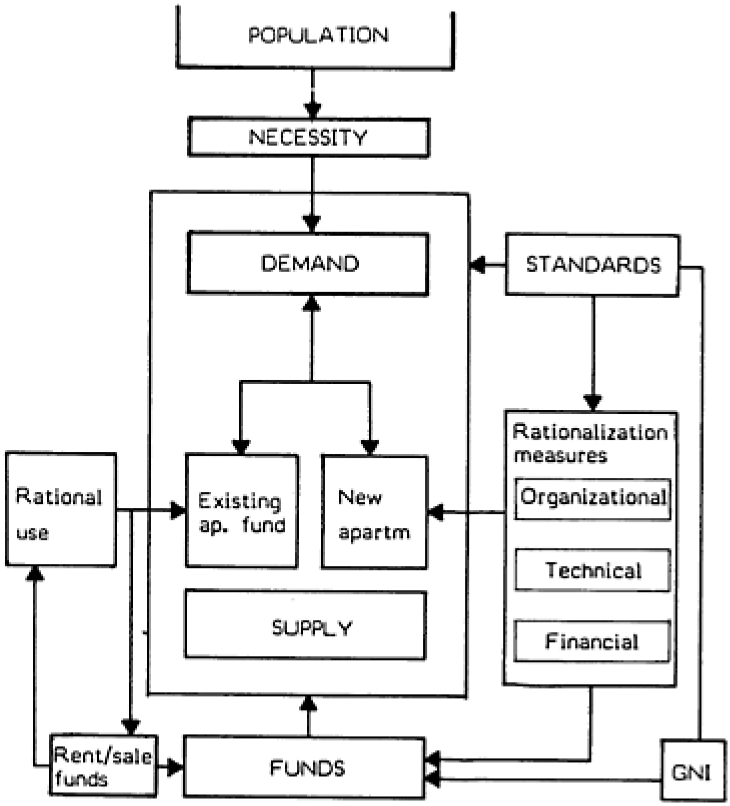


Figure 4

The extremely simplified regulation model presented in figure 4 suggests that the system of meeting the needs and of using funds that the society allocates to the field of housing is balanced in accordance with the open-market mechanisms. However, it must once again be pointed out that the satisfactory quality of relationships can not be achieved if the housing industry is to rely solely on market mechanisms.

Elements of outside limitations that considerably influence the system regulation and enable achievement of the balanced market-oriented supply and demand, imply a variety of often controversial activities but they still need to be properly balanced and defined so as to contribute as much as possible to the main objective.

It is possible to study a great number of activities and measures that influence rationalization of the entire system and such activities can constitute elements of the “new housing policy” set. Some elements have already been analyzed and studied to such an extent that the functions of influence on the process and of contribution to the main goal can be set for the global system, while other elements need to be further analyzed.

4. Conclusions

Due to the vast scope of this issue, we are forced to limit ourselves to defining only those functions that are of essential value to the system, i.e. to functions that significantly contribute to the reform objectives, that considerably influence the entire rationalization process and which, when implemented, enable functioning and further improvement of the system.

It is first of all necessary to analyze needs of the population and households and to determine the dynamic function of such needs. After the real apartment need is established, it is necessary to determine, taking into account the possible financing sources, construction and reconstruction programs through determination of alternative standards.

In addition, it is necessary to study mechanisms of using the existing housing stock, its valorization and the price of its use or sale, as a method for the rationalization of use and, at the same time, as a significant source of funds.

Rationalization measures (of organizational, financial and technical nature) also represent a very significant element of regulation of the system since such measures may greatly contribute to the cost reduction and to finding additional funding sources.

Minimum standards must be established in the programming process that represent the basis for the entire system establishment and for meeting the existing demand, by grouping all environmental and system-related limitations in order to define an optimum system of measures.

Three basic interventions must be made in order to achieve the above goals:

– housing stock valorization,
– rationalization and economic activation of the existing housing stock and
– defining the organization structure of the reform model.

A thorough study of these issues has been made and the needs that exist in the Republic of Croatia have been analyzed. Other functions of the macro-model regulation are defined on the conception stage and the guidelines for the further research work are set.

5 References

Đukan, P., Racionalizacija procesa stambene izgradnje, PhD thesis, Zagreb, 1990.
Jerkič, M., Human settlements, situation trend and policies, UN EEC, Ljubljana, 1988.
Žaja, M., General system theory (introduction), Narodne novine, Zagreb, 1985.

Author index

Subject index

This index is compiled from the 'key words' assigned to papers by their authors (plus some topics selected from the abstracts). The page numbers refer to the first page of the paper in which the reference is to be found.