Investment, Procurement and Performance in Construction

Edited by
PIERS VENMORE-ROWLAND
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Proceedings of the First National RICS Research Conference, held at the Barbican Centre, 10–11 January 1991 and organized on behalf of the RICS by Steve Brown (RICS Information Officer), Piers Venmore-Rowland and Trevor Mole.

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R·I·C·S

UK Chapman & Hall, 2–6 Boundary Row, London SE1 8HN

USA Van Nostrand Reinhold, 115 5th Avenue, New York NY10003

JAPAN Chapman & Hall Japan, Thomson Publishing Japan,
Hirakawacho Nemoto Building, 7F, 1–7–11 Hirakawa-cho,
Chiyoda-ku, Tokyo 102

AUSTRALIA Chapman & Hall Australia, Thomas Nelson Australia,
102 Dodds Street, South Melbourne, Victoria 3205

INDIA Chapman & Hall India, R.Seshadri, 32 Second Main Road,
CIT East, Madras 600035

First edition 1991

This edition published in the Taylor & Francis e-Library, 2005.

ISBN 0-203-97362-3 Master e-book ISBN

ISBN 0 419 17400 1 (Print Edition)
0442 31509 0 (USA)

British Library Cataloguing in Publication Data available

Library of Congress Cataloging-in-Publication Data available

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Preface

As part of the overall effort of the Institution to raise the general level of awareness in the surveying profession to research, the first National RICS Research, Conference was held on 10–11 January 1991 at the Barbican Centre in London.

This Conference concentrated on three critical areas of activity of the surveying profession, the investment process, procurement and management in construction and the analysis of building performance and, in each of these, presentations were given on the state of the art in practice and research, as well as contributions by outside researchers, who were able to provide a fresh and objective overview of these areas.

Within each of these, the presentations focused on particular areas of concern, such as methods of evaluation, the impact of new technology and the development of new financing techniques. This structure provided a very clear indication of the strong links which exists between research and practice, which is an underlying theme of the overall Institution policy on research and development.

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The Rt Hon KENNETH CLARKE QC MP

Sir Idris Pearce CBE TD DL FRICS
President
The Royal Institution of Chartered Surveyors
12 Great George Street
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London SW1P 3AD

Dear Idris,

I am writing to congratulate you on the holding of the first national RICS Research Conference and welcome the publication of the proceedings.

This was an important initiative. Such conferences can make a significant contribution to the nation’s research effort. I was therefore very pleased to be able to make the keynote speech at the Conference, and was glad of the opportunity to set out the Government’s policy on research funding.

With best wishes,

KENNETH C

DES

Part One

Investment

Finance

VEHICLES FOR PROPERTY INVESTMENT

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Department of Property Valuation and Management, City University, London.

Abstract

This paper discusses the types of property investment vehicles available, high-lights the different valuation techniques used for direct and indirect property investments, and looks at the implications for property investment vehicles and valuation techniques. It discusses the opportunities and threats facing chartered surveyors given the changing nature of the property market.

Keywords: Property investment vehicles, Liquidity, Correlation, Changing valuation techniques, Explicit DCF valuations, Opportunities, Threats, Commonhold.

1 Introduction

The views expressed in this paper are a combination of three different stand-points: namely as an academic, but perhaps more significantly as a former stock broker and a former investment surveyor. However, I fear that in many quarters a large proportion of my subject matter is not viewed as being part of the main stream for property investment surveyors. I firmly believe and will argue that it should be and the sooner the better.

Alas, given the time constraint I propose to cover the key factors and concepts as I perceive them and will not have time to deal with some items in the detail they deserve.

In this paper I shall dwell upon three features relating to property investment vehicles.

Firstly I shall discuss the types of property investment vehicles that are currently available.

Secondly I shall look at the differing valuation techniques used in the valuation of these vehicles and at the key differences between direct and indirect property investment valuations.

Thirdly I shall point to the implications for property investment vehicles, valuation techniques and the chartered surveying profession as a result of the changing market place and the likely growth in the number of property investment vehicles.

2.
The types of property investment vehicles

2.1
Listed property companies

These have been around for many decades and fall into two distinct categories: property investment/development companies, and property developer/trading companies. The former are valued in terms of the current estimate of their fully diluted net asset value (NAV). The latter are valued on a price earnings ratio (PER) basis in all but severe bear market conditions (as is the current position) when the main emphasis is placed on the underlying NAV. For both types of property company the valuations are subject to the companies having adequate cash flow.

The valuation and rating of property companies depends upon their performance prospects relative to the rest of the stock market. The ability to produce relative out performance is of fundamental importance in the eyes of fund managers. It is this relative dimension and the fact that their performance is often linked to the underlying sentiment of the stock market that makes property companies have different short term performance characteristics to the direct property market. In the long run the performance of property companies is directly linked to their NAVs and therefore, they may be viewed as a substitute for direct property investment for smaller investors, who are unable to put together a diversified direct property portfolio due to a lack of funds. Historically property companies have tended to out perform direct property investment thanks to several factors, including the benefits of having a portfolio part financed by debt (see Venmore-Rowland 1990).

Investment in property companies can take several forms, as shown in the table below:-

EQUITY

Ordinary shares
Convertible preference shares
Convertible unsecured loan stock *
Warrants
Options (to employees)
Traditional 3 month options
Traded options

DEBT

Preference shares *
Unsecured loan stocks

Mortgage debentures
Deep discount bonds
Zero coupon bonds
*=Investment analyst's view.

All the above categories of investment can be traded in the market place (except for employees' options).

Of the above, traded options have come from no where to being a significant investment vehicle for major institutional investors. Traded options are currently only available in Land Securities shares (approximately £6bn of underlying property assets and about 30% of the sector). Land Securities put and call options are increasingly used by institutional investors to hedge their property portfolio weightings. This investment medium has major implications for the property investment market and for the methodology of property valuations and is dealt with under the section on "valuation differences".

Deep discount bonds and zero coupon bonds as their names imply have coupons that are either below the full coupon for mortgage debentures or are zero. The choice of which to issue is largely determined by the market's and the company's perception of interest and tax rate movements, and upon the company's cash flow. These bonds are secured upon income producing properties. To issue such bonds the company does not need to be listed, but issues need to be large (£40m+) to be sufficiently liquid to satisfy investors in fixed interest stock. However, what makes them useful to the property investor in the current market is the low initial interest charge, which saves the company valuable cash flow in the early years. Also, the potential advent of commonhold and its application to commercial property, might enable companies to offer convertible deep discount or convertible zero coupon bonds where at a future date the bond holders have the option to convert their debt into the ownership of a predetermined part of the property. This would be an exciting innovation and would be a useful tool for companies undertaking large development schemes which require long term financing.

2.2
Exempt property unit trusts

These unit trusts are unauthorised and are designed for non tax paying investors, namely the pension funds and charities. They are open ended and as they are not authorised they suffer from not being widely marketed. The market for PUTs is rather illiquid. The units are valued in terms of their underlying NAV with no discount being given.

2.3
Authorised property unit trusts (APUTS)

APUTs as their name implies are authorised (and comply with the Financial Services Act 1986) and therefore can be widely advertised and marketed. In addition they are available to all types of investor. However they are being designed as a low risk form of property investment. The Securities and Investment Board's consultative paper No 49, indicates the following restrictions that are to be applied to APUTs:-

* The trust must be greater than £5m.
* Gearing is to be less than 15%.
* Developments are to be less than 15% of the portfolio.
* 20–60 year leaseholds are to be less than 10% of the portfolio, no leaseholds with less than 20 years unexpired may be held.
* No more than 15% can be invested in any one building.
* Up to 35% can be invested in Government and other public securities.
* Monthly property valuations by an independent chartered surveyor.

APUTs will be open ended and thus the manager has to be in a position to liquidate part of the trust's investments at any time in order to redeem units that investors wish to sell.

The market price of the units will be determined with reference to the underlying NAV of the trust. The units will not sell at a discount, but rather at net asset value.

I would argue that the valuers who undertake the monthly valuations should be required to provide, on a regular basis, detailed and sufficient information relating to the trust's property portfolio (eg addresses, lease details, building surveys, floor areas, etc.) so that other surveying firms can produce their own estimates of the underlying NAV and more importantly can gauge the prospective performance prospects for the trust. Thereby opening the market for APUTs to institutions and all categories of investors. The first APUTs should be launched in 1991.

The recent experience of Rodamco in Holland has shown the short comings of open ended funds that invest in relatively illiquid assets. Australian property unit trusts and American real estate investment trusts are examples of close ended trusts. Though they have also had a bad time over the past year or so, there is much to be learned by looking at their structures and their strengths and weaknesses.

Liquidity will be a problem for APUTs. I would strongly argue that serious thought be given to the formation of a well capitalised, secondary market place for APUTs (out side the stock market). Such a market place would be a far better provider of liquidity than the individual fund managers could ever hope to provide.

2.4
PINCS, SPOTS and SAPCOS

Much effort has been put into these, but alas they are stock market vehicles and whilst the stock market is far from keen on property it has not been possible to make them a viable proposition given the adverse market conditions, and the large sector average discount to NAV for property company shares.

2.5
Property futures

London Fox is proposing to introduce in 1991, four new futures contracts on: commercial property values and rents as measured by IPD's indices, and on house prices and mortgage interest rates.

Initially property futures were to be aimed at developers so that they could hedge their development risks. However futures are a zero sum game ie there is one winner and one loser. A developer who takes out a futures contract and loses, would be expected to settle in cash at the expiry of the contract. This might not be simple given that most of a developer's assets are likely to be illiquid. Property futures have subsequently moved their focus to the institutional investors. Given that the average pension fund has only 9% of its assets in property, property futures would represent a good hedging mechanism. It is the forward looking nature of property futures, coupled with a required understanding of volatility, perceived future trends, opportunity cost, gearing and the time scale that makes property futures (and traded options) a new concept for traditional property investors and advisers. As explained below traditional valuation techniques are unlikely to be robust enough to enable valuers to advise on the property futures markets.

2.6
Convertible mortgages and participating mortgages

These are secured on one or more buildings. A lower interest rate is charged in return for the ability to participate in the equity of the building or in the rents receivable.

Stanhope plc have recently launched a convertible mortgage to help finance a major City office development. Safeways launched a stepped mortgage debenture over 4 years ago, and several participating mortgages are expected in 1991. As mentioned under deep discount bonds above, the advent of a new commonhold tenure would greatly widen the appeal of this kind of financing, as the investor would end up as owner of part of the building. Under commonhold the general management and maintenance of the building would be the responsibility of the commonhold association, set up by the owners of the building. The overriding duty of the association would be the administration of its affairs and the management of the common property, and to administer and manage the commonhold in accordance with the wishes of the unit holders and in their best interests. (Aldridge 1987).

In France co-propriete works effectively and gives hope for the introduction in England and Wales of commonhold during the early 1990s.

It is the advent of and the combined effects of traded options, property futures, listed property companies, convertible and participating mortgages that are widening the scope of property investors. This coupled with the prospect of shorter leases will I believe have a profound impact on property valuation techniques.

3.
Valuation differences

It is the forward looking nature of property investment vehicles (APUTs apart) that I believe will produce this profound rethinking of traditional valuation techniques, and make valuation techniques more responsive to estimates of future cash flows.

The property market is currently in disequilibrium. There is a dearth of turnover and with buyers and sellers unable to agree on values. This suggests that the market pricing mechanism is inefficient. The stock market currently has a sector average discount of over 40% for property shares. Historically, this has tended to be on average around 25%. The analysts and the market place are currently indicating that property values are 10% to 20% too high. The difference in view stems from the fact that the stock market is forward looking in its valuation techniques and uses DCF based valuations. Whereas traditional property valuation techniques are implicit in nature. For example, constant levels of rental growth are implied, as are the effects of obsolescence. The office markets, over the past five years, have been deregulated to a point where in many locations the oversupply of accommodation has caused rental levels to fall and the prospects of rental growth are at least two years distant. This oversupply has decreased the demand for older less efficient buildings and yields have moved out at a speed historically not seen before.

A major draw back to the traditional valuation methods is that they are reliant on comparable evidence and are not forward looking. In a rapidly changing market place and, or where there are few deals being done it is fair to say that there will be a tendency for values to lag behind the investment worth of the property. On the way up the developer traders use this time lag to their advantage. However on the way down the market stalls as purchasers are not willing to pay the price as determined by the vendors' valuer.

The underlying valuation methods of the stock market are forward looking, ie appraisal based, though this market does use comparables to produce values in the short term. Share valuations set about appraising investment worth, ie the net present value of future anticipated cash flows. Moreover this investment worth is appraised in a portfolio context and not on an individual asset basis, ie (some) allowance is made for specific risk, which is diversifiable.

The valuation methodologies of the derivative markets, futures and options, by nature have to be forward looking. These markets often significantly influence the underlying markets.

Appraisal based valuation methods have a valuable role to play in assessing the investment worth of properties. When the market is in equilibrium and deals are being done, the comparables method of valuations should produce a similar answer to DCF based appraisal techniques. I would argue very strongly for property valuations in times of uncertainty and, or low turnover to be backed up by explicit DCF based appraisal techniques, since at such times valuation accuracy falls and the market pricing mechanism may become inefficient. Implicit valuation techniques backed up by explicit cash flow based appraisal techniques would high light miss-matches, and should increase martet turnover.

Further problems will be encountered with the valuation of convertible and participating mortgages. Traditional valuation methods are not robust enough to deal with these composite debt/equity investments, which require a DCF framework to include the effects of interest rates and taxation.

4.
Implications for property investment vehicles

It is argued quite reasonably, in my opinion, by the property industry that there is a place for property in a multi asset portfolio. The degree to which investors invest in property will I believe depend to a large extent upon the profession improving its valuation methods and improving the liquidity and tradeability of property.

To date the emphasis has tended towards a stock market solution eg PINCS. I would like to question this with the following in mind:

<u>Direct property</u>

<u>Pros</u>

low risk relative to equities

diversification benefits

hedge against inflation

good for matching long term inflation prone

liabilities

Cons

illiquid

management intensive

minimum portfolio size required

Property vehicles

Pros

liquidity

divisibility

management expertise

specialisation

gearing

can shift weighting/exposure

income benefits from discount to NAV

Cons

loss of control

tax slippage

short term poor relative performance

high correlation to stock market

Two of the factors that are working in opposite directions are correlation and liquidity. Direct property is relatively lowly correlated to equities, but is illiquid. Property vehicles are liquid but are more highly correlated to equities. I suggest a plausible aim for surveyors should be to keep some property investment vehicles separate from the equity markets whilst aiming to significantly enhance liquidity.

Chartered surveyors, if past history repeats itself are likely to find themselves left out of the emerging new property vehicle markets. However, this need not necessarily be the case, as I will illustrate using a SWOT analysis:

Chartered surveyors

Strengths	Weaknesses
Have a monopoly on information	No experience of screen traded markets
Good negotiators	Training too narrow
	Valuation techniques are not forward looking

Strengths	Weaknesses
	No central market place

Opportunities	Threats
Market traders available	Lose market share to: stock brokers, merchant banks, banks, major investment houses and accountants
Property based screen dealing	
Post graduate courses Commonhold	
Research	

I would like briefly to dwell on the opportunities. The likely advent of commonhold and the opening up of the land registry, provides an opportunity for chartered surveyors to make the larger investment properties more tradable and to speed up the transfer process. What is required also is more detailed information on which purchasers can rely (eg. building surveys, floor areas, legal searches, running costs, lease terms, tenant's covenant etc). If this information can be channelled through a central, computer based, market place then property investment surveyors would have the potential to deal more easily and quickly in direct property investments, but also in commonhold units, APUTs, convertible and participating mortgages, property futures, and even in property shares and options. The surveying firms have a monopoly on property information which they should exploit.

5.
Conclusion

The advent of the new alternative methods of investing in property opens up significant opportunities and threats for the chartered surveying profession.

Traditional property valuation techniques by themselves are not robust enough to deal with these new vehicles. A move towards the use of traditional valuation techniques in conjunction with explicit DCF techniques should be encouraged, and will be essential if chartered surveyors wish to gain a foothold in these new markets, and should reduce the problems of disequilibrium as faced at present.

A move to explicit DCF techniques will both increase the importance of information and research. It will place research departments in the front line, as is the case in the stock market, where research analysts are some of the highest paid people in these markets. Sadly, researchers in the property industry do not command positions of such influence. Wider use of appraisal based techniques would require many chartered surveyors to improve and hone their skills through additional education if they wish to prosper (survive) in a competitive market place.

5.1 In summary chartered surveyors need:

a) to reappraise their traditional implicit valuation techniques given the changing markets
b) to place more importance on research and forecasting
c) to look at ways of repackaging property investments to create a better range of products in which the institutions can invest and which the property companies can use.

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NEW METHODS OF FINANCING

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Abstract

This paper examines and describes the innovative methods of finance available to property companies, and concludes that UK property is financed by too much debt and too little equity.

Keywords: Finance, Equity, Bank Finance, Commercial Paper, Eurobonds, Domestic Sterling Issues, Private Placements, Deep Discount Bonds, Zero Coupon Bonds, Preference Shares, Quasi-Equity, Convertible Mortgages, Swaps.

1 Introduction

It is an interesting and, indeed, a very relevant time to consider the new methods of financing property. With the UK economy now firmly in recession, an oversupply of most types of property especially in the City of London and a shortage of funds for property investment and development makes it timely to review property financing.

Over the past few years property development, on a speculative basis, flourished basically on the back of excessive amounts of debt finance made available, especially from the UK banking system, both from UK banks and increasingly from the UK branches of foreign banks. The figures are, I am sure, known to everyone here today. The amount of bank debt currently outstanding to the UK property companies is currently around £37 billion. This figure does not include commitments already made by banks, but as yet undrawn by the property companies. This figure is not made available, but it could be significant and take the total amount of bank credit available to the UK property companies to well in excess of £40 billion. However the availability of new bank debt is shrinking and the rate of increase of new loans has also slowed significantly.

At the same time the amount of new equity made available to the property business has been somewhere in the region of £2 billion to £3 billion per annum.

The exact figure is difficult to obtain as I include in my definition of equity all monies made available to finance property other than bank debt.

The sources which most readily come to mind are: institutional purchases of buildings (over the past few years mainly from overseas), institutional take-up of debt (mainly debentures and Eurobonds) and the small amounts directly subscribed as pure equity finance. At that level, it is obvious that it will take many years to replace the bank debt outstanding and, for many years to come, it looks like the banks will be committed to “rolling over” their current outstanding positions.

This paper is not intended to address the problems which the banks are currently facing nor does it address the various problems faced by the smaller trader developers who are unable to repay bank debt as they cannot sell their assets. Assets, which in many cases have fallen in value significantly and no longer cover the principal of the loans in any event. The fundamental point that I am making is that UK property is financed by too much debt and has been starved of equity for many years. My paper is written against this background of a chronic equity shortage and excessive debt finance.

The title of this paper is “New Methods of Financing”, but it would not be complete without first commenting further on bank finance. While it must be any property owner’s wish to have a mix of finance sources, it looks likely that bank finance will continue to be, by far and away, the most commonly used source of finance over the next few years and, indeed, will be the only type of finance for certain property companies. I could not put figures on the above, but I believe that bank finance, <u>in one form or another,</u> will be used for at least 75% of all property finance.

Therefore, the new financing techniques which are available will only really be used to raise finance at the margins and will be restricted, in the main, to the larger and normally “listed” vehicles.

It is also necessary to stress that property in general is very much “out of fashion” worldwide, and, as such, means that the spreads being achieved on financings are almost double what they were twelve months ago and in many cases institutions worldwide will not subscribe for any type of property finance and many of the institutions who still subscribe for property finance will only take rated instruments.

Therefore, we have any industry perception problem with lenders, but within the lenders still in the market there has been a definite retreat to quality. The list of potential finance providers is still contracting which may drive spreads up even higher. However, finance raising is still possible and I will attempt to illustrate some of the newer sources which are available or are currently under development. I will concentrate on technically non-bank sources, but naturally much of the paper issued may well end up being held by banks.

2
Commercial Paper

The characteristics of this source are well known with Paper capable of being issued basically in Sterling, domestically in the UK or in US Dollars via a Euro-Commercial Paper offering or a domestic American Paper Programme.

This market is currently suffering from lack of investor confidence and only good quality rated names are successful on issuing. The Sterling market is virtually untapped by UK property names although there are some issues in the Euro-markets and the domestic American markets. Frequently better Sterling pricing can be achieved, in any event, by issuing in US Dollars and swapping into Sterling. I will comment further on swaps available later in this paper.

3
Eurobonds

The Eurobond market has been available for many years for UK companies and it is a market which has gained some depth in terms of the volume of institutions participating and in size of debt now outstanding.

Traditionally, Eurobonds denominated in Sterling have not done particularly well but there have been "windows of opportunity" over the years when it has been possible to issue long-dated sterling Eurobonds at maturities of 15/20 years at acceptable rates of interest. The bonds can either be at floating rates, or more normally, at fixed rates of interest. The Eurobond market does offer considerable flexibility and it is normally possible to achieve a wide spread of maturities although shorter maturities have become much more common in today's more turbulent markets.

I have already mentioned that Sterling has typically not been a very popular currency in which to issue. However, with the increasing depth in the currency swap market it has frequently been possible to arrange a Eurobond issue in a currency other than Sterling and then satisfactorily swap it into Sterling via a swap counterparty. Many UK companies have done this over the past few years and during 1990, MEPC issued two separate financial Luxembourg Franc issues and one Euro-Yen issue, both of which were swapped into Sterling at satisfactory levels. The increasing depth of the currency swap market is of major significance to borrowers who require Sterling.

Although not strictly limited to the issuance of Eurobonds, the issue of a bond can often be linked with an Interest Rate Swap to achieve the type of finance required. Increasingly, Interest Rate Swaps are used by the property company treasurer to achieve the type of finance required. For instance, MEPC has entered into in excess of £500 millions of Sterling Interest Rate Swaps, swapping floating rate Sterling into fixed rate Sterling at attractive rates. This has enabled the treasurer to achieve fixed rate finance in a market which was not receptive to fixed rate issues at anything other than the shorter maturities. The Interest Rate

Swap market is very active up to 7 years but, on occasions, it is possible to swap well in excess of 10 years if a specific issue presents itself and there is a counterparty required.

In summary, the Eurobond market does demonstrate amazing depth and also resilience in difficult times and it is normally possible via the swaps markets, both currency and interest, to obtain the currency of your choice at either fixed or floating rate.

4
Domestic Sterling Issues

Domestic Sterling issues have traditionally been of first mortgage debenture stock which is obviously fully secured. This market is still available but it is becoming rather expensive in terms of margin in today's troubled markets.

Occasionally, it has ben possible to issue unsecured domestic Sterling and MEPC issued in this market a couple of years ago at an acceptable rate for a maturity in excess of 40 years.

However, the domestic Sterling market does, in many ways, lack depth and can quite easily become saturated with too much paper. Typically no more than £1.5 billion to £2.0 billion can be absorbed in a year which is not particularly large when viewed in the context of the amount of cash required to finance UK property development and investment. However, it is a market which can and is used on a periodic basis by many property companies and, in the case of first mortgage debenture issues, it is possible for smaller companies to tap the market provided that there is an adequate package of property available as security.

5
Private Placements

The private placement market has been available for many years and because it is private there is not a great deal of written word about the depth of the market. However, it has been, over the past few years, commonplace for the larger companies to source their borrowings in many overseas markets which were receptive to a UK property company credit. Typically the markets have been in the USA, Japan and one or two of the Continental European markets.

These issues obviously depended very much on name recognition and normally the company needs to be rated to give it credence with the lender. It is difficult, as I have already mentioned, to get a feel for the volume of debt raised in this manner, but I am sure it has been quite significant. MEPC has done several deals over the past three or four years and I know that one major US Dollar deal was done by Hammerson during last year as it was particularly well documented in the financial press.

The major benefit of the private placement market is that the debt instrument created can be very much tailored to the needs of the borrower. It is frequently possible in this private placement market to get longer maturities than might be available in the public market. This better suits the needs of the property company, which wants long-term debt as property is a very long-term business. However, the spread demanded by the lender tends to be larger than would be payable in a public issue, partly to reflect the fact that the maturities frequently tend to be longer and the fact that the issues are non-liquid, which means that once a private placement is in position it is particularly difficult for the lender to "sell down" its participation to another institution. Frequently such "selling down" is prohibited under the terms of the loan agreement.

However, it has been an important source of finance and I am sure will continue to be an important source of finance over the next few years.

6
Deep-Discount and Zero-Coupon Instruments

This is not necessarily finance in itself, but more a tool which can be used to help treasurers fund a particular cash flow situation. The term covers a wide range of instruments which go from the deeply discounted issues through zero-coupon issues up to and including stepped coupon issues. These instruments can either be created via the debt instrument itself or can be manufactured via the Interest Rate Swap market although this is less common.

Because property is a business which incurs a negative cash flow for the first 5/10 years normally, these instruments are particularly useful in matching the cash flow from a building to the payment of interest on the debt financing it. While these types of instrument have not been widely used in the property business, they have been exploited by one or two companies and I am sure they will be used further in the future.

These instruments are, as I have mentioned, used to match the flow of income on a property to the payment of interest and are not intended to artificially distort the profit and loss of any one particular accounting period although there is some possible flexibility which can be built into the accounting treatment.

The concept was initially widely used in the USA as a means of acquisition financing and I am sure it will be more widely used in this country in the future.

7
Preference Shares

Preference shares have the legal characteristics of equity but the substance of such shares is basically debt.

However, some companies have successfully employed them to finance property acquisitions. It is possible to issue preference shares domestically in the UK, but the market is rather small and they can be expensive when compared to other sources of debt finance (remember that the dividend on a preference share is a distribution of profit and not tax deductible).

If the level of gearing in a company is an issue then preference shares can be quite successful as, by and large, preference shares are regarded as equity when it comes to working out the gearing covenants with your various lenders.

While, I believe, no UK property company has yet issued preference shares in the USA, where there is a growing market and where it is possible to issue preference shares denominated in US Dollars out of the parent company in the UK and get good rates of dividend because of the tax treatment of dividends available to US holders of these preference shares. The tax treatment is tabled in Appendix "A". The general nature of this paper makes it impossible to go into the characteristic of these American shares in detail. It is enough to mention that they are potentially available to a good quality, rated UK property company.

8
Quasi-Equity

This heading covers such instruments as convertible bonds and warrant bonds, which can either be issued through the Euromarkets or occasionally in some other tax jurisdiction.

Convertible bonds are bonds issued and give the holder the entitlement to convert the bond at a specified time in the future, into shares of the issuing company. In giving this equity right to the holders of the debt the interest rate achieved is normally substantially better than could be achieved via normal debt issues. However, one has to be careful on the accounting treatment.

The equity warrant situation is different and here a holder buys a warrant which is basically a right to require a company to issue shares at a pre-agreed price at a specified date or dates in the future. This has not been, to my knowledge, used by any UK property company but it is available should there be a need in the future.

The problem with all convertible and warrant issues is normally that the conversion price is a premium which is less than the discount at which the property company's shares currently stand to the current net asset value. This is unpopular with existing shareholders. Conversion then leads to a dilution of net asset value. Convertible issues can lead to an under-performance of the company shares due to the belief that the shares which will be issued on conversion could well over-hang the market for a period of time. However, at specific times in the past few years such issues have been successfully made and the companies have achieved significant savings on their normal interest bill.

9
Quasi Equity/Convertible Mortgages

I mentioned in my introduction that the biggest problem that we had in the UK was a shortage of equity to finance the property business. Over the past few years there have been many attempts to create new sources of investment in the property business which have gone under various names, such as unitisation or PINCS.

What all these vehicles attempted to achieve was a new method of investing in property with fiscal transparency.

Fiscal transparency has not yet been achieved in this country and it is unlikely that it will be easily achieved as the Treasury do not seem to be sympathetic towards amending the tax rules. However, I am sure that there will be further work done on such unitised vehicles in the future especially as there is a basic need, much more so than in previous years, to create new sources of finance to act as a "take-out" for some of the bank lines already in place.

There have also been recent attempts at convertible mortgages in the UK, and the last one to be announced was an issue by Credit Suisse First Boston on behalf of Stanhope Properties, regarding a building let to ITN in Gray's Inn Road. This convertible mortgage is still in the market and I do not yet know how the issue has gone.

What convertible mortgages seek to do is to give the borrower a lower rate of interest during the length of the mortgage, by giving the holder of the mortgage a right to convert in to part of the equity in the building at the end of the mortgage term. There is frequently an option in the mortgage whereby the lender can be paid off in cash at the end of the mortgage term if the holder does not want to participate in the equity in the building. These instruments which have been widely used in the USA can be structured tailor-made to the needs of the issuing company and there have been many in the USA which have successfully financed major property acquisitions.

There are certain problems in UK law with convertible mortgage which I do not propose to go into, as they have been well documented in the property press. However, I think that everyone should view this as an exciting potential new source of finance for property finance.

10
Summary

I hope that the few sources of finance I have mentioned are examples of what can be achieved in the finance market today outside the traditional banking-types of finance.

However, in today's market conditions, it is becoming more difficult to raise finance and the margins which the lenders are achieving are significantly higher than they were six months ago and there is no evidence that this trend will change in th foreseeable future.

There are still sources available, although at a much more expensive rate. The overall situation remains fluid.

Appendix A

US Companies

Item	Amount	Notes
Dividend (determined by auction)	$75	For every $75 in dividends the company pays
	+	
ACT related credit	$25	Each eligible US holder also becomes entitled to a $25 ACT related credit
	=	
Total of dividend and ACT related credit	$100	The total of the dividend and the ACT related credit is $100
	–	
UK withholding tax	$15	UK Inland revenue withholds $15
	=	
Cash eligible to US holder	$85	Leaving $85 to be paid to eligible US holder net of US taxes generally in a single payment on dividend payment date
	–	
US federal income tax	$19	An eligible US holder who can fully utilise credit for UK withholding taxes pays the Internal Revenue Service $19, ie 34% tax on $100 minus $15 foreign tax credit
	=	
Net income after UK and US federal income taxes	$66	Leaving $66 to an eligible US holder after UK and US income taxes

US Individuals

Item	Amount	Notes
Dividend (determined by auction)	$75	For every $75 in dividends the company pays
	+	
ACT related credit	$25	Each eligible US holder also becomes entitled to a $25 ACT related credit
	=	

Item	Amount	Notes
Total of dividend and ACT related credit	$100	The total of the dividend and the ACT related credit is $100
	–	
UK withholding tax	$15	UK Inland revenue withholds $15
	=	
Cash eligible to US holder	$85	Leaving $85 to be paid to eligible US holder net of US taxes generally in a single payment on dividend payment date
	–	
US federal income tax	$13	An eligible US holder who can fully utilise credit for UK withholding taxes pays the Internal Revenue Service $13, ie 28% tax on $100 minus $15 foreign tax credit
	=	
Net income after UK and US federal income taxes	$72	Leaving $72 to an eligible US holder after UK and US income taxes

Evaluation

METHODS OF PORTFOLIO ANALYSIS

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Abstract

The current status of property portfolio analysis is reviewed in the light of fund managers' requirements for information; the particular characteristics of property as an investment medium; and data availability. A number of analysis technique are assessed ranging from simple descriptive measures of absolute and relative performance and portfolio risk, to diagnostic measures of the sources of abnormal returns.

1
Portfolio Analysis in Context

A portfolio analysis report may not initially appear to constitute research. The most obvious products of a portfolio report will be an assessment of the investment returns achieved by the portfolio and the performance of the fund relative to the market. It thus fulfils a monitoring function which is necessary to discharge reporting obligations to trustees and investors.

Below the surface, however, a wealth of other information can be extracted from detailed comparison of a portfolio with the market. This rich resource transforms portfolio analysis from a simple measurement tool into a powerful applied research technique, which can guide strategic planning of a portfolio and its day-to-day management.

1.1
Portfolio Strategies

The development of portfolio analysis as an applied research technique requires an appreciation of the strategic and management decisions which confront a fund manager; and of the particular characteristics of property as an investment medium.

The factors to be considered by the portfolio manager will depend on the type of fund—its size, obligations, tax status, and likely flow of funds. They will, however, broadly fall into the following categories.

* The required balance between capital and income return
* Acceptable level of risk
* Timing of capital injections.
* Allocation of funds to sector and property types
* Size of holdings
* Method of funding
* Regional distribution of assets
* Selection of individual properties

Portfolio analysis must be directed towards providing fund managers and their advisers with the necessary information to guide these decisions.

1.2
Characteristics of Property

The characteristics of property as an investment are not unique. They have many features in common with the fine art market, but they do set property apart from equities or gilts in a number of ways.

First and foremost, property lacks a centralised market mechanism in the form of a trading floor and is, as yet, a non-unitised asset. It is available for purchase in whole, heterogeneous units. Trading is by negotiation and assessment of value between the parties. In some case the values of assets may be interdependent on contiguous sites. In almost all cases, transaction costs are high. Trading is uncertain, slow and expensive.

Second, property is essentially a managed asset which may be improved or altered by subsequent injections of capital. Furthermore, the assets require repair, maintenance and management of tenant income.

All these factors make it necessary for the fund manager to have available a considerable quantity of detailed information both on his own properties and on other parts of the market. The absence of a centralised market mechanism and the low level of trading, however, make data on prices and yields very scarce. Such information is essential to an efficient market and without it, the property market has been forced to turn to alternative sources.

1.3
Data Availability

IPD now hold records of almost £40bn worth of commercial property investments owned by the major UK financial institutions and some property companies. From this huge database they have evidence of a very large number of transactions. However, the extreme heterogeneity of the market means that even this volume of information is very thin when broken down by property type and region. Furthermore, sales recorded over a period of a whole year cover too broad a span of market movement to provide useful information on current yields. The results for 1989 showed that an average of about 60 sales a month might be recorded in the whole database, but this would be to few to provide a reliable index even at an aggregate level. The number of sales in earlier years was far fewer.

1.4 Valuation Based Indices

Thus analysis of the property market to date has had to fall back on the use of data derived from the statutory periodic valuations carried out on investment portfolios. The indices of market movements calculated by IPD and individual firms of Chartered Surveyors are all based on valuations, and the investment analysis techniques which have been developed for property portfolios depend on them. It is, therefore, essential to assess the possible drawbacks of valuation based indices as the peg on which to hang such analysis.

There are two questions at stake:

* Are valuations a good proxy for prices?
* What are the limitations of smoothed time series for investment analysis?

On the first issue there has always been doubt, fuelled by publicity surrounding individual “inaccurate” valuations. However, IPD has carried out a number of tests on the data it holds for the years 1980–88 and has demonstrated that on the basis of the 1400 sales recorded during that period, and taking account of time lags between the final valuation and sale dates, the valuations accounted for all but 7% of the difference in agreed sale prices. This could be taken as offering a considerable measure of reassurance that, on average, valuations are an acceptable proxy for prices. However, this analysis was carried out largely over a period of a strong and rising market when transactions evidence was fairly freely available to the valuers. The task of appraisal has undoubtedly been more difficult in the thin and fragile market of the last nine months and IPD plan to repeat their analysis following the 1990 valuations.

The second issue arises from the observation that valuations tend to generate a smoothed time series: it is possible to detect serial correlation in indices based on valuations. An obvious reason for this is that appraisals are based on comparable evidence of rent levels and yields which do not coincide with the date of valuations. Furthermore, valuations in practice are not carried out on a single day. However, the evidence on which purchasers are making their bids is exactly the same as that of the valuers and it thus seems reasonable to suggest that the market itself follows a smoother time series than that of equities, where synchronised and almost immediate information is available to dealers. A property index based on prices would be likely to demonstrate similar smoothing.

The limitation imposed by the finding that valuation based indices demonstrate serial correlation is, however, largely confined to the area of comparison of the volatility of property returns with those of equities or gilts. Here there is undoubtedly a danger that the use of valuation based indices will suggest that property is a less risky asset than the other two main classes. Asset allocation models based on comparisons of volatilities must therefore be handled with extreme caution.

The disadvantage of valuation indices for analysis within the property market are, however, less severe and, in the absence of any other sound source of information, there seems little alternative but to proceed with caution with their use. If the property market is to attain respectability alongside the more established investment markets, it must develop comparable investment analysis tools on the basis of whatever data is available in this considerably more complex market.

1.5 Other Data Limitations

The paucity of price information is not, however, the only restriction placed on property analysis. The characteristic of property as a managed asset imposes the requirement of detailed recording of both capital and revenue expenditure, which must be drawn direct from accounting records. Ideally the timing of these cash flows would be recorded precisely to calculate accurate returns on capital employed. The computerisation of all large accounting systems now makes this possible for capital payments, but this was not the case historically and many small funds are still unable to provide anything more detailed than annual reconciliations. On the revenue side, irrecoverables are rarely calculated more frequently than annually.

Confronted with these limitations of data availability, IPD offer portfolio analysis services at two frequencies. The majority of funds are valued only annually. Most have valuations at the calendar year end, but many pension funds have March valuations. A few have other set valuation dates and some still value on a rolling basis. Most Managed and Unit Linked funds, however, are valued monthly, and IPD supplies a monthly monitoring service of the performance of these funds against the benchmark of the IPD Monthly Property Index. However, the full IPD portfolio analysis service operates on the basis of annual valuations. Fund’s own results are supplied to their year end, but Comparative analysis of non-December valued funds is done on the basis of interpolated December valuations. Where funds have rolling valuations these are synchronised to December by linear interpolation.

In all cases supplementary capital expenditure is assumed to take place in the mid-point of each year. The timing of purchases and sales, however, is weighted according to the month of the transaction. Each property is recorded separately and aggregate results are calculated as money weighted averages. Data is generally recorded back to 1980 but longer time series can be analysed where data is available.

2
Methods of Analysis

Analysis of a portfolio needs to follow a simple logical sequence. It starts with an appraisal of the pattern of investment in the portfolio and an assessment of the fund's structure, then turns to the results of the portfolio as a whole and of its constituent parts. By breaking these down systematically one can define the sources of good or bad performance to begin to understand the mechanisms at work within it. Following this diagnostic process rigorously it is possible to reveal the results of past decisions and to indicate the likely outcome of future actions.

To illustrate this procedure it is helpful to look at the results of some typical portfolios. IPD cannot reveal the results of individual portfolios; the figures used in the following examples have, therefore, been adapted to indicate typical results.

2.1
Fund Size and Patterns of Investment

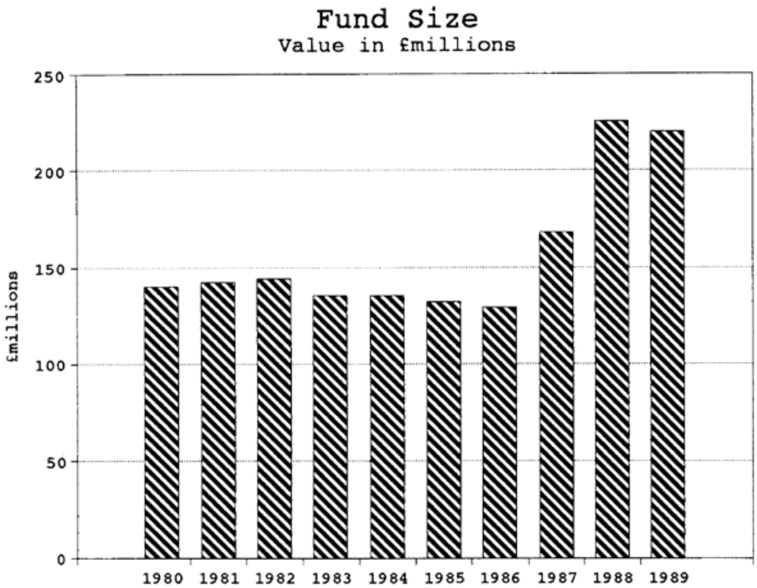
Timing and allocation of investment is fundamental. Figure 1 illustrates the pattern of growth of a medium sized fund. It shows a fund which underwent a dramatic change in management style which generated exceptionally good returns in the late eighties. In the early years of the decade it was passively managed and the value of the fund fell in absolute as well as real terms. The number of properties fell sharply as smaller holdings were weeded out.

There followed a period of substantial reinvestment in 1986 and '87, despite continued thinning of the portfolio (Figure 2). This level of investment, combined with dramatic increases in the value of holdings, resulted in a massive increase in the size of the portfolio in 1987 and '88. Significant capital appreciation continued in 1989 but was counteracted by heavy selling just before the market turned down.

2.2
Fund Structure

The high level of turnover in this fund brought about significant changes in the structure of the fund. Prior to 1986 the portfolio reflected the market sector mix very closely but by 1989 the structure had changed radically (Figure 3). The total office content had been cut to less than 30% and the London office content to

Figure 1



only a fifth of this (IPD average 39%). The proportion of industrials had increased to almost 26%, more than double the IPD average.

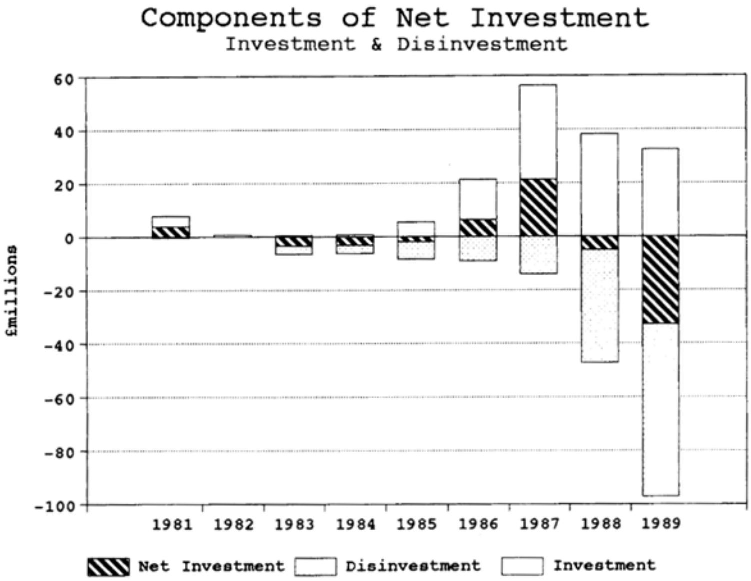
The fund's retail sector had also grown significantly and it is helpful to look at a more detailed description of the fund's asset mix by property types. Figure 4 shows how the fund had moved strongly into retail warehouses.

This type of analysis can profitably be extended to examine the composition of the fund in terms of the regional distribution of assets an particularly the size distribution. The majority of medium and large sized funds have tended to reduce the number of small properties in their portfolios, acquiring in their place a few very large holdings. The prosperity of the London office market in the 1987/88 period encouraged this as the unit of investment in that market was generally substantial. Strong growth rates further exacerbated the effect. Thus many funds now find themselves holding a high proportion of their assets in a few very large properties. The effect of this on the volatility of their returns is a matter of some concern.

Mal-distribution of property sizes can also occur in situations where funds (particularly unitised funds) are forced to sell medium sized properties in response to demand for encashment. In these cases it is often quickest for funds to sell medium sized properties, which can leave holes in the size distribution.

It is also valuable to assess the level of construction activity in portfolios. Developments inevitably drag down fund returns during their construction phase when they are valued at book cost. The timing of development programmes is thus critical both in their juxtaposition to one another and in their final arrival on

Figure 2.



the market. Long term funds may be less concerned with the impact that they may have on returns in any one year, provided that their contribution to long term performance is satisfactory. Short term or open ended funds will be considerably more sensitive.

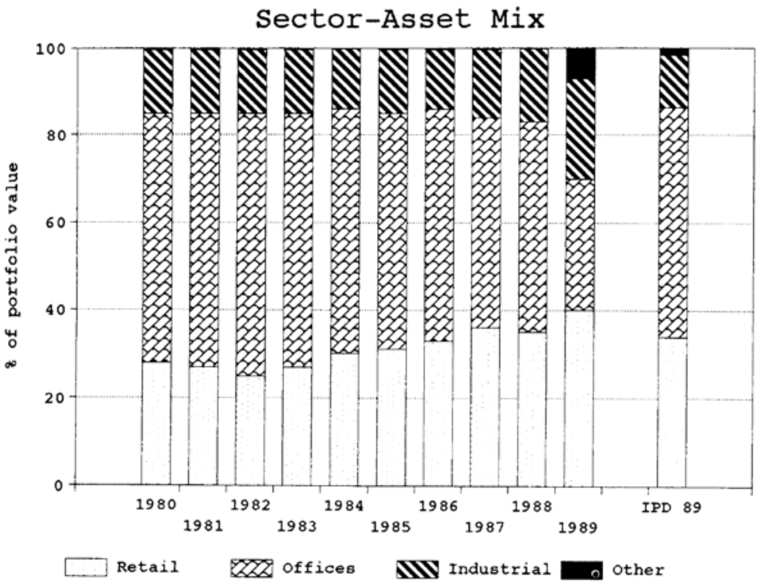
2.3 Measures of Performance

Once the underlying structure of the portfolio is understood, it provides the basis for interpretation of the fund's performance. How well has the fund performed? There are a number of ways of looking at this question.

* Performance in absolute or relative terms— relative to the market, relative to other funds of a similar type, or relative to other types of investment.
* Results in nominal or real terms
* Short or long term performance
* Money or time weighted returns
* What is the volatility or risk associated with the fund's returns?

Returning to the earlier example, the box plot display illustrates the absolute and relative performance of the fund against the market and indicates the fund's ranked position against all other contributing funds (Figure 5). Annual results

Figure 3



and long term performance are shown in terms of total return. The fund is seen to have had poor results in its early passive phase up to 1986, but improved sharply in 1987 and returned excellent results in both absolute and relative terms in the last two years.

In this case the annualised, time weighted return for the period 1980–89 is almost identical to the money weighted Internal Rate of Return for the same period. Although turnover was high in the last three years, the level of investment was not sufficiently increased to allow the later years good performance to dominate the IRR calculation. In cases of small, rapidly growing funds, the differences between the two methods of calculating long term results can be quite significant. The IRR method of calculation will always tend to give a higher result on a growing fund in a strongly rising market as the later years are weighted more heavily in the IRR calculation.

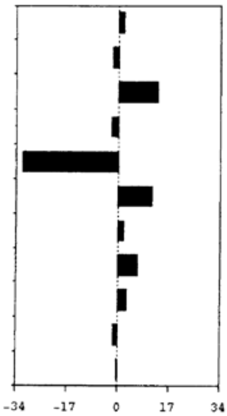
IPD generally use the time weighted, annualised measures of long term performance as these give a result which is independent of the timing of investments and thus a better measure of the quality of the assets held in the portfolio. The IRR, which takes account of the timing of capital injections, reflects the manager's skill in selecting the timing of investments.

The results illustrated in Figure 6 show the performance of the portfolio relative to all other funds in the service, and to the market as a whole. When comparison with other funds of a similar type is required, this analysis can be reproduced against any appropriate subset of funds—pension funds, Life funds, unitised funds or funds of a comparable size. Comparison with other benchmarks

Figure 4.

Asset Mix by Property Type 1989

Property type	Fund % of CV	IPD % of CV
Single shops	17.2	15.5
Shopping centres	12.5	14.3
Retail warehouse	15.1	2.1
Other retail	0.0	2.0
London offices	7.1	38.7
Regional offices	25.0	13.7
Industrial/office	3.5	1.8
Warehouses	12.5	5.9
Manufacturing	7.1	4.2
Sites	0.0	1.5
Other	0.0	0.4



such as equity returns, the FTA Property Share Index or the RPI can also be useful.

2.4
Volatility of Returns

Long term measures are generally considered to be the most significant gauge of property fund performance, but extreme volatility of returns is also a cause for concern, especially for open ended funds. The total risk of an individual asset is defined as the standard deviation of its individual returns. Sharpe has demonstrated that this risk may be divided into two parts: the systematic risk which is associated with the volatility of the market, and the specific risk of the individual asset. By regressing the returns of the individual asset against those of the market, the regression co-efficient beta may be used as a measure of the systematic risk, and the standard deviation of the error terms about the regression line acts as a measure of the specific risk. A beta of 1.0 represents an asset with no systematic or market risk.

This principle may be extended to measure portfolio risk by regressing fund returns against those of the market. Portfolio risk can be minimised by selection of an asset mix which reflects that of the market.

Figure 5.

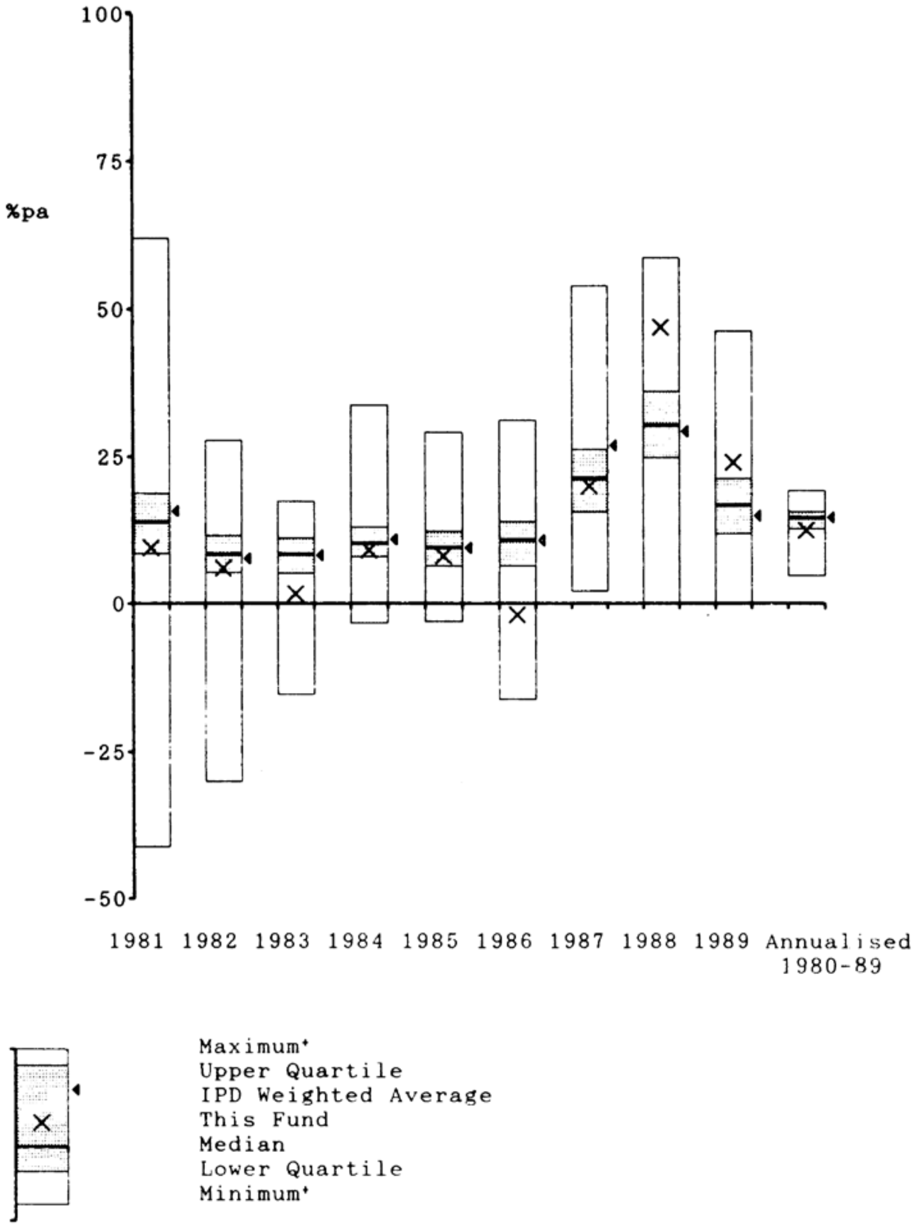
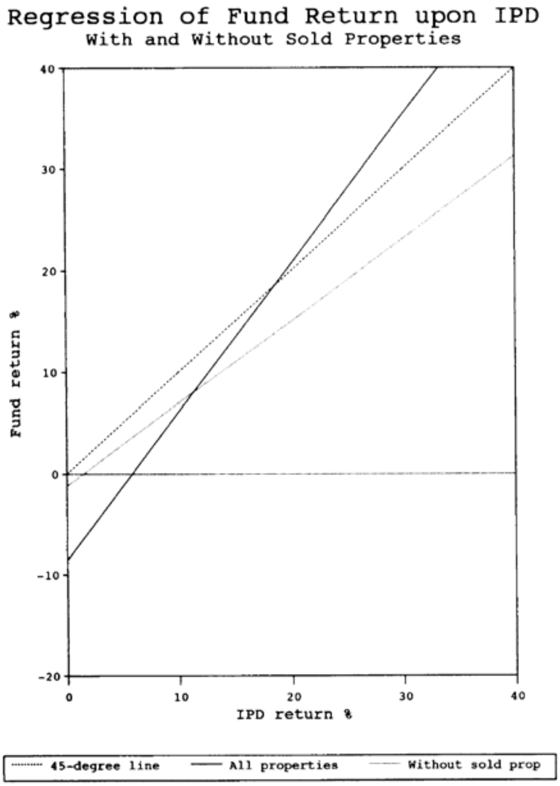


Figure 6 shows the results of this analysis for the medium sized fund described earlier. It shows two regression lines: one for the results of the entire fund

Figure 6



regressed against those of the market, and one for the fund results excluding sold properties. Looking first at the all properties results, the regression line shows a beta of 1.46. The regression is based on the fund returns including both transactions and developments and in fact much of the cause of the extreme volatility and the high beta value is associated with the trading and development activity of the last three years. The extremely low returns of 1983 and 1986, which also contributed significantly to the overall volatility, both stemmed from negative returns from the fund's provincial office portfolio.

The evidence of IPD contributors shows betas ranging as high as 1.7, with that of the median fund slightly below 1.0. This type of analysis is still in its rudimentary stages, not least because the time series available is still very short. It is included at this stage only as an indication of the direction in which risk analysis should progress. The findings are, however, already showing interesting results.

Not surprisingly, the majority of large funds tend to track the market fairly closely and generate betas close to 1.0. High betas are generally found in specialised funds with, say, high London office content; funds with a high proportion of their assets concentrated in a few very large properties; or funds with heavy development programmes. Curiously though specialised funds do not always produce high betas. It is clear that diversification of risk can be achieved within such portfolios. One fund, for example, which has over 70% of its assets in the retail sector, and almost all in standard shops, has a beta of below 1.0. Its returns have been almost flat throughout the decade, significantly outperforming the market in the early years and only dropping below in 1989. This consistency was achieved despite the downturn of the retail market after 1986 as the fund's own properties in different parts of the market successively achieved excellent results. There are more than 200 properties in this portfolio and barely a handful valued at more than £5m. The diversification has thus been achieved by very extensive and catholic regional distribution of the assets.

The second line on figure 6 which describes the regression equation for the portfolio returns excluding sold properties, is included to give an indication of the underlying risk profile of the current portfolio. It is the record of the covariance of the existing assets with the market which will indicate the likely movement of the portfolio with the market in the near future. It shows that the removal of some massive transactions from the last few years and the exclusion of some of the provincial office which had dragged down return in some of the earlier years, has reduced the beta value to less than 1.0. The substantial reduction of the London office portfolio by the end of 1989 has undoubtedly been a shrewd move to protect the portfolio against the now established downturn in the market in 1990. A beta of less than 1.0 on a falling market offers a considerable degree of reassurance that the expected return on the portfolio should be less sensitive to the market downturn.

2.5
Diagnostic Analysis

Thus far the analysis has been largely descriptive. To understand further the contributions made to overall fund returns by the various components of the portfolio, it is necessary to break down the total fund return into its constituent parts.

2.6
Capital & Income Contributions

The income contribution to fund returns has generally received little attention over recent years as capital growth has surged ahead and provided the major element in overall returns. Even in this climate, however, a few specialised funds have demonstrated the significant contribution which can be made by a high income return. The prospects for the foreseeable future will undoubtedly focus attention back on this aspect of property investment. High income return not only makes a major contribution to overall return, but also reduces risk.

It is particularly interesting in this context to look at the result of a fund which has a high proportion of short leasehold properties. Over half the fund's properties are in this category; all the properties are worth less than £5m; and the sector mix is slightly overweight in offices and standard shops. With this structure it achieved an annualised total return for the last five years almost 5.0 percentage points p.a. above the IPD average.

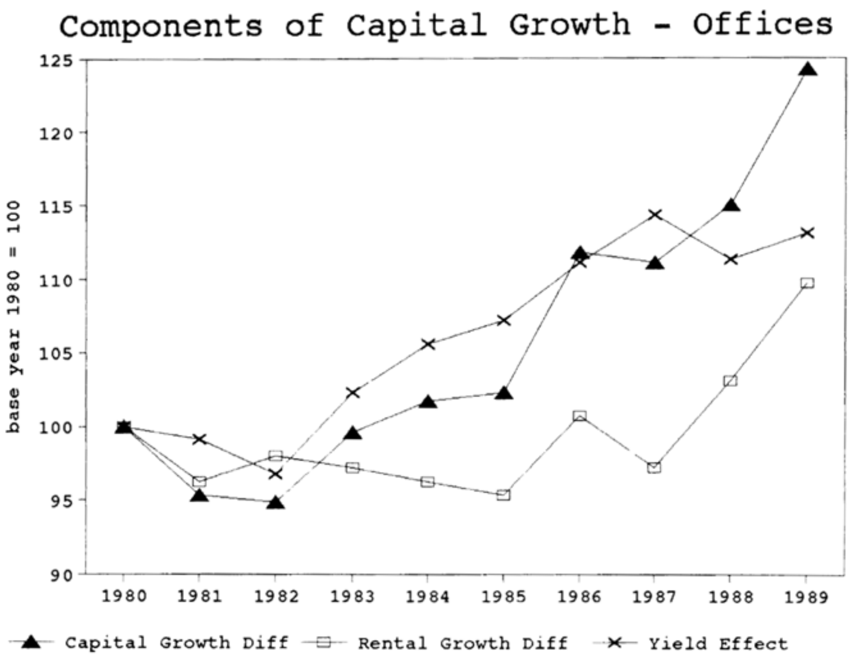
High income return may be achieved in a number of ways other than the inclusion of short leaseholds, particularly by the introduction of non-prime properties into portfolios. Low income return on the other hand may stem from a number of causes, notably reversionary properties, often associated with old leases with infrequent rent reviews. It may also reflect high irrecoverable revenue expenditure on multi-tenanted properties, high management costs or voids. In these cases it may indicate the need to take a closer look at management practices. Alternatively low income return may be an indication of high valuations and will suggest the need for a close examination of the valuation yields employed. Comparison of yield levels is dangerous at an aggregate level as it may disguise considerable variation in the property type mix, but careful benchmarking of individual properties may be revealing.

2.7 Sources of Capital Growth

The second element contributing to total return is capital growth, which is a function of rental value growth and yield adjustments. Analysis of the contributions of these two elements reveals the underlying strength of the capital growth in the portfolio. A simple and fairly effective method of isolating the two elements, is to deduct ERV growth from capital growth and assume that the residual percentage growth is attributable to the yield shift. Figure 7 shows how, by graphing the difference between the fund and IPD capital growth, rental value growth and yield effects, one can assess the contribution of the yield shift to the capital growth. In this example of an office portfolio, the strong capital growth of the fund's properties relative to the market average up to 1987 can be seen to have been the product of rather mediocre rental value growth and a sharp shortening of the yields placed on the portfolio. The capital growth of the last two years, however, has been more firmly based on relatively strong rental value growth and yield shifts in line with the market.

This method of analysing the yield shift contribution to capital growth is, however, crude. It effectively describes only the movement of the reversionary yield, failing to take account of the time to the reversion or of capital expenditure. The development of accurate equivalent yield series has been a major problem for IPD as it requires data calculated from the rent, ERV and rent

Figure 7



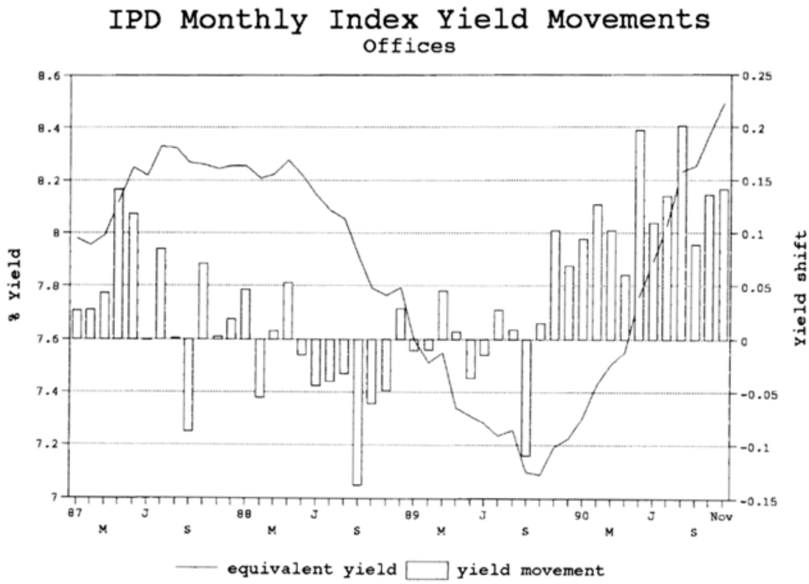
review date of each individual tenancy, to be stored historically. IPD has overcome this massive data problem by collapsing each year's data for multiple tenancy properties into a single series of ten years future cash flows, and storing these. It is thus possible now to generate a historical series of equivalent yields for any property or group of properties.

A further complication arises in interpretation of an equivalent yield series for a portfolio of properties in which the individual assets contributing to the calculation at the end of each year, change over time. The movement of the yield level over time is thus a poor gauge of actual yield shifts where the composition of the sample has changed. In order to establish the actual direction and magnitude of the yield shift on a set of properties such as standard shops, it is necessary to calculate the equivalent yield at the beginning and end of each measurement period on a constant set of properties.

IPD now publishes equivalent yield movement figures in this form. Figure 8 shows these, together with the changing equivalent yield level for the varying sample of office properties recorded in the IPD Monthly Index.

The percentage yield figure shown on the left hand scale indicates the aggregate equivalent yield for all properties included in the sample at the end of each period —an equivalent yield of 8.45% in November 1990. The right hand scale calibrates the percentage point yield shift on constant samples each month,

Figure 8



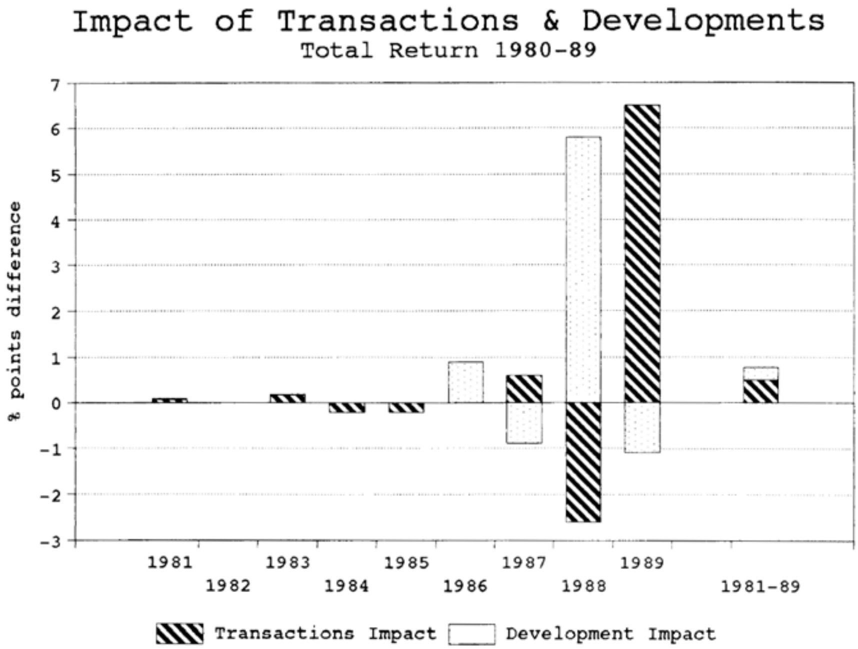
shown by the bars on the chart. From these it is possible to identify the exact extent of the yield shift sentiment at each point in time.

2.8
Impact of Transactions & Developments

When assessing the overall performance of the fund relative to the market, it is necessary to include all returns on the capital employed. The IPD results thus include all properties in the box plot analysis discussed earlier. Developments under construction and properties bought or sold during each period are included. In this way profits on development completions are taken into account; and profits or losses made on transactions between their final valuation and sale price (net of costs), or between gross purchase price and first valuation, are included.

It is, however, of value to the fund manager to know the contribution to the fund's overall return made by his transactions and developments. This can be demonstrated by calculating first the total return on standing investments, the completed properties held throughout each period; then by calculating the total return on the fund including properties bought or sold each year, the difference in overall return indicates the contribution of transactions. Repeating this process by including developments during their construction phases and comparing the

Figure 9



last two calculations, provides an assessment of the contribution of development activity.

Figure 9 shows this analysis carried out on the fund used in the first example. It demonstrates how the high returns achieved in 1988 stemmed partly from the substantial increase in the value of one significant development, which added almost 6.0 points to the total fund return; and how the sale of a second important property in 1989 added 6.5 points to the results.

Developments will usually depress returns during their construction phase and make sudden contributions on completion. Purchases also tend to depress returns slightly, when costs are taken into account, as they rarely achieve significant improvements in valuation in their first year. Sales, which are mostly carried out selectively, usually make a positive contribution to total results. When carried out under conditions of forced selling they may, however, depress returns.

Very often this analysis will go a long way towards explaining the causes of high beta values in the risk analysis. Heavy development programmes invariably increase the volatility of returns: active trading likewise, especially when very large properties are involved.

2.9
Contributions of Sector Weighting to Fund Relative Return

A powerful tool to assess the impact of a fund's sector weighting on its good or bad performance relative to the market, is attribution analysis. This type of analysis, originally designed for equity portfolios, breaks down the difference between the fund's total return and that of the market into two components. If the fund has outperformed the market, its assesses whether this good result is attributable to the heavy weighting of the fund in the best performing sectors of the market—the sector component— or the above average performance of the fund's own properties in each sector relative to the market norm for that sector—the property component.

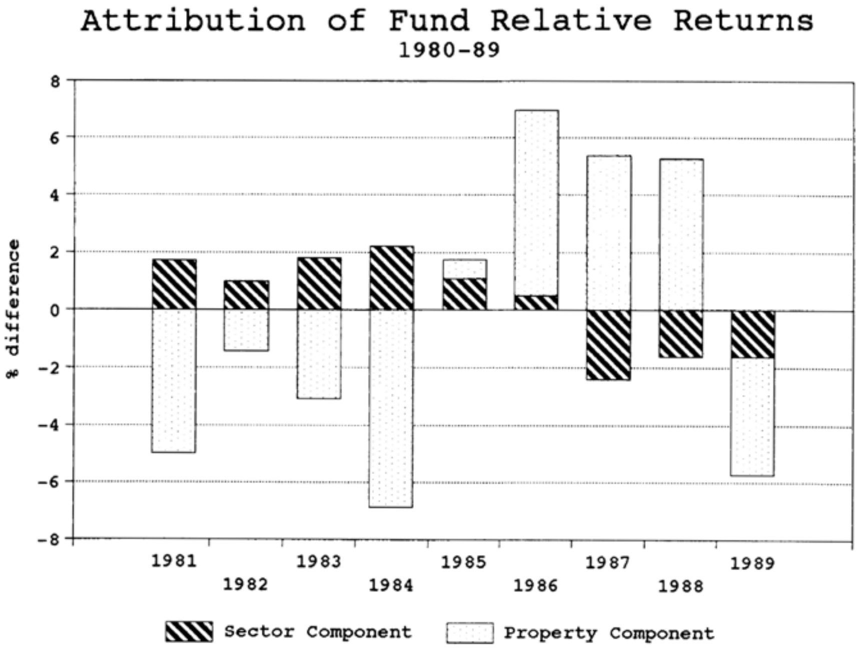
Figure 10 shows the results of this analysis for the period 1980–89 for a fund which was heavily concentrated in standard shops, with a small London office portfolio, tiny provincial office content, and average industrial weighting. It shows how the sector weighting made a positive contribution to the fund's relative return in the years prior to 1987, but has dragged down the results in the last three years as the market turned against retails. Closer inspection of the results for each year shows that the fund's own shops, which under-performed their peers prior to 1985, were consistently successful from 1985–88, but fell behind their market benchmark again in 1989. Under performance on the part of its provincial offices and industrials in 1989 also contributed to the poor performance.

This type of analysis can be a helpful guide to the fund manager in identifying groups of properties requiring closer attention, as well as sector weighting problems. IPD supplement the analysis by providing the results for each individual property (together with their values), grouped by property type and ranked in order of performance. Particular properties can thus be identified according to their weighting in the sector results and their positive or negative contribution to returns. By following the analysis through to individual properties in this way, the fund manager is provided with a tool for assessing the quality of each investment and its contribution to the portfolio.

Figure 11 shows how the analysis can be extended to provide an assessment of other structural characteristics of the portfolio—the regional or tenure distribution of properties, for example. In this case it has been used to aid diagnosis of the significance of the London weighting of an office portfolio.

It shows how the under performance of the fund's office sector in 1989 was attributable, not only to the heavy weighting of the portfolio in the City office market (43%), and under representation in other areas—especially the Midlands—but was also exacerbated by the poor performance of its own holdings in the City and Midtown areas. Fortunately this had been partly counteracted by exceptionally good performance on the part of its West End properties.

Figure 10

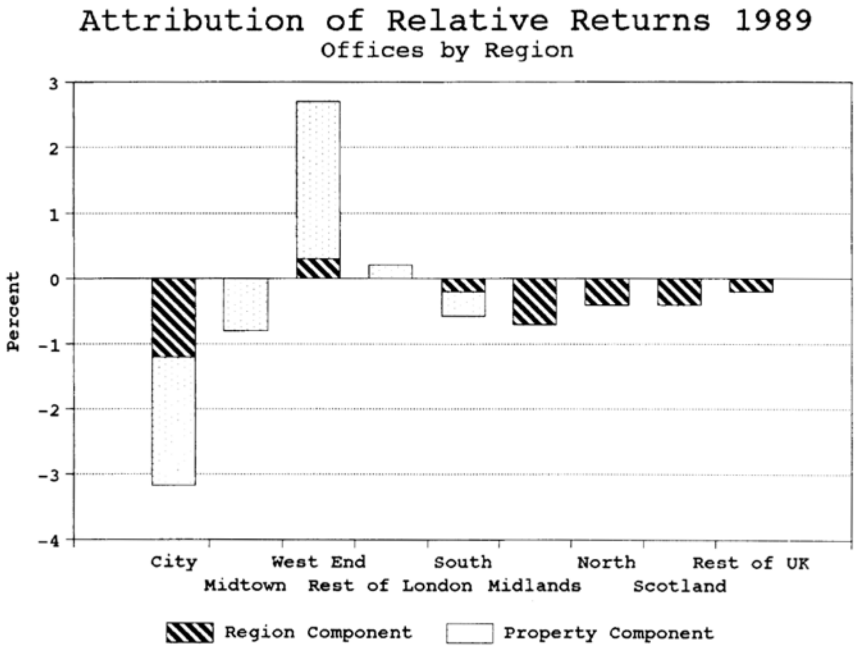


2.10
Simulation Techniques

Portfolio analysis is essentially a retrospective tool, but the accurate recording of each individual property and the resulting capacity to generate results for any part of the portfolio at will, opens the possibility of simulating alternative scenarios. The development of simulation techniques is in its embryo stage at IPD, but is clearly seen as the way forward at this point.

Historic simulation of alternative strategies has already been put into practice and offers a useful heuristic device. It is particularly valuable in the further analysis of risk in portfolios. Where the beta value of the existing portfolio has already been established, the effect on the beta of excluding particular properties, or of including different types of asset can be tested. This is especially interesting for specialised portfolios which may be considering greater diversification. What would be the effect on both the fund return, and the beta value, of greater regional diversification within the same sector: or would the fund be better served by switching sectors? What level of replacement would achieve the greatest reduction in the beta value whilst retaining an acceptable level of overall return? These questions can be answered by implanting imaginary properties, returning average results for the selected property type and region.

Figure 11



Simulation of portfolio results into the future on the basis of known sector and regional forecasts has yet to be achieved. It is, however, theoretically possible. Forecasts in the property market are currently limited to rental value growth and forecasts of yield movements are unlikely to be developed to an acceptable degree of accuracy. Forecasts on the assumption of existing yields or alternative scenarios built on underlying trends in interest rates will, however, be possible.

PROPERTY INDEXES

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Abstract

This paper discusses the validity of a valuations index and describes the methods used in calculating property indexes. Systems of weighting and averaging are also covered as are the problems associated with smoothing. The use of indexes in estimating both market and average risk are illustrated and extended to show how investment advice can be verified.

Keywords Indexes, Valuations, Prices, Weighting, Averaging, Arithmetic Mean, Geometric Mean, Regression, Smoothing, Performance Measurement, Professional Advice.

1
Introduction

Over the last decade there has been substantial growth in the development of property indexes. This is important for our understanding of the market, the risk profile of property and its investment characteristics is highly dependent on our understanding of overall market movements.

Although the continued interest in property indexes is to be welcomed the array of published numbers, each purporting to track the market, is bound to present a confusing picture to the institutional investor.

This paper looks at some of the principal issues involved in constructing a property index and shows why differences can occur in the resulting numbers. The approach is to consider property indexes within the context of performance measurement. In particular the following areas will be addresssed.

(a) Valuations and prices
(b) Property Selection
(c) Weighting
(d) Averaging
(e) Smoothing

2
Valuations and Prices

There are many commentators in the property market who seem concerned with trying to show that the valuation process is fatally flawed. Often such comments are based upon information derived from one or two abnormal transactions. The implication is that the process by which prices are derived is totally different from valuations so that valuations are always suspect.

If this were true it would have serious consequences for the property industry. For example, it would not be possible to provide reliable professional valuations because everybody would know that they were wrong. Investment advice based on valuations would be invalid as would performance measurement. Investors and professional advisors would be working completely in the dark. Property indexes based on valuations would bear no relevance whatsoever to what was happening in the marketplace.

Clearly this state of affairs does not exist in practice. The assessment of value depends on the free flow information between interested parties concerning recently traded properties. It is this flow of information which enables values to be determined. As a result there should be a close relationship between valuations and prices. If this is the case then an index based on valuations should be a good proxy for an index based on prices.

It is possible to test this proposition by taking a sample of traded prices for a group of properties and to compare them with their most recent valuations. It is important however to use open market valuations and prices as the effect of special situations could cause the results to be biased. What we are looking for is a one to one relationship between valuations and prices. Before running the analysis it is necessary to convert all the data to the same size units. In this case valuations and prices per square foot. This overcomes a statistical problem known as heteroscedasticity.

The analysis involves regressing valuations per square foot against prices per square foot for the same properties. If valuations are a good proxy for prices the regression should produce a slope coefficient of one and an intercept of zero. Both coefficients should be statistically indistinguishable from these values and the model should have a high explanatory power.

The first analysis of this type was based on a analysis of only 29 properties with open market data collected over a five year period from 1975 to 1980. The results showed a slope coefficient which was statistically indistinguishable from one. In addition the model also showed that prices explained about 99% of the variation in valuations. The intercept term was however negative and statistically different from zero. This could be attributed to the fact that the valuations and prices were not exactly synchronous. In fact over the period analysed the market was rising so that the negative intercept was consistent with the view that prices had risen relative to their earlier valuation.

A more comprehensive analysis was subsequently undertaken by IPD and Drivers Jonas based on 1442 properties using data collected over the period from 1980 to 1987. Although their analysis did not make it clear whether open market data was used they nevertheless found a similar relationship with the slope coefficient being statistically indistinguishable from one. The model also had an explanatory power of over 93%. As with the earlier analysis the intercept term differed from zero but this could also be attributed to the fact that the dating of valuations and prices was not exact. With the larger sample size however it was possible to make an allowance for differences in dating between the valuations and traded prices. With this refinement IPD were able to show that the intercept term was unstable and probably had a true value of zero.

The methodology involved in these analyses is still the subject of debate. What is clear however is that it is important to ensure that comaparable is data is being used. In other words open market valuations must be compared with open market transaction prices. If this condition is violated then it could lead to the regression coefficients being misinterpreted. For example, if sales prices are collected during a major downturn in the market then there may well be a high number of properties with forced sales values. If these are compared with open market valuations the resulting slope coefficient will differ significantly from one. Although the IPD analysis included a large number of properties the validity of their results rests on the heroic assumption that the sales prices have all been assessed in a consistent manner.

Despite these shortcomings our ex-ante belief is that open market valuations and prices should be good proxies for each other. Taken together the above analyses cover over ten years of data and on the whole produce consistent results. The main implication is that valuers are using all relevant information derived from the market to arrive at some probablility distribution of valuations. The price at which a property trades is merely a random drawing from that distribution based on the same information set. On the whole the market is interpreting the information set in the same way as valuers. We are probably safe in saying that given a large sample of valuations their average value should be the same as an equivalent sample of traded prices.

The results of this type of analysis should not be misinterpreted. It is quite possible in individual cases for there to be wide differences between valuation and price. What the analysis is saying however is that such differences are likely to be random and at the portfolio level they would be diversified away.

Further research of this type is of course needed to verify the basic proposition. It would be useful for example to have analyses carried out during different cycles of the market to see whether the process is consistent over time. What little information we do have does provide some evidence to suggest that a proerty index based on valuations will produce a reliable indicator of market movements.

3
Selection and Sampling

In developing a property index there are two specific needs which have to be taken into consideration as they affect the process of sampling and selection.

(a) Is the index merely intended to track general movements in the market?, or
(b) Is the index intended for performance measurement and other portfolio related purposes?

Whereas the second of these will also track general trends in the market the first will not be suitable for performance measurement purposes.

The essential difference between the two relates to the amount of specific risk which remains in the index. Constructing an index is rather like putting together a portfolio. As more properties are added to the portfolio the risk of holding individual properties is reduced until a point is reached when the portfolio risk can be reduced no further. At this point the portfolio is carrying the same level of risk as the market. The total risk of the portfolio can therefore be expressed as follows:

TOTAL RISK = MARKET RISK + SPECIFIC RISK

In constructing an index the main objective is to reduce the specific risk down to zero so that all that remains is market risk. How successful this is depends upon the number of properties held and the correlation structure that exists between the individual properties.

A major feature of property is that it is very sensitive to location so that the returns from one property have little influence on the returns in a different location. This of course is advantageous in terms of portfolio construction because it means that a considerable amount of the risk of holding individual properties can be diversified away. In fact it is possible to get levels of risk reduction in the order of 70% with the larger portfolios. The penalty for this low correlation however is that large numbers of properties need to be held in order to eliminate the specific risk.

To put this into context a portfolio which is considered to be well diversified would have about 95% of its variation in returns explained by the market. This latter figure can be derived by dividing the market risk by the total risk where all the figures are expressed in terms of variances. Given this information it is possible to estimate the number of properties which need to be included in an index in order to achieve this level of diversification. The resulting figure can then be compared with similar figures for a portfolio of stocks were the correlation structure is much higher. The results of undertaking an analysis of this type are given in table 1 for different levels of diversification and are based on the assumption of equal weighting in each asset.

Table 1. Diversification and number of assets

Diversification	Number of Properties	Number of Equities
95%	171	44
99%	891	228

From this it will be seen that there is a four fold difference between the number of properties and equities required to produce portfolios with the same level of diversification. It is therefore much easier to produce highly diversified portfolios with equities than it is with property.

Even though levels of diversification of 95% may seem high it should be noted that this means that there could still be about 1% per annum of specific risk which has yet to be diversified away. In the context of performance measurement it may not be possible to establish whether abnormal returns are the result of skill or random events associated with the index.

Moving from 95% to 99% diversification reduces the specific risk to about 0. 5% per annum but requires a portfolio of about 900 properties. Beyond this point it becomes extremely difficult to achieve significant reductions in specific risk without the addition of many thousands of properties. Thus the construction of an index for performance measurement purposes poses special problems.

If however the need is for an index which merely tracks general market movements the main question to ask is whether the sample used to construct the index is representative of the population. Because it is impossible to monitor the movement of every property in the market some form of sampling is needed.

In order for the laws of probability to apply to the sample of properties included in an index each property should be chosen randomly from a homogeneous group. This is known as stratified sampling. Although individual properties tend to be heterogeneous they nevertheless aggregate by type or sector to form homogeneous groups. This form of sampling should, therefore, ensure that the index is represenatative of the sectors involved. A totally random approach should not, therefore, be used.

Allied to this is cluster sampling. This is particulalrly appropriate where the index is intended to cover a large geographical area such as the whole country. The technique is to split the country up into districts and then to take from each of these a random sample of a given size. Using this approach the accuracy of the sampling process increases inversely with the square root of the sample size. There is little to be gained therefore by continually increasing the sample in an attempt to reach the population. The minimum number of properties which should be included should not be less than about thirty. Below this figure the sample is unlikely to be normal.

In order to be representative of the whole market not only should each sector be included but within each of these it will be necessary to include a sample of prime, secondary and tertiary properties. These latter classifications refer to the desirability of each of the property types relative to location, building quality and tenant status. Thus for any given district each of the three sectors should be represented by properties within the three classifications given above. Assuming a minimum sample size of 30 properties for each classification and sector it will be seen that at least 270 properties will be needed to construct an index for any given district. As it is common to split the country up into about 10 geographical regions it will seen that a representative index of about 2700 properties would be needed. There are of course very few commercially available indexes which meet these numbers in terms of coverage.

3.1 Relevance of data

The index should also be designed to reflect the changes that take place in the property market as a whole. As the major force in investment buying comes from the institutional sector it is essential that the data should reflect their preferences. Generally speaking therefore properties such as residential, hotels or anything non-standard should be excluded. The composition of the index should also change over time in order to reflect any variations which may occur in institutional preferences. This latter point is important as it is essential to ensure that the index is tracking changes in market movements and not changes in age.

3.2 Weighting

Indexes are usually weighted to reflect the importance of each element included. The two most common methods used are by capital value or by equal weighting the changes in value.

Capital value weighting would usually be appropriate for measuring changes in the aggregate market value of the properties included in the index whereas equal weighting would be more representative of changes in the average property.

Clearly a value weighted index would attach more weight to the largest valued properties and this may not be desirable as an index of overall market movements when used in the context of performance measurement.

The reason for weighting an index is to ensure that the index reflects the relative importance of each property in a way which is suited to the purposes of the index. The procedure which is frequently adopted in constructing property indexes is to use equal weighting within each region and sector, in order to establish an index for the average property, and then to value weight the regional indexes to reflect their relative economic importance. Indexes are generally based on value relatives.

3.3
Averaging

Irrespective of whatever weighting is used the group of prices or values need to be combined into a single decriptive measure. Although there are a number of different methods of averaging the two most common are the arithmetic and geometric mean.

The arithmetic mean is simple to calculate and is well understood by most people. For this reason it has been widely adopted. Nevertheless some critics argue that it has a tendency to overemphasise increases in value and underemphasise decreases. For example an asset changing in value from from 100 to 200 shows an increase of 100% whereas a change in value from 200 to 100 only represents a decrease of 50%. The alternative geometric mean overcomes this problem.

The arithmetic mean is simply calculated by summing the individual changes in value for each asset and then dividing by the number of assets if each is assumed to carry egual weight. Alternatively the proportion that each asset represents of the total can be used as the method of weighting.

By contrast the geometric mean involves multiplying each change in value and then taking the nth root were n represents the number of assets involved. Again this assumes equal weighting. If value weighting is involved each change in value has to be raised to a power represented by the relative value of the asset prior to multiplication and taking roots. Because of the magnitude of the numbers involved it is more convenient to use logs. The following examples illustrate the calculations involved based on a sample of three assets which have values in years 0 and 1. The index in year 0 is 100. The computations derive an index in year 1 based on the unweighted and weighted arithmetic and geometric means.

Table 2. Calculation of the Arithmetic mean (Unweighted and weighted)

Asset	V(0)	V(1)	% inc	% weight	Weighted Increase
A	100	120	20. 00	15.38	3. 08
B	300	500	66.67	46.16	30.77
C	250	260	4.00	38.46	1.54
Total	650	880	90.67	100.00	
Average Growth			30.22 (EW)		35.39 (VW)
Index (EW)	100		130.22		
Index (VW)	100				135.39

Table 3. Calculation of the Geometric Mean (Unweighted and weighted)

Asset	V(0)	V(1)	Inc	In [V(1)/V(0)]	V(0){ln[V(1)/V(0)]}
A	100	120	1.20	0.182	18.20
B	300	500	1.66	0.507	152.10
C	250	260	1.04	0.039	9.75
Total	650			0.728	180.05
Number used for average:				3	650
Averages (EW)				0.243	
(VW)					0.277
Antilog				1.275	1.319
Average Growth				27.50 (EW)	31.90 (VW)
Index	(EW)				
	100			127.50	
Index	(VW)				
	100				131.90

This simple example shows that the geometric mean is more complex to calculate. It also has a major disadvantage caused by multiplying the returns. If one asset shows zero growth then the product of all the other returns will automatically be zero irrespective of their individual value. This could easily be a problem with property indexes where one or more properties shows no growth. This problem does not of course arise with the arithmetic mean.

In both cases an arbitrary value of 100 is assigned to the base period and all changes in value are made relative to that figure. Although averaging is involved the resulting index number is not an average. It is interesting to note that the Dow Jones Averages are not indexes but merely averages of the component stocks.

As far as property indexes are concerned the arithmetic average tends to be the favoured method of calculation.

4.0
Other Methods of Calculation

The methods described above rely upon two values being available before an asset can be included in an index. If the market is slack there may well be a tendency for valuers to underestimate the full effect of true market movements due to a lack of sufficient comparable evidence.

An alternative approach to estimating values is to use regression methods. In practice this would mean developing a model which explains the price of a recently transacted property in terms of a number of explanatory variables. This model can then be used to estimate the value of all those properties for which there is no value. It is then a simple matter to derive an index from the resulting figures.

This method has a lot of merit because it can be used to value new properties for which no previous value has been obtained. It therefore does not rely on a system which requires two valuations. It also has the ability to keep the data sample up to date so that the index is not prone to tracking changes in age. It is also statistically sound and is more likely to be sensitive to small changes in the market and therefore make the index more useful for performance measurement purposes.

5.0
Smoothing

It is invariably the case that properties are not valued on the exact date of publication of the index number. In order to keep the sample size high properties are frequently included in an index which have values on either side of the index date. Although this may sound like a fairly innocent practice it nevertheless introduces severe statistical problems into the resulting index series.

In addition if valuers are not processing information correctly and are underestimating changes in value in a depressed market and overestimating in a buoyant market there will be a tendency for the resulting index to smooth out the true changes in the market so that the resulting index behaves like a moving average.

Although adjustments can be made to the values to compensate for differences between the date of the valuation and the index date these can still introduce smoothing. IPD for example use simple linear interpolation between the date of a valuation and the index date. This however does not overcome the smoothing problem.

Property indexes tend therefore to be moving averages and do not pick up true changes in market movements. The main problem that this creates is that comparison with other economic indexes give the impression that property is much less volatile than it is in reality.

If a property index is used only for illustrating general trends in the market then the fact that the index is smoothed should not cause too much of a problem. If however the index is to be used for performance measurement purposes or for risk analysis and asset allocation then the smoothing problem is a major issue.

Smoothing can be measured by calculating the degree of correlation that exists between successive changes in an index. If valuations are present values then they should only change when new information becomes available. Because that information is new the change in valuation will be independent of the previous valuation. At this level the market is efficiently processing all available information and impounding it into valuations. Under these conditions we would expect successive price changes to have serial correlation coefficients close to zero. High serial correlation coefficients would imply high levels of smoothing. The following table presents first order serial correlation coefficients for different indexes calculated for different periods.

What is noticeable from this table is that as the interval between the index date gets shorter the serial correlation coefficient increases. Thus monthly indexes show a greater degree of smoothing than do annual indexes. Of the indexes shown above only the Jones Lang Wooton and Hillier Parker annual indexes exhibit little serial correlation.

Fortunately it is possible to remove the serial correlation to arrive at an index which does track intertemporal changes. For example, taking the IPD monthly index it is possible to recompute the index taking out the smoothing. Fig 1 shows the results of doing this. Using the unadjusted figures the annual standard deviation of returns over the period from 1987 to 1990 was calculated as 2.54%. After adjustment this figure increased to 8.80%. From this simple illustration it will be seen that monthly indexes understate the true risk by a factor of almost 3.5!

Table 4. Serial Correlation Coefficients

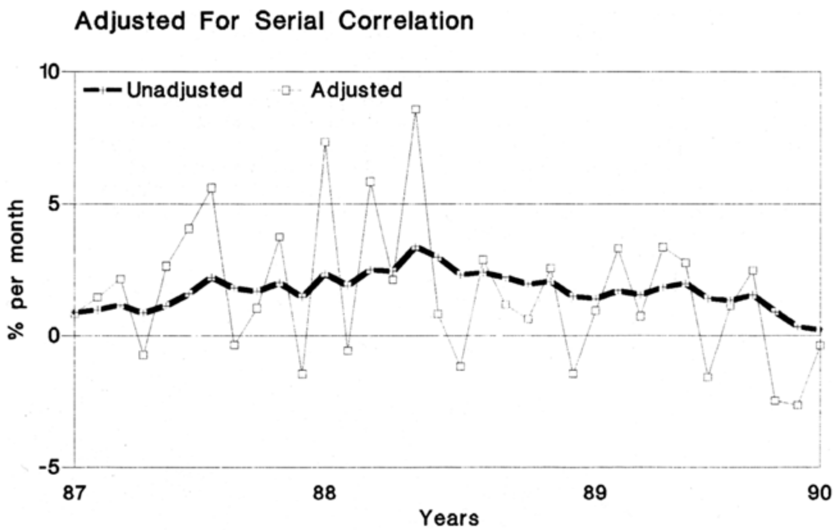
Index	Frequency	1st Order Ser Corr
Weatherall Green & Smith	Annual	0.30
The Property Index	Annual	0.54
Morgon Grenfell Laurie-CIG Index	Annual	0.55
Jones Lang Wooton Index	Annual	0.09
Hillier Parker	Annual	−0.03
Jones Lang Wooton Index	Quarterly	0.70
Investment Property Databank	Monthly	0.74
Richard Ellis	Monthly	0.74

Once we have some valid information about the property market derived from indexes it is possible to use it in more interesting ways. For example it is possible to say something about how risky is the average property using information derived from our knowledge of diversification.

It is possible to show that a well diversified portfolio of property should enable about 68% of the risk of the average property to be reduced. This is quite a high figure and is determined by the correlation structure of returns that exists between individual properties. Knowing that over the period from 1987–1990 the true market risk after diversification was about 8.80% per annum it is possible to work backwards to derive the risk of the average property. In this case, assuming a 68% reduction in risk, the appropriate figure is 27.50% per annum (ie 8.80/[1–0.68]). This figure is probably much higher than most people imagine but nevertheless clearly reflects the riskiness of the recent past.

If the adjustment for smoothing had not been taken into consideration the average property risk would have been computed as 7.94% per annum.

Fig 1: The IPD Monthly Index



Risk however does not remain constant but will change as market confidence changes. This in turn will change the risk of the average property and will signal when projects should or should not be accepted. The changes in market risk can be illustrated in relation the Jones Lang Wooton Index by computing the changes in risk on a annual basis. This is illustrated for the period from 1972 to 1990 in Fig. 2.

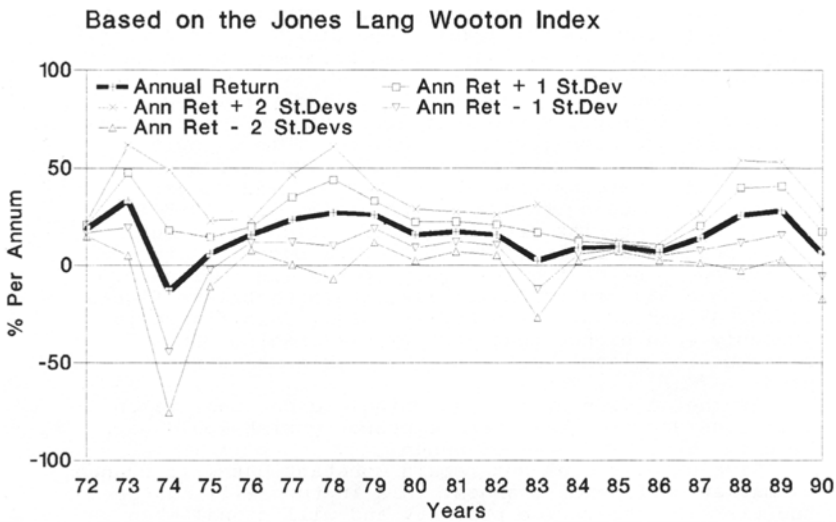
6.0
Assessing Investment Advice

Developing a property index which is free of the problems discussed above can lead on to a number of interesting areas which will help the property investor. Asset allocation and performance measurement are two areas which readily spring to mind.

Allied to this is an analysis of how good professional advice is likely to be and to verify how long it will take to justify whether professional advice is correct or not. A simple example will illustrate the principles involved.

The only way that a portfolio can achieve an abnormal returns is if it is not efficiently diversified. The returns from period to period will therefore fluctuate round some average value. This can be positive or negative and will vary over time. By assuming that the investor maintains the same level of indifference to both the systematic and residual components of the portfolio it is possible to assess his target abnormal return given information concerning the long term market premium, the target risk class for the portfolio together with the long term

Fig 2: Changes in Market Risk 1972–90



market variance. A simple case would assume that the investor is trying to maintain the same level of risk as the market and that the long term risk premium is assumed to be 2.00% per annum. The long term market variance is however more difficult to assess as we do not as yet have sufficient information to estimate this figure accurately. Assume however that in standard deviation form it is about 8.00% per annum. This would give a variance figure of 64%.

From this information the target abnormal return would be directly proportional to the residual variance in the portfolio. Given the conditions stated above the target abnormal return can be estimated from the following:

```
Target                 Portfolio Residual Variance
Abnormal = 2.00% [ --------------------------- ]
Return                      Market Variance
```

If the portfolio that is being managed has a residual standard deviation of 5.00% per annum its variance will be 25%. We have assumed that the variance of the market is 64% so that the target abnormal return can be estimated to be 0.78% per annum. In other words after having made an adjustment for risk the portfolio would need to earn on average 0.78% per annum in order for it to be compensated for the risk that has not been diversified away.

The next question to ask is how long would it take before we can be certain that the professional advice being given was actually providing compensation for the additional risk taken on?. To put this another way how long does it take before the abnormal return becomes statistically signicant?.

If returns are measured over longer and longer periods the holding period risk will reduce. The precise relationship is that it will reduce inversely as the square root of time. For example the residual risk of 5.00% per annum will if the return is measured over a 25 year period reduce to 1.00% per annum. Using this information the abnormal return can be converted into a t-value. The relationship can be turned round to calculate the time required in order for the t-value to become statistically significant. In this particular case we are only interested in a one tailed t-test which would be appropriate for positive abnormal returns. The relevant number to achieve is 1.64 and the time required can therefore be estimated from the following:

$$T = \left[\frac{1.64 \text{ (Residual Standard Deviation)}}{\text{Target Abnormal Return}} \right]^2$$

Assuming constant conditions the time required in the example given above would be 110.5 years! This set of calculations is however very sensitive to the calculation of market risk but it does illustrate that it will take some time to confirm that an investment strategy is providing the expected results.

7.0
Conclusions

A good index can provide valuable information not only about market trends but also about risk and return and investment strategy. At present the commercially avaiable indexes are really only providing information about market trends. Although all indexes are generally telling the same story there are individual differences due to the different sample sizes and methods involved.

In the future it would be more useful for there to be a single adopted index which could accurately pick up intertemporal changes. Such an index would be of significant benefit to the property profession and herald the development of different types of property based products reflecting the fact that property is being regarded as an integral part of the capital markets. Because such an index will almost certainly need to be constructed in an unconventional manner it will take some time before it would be accepted by the whole profession Nevertheless this is what we should be striving for.

THE PROBLEMS OF FORECASTING RENTAL GROWTH AT THE LOCAL LEVEL

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Abstract

This paper reviews the current state of forecasting for the commercial property market in the UK. It argues that there is now the need and the scope to move towards local area forecasting. The conceptual and practical difficulties in making such a transition are discussed.

Keywords: Property Market, Forecasting. The views represented are personal and do not necessarily reflect the views of Prudential Portfolio Managers Ltd.

1 Introduction

We should be under no illusions about one central truth, namely, that all those involved in the investment world are engaged in forecasting in one form or another. This paper reviews the way in which property market forecasting is developing in the UK and the way in which it should develop in the future. After demonstrating that all those involved in the property market are engaged in forecasting, whether implicitly or explicitly, the paper outlines the principles to be adopted in the forecasting process and argues the case for local area forecasting.

1.1 Implicit forecasting in the property market

Basic investment theory tells us that the value of an investment is determined by discounting all expected future income streams at the investors predetermined “target” or “required” rate of return. Forecasting is clearly essential to estimating future income streams. It is indirectly essential, through exploring plausible variations in possible outcomes, to assessing likely variations in the level of that income stream over time which many equate with determining the risk premium on an asset and which, in turn, feeds directly into determining an investor’s required rate of return. Irrespective of whether we assess income streams and likely variations in a systematic way or we work by the legendary "gut feel", we are engaged in forecasting. This simple point can be illustrated by an example.

In June 1990, the Chartered Surveyor Weekly magazine contacted six top UK surveyors and asked them to give their views on how three hypothetical properties across the City of London would perform over the following five years. Three specific locations were chosen; one in Minories (250,000sf); another on the site of the Bank of England site (50,000sf); and a third on Holborn Viaduct (150,000sf). Together these three sites give a cross-section across the City of London office market. Each property was assumed to be occupied by good covenants on 25 year leases.

The results were as follows:

Table 1. Predictions for Minories

Surveyor	**Yield**	**Rent**	**Value**	**Yield**	**Rent**	**Value**
June 1990	June 1990 £psf	June 1990 £m	June 1995	June 1995 £psf	June 1995 £m	
A	7.00	40.00	143	6.75	47.50	176
B	7.25	45.00	145	8.00	65.00	210
C	8.00	40.00	125	7.75	45.00	145
D	7.50	35.00	114	7.50	40.00	130
E	8.00	37.50	117	8.00	55.00	172
F	7.50/ 8.00	40.00/ 43. 00	125/ 143	Uncertainties are too great		

As Table 1 shows, the views held by surveyors can vary considerably despite the City of London office market being one of the best informed property markets in the world. There is a spread of views about current rents and yields on the Minories site giving a range of capital values of between £114 million and £145 million as at June 1990. However, the captured forecasts show the range of views on yields is widened with one surveyor seeing yields moving down while two others see them moving up. A range of rental levels between £40.00psf £65psf is forecast for the property at June 1995. These variations lead to major variations in forecast capital values.

Table 2. Predictions for the Bank of England site

Surveyor	**Yield**	**Rent**	**Value**	**Yield**	**Rent**	**Value**
June 1990	June 1990 £psf	June 1990 £m	June 1995	June 1995 £psf	June 1995 £m	
A	5.25	65.00	61	4.75	75.00	80
B	5.25	65.00	60	5.00	95.00	90

Surveyor	**Yield**	**Rent**	**Value**	**Yield**	**Rent**	**Value**
June 1990	June 1990 £psf	June 1990 £m	June 1995	June 1995 £psf	June 1995 £m	
C	5.00	62.50/ 65. 00	62.5/ 65	5.00	80.00	80
D	4.75	75.00	86	3.25	80.00	126
E	5.25	72.5	69	5.25	120.00	114
F	5.75/ 6.50	55.00/ 58. 00	42/ 50	Uncertainties are too great		

In the example given in Table 2, there is some uniformity of view about a general downward trend for yields over the five year period. However, the range of yields five years out widens from that relating to the current views. The rental forecasts (and, by definition, the implied levels of rental growth through the period) are very different between the surveyors. Again, the variation in the forecast capital value is extensive.

Table 3. Predictions for Holborn Viaduct

Surveyor	**Yield**	**Rent**	**Value**	**Yield**	**Rent**	**Value**
June 1990	June 1990 £psf	June 1990 £m	June 1995	June 1995 £psf	June 1995 £m	
A	7.50	40.00	80	7.00	45.00	96
B	8.00	40.00	75	7.50	57.50	100
C	7.25	45.00	93	7.25	60.00	124
D	7.00	47.50	100	6.00	50.00	131
E	6.50	55.00	127	6.00	115.00	288
F	7.25/ 7.75	40.00/ 43. 00	77/ 89	Uncertainties are too great		

Table 3 confirms that, even in the City of London office market substantial variations can exist between surveyors in terms of their rental growth forecasts. In the Holborn Viaduct example, there is a predicted range of rental levels between £45 psf and £115 psf after five years with correspondingly massive differences in capital values.

It should be made clear that the intention of this example is not to criticise surveyors. Rather, these hastily gathered figures are used merely to illustrate that most practicing surveyors, whether or not they every engage the services or property researchers, possess models and forecasts for the markets they deal with. This particular press article has simply captured those forecasts for subsequent inspection.

The figures also demonstrate the major variations in view for a market which one would generally believe to be well and commonly understood by those who participate in it. This in turn suggests that, even for a well documented market like the City of London, there is little open debate about the accuracy or otherwise of the assumptions being used by individual surveyors in building their forecasts or models of their markets. Any potential client going to any of these surveyors is likely to be given a very different view of the City office market.

1.2
Pressure for formal forecasting in the UK property market

Concerns over the range of views or the lack of explication about views on the UK property market has been one of a number of stimuli increasing interest in a process of forecasting property markets which formally and explicitly addresses the variables and issues deemed to influence rental growth or property performance. One element of this is clearly the problem of forecasting rental growth. (The other is how to deal with the forecasting of yield levels. This issue will not be addressed in this paper).

The rest of this paper will

(a) outline the principles which should be adopted in making property market rental forecasts;
(b) review briefly the current state of forecasting in the UK commercial property market;
(c) argue the case for local property market forecasting; and
(d) record some of the conceptual and practical problems with local property market forecasting.

2
Principles of forecasting

There are certain principles to be applied to the forecasting of property markets. Among other things, forecasting should,

(a) exhibit theory-based connections to real world processes active at the relevant spatial scale;
(b) be capable of utilising similar explanatory frameworks across different locations; and
(c) be treated with great caution and subjected to testing on the basis of intuitive and explicit understanding of the markets to which they apply.

We will explore each of these in turn.

2.1
Theory-based connections to real world processes active at the relevant spatial scale

The ability to explain forecasting models and their results by reference to real world processes (i.e. relating to known and understood causal relationships) is essential for the long term credibility of an explicit approach to forecasting rental growth.

There is a lot of vaguely relevant data available upon which models of rental growth could be based. For example, a model seeking to forecast rental growth in the Edinburgh retail market based on local consumer expenditure growth, local tourist expenditure growth, current property vacancy levels and the forthcoming new supply pipeline, is likely to give satisfactory forecasts more often and serve the forecaster more fully than, say, a model based on some observed, lagged, relationship between rental growth for Edinburgh retail and rental growth for West End of London retail units.

This is not to say that "abstract empiricism", where data is reviewed extensively in an attempt to discern patterns or regularities, does not have its uses. In the example just quoted, the appearance of a lagged relationship between West End and Edinburgh retail markets in terms of rental growth may generate enquiry into the possible reasons for such a pattern. Examination may throw up causal relationships. In this hypothetical example, it could be that the observed lagged relationship occurs because there is a spillover of overseas tourists visiting London one year and returning to the UK and visiting Edinburgh the following year. If this was the case, then an important piece of information has been discovered.

It is also important to realise that the explanatory framework used in a forecasting model should be relevant to the spatial scale to which the forecast relates. The factors which influence rental growth at different spatial scales are likely to vary. For example, modelling rental growth at the regional level does not require a specific review of the political processes which influence land use and development. However, the economic processes affecting rental growth at the local, town, level are significantly affected by the land use planning "filter". It could be the case that the observable patterns of rental growth for offices in two adjacent towns are heavily influenced by the differing political attitudes to new development. One might be a generally preferred office location but subject to tight planning restraints, the other may be a sub-optimal location which is happy to accommodate overspill from its neighbour. These contrasts will average out at the regional level and will not emerge as a key factor in the forecasting model. However, at the local level, they are crucial tot the forecast and to the subsequent pricing of assets.

2.2
Similar explanatory frameworks across different locations

One test of a good explanatory framework is that it proves "transportable" from one location to another. This does not mean that we would expect the parameters of the model to be identical in different locations. For example, the office market is driven by a slightly different combination of factors in, say, Stockport than in Manchester because the government/private sector mix is slightly different. However, in both cases, we would expect to look at the office market in terms of, say, a combination of the growth in employment in the public and private sectors and growth in office floorspace (notwithstanding earlier comments on the need to isolate any differences in attitude to office development between the two locations). Indeed, we might expect to carry an "employment versus floorspace growth" type model between locations.

The actual variables used may differ between forecasters as a result of differential access to data and the level of substitutability that exists between variables. For example, population growth and housing growth may act as substitutes for models of rental growth in the retail sector. However, a client for forecasting services would be justified in asking why a model of Manchester office rents is driven by business service employment in the local subregion while the Liverpool office market is driven by some apportionment of regional Gross Domestic Product.

2.3
The trust placed in modelled forecasts

We must never lose sight of the fact that the world is very complex. The subtle differences and nuances that exist between locations mean that we should not expect a simple forecasting framework using a handful of economic, demographic and social variables to do more than point a forecaster in broadly the right direction. This is especially the case at the local level (see below). Property market forecasting is in its infancy. All mechanically generated forecasts should undergo critical review to see if they feel right in the light of available evidence, both quantitative and qualitative. Results generated from the "top down" should be broadly in line with those discerned from the "bottom up". Clearly, as the sophistication of models develops, the importance of this form of critical review will diminish. However, it is highly unlikely that forecasting will ever be possible without some level of subsequent qualitative review and fine tuning of mechanically modelled out puts. The implications of this is that, for the short term at least, property market forecasting will remain a labour intensive exercise with property researchers seeking to capture the complexity of the observable world, formally, through the modelling process and, informally, through wide ranging information assembly.

3
The current state of forecasting for UK property markets

Not wishing to betray any confidential trade secrets, my review of the current state of forecasting for UK property markets will be kept at a very general level. To begin this discussion it is, first, appropriate to describe the forms of forecasting services that are currently available.

3.1
Currently available forecasting services

A number of published forecasts are now available. These are usually published for either “all sectors/all regions” (i.e. a national forecast for property as a whole) or “one sector/all regions (i.e. a sector forecast). These published forecasts usually relate to the next year. These forecasts are usually produced by chartered surveying firms (viz. Baring Houston Saunders and Richard Ellis). In addition, there is now a wide range of investment advisory organisations and investment houses, including a number of chartered surveying firms, producing more detailed forecasts on a regular or consultancy basis for property investors. Most of these comprehensive forecasting services tend, at present, to focus more closely on “sector/regions” of the UK. Some forecasts are also now being produced for European centres. It is common practice for these forecasting agencies to gather together consortia of investors to help spread the high cost of producing property market forecasts. However, the major investing institutions are increasingly developing their own in-house forecasting capacity which seeks to take and customise the forecasts made available through consortia. Examples include the Prudential Portfolio Managers Ltd., Norwich Union Real Estate Managers Ltd., and Legal and General Properties Ltd.

Other forecasts are provided for local centres or locations when commissioned directly by an investor, usually in relation to an opportunity they are considering.

(It is also worth mentioning here the large number of information services that have emerged over the last decade which are essential to the process of qualitative review of mechanically derived forecasts mentioned above. Examples include FOCUS and PROMIS).

The clients of forecasting services will already be aware of some obvious differences in both the inputs and outputs of the various agencies producing forecasts. These differences are understandable and relate to:

(a) the different sources the different agencies draw on for forecasting purposes (for example, some have access to individual property data, others have collected data on hypothetical properties for many years);
(b) the different technical approaches adopted when forecasting;

(c) the different approaches they adopt when handling fundamental background data on economic variables, (for example, some use one source of economic data, others use a cocktail of economic forecasts); and
(d) the different approaches to dealing (or not) with different economic and property based scenarios.

Each of these factors affects either the raw data used for forecasts or the treatment of the data when gathered. Differences in forecasts from the agencies is therefore not surprising.

3.2
Evaluation of current forecasting services

As both a producer and consumer of forecasting services, one can draw together both the current trends in UK property market forecasting and criticisms of the art of forecasting together. This is because most of the problems that can be readily identified are, in fact, currently being addressed by those in the field. These are summarised below.

First, there is a trend away from straightforward, mechanistic forecasting towards a more sensitive approach using qualitative adjustments to modelled results.

Second, there is clear movement towards not only forecasting rental growth but also total returns. It is manifestly the case that rental forecasting is <u>not</u> the ultimate target for property market forecasting. For example, East Anglia may well be the fastest growing region in rental terms but if everyone knows that and the market becomes subject to major purchasing programmes by investors, the price of property in East Anglia could well rise above that representing "good value" resulting in poor total performance in the long term.

Finally, and it is a trend to which the rest of this paper will address itself, there is a definite move towards local area forecasting. This is both necessary and to the benefit of all those involved in property investment in the UK.

This is not to say that sector/regional forecasting does not have uses. However, consider the situation of a property forecaster meeting clients to present rental growth forecasts and suggesting that rental growth for retail property in the East Midlands will average 7.5% nominal over the next five years. Looking at the other regions, it is entirely plausible that the forecaster will suggest a similar average growth figure for retail property in the West Midlands, the North West, the North, Wales and Scotland. In this case, the client may well wonder what benefit the forecasting process provides, given his or her need to identify location-specific opportunities. Similar questions may be raised about a single South East regional forecast for industrials. Such a forecast relates to settlements as distinct and distant as Folkestone, Southampton, Bedford and Chelmsford. Given the variability within regions, town level forecasts must be the ultimate goal for forecasters and, by default, for the setting and monitoring of fund strategy. This has been grasped and action is now being taken to move towards local area forecasting.

One issue that has not yet had sufficient attention paid to it is that of dealing with varying scenarios using both different economic and property market scenarios. Some forecasters do use different economic scenarios to generate a range of forecasts for the property market. However, not enough attention has been given to possible property market scenarios and their interrelationship with economic scenarios.

4
The need for local area forecasting

One of the main functions of property market forecasts is to service the process of portfolio construction. The key to managing property portfolios lies in structuring purchases and sales of assets to achieve required rates of return (or above, if opportunity arises) within a predetermined level of risk to the portfolio as a whole. While sector/region forecasting is a useful aid in this process it is by no means sufficient.

The description of the structure of a portfolio and any benchmark which it might be trying to outperform requires a division of property assets into a meaningful classification using certain property characteristics. As suggested, the most common current classification of asset types in property portfolio construction is the sector/regional split. This is largely an historical phenomenon relating to the availability of data. However, few would argue that a sector/regional division is the most meaningful way to divide up the UK commercial property market. Regional property markets do not exist as coherent entities.

This being the case, there are dangers in utilising a sector/regional approach to portfolio construction based on the sector/regional forecasts. Once one has a meaningful classification of asset types, providing the performance for the different asset types varies one can diversify risk and stabilise returns by purchasing assets across the different asset types. However, with a sector/regional classification, it is entirely possible to construct a number of different portfolios that are disperse across UK regions which are highly unstable. A “New towns” portfolio or a “Cathedral towns” portfolio would be examples. A New towns portfolio though geographically dispersed, would be highly vulnerable to government policy and a Cathedral towns portfolio would be highly vulnerable to factors influencing overseas and domestic tourism.

These are clearly extreme examples. However, as “systematic geographers” are aware, there are less obvious regularities in the industrial and business structures of cities which may well be overlooked if portfolio construction is conducted purely at the sector/regional level. A property portfolio constructed in the explicit knowledge of sub-regional regularities will be much less exposed to "extra market risks" (i.e. systematic effects not captured by the sector/regional asset breakdown).

Local area forecasting will not eliminate this problem. Another dimension of property performance, for example the age of properties, may still cause extra market risk. However, by arguing for local area forecasting an explicit case is being make that the local area level is the most appropriate for classifying property asset types. We should talk about "Manchester shops" and "Middlesborough industrials" rather than "Scottish retail" and "South West offices" and we are fast reaching the point where the data is good enough to make the transition.

Regional analysis will retain some value through its role in monitoring and reviewing aggregative local area forecasts. It also has a role in complex multi-centre regions such as the Outer Metropolitan Area of London where the definition and analysis of individual property markets is virtually impossible (see below). However, when local area models have reached the requisite level of sophistication and confidence, one would expect regional property market modelling to wither.

The transition to local area forecasting faces a number of conceptual and practical problems. These are explored in the next section.

5
Conceptual and practical problems for local property market forecasting

The first problem with local area forecasting is one of definition. What is a local property market, how should such a phenomenon be defined? Because of the spatial concentration of certain land uses in city centres, it has been possible until quite recently to talk without too much difficulty of the "Bristol retail market" or the "Leeds office market". However, the current levels of geographic dispersal (which have always described industrial markets and now reflect office and retail markets) make such simple definitions impossible. For example, what does the Newcastle-upon-Tyne retail market now mean? Does it include the Metro Centre and Gosforth suburban centre?

It is not the place of a review article like this to set out an answer to such a problem but the solution will most surely lie in defining markets as some limited form of "functional regions". It will also rely on reference to a clearly defined benchmark property type. In this way the property "unit" being forecast is unambiguous and the market being forecast is definable in relation to real world processes. For definitional purposes labour market areas may well be the most relevant definitions for the industrial and office sectors whereas retail catchment areas may be more appropriate for the retail market. (Note that this means that the "Norwich office market" will not be coterminous with the "Norwich retail market").

Once the definitional problems have been resolved, the local area forecaster will have to cope with the interpenetration of property markets in urban conurbations or complex urbanised sub-regions. For example, the office, industrial and retail property markets of Esher, Sutton , Epson, Merton areas in outer London all overlap. The growth of rents in any one market will depend to some extent on a variety of factors affecting the others. Differential levels of planning restraint influence this complex market situation. The availability of land in any one area may well force developers or occupiers to move to a neighbouring area to find space; population growth in one area may well supply labour for firms in another area; and shoppers from one location can shop with relative ease in any of the retail centres.

A very clear understanding of the dynamics of these interpenetrated regions will be required in order to produce meaningful forecasts. One suspects that the different centres will, in fact, have to be treated as one entity for forecasting and some form of apportionment of growth using knowledge of localised factors will be required to generate town specific rental forecasts. This would represent a more complex form of sub-regional forecasting to that use for monocentric centres.

A third conceptual problem to be faced is how to treat "soft" variables. Once modelling of local areas begins, many new forms of variable will have to be accounted for. Many of the new variables will relate to political factors. Examples could include, say, the likely influence on retail rental growth rates of the recent reversal in Manchester City Council's view of car parking in the central city which was introduced to combat the perceived threat to central Manchester from out of town shopping developments. The influence on rental growth of the creation or not of an enterprise zone or urban development corporation would be another policy issue to be considered. Local area forecasters may wish to make use of local surveys of business confidence produced by Chambers of Commerce. All of this new information will have to be assimilated in a disciplined manner. This will require the development of methodologies to handle this more qualitative form of data.

Turning to practical problems, the most major hindrance to local area forecasting will inevitably be the availability of data. The lamentable attention paid by successive governments to the collection of data on land ownership and property development has repeatedly proved costly in terms of wasted resources ploughed into property markets by developers ignorant of the true circumstances of the property markets in which they are dealing. The savings made on data collection (viz. the penny pinching measure not to continue publication on the Commercial and Industrial Floorspace Statistics) are minute when compared with the cost of money tied up in vacant buildings. It is despite, rather than because of, government efforts that property researchers have managed to assemble sufficient data to help them forecast sector/regional property markets. Government could certainly help in the future by aiding data assembly and the Royal Institution of Chartered Surveyors and the Society of Property Researchers could both play an important role in lobbying government to this effect.

6
Conclusion

Whether implicitly or explicitly, property investment depends on forecasts of future performance. Forecasting is already central to good property investment and will become even more important to property investment if there is any movement towards a securitised vehicle for property. It is beneficial to forecast "explicitly" in a reasoned way because the models being used to forecast performance can be examined and critically reviewed. the existence of explicit forecasts also facilitates consistency between individuals in the same investment house.

It has been argued that the most appropriate level for property market forecasting is at the town level. Property market forecasters are beginning to tackle the conceptual and practical problems of local area forecasting but this important work remains in its infancy. The government could certainly assist by paying more attention to the collection of good information on land ownership and property development. Until local area forecasting is a reality, the construction of property portfolios on a sector/regional basis will continue to carry some risks.

7
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Risk

SINGLE ASSET RISK

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Abstract

The appraisal of risk relating to individual property investments in the UK is an under-researched topic, being overshadowed by the greater interest in portfolio risk. However, single asset risk is of importance to the majority of investors who are unable to diversify sufficiently, due to the large lot sizes in property investment. This paper gives an overview of the research undertaken in this area and covers both the theoretical studies and the empirical work concerning the investment market-place. The wide gap between theory and practice is highlighted and suggestions made as to how researchers and practitioners can narrow that gap.

Keywords: Risk, Investment, Valuation, DCF, Sensitivity Analysis, Scenarios.

1. Introduction

This paper examines the perception and evaluation of risk in relation to individual property investments in the UK from both the theoretical and practical viewpoints. It is a subject that cannot readily be considered in isolation from other aspects of property investment. However, the paper does not attempt to deal with risk in relation to property development: for a treatment of this topic see Byrne and Cadman (1984).

2. Context

The word 'risk' has several connotations in common use and concepts of risk enter into various aspects of economic activity {see Moore (1983)}. For this paper a simple definition from finance theory is used viz. risk is the "uncertainty regarding the expected rate of return from any investment" {Reilly (1985)};

although it is acknowledged that in certain studies 'risk' is distinguished from 'uncertainty' {Moore (1983)}.

Thus, risk is viewed in this paper from an investment angle whereas a number of property investors tend to associate 'risk' first with the various sources of risk for a property, eg tenant insolvency or depreciation (see section 4.2 below).

Risk in relation to property investment should be set in the historical context of the considerable research that has been carried out in the UK, and more especially in the USA, in the field of equity investments from the 1950's onwards. It has been estimated that the real estate world lags behind the financial world in this area of research by decades rather than years.

Thus, much research in property risk has been devoted to the application of measures already devised for equity investment to the property market and these have generally related to portfolio risk analysis.

Baum & Crosby (1988) have identified three levels of analysis to aid decision making. The first and most basic level (being the minimum that investors should expect from their advisors) comprises present value or internal rate of return analyses based upon projections of income and expenses.

The next level consists of risk analysis of single property investments while the third level relates to risk and the portfolio. Portfolio analysis is outside the ambit of this paper, but boundaries are not watertight in property investment and there are significant links between risk analysis at single asset and portfolio levels, forecasting and market valuation. This paper, however, concentrates on the first and second of Baum and Crosby's levels of analysis.

The key sources for an introduction to single asset risk are Morley (1988) and Baum & Crosby (1988), while the author's own empirical work, Waldy (1989), also contains a fairly full list of references on the subject of property risk.

Finally, it should be noted that the subject of risk is growing in importance as property investment comes under increased scrutiny, both within the property world and in comparison with other main investment sectors. When property investments in general are producing very poor returns {eg IPD (1990)} the need for supportable means of measuring risk assumes even greater importance to engender confidence in property investment.

3. Overview of published research

3.1 Risk in general

Not only is property risk still a relatively under-researched subject in general, but the majority of the work that has been carried out relates to portfolio risk aspects.

Whilst portfolio risk has attracted greater attention, the main argument for considering single asset risk to be equally as important in practice is that most investors in the UK are not able to diversify away the individual property element of risk adequately {Baum & Crosby (1988)}. Thus there is a need to consider risk on a property by property basis and a need for research in this area.

However, prior to the research by the author, {Waldy (1989)} there was little evidence as to whether property investors based their attitudes to risk on portfolio or single asset principles. Nevertheless investors were believed to hold a variety of different perceptions of what constituted risk. This will be examined in section 4.2 along with the assertion that practitioners are ignoring the results of research and only have an "extremely imprecise conception" of the application of risk to commercial and industrial properties {Baum (1987)}.

3.2
The intuitive approach

It can be argued that the traditional investment valuation techniques do make an assessment of risk in that a suitable 'all risks yield' (ARY) has to be chosen to take into account the risk profile of the property.

Unfortunately the consideration of individual risks is hidden in the ARY. Accordingly this approach has been criticised by Trott (1986) in that the adjustments to the ARY the valuer makes to allow for risk are "subjective, arbitrary and altogether too robust and unsophisticated for the needs of the modern investor". However, the ARY method of dealing with risk as well as being implicit, embodies the intuitive approach to the problem of risk.

It is outside the scope of this paper to enter into the debate over whether an 'investment worth' of an asset can exist as distinct from market value {per McIntosh & Sykes (1985)} or whether as Baum & Crosby (1988) argue this is an illogical distinction. Nevertheless an investor in paying a certain price to buy a property takes on the risk inherent in that property and if his or her decision is based solely on ARY appraisal techniques then the ARY is the method of 'handling' the investment risk.

3.3
Explicit techniques

In contrast to the intuitive approach are the explicit methods of appraising value and assessing risk and these methods are based not on traditional valuation techniques, but on the discounted cashflow (DCF) model.

In its simplest form it represents Baum & Crosby's first and basic level of analysis (mentioned in section 2 above) to deal with risk using forecasts of income, expenses and capitalisation rates in a DCF to produce a net present value (NPV) or internal rate of return (IRR). At this level the investor can consider not only rates of rental growth but also depreciation of buildings and other relevant variables and make explicit their effect on the cashflow of the investment.

The relative merits of NPV and IRR have been debated in the wider financial world with the result that the NPV is seen to be generally superior to the IRR. However, in the real estate world the IRR continues to be preferred, according to Baum & Crosby (1988) because it is easier to use.

The DCF framework can be developed, with increasing degrees of sophistication, to allow risk analyses of single assets (Baum & Crosby's second level of analysis) to be undertaken. Among the less complex of these analyses are sensitivity analyses and scenarios.

Sensitivity analysis measures the effect upon capital value of a change in one or more the variables in the analysis. For a detailed examination see Sykes (1983a). The levels of sensitivity for variables can then be compared between different investments as a rudimentary form of risk comparison.

In a similar way different scenarios can be postulated by assigning appropriate values to the variables. Typically, optimistic and pessimistic scenarios are included to give a range of capital values for the subject property.

Both sensitivity analysis and scenarios provide only a crude analysis of risk as they fail to assign explicit probabilities to the various values of the variables.

Another criticism is that sensitivity analyses and scenarios merely give the investor yet more figures to interpret while a simple DCF can give a NPV "which provides a single unambiguous figure which leaves little doubt about the accept or reject decision" {Brown (1984)}. Furthermore Brown argues that risk can be taken into account by the choice of discount rate.

This line of approach to risk has been developed by the production of more sophisticated varieties of DCF analysis devised to make allowances for risk and still provide relatively clear results for the decision maker.

These DCF techniques make adjustments to the discount rate as in the 'risk-adjusted discount rate' method to reflect the riskiness of each cashflow or in the rental flow as in the 'risk-free discount rate' (or 'certainty equivalent') method. The latter requires income flows, which have a high likelihood of being achieved, to be estimated. These income flows are then discounted at a risk-free rate.

A further technique has been developed as a hybrid of these two techniques and is called the 'sliced income approach', which is not to be confused with the traditional 'layer' or 'hardcore' approach to valuation.

These three techniques are examined in detail by Baum & Crosby (1988), however, the authors refer to the "wealth of criticism" engendered by the "subjective and arbitrary nature" of the techniques.

3.4
Probability analyses

The next stage in single asset risk appraisal is not only to assign values to the variables over time but also to estimate the probability of their occurrence. The decision-maker should be assisted in weighing risk against return by having a measure for each of them. Returns can be quantified as the expected NPV or IRR while risk can be measured as the standard deviation of the returns.

The mean-variance criterion, a decision-making rule using the two measures just outlined, will often not be appropriate as investments offering higher returns may unsurprisingly be found to have higher risk as well. Baum & Crosby suggest the coefficient of variation of returns as a method of expressing risk per unit of return, although the subjective risk-aversion level of the investor still has to come into the decision {Baum & Crosby (1988)}.

There are several problems associated with this area of risk analysis including the continuous distribution of variables, skewness and serial correlation between cash-flows. For dealing with the last problem the Hillier method (1963) as adapted by Sykes (1983b) is considered by Baum & Crosby (1988) as well as Morley (1988), although the method becomes unwieldy in more complex cases and consequently the authors go on to consider the use of Monte Carlo simulation.

Monte Carlo simulation is not without its problems in practice and while Morley (1988) thinks they are theoretically possible to solve, it may be some time before they are actually resolved.

4. Assessment of risk in practice

4.1 Surveys of practice

Section 3.1 above referred to the belief that practitioners have ignored the results of research in this area but there has not been much empirical work carried out in the UK to determine what actually happens in the market place.

Recently, however, Rydin et al (1990) conducted a telephone survey of 39 decision makers in the UK property investment market from pension funds, insurance companies, investment trusts and external property advisors. The survey looked at the reasons institutions invested in property and included their perceived risk-return profiles.

Crosby (1989), in his survey on valuation techniques, received 160 responses to his postal questionnaire and held 23 interviews. The survey covered private practice, property companies, financial institutions and central and local government. The research examined the use of both traditional and explicit techniques for production of market valuations of freehold reversionary investments.

The perception and appraisal of risk is not the central focus of the two surveys just outlined and most of the evidence for the views put forward in section 4 of this paper come from the author's research {Waldy (1989)} into the attitudes and practice of property fund managers. This survey, comprising 43 fund managers, was carried out by means of 21 in-depth interviews and 22 returned postal questionnaires. The fund managers were from pension funds, insurance companies and management companies. The survey concentrated on perceptions of risk and the methods employed to deal with risk.

4.2
Risk perception and measurement by practitioners

The views put forward in the literature that risk in property is perceived in different ways by different practitioners was confirmed by the empirical work. A number of investors envisaged risk firstly in terms of individual sources of risk, such as voids or depreciation, rather than in investment terms, eg the risk that the returns from the investment would not match expectations. A sizeable minority appeared not to have given risk much serious consideration prior to be interviewed.

When suggested components of risk, eg illiquidity, were put forward in terms of their importance when considering risk, there were widely varying ratings given by different investors. However, there were indications that investors were more concerned about single asset risk than portfolio risk.

Nevertheless, the research showed clearly that when it came to measuring the risk attaching to either an individual property or a property portfolio 77% of the fund managers did not do either. With closer questioning of the remainder it would seem that, of the sample as a whole, over 90% do not measure risk specifically {Waldy (1989)}.

For those who said that they did measure risk, the means they used were scenarios, sensitivity analysis and probability analysis. However, it was found that these techniques (especially the first two) were also used by other investors who did not claim to measure risk. This suggests that their use of these techniques was for an overall appraisal of the investment rather than an attempt specifically to isolate a measure of risk.

The use of such appraisal techniques was not widespread. The proportion of investors who carried out DCF calculations (other than the most simple) on a frequent basis was below 35% with sensitivity analysis and scenarios being the techniques employed. This lack of use of DCF techniques by the majority corresponds to Crosby’s finding that valuers generally felt that DCF “should not be used to produce a market valuation except in certain abnormal circumstances” {Crosby (1989)}.

The risk-free, risk-adjusted discount rates, and sliced income approaches developed by the theorists and outlined in section 3.3 were hardly ever used for appraisal purposes.

Similarly, probability analyses were shown to have a very low level of use in practice.

4.3
The intuitive and explicit approaches

Having carried out their appraisals (whether they used few or many of the available techniques) the investors still had to make a decision. The key question was whether they gave greater weight to the results of the explicit appraisal techniques or to the intuitive approach epitomised by the all risks yield.

The investors surveyed split neatly into three groups of about equal size. The first group did not venture into undertaking much explicit appraisal and thus not surprisingly preferred the intuitive approach. The second (and opposite group) carried out explicit appraisals and said they preferred the explicit to the intuitive approach. The third group used explicit techniques but when it came to a difference in result would still make their decision on the basis of the intuitive approach. Thus in total, two thirds relied on intuition and one third on explicit techniques.

However, the property market does not stand still and changes in practice are likely, especially with the increase in post-qualification courses, such as the RICS Diploma in Property Investment. Thus, the surveys should be repeated over time.

In addition, the main source for this section {Waldy (1989)} did not attempt to survey the attitudes and practices of investment practitioners in firms of surveyors which might have caused problems of commercial sensitivity, although informal interviews were held and the limited literature available was considered eg Jones Lang Wootton (1987). Further research is needed to examine this area, however the main source, (consisting of property fund managers), did canvass the views of the decision makers who in the last resort are responsible for their investment decisions and thus, in theory, likely to have the keenest interest in the risks being run.

5.
Conclusions

It is hard and perhaps dangerous to divorce the question of single asset risk too far from portfolio risk and also from valuation. In terms of property research single asset risk has been a somewhat neglected subject as the main thrust has been towards the application of equity portfolio research to property portfolios.

What appears to be required is a detailed framework or suggested programme of research for risk and property investment. This framework (which could be developed from Baum & Crosby’s three level approach) would allow risk research already carried out to be put into a perspective and future research projects identified so that, in time, a more coherent picture of property risk could be obtained. It should then be easier to persuade the practitioners to consider risk more closely than they do at present.

Leading on from this is the conclusion that the gap between theory and practice is far wider than is healthy. While it is natural in any discipline for there to be a time lag between the publication of research results and their incorporation into actual practice the delay in property investment appears unduly long.

The reason for the gap does not lie entirely with the practitioners as researchers still have to improve the more complex techniques to make them practicable, but research suggests that this does not appear to account for the non-use of the more straightforward explicit techniques {Waldy (1989)}.

The practitioners would seem to be responsible for their own ignorance of the weaknesses of traditional appraisal techniques and the advantages of the newer techniques as the subject has received wide publicity for a number of years. Nevertheless, it would appear that the methods of dissemination have failed so far to reach or convince practitioners and thus the question of dissemination of research results needs to be examined afresh. The dismissal of explicit techniques for reasons of 'lack of time', 'ignorance of techniques' or 'lack of computers' (which were all given by interviewees) is not likely to impress outsiders to property, particularly when the decisions to be taken refer to assets of tens of millions of pounds.

Over time the growth in numbers completing post-qualification property investment courses, such as the RICS Diploma (mentioned above) or the part-time MSc at the City University, together with the rise to positions of influence of surveyors whose vocational training included more advanced DCF techniques, may change the habits of the market. In the shorter term the new requirement for Continuing Professional Development (CPD) for all chartered surveyors and the efforts of the Investment Surveyors Forum to encourage further professional education may result in greater use of the explicit techniques.

As part of any attempt to narrow the gap between theory and practice, researchers should give more attention to the role of intuition in property investment decision-making. Greater understanding of the way investment practitioners use the intuitive approach to come to their opinion may help communication between the two sides, since it is not necessarily ignorance of explicit techniques that makes investors depend on intuition. As the empirical work demonstrates (section 4.3 above) a third of fund managers surveyed knew about and used explicit techniques but ultimately relied on their intuition.

Finally, it would seem prudent for investors to undertake far more analysis than the majority do at present and by making greater use of DCF techniques, such as sensitivity analysis, to seek to improve their intuitive 'feel'. For the near future they can follow Hargitay (1983) who considered scenarios to be a reasonable interim approach to incorporating risk into property appraisal, pending the resolution of the problems attached to the complex probabilistic methods.

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PROPERTY PORTFOLIO RISK

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Abstract

This paper reviews the methodology available to property investment managers and develops a strategic framework in which property investment decisions should be made. It explores the benefits of portfolio diversification and points to the problems and short comings relating to property.

Keywords: Risk, Expected Returns, Modern Portfolio Theory, Indifference Curves, Capital Asset Pricing Model, Market Risk, Capital Market Line, Benchmarking, Tracking Error.

1
Introduction

The previous paper dealt with risk at the level of the individual property; this paper considers risk at the portfolio level, that is for a group of properties.

Surveyors have traditionally paid little explicit attention to risk. Some developments have been made by the profession for the analysis of individual property investments but portfolio risk has not received much attention from surveyors in practice.

Traditionally, property portfolios have been considered as collection of buildings each with their own characteristics, rather than as an aggregate investment with its own characteristics, such as structure (such as sectoral and regional composition) and risk. The developments which have been made at the aggregate level have typically been by non-surveyors working on property investment, or by academics. Few, except the largest institutions and specialist independent property portfolio advisers have tried to apply the analysis to practice.

This paper considers three aspects of portfolio risk: volatility of expected returns (and associated aspects of Modern Portfolio Theory and the Capital Asset Pricing Model); business risk (which is strongly linked to the first); and liabilities risk. It concentrates on the first.

2
What is risk?

Risk is synonymous with uncertainty. As investment decisions require the calculation of future returns, it is necessary to consider not only the best estimate but also the probable variation from this estimate. Risk is, therefore, a measure of what is expected to happen, not actually happening. Thus, in investment, it is a measure of the expected return not being achieved.

The traditional measure of risk is the variance or standard deviation of expected returns. Historical data is used to calculate both the expected return and the risk measure: it is thus assumed that the past gives a good indication of the future. **It is important to note that the analysis should be based on <u>expectation</u> of return and risk: the use of historical data as a proxy is merely a convenience.** The consequences of this will be discussed later in the paper.

3
Portfolio risk

Risk is a well known concept, if only intuitively. For example, **a bird in the hand is worth two in the bush,** can be regarded as risk aversion or the trade-off between risk and return. (For more risk averse investors it may be that a bird in the hand is worth three in the bush!)

The basic concepts of the formal analysis of portfolio risk are also intuitive: it is not that most investors ignore the principles of portfolio risk but rather that they do not formalise the analysis. **Don't put all your eggs in one basket** is advice to diversify risks; and diversification is the central concept of portfolio risks and of Modern Portfolio Theory.

4
Modern Portfolio Theory

Modern Portfolio Theory (MPT) was developed for the equities market. As most investors hold portfolios of assets rather than one asset, return and risk of individual assets are important only because these are used to calculate the portfolio risk and return.

When assets are combined in a portfolio, the expected return of a portfolio is the weighted average of the expected returns of the component assets. However, unless the assets are perfectly correlated, the risk is not the weighted average: it is determined by the covariance structure of the component assets. The way in which assets co-vary is central to portfolio risk: it provides diversification opportunities.

Ex: Consider two assets with same expected returns. Consider first the case where their returns always go up and down together. Now consider the case where, if the return on one falls, the return on the other rises and vice versa.

In both cases, the expected return (best guess) will be the same; but the risk will be different. In the first case, there is either high return or low return; in the second there is always an average return. **The first is riskier.**

The objective of MPT is:

Either, for a given level of risk, to achieve the maximum return;
or, for a given return, to achieve minimum risk.

The output of the analysis is the proportion of funds to be invested in each asset, and a measure of the expected return and the risk.

If two assets have perfect negative correlation, then it is possible to create a portfolio with no risk, by selecting the correct weights (proportions) in each. The weights should be in inverse ratio to the standard deviations:

$$W1/W2 = S2/S1$$

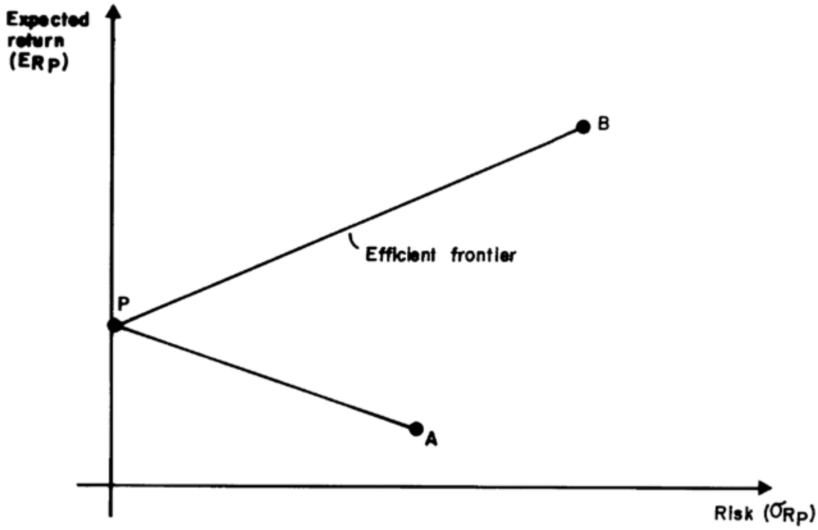
Where W1 and W2 are the weights for assets 1 and 2 respectively; and S1 and S2 are the standard deviations of assets 1 and 2 respectively.

The line of all possible combinations of risk and return is shown in Figure 1. In this case, the upward movement of one is cancelled exactly by the downward movement of the other. The return is guaranteed as the weighted average of the returns and there is zero risk. Needless to say, in reality, this never happens: two assets never have perfect negative correlation. It can be seen from Figure 1 that some combinations of the two assets (along the line AP) are not optimal, that is, it is possible to obtain higher return for the same risk.

If the correlation coefficient is greater than -1, the risk cannot be zero. The line of all possible risk combinations is more likely to look like that in Figure 2. The decision of which combination to choose depends on the risk/return trade-off, the indifference, of the investor.

If there are more than two assets there is an area of possible risk/return combinations, rather than a line, as shown in Figure 3. In this case, there are clearly combinations which are optimal: it possible to get extra return for the same risk or to have less risk for the same return. By eliminating the sub-optimal points it is possible to construct the Efficient Frontier. The decision of which combination of risk and return to chose along the efficient frontier depends on the trade-off, the indifference between risk and return, of the investor.

FIGURE 1: Risk and return combinations with two assets and perfect negative correlation



5
Indifference curves

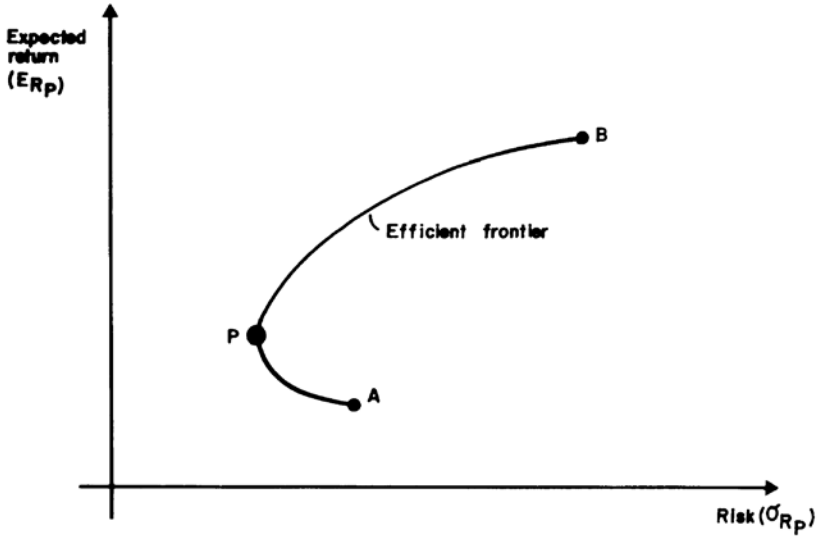
One of the most important concepts in investment theory is that of a trade-off between risk and return. A higher risk has to be compensated by a higher expected return. This can be formalised in the mean-variance criterion which states:

> If there are two investments A and B, A is preferred to B by all investors, only if the expected return on A is greater than the expected return on B and the risk of A is less than the risk of B.

If these two conditions do not hold, it is necessary to know the trade-off which any particular investor will make between return and risk. In other words, it is necessary to know the investor's indifference between return and risk. Different investors make different trade-offs: some are less risk averse than others and so are prepared to bear additional risk for a smaller additional return.

From the indifference curves it is possible to determine the optimal portfolio mix and the return and risk of the portfolio for that investor. The indifference curves and the optimum portfolios for a risk taker (RT) and a risk averse investor (RA) are shown in Figure 4.

FIGURE 2: Risk and return combinations with two assets and low positive correlation

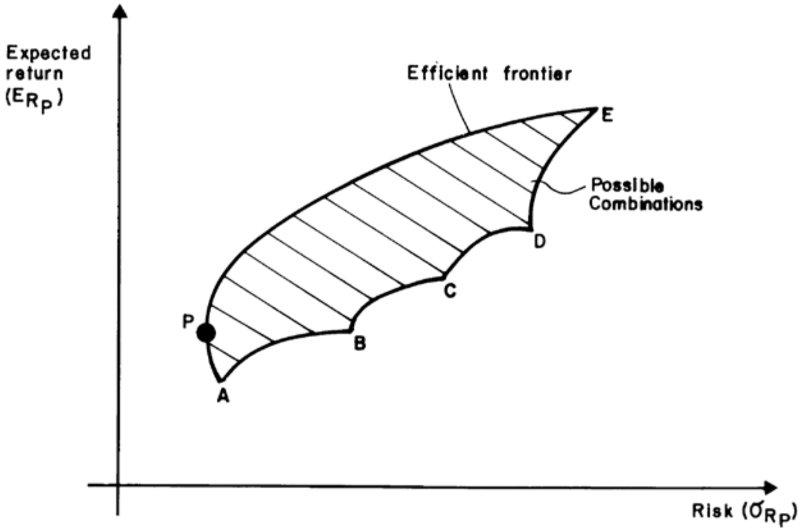


6
Practical applications

In principle, MPT can be used to construct an optimal portfolio for an investor but in practice there are a number of restricting problems.

(a) Identifying the indifferences of investors is not easy. In practice it may be overcome (more accurately, side-stepped) by offering investment decision-makers a small number of options. This may be termed "template" portfolios.
(b) There are problems of the lack of the necessary technical skills: virtually all those who are applying these procedures in practice are not trained surveyors. New ideas and techniques introduced from other investment markets can only be an asset to surveying, but the education of surveyors in the future requires to incorporate this type of training.
(c) **Defining the assets** is not straightforward. MPT was developed for the equities market, for construction of portfolios with shares. Each share in a company is the same as any other, so shares in a company could be defined as the asset class: any member of the asset class would have identical return and risk characteristics. In property, there is no such homogeneity within an asset class: it is necessary to use asset classes which perform similarly. Typically, sector/region combinations, such as retail in East Anglia, have been used. It may be possible to construct other classes: urban structure (properties in different sizes or types of town); age or size of properties; and

FIGURE 3: Risk and return combinations with five assets



lease structure have been suggested. However, there are substantial data problems and forecasting problems with such classifications.

(d) The **period of analysis** in important. Either MPT can be used to determine a long term structure of the portfolio (a neutral position) based on long term average expected returns. Or, if a view is taken on expected annual returns which differ from the long term expected value (that is, if the investor has some forecasting ability), to determine short term structure.

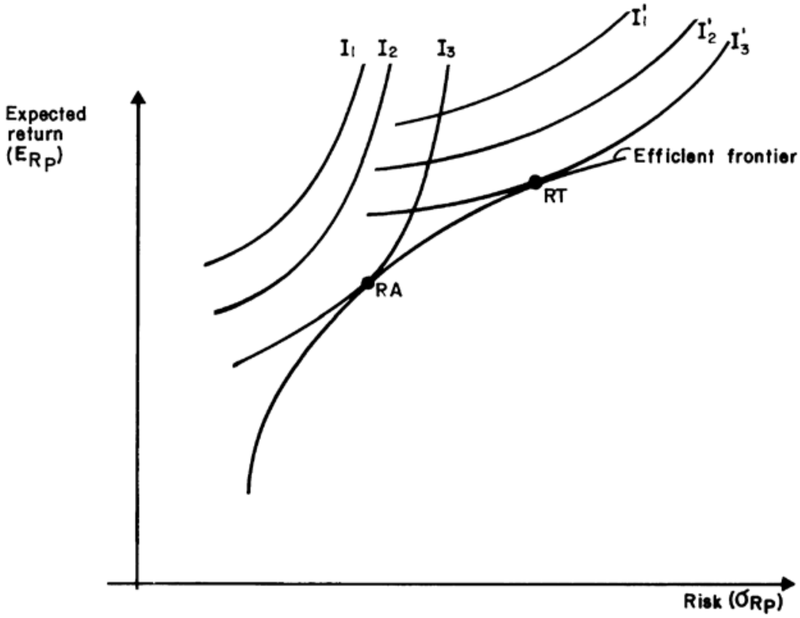
For the first, if the adopted neutral position is different from the average of competitors, then there is a risk of underperforming competitors and losing business. This **business risk** is discussed below.

For the second, the problem is that the optimum structure of the portfolio may be different from the long term structure and may change dramatically from year to year depending on new forecasts of returns. Changing the sector/region structure of a property portfolio quickly is not easy and it may be impossible for a large portfolio.

Taken together these problems suggest the importance of knowing the structures of competitors' portfolios and adopting this as a neutral position or "competitive benchmark". "Bets" may be taken, based on short term forecasting, around this competitive benchmark, and risk redefined relative to this (see below).

(e) The **calculations** required are tedious, although with the advent of PC's are relatively straightforward. However, the data is poor: the available indices have short time series; are constructed in many different ways; and are based on valuations rather than market price. Therefore, the use of expected return

FIGURE 4: The efficient frontier and indifference curves



and risk measures based on suspect historical data is not the best way forward.

(MPT has also been used to argue for large proportions of property to be included in the multi-asset portfolio. Such analyses also suffer from the inadequacy of the data.)

In order to apply the techniques to the management of real property portfolios, a shorter and more robust procedure is required. This should be based on expectations, economic fundamentals and regional economic change. This may be informed, but not determined, by historical data. In general, there is a need for more research on the role of property in the economy.

7
The Capital Asset Pricing Model (CAPM)

Sharpe introduced the Capital Asset Pricing Model (CAPM) in the early 1960's as an extension of MPT. It is from CAPM that we get "beta", a well know, though not necessarily well understood, concept in investment.

Sharpe argued, that as most shares are positively correlated, there is a common market response in their returns. Under CAPM, the only common factor affecting returns (and their riskiness) is the return on the market. The returns on all shares are related to a common index (the market as a whole) rather than to each other as in MPT.

7.1
Market and non-market risk

Fundamental to CAPM is the assumption that the risk of an asset can be divided into two parts. The first is called systematic (or market or non specific) risk and cannot be diversified. The second is called unsystematic (or non market risk or specific) risk. It is particular to an asset and can be diversified away when the asset is held as part of a portfolio.

Thus, systematic risk affects the entire market, whereas unsystematic risk is a function of specific factors relating to individual assets, rather than to the market as a whole. Put simply, and in words rather than algebra, this means that the larger the proportion of the portfolio is held in any building, the greater is the impact of poor or unrepresentative performance from that property.

By holding 10 shares, an investor can diversify away 90 per cent of specific risk leaving the specific risk as one third of the total (Rutterford, 1983). Figures for property suggest holding 10 properties diversifies 70 per cent of the specific risk, leaving it as half of the total (Brown, 1988).

7.2
Risk and return

In a market dominated by holders of portfolios constructed using the Markowitz efficient frontier approach, the only risk rewarded with greater return is market risk. This is important as 80 per cent of the equities market is held by the financial institutions who are able to hold diversified portfolios.

Any remaining risk (non market or specific) would not be compensated by a higher return because it can be diversified away by holding more assets. Therefore, investors are not compensated for all the risks they take. This understanding has led to the development of asset pricing models as a means of determining the correct price of an asset: that is the correct reward for risk taking.

However, there are problems when the analysis is applied to property. It is possible to obtain small amounts of many shares and so diversify specific risk; but there is a limit to this for most investors in property because of the large lot size. The result is that diversification in property portfolios is more difficult and even quite large portfolios can have a large amount of specific risk. The property market, therefore, is not likely to be dominated by investors able to eliminate specific risk. For those who can there should be underpriced assets. This whole area requires more research.

8
The Capital Market Line (CML)

The relationship between the return on the market; the return on an asset; and the market risk of an asset is central to CAPM. To extend the analysis, CAPM introduces a **risk free asset** and allows for investment in this asset or for borrowing at this risk free rate. This development requires a number of further assumptions about the investment market. These are as follows (Rutterford, 1983).

(a) A perfect securities market, that is: no taxes; no transaction costs; no restrictions on selling short; all information is free and simultaneously available to all investors; securities are infinitely divisible; no individual can affect the market by buying and selling; and investors are rational maximisers.
(b) All investors agree on the period under consideration and have identical expectations about risk (this is not needed for MPT).
(c) Unlimited amounts of money can be borrowed or lent by all investors at the risk-free rate.
(d) If inflation exists it can be fully anticipated in interest rates.

The conclusion of the CAPM analysis is that all investors should hold a proportion of their funds in a market portfolio, which is common to all investors, plus an investment in the risk free asset. The new line of possible optimum combinations or risk and return is know as the **Capital Market Line**.

In Figure 5, all investors, no matter what their risk-return indifference can obtain a portfolio with higher return for the same risk. This is done by investing in the market portfolio M and the risk free asset RF.

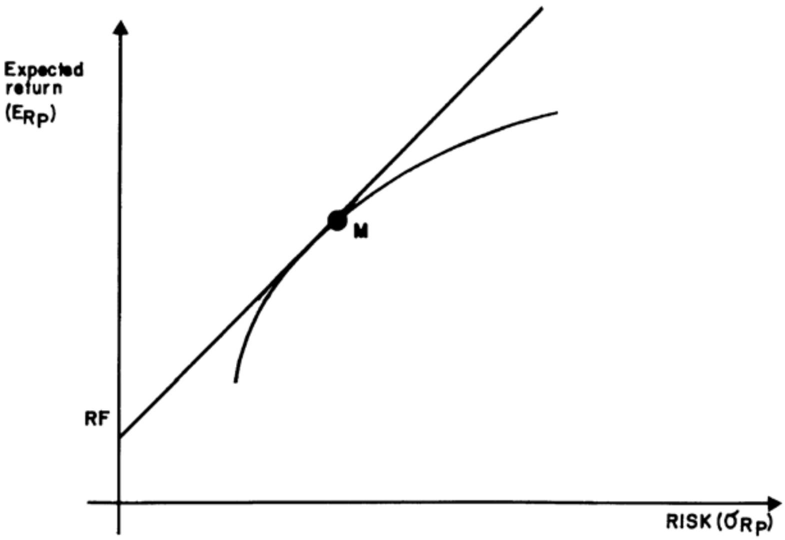
The investment in the risk free asset can either be positive or negative: it is possible to invest money in the risk free asset or to borrow funds at the risk free rate of the asset in order to invest more in the market portfolio. In effect, this is borrowing and gearing to increase the risk and the expected return of the total investment.

9
Security Market Line

From the assumption that the market effect is the only common effect, and that there are no economic factors which affect only some sectors or some industries, a relationship can be derived between the return on the market; the return on an asset; and the market risk of an asset. The equation, known as the **Security Market Line** is:

$$E(Ri) = Rf + [E(Rm) - Rf].B$$

Figure 5: The Capital Market Line



where:

E(Ri) is the return on an asset

Rf is the risk free rate

E(Rm)−Rf is the return on the market in excess of the risk free rate

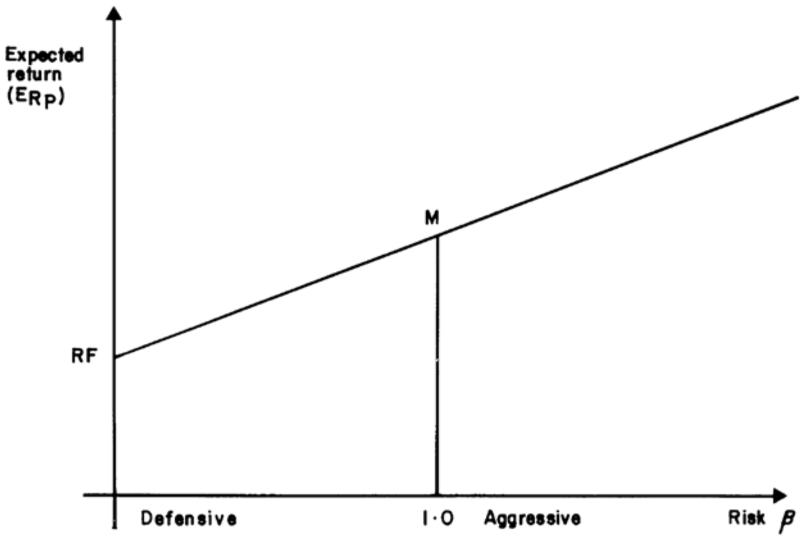
B=COVim/Sm^2 is beta, (where COVim is the covariance of the individual asset with the market and SM^2 is the variance of the market) is a measure of the risk of an asset relative to the market.

If beta is 1, then the asset has the same risk as the market and the return will be the same as the return on the market. If beta is zero, there is no risk and the return is the same as for the risk free asset. If beta is less than 1, the return is less than the market and if beta is greater than 1, the return is greater than the market.

10
Pricing

The Security Market Line shows that there is a linear relationship between the market risk of an asset (as measured by beta) and its expected return. This can be used as a pricing procedure. If the market risk of the investment is known and the expected market return is known, the expected return on the asset can be calculated and compared against the return which the asset is priced to deliver. This shows whether the asset is correctly priced. Figures for beta are available for all quoted shares on all major stock exchanges and are regularly updated.

Figure 6: The Security Market Line



Although CAPM is appealing there is no reason to believe that it is possible to make the necessary assumptions to permit the analysis. The most basic problem is the difficulty in defining the property market.

11
Single index models and multi-index models

CAPM is a single index model: that is, it assumes that the only common factor affecting returns (and their riskiness) is the return on the market. This is measured by beta (the covariance with the market). Multi-index models have been developed which link returns on a share to other common factors such as industry specific factors. For property, there are factors which affect some sectors rather than others: retail sales affect the retail sector most, while manufacturing output affects the industrial sector. There are also factors which affect regional economies in different ways, such as export dependency in the manufacturing sector.

Therefore, it seem possible that there is scope to develop a multi-index property model which could be used as a basis for risk analysis and pricing for holders of property portfolios. This whole area of portfolio risk requires further research.

12
Other forms of risk

Two other forms of risk are worth mentioning. These are business risk (losing out to competitors) and liability risk (the risk of being unable to meet liabilities). These are both concerned with the range of expected returns in relation to something else, rather than in an absolute sense.

12.1
Business Risk

For business risk, the risk measure is not absolute volatility but relative volatility. If all competitors have the same portfolio, which has a high absolute risk measure, there is no business risk. A fund will be compared with its competitors, so if they all take risks and lose, it will be compared favourably as all have taken the same risks and have the same poor performance.

However, if a fund does not take the same risk as its competitors, but constructs a lower risk portfolio, and its competitors obtain a higher return (that is, risk pays off) it may lose business to them. This is particularly a problem as fund managers can lose business on the basis of one year's bad results rather than a longer term average.

Tracking the performance of competitors is know as benchmarking. It is a variant on indexing. Rather than take the market as a whole as an index, a specified set of competitors is used instead. The **formal** risk measure is the variance of the expected return **relative** to the market average or specified competitors. This is known as the **tracking error:** it has been adapted for property specifics.

12.2
Liabilities

Consideration of liabilities leads to consideration of duration. An investment strategy could be seen as attempting to match liabilities with assets: by equating present values. One important factor which causes the present value of liabilities to alter is the interest rate which is used to discount future cash flows. Duration a measure of the responsiveness of the present value of liabilities or (assets) to changes in the discount rate.

To minimise this form of risk (not being able to meet liabilities) it is necessary to match the duration of liabilities to the duration of assets. Thus, if the interest rate changes, the present values of both assets and liabilities change in the same way. This adds another dimension to risk. Duration, and particularly in property, is still largely an academic subject, but its importance may grow and research is required.

13
Conclusion

An explicit analysis of portfolio risk is an important aspect of the construction and management of an investment portfolio. Modern Portfolio Theory (MPT) has formalised the analysis of risk and return in a portfolio context. It was extended into the Capital Asset Pricing Model (CAPM) by assuming that there is only a single factor affecting all asset returns, namely, the return on the market.

CAPM is a single asset model and so is rather simplistic. Multi-asset models have been developed and their application to property is worthy of further exploration.

There are two kinds of risk: market and non market. Investors are rewarded only for market risk as non-market risk can be diversified away by holding more assets. By assessing the market risk of an asset, it is possible to derive an asset pricing framework.

None of these is widely used in the property investment market but the basic concepts and the analytical framework have some practical value. Much research is required, both fundamental and applied, to develop the application of these techniques to property portfolios.

However, enough is already known, even if the skills are in short supply, to apply these techniques to the strategic management of property portfolios. This would improve the risk management and, therefore, the return of property portfolios.

14
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PROPERTY AS A GLOBAL ASSET

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Abstract

This paper examines the attractiveness of property as a discrete asset class in the context of global institutional investment strategies, and looks at the likely impact on UK property investors of globalisation and deregulation in Europe.

Keywords: Investment, Strategy, Institutions, Asset classes, Risk, Returns, Inflation hedging, Benchmarking, Overseas, Diversification, Globalisation, Europe.

1
Introduction

The contents of this paper are derived from a number of projects undertaken by the author and his colleagues at the University of Reading and Real Estate Strategy Ltd. These include in particular RES' Asset Allocation and Property and the RES/CEPR contribution to Prudential of America's Global Watch Report.

The contributions of Professor Charles Ward, Professor Bryan MacGregor, Nick French, Marshall Hsia, Bridget Rosewall and Charles Wurtzebach to these projects and therefore to the contents of this paper are acknowledged.

1.1
Objectives

This monograph has two main purposes. These are as follows.

First, at a time when property is falling from favour, the attractiveness of property as a discreet asset class in the context of institutional investment strategies is examined. Second, at a time when Europe is emerging as a so-called single market, and when investment strategies are increasingly driven by globalisation, the likely impact of these twin processes upon UK property markets and investors is examined.

An answer to the first issue is provided with specific reference to the UK institutions. A small sample from this group provides some indicative evidence of the processes which currently operate. An answer to the second is attempted by looking through the eyes of an overseas institutional player, namely the US pension plan.

The second issue cannot be considered without reference to the first. Only when it has been possible to establish the function that property performs in the portfolio can the case for non-domestic property be examined. And to address the first without the second ignores a change in investment behaviour which is so powerful that without it the basis of the early part of the paper might be invalidated.

It is not possible for many to resist the desire to speculate about the future. A presumed insight into the present will destroy any prospect of that desire being resisted. Section 6 concludes by illustrating this common weakness.

1.2
The UK institutions

UK institutions have built massive power in the UK securities markets: for example, one institution alone (Prudential) controls as much as 3.5% of the UK equity market. Broadly these same institutions (pension funds and insurance companies, but added to by property unit trusts and others) now control around one-third of the commercial property market. They became major players in the UK property market in the 1970's, building up their property portfolios to nearly 19 per cent of total assets in 1981, through a combination of investing, developing, funding developers and improving existing assets.

The average property weighting in the UK institutional portfolio has now dropped back to around 12 per cent. It is not clear whether this is the result of a positive plan to disinvest or whether it is the result of the strong performance of equities in the 1980's. It is not clear whether the recent reduction in the percentage of assets allocated to property will continue through the 1990's. It is not clear whether institutions will act as developers, whether they will fund property company developments or whether they will concentrate solely on investment and the active management of existing assets.

On the other hand, it **is** clear that:

(i) institutional investors can now choose between a much greater variety of domestic and overseas investment vehicles than was the case ten years ago;

(ii) the property industry generally lacks the tools needed to market property successfully to institutional investors who have a choice of many asset types; and

(iii) there is currently concern in the UK over the possibility of a continued decline in institutional commitment to property.

1.3 Structure

The remainder of this paper is in five parts.

In Section 2, UK institutions are defined and categorised. The current and recent property weightings of these sub-categories of institutional investor are presented. The larger and more important players are listed by category, and the asset allocation process is briefly examined. A small survey of fund managers is used to examine typical institutional attitudes to property.

Section 2 also presents material which will allow conclusions to be drawn concerning the attractiveness to the various investor types of direct development, funding developments and other routes to property exposure.

In Section 3, the reasons why institutions buy any asset are dealt with and property's position is examined in some detail. The attractiveness of property to the main categories of institution is identified.

Section 4 examines the case for a global property strategy. This continues the theoretical perspective of Section 3 and repeats the method of approach. It goes on to make a case for an investment strategy based on three global zones, and describes the process which is currently taking place with the object of developing a single market in Europe and suggests that UK markets must be analysed in the context of that new market.

Section 5 concludes by speculating on the likely future behaviour of investing institutions. It examines whether property will become more or less attractive to particular institutional types, whether developments, fundings or joint ventures are likely to be more or less popular, and discusses the impact of globalisation both on investor strategies and on global property markets.

2 The UK Institutions and Property

2.1 Objectives and background

The main purpose of this section is to define and categorise those investing institutions which constitute the single most powerful influence in global property markets.

Because their influence has been strongest for longest in the UK, Section 2 concentrates on the UK institutions to enable some relatively simple analysis to be carried out and to serve as an example for the remainder of the paper. The current and recent property weightings of these sub-categories of institutional investor are presented. The larger and more important players are listed by category, and the asset allocation process is briefly examined.

2.2
Pension funds

Pension funds are established to meet the future pension liabilities of the employees of a particular organisation. Occupational pension schemes have grown rapidly over the last 30 years with half of the UK working population now being members of a pension scheme.

A distinction may be made between 'insured' and 'self-administered' schemes. The former is normally managed on behalf of the trustees by a life office which will bear the actuarial risk. The latter carries the risk itself with the management to be carried out in-house or contracted to an external fund manager.

Occupational pension schemes may be either funded or unfunded. The former involves the setting up of an investment fund, while the latter provides benefits directly out of current contributions from existing employees. Most UK occupational schemes are funded.

Funded schemes may be further categorised into 'immature' and 'mature' funds.

An immature fund is one where the net contributions made by the existing employees match or exceed the payments to be made to retired members. In such a scheme there is a surplus of contribution income each month for the fund to invest. The investment income from existing investments compounds this surplus of current income. Therefore, the objective of an immature fund is to invest in assets which will provide future income flows to match the liabilities that will occur as the fund matures, and to reduce the future contribution rate as far as possible.

A mature fund is one where the net contributions made by the existing employees are not sufficient to meet the liabilities to retired members. Investment income is therefore required each month to supplement the contribution income. Therefore, the objective of a mature fund is to have investments which provide an income flow which is sufficient to meet current liabilities, yet at the same time have the future growth potential to meet future liabilities and reduce the contribution rate as far as possible.

There are very great difficulties associated with measuring the maturity of a pension fund, and the scheme's trustees and actuaries retain considerable influence over this question through the exercise of policy. Immaturity is, however, more likely in a growing industry.

The largest UK pension funds by size are shown in Table 2.1. They can be broadly grouped into three categories: manufacturing, energy, and services. There has been a continual shift in the employment structure away from the traditional manufacturing industries. This shift is expected to continue and implies that pension funds in the traditional manufacturing sectors, such as ICI and British Steel, are likely to become more mature.

The energy industries are also likely to experience a reduction in employment, particularly the coal industry but also the oil, gas and electricity industries. Pension funds in these industries are likely to become more mature in the future.

By contrast, many of the service sectors are still expected to grow rapidly. These industries include banking, air transport, the post office, and education. Pension funds in these industries are less likely to mature quickly in the future.

Table 2.1 Largest pension funds (£bn)

Industry	Size
British Coal	12.00
British Telecom	12.00
Electricity Supply	8.50
Post Office	7.75
British Railways Board	7.00
Universities Superannuation Scheme	5.80
British Gas	5.75
Barclays Bank	5.20
ICI	4.15
National Westminster	4.05
British Steel	4.05
British Petroleum	4.00
Shell	3.80
British Airways	3.35
Lloyds Bank	2.75
Midland Bank	2.55
Unilever	2.20
Water Authorities	2.20
Strathclyde Regional Council	2.15
BBC	2.05

Source: Pension Funds and their Advisers, 1990

2.3
Insurance companies

The activities of insurance companies are defined as either long-term or general. The funds for each of these categories are required to be kept separate by law. Life assurance forms part of the overall category of long term business, which involves the accumulation of funds over long periods of time.

Life assurance policies may be either with-profits or without-profits. The former guarantee a base payout which must be met by the insurance company and also entitles the policy holder to a share of the profits of the office.

The latter are policies whereby the payout is determined and fixed in advance. The top ten UK life assurance companies by size are shown in Table 2.2.

Table 2.2 Life assurance companies (£bn)

Company	Size
Prudential Corporation	27.10
Norwich Union Life Assurance Society	13.90
Legal and General Group	12.50
Standard Life Assurance	11.50
Scottish Widows' Fund and Life Assurance	7.00
Pearl Group	6.70
Commercial Union Assurance	6.50
Sun Alliance Group	6.40
Sun Life Assurance Society	6.10
Royal Insurance Holdings	5.40

Source: Extel

General insurance includes classes such as fire, accident, household and motor insurance, which by their nature represent short term liabilities.

As the essential characteristic of an insurance company is to spread risk either over time or between policy holders, or both, it is important that each fund has regard to the nature, mix and term of the relevant liabilities.

The top ten UK general insurance companies by size are as shown in Table 2.3.

Table 2.3 General insurance companies (£bn)

Company	Size
Royal Insurance	3.30
General Accident Fire and Life Assurance Corporation	2.60
Sun Alliance Group	2.30
Commercial Union Assurance	2.20
Guardian Royal Exchange	1.60
Eagle Star Holdings	1.20
Prudential Corporation	0.90
Norwich Union Fire Insurance Society	0.85
Co-operative Insurance Society	0.42
Cornhill Insurance	0.40

Source: Extel

2.4 Property unit trusts

A unit trust is a legal claim to a fractional part of a trust's total portfolio. It allows a small investor to benefit from full portfolio diversification and specialist management without requiring the individual expertise and financial resources that would be necessary if investing directly in the same investment portfolio.

A Property Unit Trust or PUT invests solely in property, but holding units differ from holding shares in a property company. While the former is subject to trust law, the latter is subject to company law. A PUT is generally 'open-ended', meaning that it can contract or expand according to demand and supply. Units in PUTs are not marketable in a secondary market and can only be acquired or redeemed through the unit trust, while company shares are traded on the stock exchange. While property companies are often highly geared, borrowings of PUTs are usually small. Finally, while PUTs are tax transparent, company shares pay dividends out of taxed profits.

PUTs have traditionally been unauthorised, so that they cannot be marketed direct to the public. This is now changing, although the essential function of the PUT, to provide a medium which enables tax exempt pension funds and charities to invest in property without taking excessive risk, will ensure their continuation. Problems associated with their open-ended nature will, however, need to be remedied.

2.5 Traditional institutions

The Church, the Crown and local authorities have accumulated large portfolios of investment land and property through bequests, deaths intestate and government sanction. While generally regarded as operational land, these holdings are increasingly subjected to investment performance criteria. Almost falling into this category are other private estates including the Grosvenor Estate, which is now a major property developer and investor.

2.6 How institutions invest in property

2.6.1 Introduction

Institutional investors can gain exposure to property in a variety of ways, including direct investment, direct development, active management, funding developments, investing in property unit trusts, buying property shares, issuing property-backed mortgages and others.

Investing in shares and mortgages is undertaken typically as part of the equity and debt portfolios and is not counted as part of the property portfolio. It is not discussed further in this section.

The 1990's is likely to see changes in the pattern of institutional property investment, and for this reason it is useful to briefly examine the current position.

2.6.2 Investment

Direct investment is typically undertaken through the purchase of new or second-hand properties or through buying interests in properties already at least partly owned. Purchasing units in PUTs, a form of indirect investment, is attractive to small pension funds, but most pension funds of £200 million or more will hold a direct property portfolio, the average exposure being between eight and twelve per cent of the total portfolio. Buying-in other interests and other forms of active management may be more difficult to achieve successfully unless the fund has an in-house property team.

2.6.3 Development

Institutions and property development

Institutions also invest in property through direct development, funding developers, refurbishment and joint ventures.

Property investors naturally become involved in active asset management as existing properties come to be in need of refurbishment. This leads naturally to direct development activity. Many large institutions have become major property developers in this way.

While all net pension fund investment in direct property in the 1980's can be attributed to commitments to developments, very few pension funds have concentrated their activities on direct development. Those funds that have done so have not always had a positive experience, the example of ESN and the Trocadero being prominent. PosTel (which manages both Telecom and Post Office pension funds) and BP each continue to be involved, but it is the insurance companies which are easily the most prominent.

Almost all of the large companies have been active. Large schemes have been undertaken by Prudential, Norwich Union, Legal and General, Eagle Star, Commercial Union, Scottish Widows, Scottish Amicable, Scottish Life, Britannic, Guardian Royal Exchange and Sun Alliance.

Funds have typically acquired slightly less than half their property interests by investment purchase and slightly more than half by development and refurbishment and by purchases related to active management of existing assets (IPD, 1990). Retail properties are more often purchased as standing investments than either offices or industrials.

Bigger insurance companies prefer to concentrate on direct developments, and some, such as Sun Alliance, GRE and Scottish Widows, have a particular concentration on development. However, the profitability of development for insurance funds is not clearly proven and several funds are likely to follow the lead of Prudential and concentrate on refurbishment projects drawn from the existing portfolio for the next five years or so.

Direct development by funds has damaged the availability of equity finance through fundings for property development companies. As institutions have undertaken direct developments with in-house teams, the need to share development profits with property companies has disappeared, and this has been a major factor leading to the current mountain of debt (£40bn or more) attached to the corporate property sector.

It has already been established that long term life funds are a key part of the property-buying institutional establishment. If the very largest of these have stopped funding developers for good, this is an issue of some significance for the debt-ridden corporate sector in 1990.

However, some long-standing relationships exist between property companies and institutions. These include significant shareholdings, as shown in Table 2.4.

Table 2.4 Institutions' shareholdings in property companies

Property company	Institution	Shareholding (%)
Hammerson	Standard Life	23.7
Brixton	Clerical Medical	22.4
MEPC	Co-operative	16.3
Brixton	Royal	15.2
Greycoat	Legal and General	10.4
Hammerson	AMP	9.2
British Land	Provident Mutual	6.5
Land Securities	Scottish Widows	3.8
Rosehaugh	Commercial Union	3.4
Slough	Britannic	3.4

Source: UBS Phillips and Drew

Problems associated with institutional property development

Institutions became jealous of development profits in the 1950's and 1960's when fixed interest finance provided in the form of debt finance by institutional lenders allowed the property company to keep the whole of the gain created by rising rental values. There are, however, serious problems for institutions which become involved in direct development, and these issues will become more prominent in the 1990's.

The first of these is staff recruitment, motivation and retention. There are strong reasons why institutions cannot expect to employ those entrepreneurs who are most likely to create development profits consistently. As a result there is evidence to suggest that development for institutions is not very profitable, and does not compensate for the risks involved.

The second is the focus of the investing institution on investment performance and the conflict that this can create with profit-motivated activity. The result can be loss of motivation and unprofitable development. The natural activity of the institutional investor is investment and active asset management, and this is increasingly recognised.

It is clear that institutions have a considerable commitment to the property company sector. Property shares have produced significantly higher returns than direct property, and it is not clear that in-house developments by institutions are successful. There is a strong case for the strengthening of relationships between institutions and property companies and a return to institutional funding of developers.

2.7
A survey of UK institutions

Table 2.5 Investor types answering questionnaire

Immature Pension Funds	4
Mature Pension Funds	6
Life Assurance Funds (with profits business)	2
General Insurance Funds	2

In terms of market influence, life assurance companies are most important, followed by pension funds and then by general insurance funds. To illustrate the differences between the major investor categories, a small survey was carried out at the University of Reading in July 1990. The results are presented below. This survey should be regarded only as an indication of the views held within the community of property fund managers.

In total fifteen fund managers were approached of which nine provided full answers and supporting comments to the questions asked. Of the respondents, five gave information relating to two separate fund types so that the final sample of 14 covered the investor types as shown in Table 2.5.

The survey covered a range of funds of between £10 million (general insurance fund) to £10 billion (mature pension fund).

2.7.1
Percentage holdings of asset classes

Each respondent was able to provide a detailed percentage breakdown of the fund's holding in each investment class. Of the fourteen funds which responded only two currently did not hold any property assets, with the remainder having holdings ranging between two and thirteen per cent. There was no discernible pattern of holdings within each investor type, but the larger funds (in excess of £400m) tended to hold proportionately more property within the overall portfolio (seven to thirteen per cent, compared to two to three per cent for the small funds).

2.7.2
Property holdings five years ago

With only one exception (a zero-property fund) all funds held proportionately more property in the portfolio five years ago. In most cases, while there has been little change in the capital value of the property component, the property holding has halved in percentage terms since 1985.

Many respondents commented that this had been a deliberate policy. The objectives of the relevant fund had been to decrease the relative size of the property holding.

2.7.3
Property holdings in five years' time

There was very little consensus among the respondents upon their estimation of property's relative importance in five years' time. Most indicated that they believed that the property market was likely to fall over the next 12 months, and few felt that property would perform particularly well over the next five years.

However, a number commented that property is becoming relatively cheap and therefore they expected the percentage holding of property in the portfolio to increase over the medium term. Five of the respondents indicated that they believed that there would be a flattening-out of property holdings and the level of investment would at least remain static.

2.7.4
Property shares

Without exception, the respondents indicated that property shares were considered to be part of the equity portfolio.

2.7.5 Competing asset classes

There was a broad consensus among the respondents that equities offer the closest alternative to property, as they share many of the same investment characteristics. One respondent indicated that index-linked gilts could be considered a second alternative, representing a real asset at low risk, albeit providing a lower rate of return than equities. Conventional gilts and cash would not be considered as alternatives, although receipts from property sales may be held as cash in the short term before re-investment.

2.8 The asset allocation process

Of the fourteen funds in the sample only three allocated assets by an internal committee using in-house expertise. The majority of the sample employed external consultants as fund managers (with the final asset allocation decision being made internally), or used investment advisers with full authority to make the asset allocation decision for the fund.

Most investment advisers stated that, even where complete authority was delegated to them, it was normal practice to have regular meetings with the trustees of the relevant fund to discuss a broad strategy for asset allocation. In certain cases, the delegated authority was limited to allocating assets within pre-determined ranges fixed annually by the trustees, but in practice the ranges were so wide that this did not represent a significant restriction to the asset allocation decisions of the fund manager.

While it is recognised that the final asset allocation process may be decided by any one of these routes (internal committee, internal committee/external consultant or investment adviser), it was noted by the majority of the respondents that the process was consistent in all three cases. The final decision is made by committee but is based on analysis and advice from experts, whether in-house, external or a mixture of the two.

It was agreed that the process of asset allocation was one of continual discussion and reappraisal in the light of changing market and economic factors. In general, formal meetings take place on a monthly basis where the views of all the individual market and economic specialists are pooled and discussed. These meetings include fund managers as well as representatives of various research teams for each of the major investment types. Recommendations will then be passed to the asset allocation committee which will determine the final policy.

Only two funds in the sample indicated that they relied solely on quantitative modelling to determine the respective weightings between investment types. The majority ultimately relied on subjective analysis although most of these did use some form of modelling in support.

While there was some agreement between respondents about their reasons for holding property as part of the portfolio, there was little consensus about the ranking of these reasons. The main reasons are discussed below and developed in section 3.

2.9 Reasons for holding property

2.9.1 Introduction

While there was a degree of agreement between respondents about their reasons for holding property as part of the portfolio, there was little consensus about the ranking of these reasons.

2.9.2 Return/risk characteristics

All respondents had a good knowledge of the theory of risk and return and in particular of portfolio theory. They appreciated the theoretical role of property within the portfolio, with particular reference to its risk and return and co-variance with other assets. Its apparent negative correlation with other asset classes was stressed by four of the respondents and its role as a diversifying asset was highly ranked by most respondents. In the absence of a policy regarding liabilities, and if there were no performance measurement, this factor becomes primary. It appears to be regarded as the default factor, underpinning policy in the absence of positive strategies.

2.9.3 Liability matching

A fund should have a portfolio profile which matches the liabilities of that fund. For example, a general insurance fund would be expected to hold significant liquid assets as the liability stream will be of very short duration, meaning that the majority of funds would expect to pay out the contributions received within a short time of receipt.

While noting the limitations of the sample survey size, there appears to be no identifiable correlation between the theory and the practice of the investor class. All the funds appear to follow a broad segregation pattern between the investment types, but not to the extent that one can identify the investment class by the profile of the portfolio. Yet the majority of respondents indicated that they held property as a liability match.

2.9.4
Inflation hedging

Property is often regarded as an inflation hedge, and this factor influenced the rapid increase in property weightings through the 1970's. There is, however, a great deal of confusion regarding exactly what a hedge against inflation implies. This confusion was demonstrated in the interviews.

Simplistically, an asset can be viewed as an inflation hedge if its nominal returns vary with the rate of inflation. It is, therefore, in this context that property is viewed as an inflation hedge in Section 3.

2.9.5
Competitors

It is suggested that the objective of the investor is primarily to outperform competitors without risking significant underperformance. This is particularly true when the client (the fund trustees) has the ability to switch from one manager to another in an attempt to achieve higher returns.

Many managers are judged either directly against their competitors, or against an index. Failure to perform against that index (often in the short term) will affect their reputation and rewards. Ideally this should not significantly affect the asset allocation procedure, but a pragmatic view, borne out by comments made by many of the respondents, indicated that this is a major consideration for most fund managers. It may explain the apparent lack of impact of liabilities upon weights.

The exact question asked of interviewees was: 'Do you hold property because your competitors do?'. Respondents either dismissed this notion totally or ranked it very highly. Of the respondents, nine believed it had no effect at all. The remaining five ranked it as number one or two in importance.

2.9.6
Asset class size

It was interesting to note that, while there was a recognised correlation between the size of the equities market and the gilt market and the funds' percentage holdings in each, there is no similarly recognised relationship in the case of property. Significantly the majority of respondents rejected the suggestion that property should be held because it is a significant asset class.

2.9.7 Quality of income

When questioned, interviewees did not feel that its quality of income flow (rent is prior to dividends as a charge on assets) was a significant reason for investing in property.

Section 3 concentrates on those issues found to be of most interest. These are: risk, return and diversification; liability matching and inflation hedging; and benchmarking.

3 Property and Asset Allocation

3.1 Risk and return on assets

3.1.1 Introduction

All respondents in the Reading survey had a good knowledge of the theory of risk and return and in particular of portfolio theory. They appreciated the theoretical role of property within the portfolio, with particular reference to its risk and return and co-variance with other assets.

In this body of theory, risk is equated with year on year volatility of nominal return. This may not be of primary importance to the investor. Other risks may be the risk of failing to match liabilities or the risk of falling behind competitors. Real returns, and the volatility of real returns, may be more important than nominal volatility.

Table 3.1 Annual return and risk, 1968 to 1990 (%)

	Property	Gilts	Equities
Nominal return	15.4	10.0	18.7
Nominal risk	10.2	12.5	22.0
Real return	5.6	0.6	8.7
Real risk	11.0	12.6	21.7

Source: JLW, Real Estate Strategy Limited

As result, increasing attention is now being paid to the objectives of investors and the relevance of traditional risk and return theory to those objectives is beginning to be examined.

However, the traditional theory retains some relevance. Low nominal volatility of return aids strategic planning for investors with nominal liabilities. It also appears to give comfort to trustees. Table 3.1 therefore shows relevant historic values (nominal and real) for property, gilts and equities.

This shows that over the last two decades equities have out-performed gilts and property, but the returns in both real and nominal terms have been far more volatile. Meanwhile property has shown considerably more return than gilts and also less volatility. Without examining the correlation between assets, this evidence would suggest that a portfolio containing property in the place of gilts would have delivered greater return with lower risk than one excluding property.

Table 3.2 Annual return and risk on property vehicles, 1978 to 1989 (%)

	Property	PUTs	Property shares	Equities
Nominal return	16.1	15.1	19.1	21.8
Nominal risk	7.8	8.0	13.5	10.3

Source: UBS Phillips and Drew

Table 3.2 shows the relative performance of direct property, property shares and property unit trusts over the period 1979 to 1989. Property shares have underperformed the equity market in return and have been riskier; property unit trusts have underperformed the direct property market. Direct property and PUTs have delivered less return than property shares but have also been less risky.

3.1.2
Future returns and risk

The analysis above relies wholly on historic data. It is important to assess the likelihood of the above returns and risk occurring in the future.

Nominal returns on all assets are likely to be lower in the future than stated above, simply because future inflation is expected to be lower than the average for the period 1968 to 1990.

It is likely that the **risk** (volatility of returns) of property will be higher in the future than it has been in the past. Much of this will be due to more appropriate valuations which are becoming more responsive to information in the market. Illiquidity may be taken into account as an additional risk factor.

3.1.3
Correlations of returns

Table 3.3 shows the correlation between returns on equities, gilts and property between 1968 and 1990. The historic correlation of property returns with returns on other assets is low while the correlation of returns on equities and gilts is relatively high. Property would appear to offer good diversification opportunities.

Table 3.3 Correlations of nominal returns 1968 to 1990 (%): 1

	Property	Gilts	Equities
Property	100		
Gilts	14	100	
Equities	15	64	100

Source: JLW, Real Estate Stra ategy Limited

However, it is by no means clear that these relationships are stable over time. Tables 3.4 and 3.5 show how unstable these relationships are by examining correlation coefficients for shorter time periods.

Table 3.4 Correlation of nominal returns, 1968 to 1990 (%): 2

Start	1968	1968	1968	1968	1968	1968	1968	1968	1968	1968
End	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
P and E	50	50	32	33	30	26	24	15	14	15
P and G	48	45	20	21	20	15	15	12	10	14
E and G	66	60	67	67	67	68	65	64	64	64

Source JLW, Real Estate Strategy Limited
Note: P stands for property, E for equities and G for gilts.

Table 3.4 suggests that over the last twenty years, the correlation coefficient of returns on property and those on gilts and equities has been falling. Over the period 1968 to 1980, the correlation of returns on property to those on gilts and equities was almost as high as the correlation of returns between gilts and equities.

There is a marked fall in the correlation coefficient when 1983 is included in the analysis. When the period of analysis is extended from 1982 to 1983, the correlation coefficients between property and equities and property and gilts fall substantially. This result is caused by the particularly poor property returns in 1983 compared to very good returns on both gilts and equities in that year.

This suggests that a fund manager assessing asset allocation in 1980 would have concluded that property was not a particularly good diversifier of risk.

Table 3.5 Correlation of nominal returns, 1968 to 1990 (%): 3

Start	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
End	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
P and E	15	16	17	16	13	12	25	−43	−40	−40
P and G	14	15	16	16	15	16	30	−25	−21	−21
E and G	64	79	77	78	79	80	79	59	57	57

Source: JLW, Real Estate Strategy Limited
Note: P stands for property, E for equities and G for gilts.

Table 3.5 measures the correlation coefficient by reducing the sample period by one year from 1968. After remaining relatively stable and positive when estimated between 1968 and 1990, and 1974 and 1990, the correlation of property and equities, and property and gilts suddenly becomes very negative and around 40 per cent, after the positive contribution of 1974 is lost.

This suggests that a fund manager evaluating asset allocation in 1990 with only information after 1975 would have concluded that property was a very good diversifier of risk.

This brief analysis suggests that depending upon the time period chosen a correlation coefficient of between plus 50 and minus 40 per cent between returns on property and returns on gilts and equities is attainable. This suggests that empirically there is no clear-cut message that property is either a poor or good diversifier of risk.

It is possible that the poor correlations between equities and property and gilts and property arise from differences in the measurement period. Returns on gilts and equities are reported on the basis of current transactions. By contrast, property returns are based on subjective valuations. The comparative method of valuation may result in valuations being based on information that obtained in the market some months ago. This implies that there may be a systematic delay in the reporting of property returns, which may cause the low correlations.

Table 3.6 reports correlation coefficients between property returns and equity and gilt returns six months before and a year before.

Table 3.6 Correlation coefficients with nominal property returns, current, six month lag and one year lag, 1968 to 1990 (%)

	Current	Six monthly	Annual
Equities	15	23	25
Gilts	14	11	20

Source: JLW, Real Estate Strategy Limited

The correlation coefficient between property and equities and property and gilts is marginally higher when using equity and gilt returns lagged a year.

3.1.4
Future correlations

The above analysis shows that much of the contribution to negative and positive historic correlations can be explained with reference to performance lags and to the special characteristics of the market at the time. For example, 1973 showed a massive fall in equities and strong property performance. This makes a considerable negative contribution to the correlation value for these two assets.

However, hindsight shows that both markets crashed at roughly the same time, the anomaly of 1973 being explained by the slightly greater reaction and reporting time required in the property market.

There is no strong theoretical evidence to suggest a stable and poor relationship between the returns on equities and property. Correlations are likely to increase and the case for property will therefore fall on these grounds.

3.1.5
Conclusions

The contribution of an asset to the risk and return of a portfolio is in three parts. It should deliver return; it should have low risk; and it should provide diversification opportunities.

Returns on property have been lower than those on equities over the last two decades but higher than returns on gilts. Over the last two decades, equity returns have exceeded those on property by around three per cent each year. Given the current high level of yields, returns on property may be higher in the 1990's than they were in the past decade, but it is not expected that returns on property will exceed returns on equities in the long term.

The risk on equities as measured by the standard deviation of returns is higher than that on property and gilts. This ignores the illiquidity of property, which has the effect of increasing the risk on property to a level comparable to that on equities. The apparent risk on property is lower than that on gilts, although a great deal of this effect is caused by the valuation process. As valuations become more responsive to information in the market, then returns on property are likely to become more volatile in the future.

Over the period from 1968 to 1990, property returns appear to be uncorrelated with the returns on other assets. This is highly dependent upon the time period chosen. One may generally expect a positive relationship between equity returns and those on property, and some of the poor historic correlations may be explained by reporting lags. There are reasons to suppose that the correlation between property and equities will increase, reducing the case for property simply on these grounds.

Property is less attractive than the numbers suggest, but despite this retains some risk/return benefits for the portfolio. The extent of these benefits and the attractiveness of property to a particular institution depends on the degree to which volatility is problematic for that investor.

3.1.6 Which institutions do not like volatility?

Immature pension funds

Volatility is not a concern for the highly immature fund whose main concern will be to ensure that wage-inflation linked pensions can be paid out long in the future, with a subsidiary consideration being the need to reduce the contribution rate as far as possible. Returns varying greatly from year to year should not create difficulties.

Mature pension funds

The same is not true of the mature fund, for which relatively stable outflows are best matched by relatively stable investment returns. Property may be attractive to these funds, although illiquidity will be a small negative factor.

Life assurance (with profits)

Volatility should not be a problem for the life fund whose liabilities are long term. Liquidity is not a problem either, as long as the requisite percentage of liquid assets is held.

General insurance

The main concern of the general insurance fund will be liquidity. Extreme volatility of returns would be a problem if it began to affect solvency.

3.2 Liability matching

3.2.1 Introduction

A profitable company will go out of business if its cash flow cannot match its debt repayments. In the same way an institutional fund should have a portfolio profile which matches the liabilities of that fund.

For example, a general insurance fund would be expected to hold significant liquid assets as the liability stream will be of very short duration. The majority of funds would expect to pay out the contributions received within two years of receipt.

Similarly, the long term requirements of an immature pension fund would suggest relatively few liquid assets, with a concentration on growth assets such as properties and equities to match future inflation-linked liabilities. To a lesser extent this will also be true of mature funds.

Life assurance funds, however, might have significant gilt holdings to match the 'base figure' liabilities, investing in equities and property to meet the bonus liability of a with-profits policy.

3.2.2
Measures of liability matching

Two measures are typically used to help the fund manager assess the extent to which the assets he holds are good matches for his liabilities. These are: duration, a measure of the average life of an asset; and the extent to which assets are a **hedge against inflation**.

3.2.3
Duration

Intuitively, duration measures the average life of an investment. However, it also indicates the sensitivity of the present value of an investment to changes in interest rates. Three simple examples are given in Table 3.7.

Table 3.7 Estimated duration (years) for three different assets

Asset	Cash flow					Value (10%)	Value (12%)	Duration
Year	1	2	3	4	5			
A	0	0	0	100	0	68.3	63.6	4.0
B	30	30	30	30	0	95.1	91.1	2.4
C	5	5	5	5	100	77.9	71.9	4.5
Total	35	35	35	135	100	241.3	226.6	3.5

Source: Real Estate Strategy Limited (1990)

This table reveals the characteristics discussed above. The duration (average life) of asset A is 4 years because no cash is received until the end of that time, whilst the duration of asset B is just less than half the maturity (because duration is a weighted average which places more weight on the earlier cash flows).

When interest rates rise to 12 per cent, the relative fall in value is greatest for the asset with the longest duration. (The percentage falls are 7, 4 and 8 per cent for A, B and C respectively.) Most importantly, the duration of the total portfolio (formed by combining A, B and C) is the weighted average of the duration of each asset. This last characteristic provides the basis of using duration in minimizing the risk of not hitting a target return.

Suppose a fund has identified the following liabilities: £240,000 after three years and £98,220 at the end of five years. At a discount rate of 10 per cent, the present value of these liabilities is £241,300. At a discount rate of 12 per cent, the present value is £226, 600. By referring to Table 3.7, it is possible to see that investment in a portfolio consisting of the three assets A, B and C will have the same value as the present value of the liabilities both at 10 and 12 per cent. In other words, without matching the cash flows of assets and liabilities, the effects of changing interest rates have been neutralised or immunised because the values of the assets are the same as the values of the liabilities irrespective of interest rates. This has been accomplished because the duration of the liabilities is equal to 3.5 years, which is the same as the duration of the portfolio formed from A, B and C.

This simple example suggests that provided a fund starts with sufficient assets, it can continue to fund a stream of required cash flows by matching the duration of the investment portfolio to the duration of the liabilities.

3.2.4
Measuring duration

Measurement of the duration of a fixed interest bond is straightforward since all the cash flows are known and only the relevant interest rates have to be estimated. Many analysts estimate and routinely report to their investment clients the duration (or the volatility) of fixed interest stocks. It is not so easy to measure the duration of equities or property. There are two methods commonly used, one analytical, the other empirical. The analytical method is derived from a discounted cash flow approach to valuation.

In the case of equities, the conventional approach is to use a dividend discount model in which dividends are expected to grow at a constant rate in perpetuity. An equivalent technique may be used for property.

Using these methods, estimates of equity and property duration of between ten and thirty years may be arrived at, while gilt durations are lower, ranging from four to twelve years. There appears to be no significant difference between the duration of equities and property.

However, neither property nor equities react to interest rate changes as sensitively as would be expected given these estimates. Accordingly an empirical method has been devised to estimate the duration of assets for which the analytical method is suspect. These empirical estimates generally produce lower duration estimates for equities, which may strengthen the case for property as a long duration asset. Work continues in this area.

3.2.5
Which institutions are concerned about duration?

Two issues are important when analyzing the various type of fund with respect to duration-matching characteristics. The first is the basic issue of maturity—the longer the maturity of the liabilities, other things being equal, the greater the duration.

The second issue is the link between the liabilities and the interest rate. If the liabilities are denominated in real terms, an increase in interest rates might be expected to accompany an increase in inflation and an associated increase in the cash flows required. It follows that the fund liabilities will have a longer duration if denominated in real terms, and that the inflation-hedging qualities of assets become important (see Section 3.2.6).

Pension plans are usually valued by actuaries in real terms and the liabilities of schemes based on final salaries will also be real because final salaries will in the long run reflect real economic variables such as economic growth.

Immature funds will have large cash inflows in the early years and only in the distant future will they have corresponding cash outflows. Other things being equal, the duration of the liabilities will be long and the fund will be looking for long duration assets for minimum risk management. Inflation hedging qualities, or more specifically the prospect of high real returns with little risk of negative real returns, becomes important. The case for property as a liability match appears to be strong for immature pension funds.

For a mature fund, the situation will be rather different because the duration of the liabilities will be shorter. Correspondingly, a matched duration policy will require a different mix of equities, fixed interest and property assets. Shorter liability durations will in general involve less property; mature pension funds will find property less attractive as a liability match than immature pension funds.

For life assurance companies, liabilities are denominated in nominal terms, the sum assured is nominal, and therefore the duration of liabilities will tend to be lower. On the other hand, the target return may be influenced more by other funds, and in particular, by the performance of pension funds. Although this might mean that long term life funds are managed more aggressively, the probable increase in duration of assets will lead to a consequent mismatch between asset and liability durations.

The role of property in the life fund is to aid competitiveness by providing real long term returns, and to produce diversification by acting as an equity alternative. Expectations of this become more important than liability issues.

The liabilities of general insurance funds are designated in nominal terms and are of short maturity. This suggests short durations. A low risk strategy will therefore imply a similarly low duration in the investment portfolio.

Less property is likely to be held as a liability match in the general insurance portfolio.

3.2.6
Property as an inflation hedge

Introduction

Property is often regarded as an inflation hedge, and this factor influenced the rapid increase in property weightings through the 1970's.

The purpose of a hedge is to neutralise risk. The purpose of a hedge against inflation is to reduce or cut out the risk of negative real returns. An asset can therefore be viewed as an inflation hedge if its nominal returns vary with the rate of inflation.

Property and equities should be a hedge against inflation because the expected **real income stream** from both property and equities is independent of the rate of inflation. Most forecasts of rental growth and dividend growth are undertaken in real terms and depend upon the real growth of the economy.

Empirical tests of the case for property as an inflation hedge have not produced clearly positive results. However these tests, based on year on year regressions of inflation on returns, are usually flawed.

Inflation and total returns

The regression methodology is used by many academics in studies of equities and has only recently begun to be applied to property. Hartzell, Hekman and Miles (1987), for example, claim to have found strong evidence to suggest that US real estate is a strong hedge against both expected and unexpected inflation. However, most studies produce poor or meaningless results.

Academic studies are often flawed by the methodology adopted and show a lack of understanding of the ways in which returns are delivered by assets. Poor results are not, therefore, altogether surprising.

There is a strong **logical** reason why equities and property should act as hedges against inflation. The expected real income stream from property and equities is independent of the rate of inflation, and there is some evidence of historic rental values keeping broad pace with the retail price index (see, for example, Baum and Crosby, 1988, pages 24 and 69, and the Hillier Parker Rent Index).

However, rental values are **not** returns. Assets will only act as inflation hedges if inflation is perfectly correlated with income returns and if the contribution of capital return is nil. Hence the regression hedging test will produce strong positive results only if there is no contribution from capital return and if inflation is perfectly correlated with income returns from year to year.

Neither is likely. First, the contribution of capital return is often considerable (see IPD, 1989). Second, inflation may not be perfectly correlated with income returns, both because errors may be made from year to year in forecasting an income flow which is **on average** expected to keep pace with inflation, and because, in the case of property, rent review periods produce a negative correlation between income return and inflation.

Inflation and capital return

Yields may move as the required real returns on property and equities change. If the required return on an asset increases, then yields will move out and the delivered return will be lower than expected; if the required return on an asset decreases, then yields will fall and the delivered return will be higher than expected.

For example, the recent outward movement of yields on UK retail property suggests that the risk premium on retail property has increased in response to, among other things, the threat of out-of-town retailing, and this has caused unexpectedly poor capital returns in this sector, irrespective of inflation.

In some cases, inflation may itself **increase** the required return: for example, interest rates tend to increase in periods of high inflation and property yields may move in line. This can produce a **negative correlation** between inflation and returns.

Inflation and income return

If the asset is a perfect hedge, the delivered nominal income return is expected to be perfectly positively correlated with inflation, and real income returns are expected to be constant. While this may be the case over the long term, the delivered income return may differ from the expected income return from year to year because of errors made in forecasting income flows.

Unexpected inflation may be co-incident with shocks to the real economy that make rental growth differ from that expected. For example, unexpected inflation may be co-incident with faster growth in the real economy than was expected. Under these circumstances, nominal rental growth will be higher than expected because of both higher inflation and higher real rental growth caused by a more quickly growing economy. Real property returns would correspondingly be higher than expected, and this would reduce the correlation between inflation and returns and damage year-on-year regression results.

Inflation and rent review periods

However, even if property offered a negligible capital return from year to year and **rental values** marched in perfect step with an inflation index, UK property in particular would not act as a perfect hedge against inflation because of the effect of the typical UK lease on the **timing** and **reviewing** of rents.

Five-yearly rent reviews have the effect of introducing negative correlation between the expected rate of inflation over five years and the real return on property, given that rents are fixed in nominal terms and decline in real terms over five year periods. Hence even if the findings of Hartzell, Hekman and Miles were accepted, there would be no reason to suppose the same effect in the UK. In this respect UK property appears to behave more like a gilt or bond than an equity or stock over the short term.

There is nonetheless some evidence to suggest that both equities and property offer some inflation hedging qualities, especially through the performance of rental values and dividends in the long term. Each is clearly superior to gilts in this respect. However, property is less attractive than equities as an inflation hedge.

3.2.7
Which institutions are concerned about inflation?

Immature pension funds

Inflation hedging qualities, or more specifically the prospect of high real returns with little risk of negative real returns, is important for immature funds whose liabilities are final salary schemes which are wage inflation linked. The case for property appears to be strong for immature pension funds.

Mature pension funds

For a mature fund, the duration of the liabilities will be shorter and inflation will be less of a concern. Mature pension funds will find property less attractive than immature pension funds.

Life assurance (with profits)

Liabilities are denominated in nominal terms and the sum assured is nominal. However, life companies are often forced into competition with pension funds. The role of property in the life fund is to aid competitiveness by providing long term real returns, and to produce diversification by acting as an equity alternative. Property is attractive to life funds.

General insurance

The liabilities are designated in nominal terms and are of short maturity. This inevitably suggests short durations. A low risk strategy will therefore imply a similarly low duration in the investment portfolio. Less property is likely to be held in the general insurance portfolio.

3.3 Benchmarking

3.3.1 Introduction

The objective of many institutional investors is primarily to beat competitors without risking significant underperformance. This is particularly true when the client (the fund trustee) has the ability to switch from one manager to another in an attempt to achieve higher returns.

Many managers are judged either directly against their competitors, or against an index. Failure to perform against that index (often in the short term) will affect their reputation and rewards. Ideally this should not significantly affect the asset allocation procedure, but a pragmatic view, borne out by comments made by many of the respondents in the survey described earlier, indicated that this is a major consideration for most fund managers. It may explain the apparent lack of impact of liabilities upon weights.

3.3.2 The impact of performance measurement on asset allocation

The 'herd instinct' among fund managers derives directly from performance measurement. Wherever a fund manager is subjected to performance measurement on an annual basis, the trustees responsible for the asset allocation decision are guiding the asset split toward that of the average fund in the appropriate universe of competitors.

Departures from that average asset split represent a risk for investment managers. Investment managers are rarely dismissed for average performance. It is frequently said that around 90 per cent of performance comes from asset allocation: the result will naturally be, in many cases, to attempt to outperform at the margin or in other ways, for example by picking good stocks within the average asset split.

Mercer Fraser has suggested that if 90 per cent of performance comes from **strategic asset allocation,** the identification of the average or benchmark will account for 85 per cent of that performance. Varying asset allocation around the benchmark may account for an extra five per cent, while the remainder comes from **stock selection,** or the choice of cheap or dear assets within defined categories of assets. The result will be clustering of returns around an average and the introduction of significant business risks for the manager who varies his asset allocation from that benchmark by more than a little.

3.3.3
The size of the property market

The size of markets is a rudimentary benchmark. It is difficult to measure the size of the UK property market, but some information is available. At the time of writing, the following estimates can be made.

1. The total listed equity market capitalisation is around £460bn.
2. The value of all conventional gilts currently in circulation is around £110bn.
3. The value of all index-linked gilts currently in circulation is around £13bn.
4. The investable commercial property market, to include both institutional and property company sectors (minimum estimate) and owner occupied property (maximum estimate), is worth between £100bn and £280bn.
5. The property market ranks below listed equities in size but well above index-linked gilts and probably above conventional gilts.

3.3.4
The identification of the benchmark

More precise estimation of benchmark asset weightings can be arrived at in two ways. These are: the use of government statistics; and the use of performance measurement service universes.

The Central Statistical Office (CSO) collects data describing the values of all assets held by institutions, including property, so that an estimate can be made of the percentage allocation by type of institution. Table 3.8 shows these weights by institution type between 1980 and 1988.

It shows a fall in property weightings which is due to both net disinvestment and the increase in the value of other assets. There are several reasons for reductions in pension fund net investment in property.

First, pension funds are generally growing more mature and the cash available for investment is falling. Hence investment into all asset classes is being cut back.

Second, there are now more asset classes from which pension funds may choose. The introduction of index-linked gilts and the increasing popularity of overseas equities have both made inroads into property allocations.

Third, pension fund advisers and consultants, generally securities specialists, have not been able to assimilate property into the management structure of the portfolio and property advisers have not done a good job in providing relevant advice.

Fourth, the poor performance of property in the early 1980's at the time of an equity boom had a significant negative impact on property sentiment.

Table 3.8 Property weightings by institution type, end year (%)

Year	80	81	82	83	84	85	86	87	88
Pension funds	15.2	15.2	12.5	10.1	9.2	8.3	7.3	8.0	8.5
Long term funds	23.0	23.8	20.1	17.9	16.5	15.5	13.9	15.6	17.0
General funds	11.1	11.0	9.6	8.7	6.8	6.0	5.3	5.8	6.7
Total	18.3	18.6	15.6	13.3	12.0	11.1	9.8	11.0	12.1

Source: CSO

This data should be unquestionable as the source of a benchmark property weighting. There are, unfortunately, several problems associated, and this is not the benchmark which fund managers use.

3.3.5 Performance measurement services

There are two performance measurement services which cover all assets and whose universes can be used for benchmarking at the asset allocation level. These are WM and CAPS.

The World Markets Company or WM is a performance measurement company with particularly strong coverage of pension funds, including the very large funds. It currently measures the performance of 1552 pension funds with a total value of £234.8bn and an average size of £151m.

Combined Actuarial Performance Services (CAPS) is a joint venture formed by the larger actuarial practices, providing performance measurement services with exclusive reference to pension funds. In its Investment Manager service it currently measures the performance of 1524 pension funds with a total value of £141bn and an average size of £93m. The main service, the Trustee service, covers a smaller number of funds with an average value of £108m.

There is considerable variation between the quoted property weights of the CSO, WM and CAPS pension funds universes. These vary from 2.7 per cent (CAPS, 1989), through 9 per cent (CSO, 1988) to ten per cent (WM, 1990). There is also variation between categories of pension fund, the most significant and relevant being fund size. Differences in these estimates are a function of:

(i) the measurement method employed in average estimation; and

(ii) the importance of the constitution of the benchmark or universe, and in particular the impact of fund size and type on the average within a benchmark.

Measurement method

Bigger pension funds, on average, hold more property. Consequently, there is a considerable difference between the simple mean and weighted mean allocation to property. WM annually provides information on the property proportion held by constituent funds in the universe, and uses the weighted mean for this purpose. CAPS, on the other hand, uses the unweighted mean. The median is also used to describe average exposure.

Fund size and type

Property is a highly lumpy asset class, meaning that efficient, well-diversified portfolios can only be constructed from a minimum allocation of resource. Reasonable diversification will require 20–30 properties, which usually implies a commitment of close to £50m. Unless property weight is to exceed historic highs, this requires a total fund size of at least £200m, considerably in excess of the mean size of CAPS and WM funds. The result is that a great number of small funds holds no direct property.

The nature of the insurance and pension fund industries means that small funds are far more likely to be drawn from the pension fund sector, which explains the lower averages in WM and CAPS, both pension fund dominated, than that shown by the CSO.

Even though property unit trusts have become unpopular, many small funds use this means of diversification to provide some property exposure, and these weights are included in WM and CAPS statistics. (In the latter only 0.6 per cent of the average allocation of 2.7 per cent is in direct property.) Generally, therefore, larger funds hold more property. This is shown by Tables 3.9 and 3.10

Table 3.9 WM weightings by size

Description	Size (£m)	Weight (%)
Very small	0–5	2.0
Small	5–15	2.0
Medium	15–100	2.0
Large	100–1000	5.0
Very large	1000+	12.0
Weighted mean		9.0

Source: The World Markets Company

Table 3.10 CAPS weightings by size

Description	Size (£m)	Weight (%)
Very small	0–5	3.1
Small	5–20	2.0
Small/medium	20–50	2.7
Medium/large	50–100	3.0
Large	100–500	4.8

Description	Size (£m)	Weight (%)
Very large	500+	7.9
Unweighted mean		2.7

Source: Combined Actuarial Performance Services

3.3.6
Conclusions

Benchmarking is certainly a significant factor amongst those determining the exposure of pension funds to property. The importance of benchmarking is likely to remain high throughout the 1990's despite pressures to adopt longer

term performance horizons for property fund managers.

The choice of benchmark and the type of average used each have a significant impact upon the asset split adopted by a fund. This is largely due to the very great influence of fund size on allocations to property. The appropriate benchmark should take into account fund size. Unless the objective of the fund is to beat a very broadly-based universe of all funds, the benchmark should therefore be taken from the appropriate size band in either WM or CAPS. For very large funds of a total size in excess of £1bn, WM is of more relevance than CAPS. either WM or CAPS. For very large funds of a total size in excess of £1bn, WM is of more relevance than CAPS.

3.3.7
Which institutions are concerned about benchmarks?

The major factor determining the importance of benchmarks to investors is the degree to which the organisation is in competition with other similar organisations. Some institutions may not be in direct competition but expect their fund managers to be measured against other fund managers on a regular, at least annual, basis, and the effect in such cases may be the same.

Institutional funds with long liabilities are more likely to be in this position as attention is focused less on liability matching than on performance.

Immature pension funds

These are likely to reward their fund managers on the basis of competitive returns and will have regard to the WM and CAPS benchmarks.

Mature pension funds

These are more concerned with liabilities and will be influenced more by actuarial considerations.

Life assurance (with profits)

Life companies will have regard to competitive performance as a means of measuring internal managers. They are also in an increasingly competitive environment for external fund management, and organisations like Prudential, Legal and General and Scottish Amicable compete directly with each other and with Merchant Bank-based fund managers in the search for new pension fund business, both segregated and pooled. It is for these organisations that benchmarking is of prime importance.

General insurance

Like mature pension funds, these are more concerned with liabilities and will be influenced more by actuarial considerations.

3.4
Conclusions

Immature pension funds

Volatility is not a concern for the highly immature fund whose main concern will be to ensure that wage-inflation linked pensions can be paid out in the future, with a subsidiary consideration being the need to reduce the contribution rate as far as possible. Returns varying greatly from year to year should not create difficulties, so property's attractions in this regard should not be oversold.

Immature funds will have large cash inflows in the early years and only in the distant future will they have corresponding cash outflows. Other things being equal, the duration of the liabilities will be long and the fund will be looking for long duration assets (like property) for minimum risk management.

Inflation hedging qualities, or more specifically the prospect of high real returns with little risk of negative real returns, is important for immature funds whose liabilities are final salary schemes which are wage inflation linked. Property is attractive in this regard.

These funds are likely to reward their fund managers on the basis of competitive returns and will have regard to the WM and CAPS benchmarks.

The case for property appears to be strong for immature pension funds.

Mature pension funds

For the mature fund, for whom relatively stable outflows are best matched by relatively stable investment returns, property may be attractive as a diversifier, although illiquidity will be a negative factor.

The duration of the liabilities will be shorter and inflation will be less of a concern. Shorter liability durations will in general involve less property.

Mature pension schemes are concerned primarily with liabilities and will be influenced more by actuarial considerations than by competitive performance.

Mature pension funds will find property less attractive than immature pension funds.

Life assurance (with profits)

Volatility should not be a problem for the life fund whose liabilities are long term. Liquidity is not a problem either, as long as the requisite percentage of liquid assets is held.

Liabilities are denominated in nominal terms, the sum assured is nominal, and therefore the duration of liabilities will tend to be lower. On the other hand, the target return may be influenced more by other funds, and in particular, by the performance of pension funds.

Life companies will have regard to competitive performance as a means of measuring internal managers. They are also in an increasingly competitive environment for external fund management.

Property is attractive to life funds. Its function is to aid competitiveness by providing long term real returns, and to produce diversification by acting as an equity alternative.

General insurance

While extreme volatility of returns would be a problem if it began to affect solvency, the main concerns of the general insurance fund will be liquidity and liabilities.

The liabilities are designated in nominal terms and are of short maturity. This inevitably suggests short durations. A low risk strategy will therefore imply a similarly low duration in the investment portfolio. Inflation hedging becomes less important.

Like mature pension funds, they are concerned more with liabilities than with competitive performance, and will be influenced more by actuarial considerations.

Property is not attractive to general insurance funds. Less property is likely to be held in the general insurance portfolio.

This analysis has concentrated on wholly domestic issues. Yet the investment processes of the 1990’s are certain to become increasingly global. How will UK property investors and UK property markets behave in the context of globalising investment strategies? These questions are addressed in sections 4, 5 and 6 below. This begins in Section 4, where an external perspective on the UK in the context of the global market is gained by addressing the issue largely from the point of view of the US institutional investor.

4
Global Institutional Property Investment

4.1
Background

Domestic pension plans have become important US real estate investors since their entry into the field nearly two decades go, and the flow of domestic pension plan investment to US real estate grew dramatically during the 1980's.

The initial entry of pension plans into the real estate market had been through geographically and sectorally diversified open-ended co-mingled funds, but in the 1980's closed-end vehicles, focussing upon specialised sectors or regions of the US real estate market, were used as a first step towards exposure to a direct real estate portfolio. Direct portfolios structured from individual buildings began to be built by the largest and most sophisticated pension plans during the late 1980's. Now their attention is turning to non-US real estate.

Pension plans and pension funds based in other countries, including Australia, the UK and Japan, are of considerable and growing importance as global investors. In some cases, notably the UK, pension funds have been in real estate for longer than their US counterparts, and they too are seeking overseas opportunities in real estate.

The rationale for a global real estate portfolio should be examined in two stages. First, what is the justification for investing in real estate? Second, what advantages does a global strategy add?

4.2
The case for real estate

In the US, the Employment Retirement Income Security Act of 1974 (ERISA) in essence required diversification across asset classes by pension plans. Commercial real estate was one asset class that was identified as an asset to be considered in achieving diversification. The development of appropriate vehicles has already been described. However, their success required evidence that real estate was an attractive asset class in risk and return terms.

Early evidence was along the lines of the arguments examined in Section 3.1. It was suggested that commercial real estate provided high returns, accompanied by low variability of returns. In terms of simple risk-adjusted returns, therefore, real estate appeared to be competitive with stocks and bonds.

The correlation of real estate returns with returns on stocks and bonds was found to be low, so the addition of real estate to a stock and bond portfolio was likely to be beneficial in reducing portfolio volatility.

Finally, for those pension plans whose risks were denominated in real rather than absolute terms, commercial real estate added a further risk limitation to a portfolio, since it was believed to provide a hedge against inflation.

Commercial real estate therefore appeared to offer the rare combination of relatively high and stable returns that did not move in parallel with other asset classes and insulated the portfolio from the effects of inflation. In a mixed-asset portfolio context, adding commercial real estate was likely to enhance total portfolio performance. (These issues are examined in nmore detail above: see Section 3.1.)

The same findings drove pension funds outside the US into domestic real estate. In the UK, for example, pension funds had invested as much as 15% of total assets in property by 1980 (see Table 3.8). The data used to establish the above rationale are not without shortcomings, and may be argued to overstate the case for real estate: see Baum (1988) and Section 3. Nonetheless the perception of real estate as a diversifying asset persists: see Section 2.

In 1990, a large number of experienced and sophisticated pension plans are now familiar with direct commercial real estate investment. Real estate, despite recent returns in the US and elsewhere lagging returns in stock and bond markets, has generally proved to be an effective diversifier in a mixed-asset context.

4.3
The case for non-domestic real estate

As the investment markets become global through a process of exchange of information, expertise, personnel and goods and services, there is a radical change currently taking place in the strategic planning of investment portfolios around the world. The focus is shifting from domestic markets and domestic benchmarks to new global equivalents. The result is that pension plans suddenly appear to be underweight in foreign markets.

Consequently, what were previously minor excursions outside domestic stock and bond markets are increasingly likely to represent the foundation stones for significant non-domestic investment by pension plans. The Single European Market will create a shift in benchmarks from domestic markets within Europe to pan-European indices, and the result will be hefty exchanges of stocks and bonds between European markets players. Yamaichi, for example, forecast massive increases in overseas equity holdings for UK institutions: see Table 4.1.

The rationale for non-domestic real estate investment by pension plans is driven by similar issues, and by similar issues to the ones which initially drove pension plans into real estate. The arguments are as follows.

Diversification into non-domestic real estate offers attractions in terms of risk, return and portfolio diversification.

The move towards a Single European Market has focused the attention of investors upon the emergence of three world economic zones (North America, Pacific Rim and Europe). The impact of the changes in Europe has been at the same time to simplify a global real estate strategy and to simplify real estate investment in that global region.

Table 4.1 Global asset allocation

Asset class	1980 (%)	1989 (%)	2000 (%)
UK equities	45	53	40
Overseas equities	9	21	35
Bonds	21	8	10
Index-linked	0	2	2
Property	20	10	8
Cash	4	6	5

Source: WM Company, Yamaichi

Real estate investment in Europe will become more straightforward as the specific risk associated with different political and economic systems evaporates. Currency and political risks will be reduced or even disappear as monetary integration progresses and laws, systems and markets become more similar.

This will reduce the need for widespread diversification within Europe. However, it will also reduce the effectiveness of a policy of naive diversification. Reduced differences between European markets will make it appropriate to buy larger units in a small number of locations, accepting local volatility in return for a reduction in global risk, and concentrating resources on an efficient strategy.

Diversification will nonetheless continue to be necessary to control this risk. In a globalising market, centres of manufacturing, services and government cease to be protected by national boundaries and compete for position. This will increasingly require and reward a research-driven expertise and efficiency in real estate portfolio construction, as this will enable the appropriate markets to be targeted and combined.

Geography and location will continue to be crucial factors in successful real estate investment, even in a global economy. Arguably, therefore, global diversification is more important for real estate than it is for stocks and bonds.

Diversification of a US real estate portfolio into Europe and the Pacific Rim will become necessary for US investors as a means of reducing the risk associated with dependence upon a US economy within the world economy. The current weakness in US real estate market fundamentals is a further incentive for US pension plans to look outside the US. Pension funds and other institutions in other countries, Japan and Sweden being particularly extreme examples in 1990, are affected to varying degrees by similar considerations.

Recent data suggests that a properly-constructed global portfolio would provide the prospect of higher portfolio returns for reduced portfolio risk. The following illustrations are based upon the perspective of a US investor, but the case can be made for investors of almost all domiciles. The UK is no exception.

4.4
Overseas diversification by UK institutions

Information regarding international property exposure by UK institutions is not generally available. However, a recent survey of UK institutions revealed some information which is both rare and of interest. Browning (1989) found the following.

The majority of UK pension funds surveyed held more than 15 per cent of their property assets overseas. Insurance companies, on the other hand, held much less, and even the largest held less than 7.5 per cent. More UK institutions held property in North America than in any other region including Europe.

Their main reasons for holding overseas property were diversification and the potential for better performance: in other words, risk, return and diversification. Most funds expect to increase their levels of overseas property investment, particularly in the EC.

However, overseas diversification was not seen to be without problems. To date, few overseas investments have been as successful as domestic projects, and managing overseas properties and coping with legislative differences were significant disincentives. Section 4.8 below considers these issues in more detail.

4.5
Returns

For the US investor, non-domestic real estate has shown higher returns over the last five years than has the domestic market. Table 4.2 shows this clearly.

Table 4.2 Global returns

Market	IRR (%)
US	7
UK	15
Spain	30
France	20
Germany	25
Japan	40

Source: Goldman Sachs

4.6
Risk

Vacancy rates and rent levels have been less volatile in non-US markets. Wurtzebach (1989) shows that non-US office market vacancy rates, as represented by London, Frankfurt and Paris, have been more attractive and less volatile than US office vacancy rates, as proxied by New York.

While this data is not without its problems, Table 4.3 shows less volatility over the period 1978–1988 for most non-US rental growth (nominal, in local currency) than was the case in US markets.

Table 4.3 Rental growth and volatility

Market	Rental growth (%)	Volatility (SD, %)
New York	10.4	5.8
London	14.1	3.6
Sydney	17.4	4.1
Hong Kong	16.7	9.7
Paris	12.7	2.6
Frankfurt	6.3	2.6
Brussels	7.7	2.9
Madrid	14.8	5.1

Source: Richard Ellis

4.7
Correlations

Correlations between returns in different markets can be much lower than between regions of the same market. Rental growth is not necessarily a proxy for return, as shown by a comparison of the figures for Germany/Frankfurt in Tables 4.2 and 4.3 above, and again the data may be flawed but Richard Ellis (Sweeney, 1989) has suggested negative correlations of rental value growth between New York and Brussels, New York and Frankfurt and New York and Tokyo over the period 1978–1988, and this may be an indication of a prospective low correlation between returns.

Because returns have been higher outside the US, because risk has often been lower outside the US and because correlations can be low or negative, more efficient portfolios can be constructed by combining different markets together than by concentrating on the domestic market. Richard Ellis suggest a portfolio combining Sydney, Paris and London would have shown very high rental growth and reasonably low volatility of rental growth over the period 1978–1988; adding Toronto would have reduced risk significantly, for only a small reduction in return (Sweeney, 1989). Jones Lang Wootton and the Prudential Realty Group (Wurtzebach, 1989) have shown that a global portfolio combining London, Frankfurt, Sydney, Paris and New York would show desirable characteristics (Table 4.4).

Table 4.4 Portfolio returns, 1979–1989

Market	Return (%)	Volatility (SD, %)
New York	13.2	8.1

Market	Return (%)	Volatility (SD, %)
London	21.6	10.6
Sydney	25.1	12.3
Paris	22.4	9.2
Frankfurt	16.0	8.1
Global	19.7	4.8

Source: Jones Lang Wootton, Prudential Realty Group

As Table 4.4 clearly shows, the impact of adding non-US markets to a US portfolio is beneficial. The global portfolio indicates a very competitive total return accompanied by an extremely low portfolio standard deviation. The global portfolio return exceeds those of three of the individual markets and the global portfolio standard deviation is lower than each of the individual markets.

Global diversification clearly offers outstanding opportunities to improve the risk-return profile of a real estate portfolio, as long as the basic analytical technique is accepted. This is not beyond question: see, for example, Section 2 and Baum (1989).

4.8
Liabilities

While multinational liabilities are not yet a recognised US trend, domestic corporate pension plans are discovering that as their firms expand their international business activities they are acquiring increased non dollar-denominated pension liabilities.

The emergence of the multinational firm is leading a number of US corporate pension plans to consider the role of non dollar-denominated real estate in the multinational pension plan.

Even for wholly domestic pension plans, there is a case for overseas real estate as a match for liabilities. Firstly, real estate is a high duration (long term) asset class. This means provides a defensive asset which also acts as a long term it liability match. Secondly, it appears that real estate is an inflation hedge. It is therefore particularly useful as a liability match for immature pension funds whose liabilities are denominated in real terms.

Thirdly, a proportion of the goods which pensioners buy is imported. There is an argument to the effect that protection for pensioners against inflation, which is driven by exchange rates as well as by the domestic economy, will be enhanced by a global investment strategy.

Non-domestic real estate has strong attractions as a liability match for many pension plans.

4.9
Performance and benchmarks

UK pension funds currently allocate just over 20% of their assets to all overseas investments. The proportion of the typical real estate holding allocated to overseas real estate is growing. For Dutch and Scandinavian pension schemes, these allocations are much higher. As the Single European Market becomes a reality the home country will become a regional component of a European universe, and the neutral weighting in home-based investments will dramatically fall (see Table 4.1).

As the investment community moves towards recognition of a three-zone globe (see Section 5), investors will increasingly have regard to the changing non-domestic weightings of their competitors or rivals, and this will raise their own level of comfort with non-domestic assets. Following the changes in stock portfolios which have already taken place, real estate is becoming part of this process.

4.10
Other factors

4.10.1
Choice of product

There are reasonable concerns over the depth and breadth of particular non-US real estate markets. Nonetheless, there are occasions when the wider choice presented by a global investment strategy would be advantageous in terms of diversification.

In a market where investors move together, there can be periodic shortages of product at a reasonable price. For example, high quality domestic shopping centres have in recent years been attractive to US pension plan investors for reasons of diversification. Demand has been such that prices have been driven high and there has effectively been a shortage.

Similar factors have been particularly influential in guiding Scandinavian, Dutch and Japanese investment towards heavy investment in non-domestic real estate.

4.10.2
Education

Standard leases, development and marketing methods and styles of architecture and design have become the norm in many real estate markets. In the UK, for example, 25 year leases with reviews of rent every five years to open market values are standard. In France, however, the indexing of rents to achieve rent increases in line with inflation is standard practice. US shopping centres are often leased subject to turnover rents. Locally standard practices may not be the best practice in every case.

Non-domestic real estate markets and practices provide an education and an insight into real estate investment management in both foreign and domestic markets. This will contribute to the investor's ability to actively manage real estate assets, and in addition to attract, retain and develop staff resources.

4.10.3 Business development

Exposure to foreign markets can lead to the development of relationships with local financiers, joint venture partners and tenants which can promote the home business.

Real estate forms a central part of the process by which a multinational company is created. This has been the case in Europe for retailers, for property development companies with construction arms, for insurance companies with real estate subsidiaries, and others. Real estate investment and development in non-domestic markets can lead to increased sales of products and other valuable relationships. For pension plans, the parent indusytry from which the pension plan derives may benefit in this way.

4.11 Problems associated with investment in non-domestic real estate

4.11.1 Introduction

The case for global real estate investment is strong. It should nonetheless be recognised that there are major risks associated with domestic pension plan investment in non-domestic real estate.

4.11.2 Lack of local market knowledge

Lack of knowledge creates specific risk. There is a risk of choosing the wrong market (country), the wrong submarket (sector or region) or the wrong type of building. Land ownership and taxation laws and an array of cultural differences, including negotiating methods and common lease terms, add to the argument that the importance of expertise and local contacts should not be underestimated. Risks such as these may be mitigated by creating joint ventures with reputable non-domestic real estate operators.

4.11.3
Political risk

Part of the risk of investing in non-domestic markets relates to political risk, in particular the risk of nationalisation or of government controls on the freedom to deal in or manage real estate assets. This factor can be over-stated, and is currently reducing in importance in Europe and other regions. However, it provides a source of concern for some investors and continues to require expertise and caution in the choice of market.

More tangible concerns include the potential difficulties that certain countries and localities present in gaining permits and access to local government services.

4.11.4
Currency risk

In theory, international investment should carry with it no currency or exchange risk. Purchasing power parity suggests that the real return on an asset is identical for investors from any country, because any movements in exchange rates perfectly reflect differences in local inflation. If nominal return to an overseas investor is constituted by local real return, local inflation and exchange rate movements, the latter two factors should cancel, and real return is the same to domestic and overseas investors of any domicile.

However, this implies that real returns are not affected by inflation. This is not the case: see Section 3.2.5. Purchasing power parity does not hold (over the short term, at least); exchange rates do not neutralise inflation differentials in real terms. Thus the investor in non-domestic markets is exposed to exchange rate variability, and changes in exchange rates can cause returns to differ from the expected.

This risk is standard to non-domestic investment of all types and can be eliminated by hedging, but hedging may be expensive and imperfect over a long period for an asset which produces intermediate income flows (like real estate). Again, there is a need for expertise in managing currency risk.

4.11.5
Specific risk in local real estate markets

The standard unit of property investment in many European centres is smaller than is typical in the City of London, Japan and the US. This reduces the ease with which large portfolios can rapidly be diversified across the globe, and restricts the appeal of many centres for the larger pension plan.

Additionally, smaller real estate markets may be dominated by a small number of employers or industries. This creates a risk. A small amount of stock and a small amount of demand can further increase the risk of a market. On the other hand, tight controls on supply can reduce this risk to levels below those common in, for example, the US.

An understanding of the vulnerability of markets and the risks they exhibit is vital.

4.12 Europe and the new global economic geography

4.12.1 Background

Europe is made up of 29 countries grouped into a number of more or less integrated trading blocs within the established capitalist democracies of Western Europe and the socialist states currently experiencing democratisation in Eastern Europe.

Western Europe includes the member countries of the European Community (EC), the European Free Trade Association (EFTA) and the 'independent' states of Cyprus, Malta and Turkey. The EC is by far the larger and more powerful of the two trading blocs. The European Community (EC) represents a group of twelve countries bound together under a number of international treaties, the first of which was the Treaty of Rome of 1957.

The primary aim of the Treaty of Rome was to create a common market within the Community which allowed the free movement of goods, labour, services and capital. The first stages of economic integration revolved around the creation of a customs union through the establishment of a common external tariff for non-EC products and the removal of customs duties and quantitative restrictions on goods passing between Member States. Other measures stipulated in the Treaty included the adoption of a number of common policies, the creation of several European federal institutions and the setting up of procedures to promote the harmonisation of national laws.

4.12.2 European trading partners

A combined EC population of 325 million people and gross domestic product (GDP) of some US$4,800 billion in 1989 makes the EC one and a half times more populous than the US and with output of a similar value.

Following the launch of the plan in January 1990 to create a European Economic Space (EES) by 1993, the six EFTA countries would have a say in the 'decision-shaping' process of laws affecting the EES, in addition to the present free trade agreement on industrial goods between EFTA and the EC.

The European market (EC and EFTA combined) would then represent an economy more powerful than the combined countries of North America. The combined GDP of the two trading blocs amounted to some US$5,540 billion in 1989: see Table 5.1.

Table 5.1 European trading partners, 1989

Bloc	Country	Population (Mn)	GDP (US$bn)
EC	Belgium	9.9	151
Denmark	5.1	104	
France	56.2	948	
Greece	10.1	54	
Ireland	3.7	33	
Italy	57.3	866	
Luxembourg	0.4	7	
Netherlands	14.8	223	
Portugal	10.3	45	
Spain	39.3	377	
UK	56.9	827	
West Germany	60.5	1196	
Total EC	**324.5**	**4,831**	
East Germany (1988)	16.7	207	
EFTA	Austria	7.5	126
Finland	5.0	116	
Iceland	0.3	5	
Norway	4.2	93	
Sweden	8.3	190	
Switzerland	6.5	175	
Total EFTA	**31.8**	**705**	
	US	250.0	5,000 (est)

Source: UN, OECD, IMF

4.12.3
The Single European Act

Many of the objectives outlined in the Treaty of Rome are now being implemented through the Single European Act (SEA) which came into force in July 1987. In addition to a number of amendments to the Rome Treaty, the Act provides a schedule for the realisation of objectives concerned with the completion of the internal market by the end of 31 December 1992. Although not legally binding, the 1992 deadline is now generally associated with a unified European market.

The Single European Act is primarily concerned with measures to facilitate the removal of these non-tariff barriers. These include, firstly, physical barriers such as border checks, customs formalities and documentation; secondly, technical barriers including differences in professional and technical standards; and thirdly, fiscal barriers such as differences in excise duties and value added tax.

Monetary integration is a further significant and symbolic goal of the EC. The move towards monetary integration appears inevitable in the long term, particularly in view of Britain's recent entry into the Exchange Rate Mechanism (ERM), an instrument which limits the fluctuations between national currency exchange rates Despite reservations from a number of national governments regarding the pace and degree of monetary integration, the ultimate adoption of the European Currency Unit (ECU) and the move towards a federal Europe is not in doubt.

4.12.4 The impact of the single market

The economic and social gains arising from the Single European Market (SEM) are likely to be considerable. The Cecchini Report published in 1988 examined the potential effects of the completion of the SEM. It found that EC market integration will in the medium term lead to an increase of 4.5 per cent in EC GDP, deflate consumer prices by about 6 per cent, improve the balance of public finances by 2.2 per cent of GDP and lead to the creation of some 1.8 million jobs.

The rationalisation of European industry is already presenting opportunities for both EC and foreign investors. Corporate strategies looking to take advantage of the opportunities presented by the Single European Market are providing a stimulus to industrial activity.

Many European real estate markets are reaping the benefits of this stimulus. In addition to the spate of mergers, acquisitions and associations springing up amongst commercial real estate agents across Europe, European and Pacific Rim investors are beginning to make inroads into the Continental market.

Prompted both by trends in corporate demand and the progressive removal of investment restrictions by Member States, institutional investors are taking full advantage of the SEM. Community-based investors are not the only players in the market. Swedish institutions, following the removal of their own domestic regulations, have built up significant holdings in the EC. The presence of the Japanese is also being felt in Continental Europe following their acclimatisation to the UK market. Now that exchange controls have been eliminated for transactions between all but two of the Member States it would be surprising if significant investments on an EC-wide basis were not to become the norm.

4.12.5
The new economic geography

This process of massive and rapid change has suddenly created a new Europe as a single market with the population and economic strength to rival North America.

The rise of the Far East and Asian Pacific Rim as an economic powerhouse over the last twenty years completes the new economic geography of the globe. As an example, it has been estimated by ISF that three-quarters of the market capitalisation of stock markets in the emerging markets of South East Asia, the Indian subcontinent, the Middle East, Africa, Latin America and the new European markets is concentrated in South East Asia alone.

The combined capitalisation of the markets in Hong Kong, Thailand, Malaysia, Singapore, Taiwan, the Philippines, Korea and Indonesia at around $US565 rivals the London market, by far the most powerful of the European markets. When Japan is included the Asian Pacific Rim is immediately established as a third force.

The average GDP growth rate of this region over the 1990's has averaged between 7 and 9 per cent and is forecast by Yamaichi to continue at around 6 per cent. These figures are more than double the relevant estimates for both North America and Europe.

Yamaichi forecast that while UK institutions currently hold around 6 per cent of all assets in Pacific Rim equities, this figure will increase to 12.5 per cent by 2000, to compare with values of 7.5 per cent for North American equities and 10 per cent for European equities. Increasingly, business strategies will be influenced or even directed by this new three region world.

4.12.6
Global business and occupier demand

In addition, and fortifying the trend in capital markets, occupier demand for property will be increasingly both international and multinational. Conglomerates are beginning to be as apparent in the service sector as in manufacturing.

It suggests that in many industries, each nation will have its own element of the group, but it will be possible to switch resources between them. Movements of capital will become much more easily achieved than before. This means that an area will not easily survive a loss of competitiveness, and time to correct errors will be small.

Alongside this change in management there is likely to be a change in production methods. Over the past ten years, Western companies have been moving out of low value added products, energy intensive production techniques and so on. Companies have been shifting out of basic chemicals into fine chemicals and pharmaceuticals, and out of steel production into tubes or wire production. Rises in the oil price will hasten this trend.

These trends are global, based on increased access to travel, improved communications and modern production techniques. In Europe, 1992 is focusing minds on ways of exploiting this opportunity. Companies are planning European distribution and manufacturing systems. They are considering how far their market might be homogeneous.

The IBM model of independent but linked companies which think of themselves as connected with a particular country is now common to many multi-nationals. These companies' management methods and organisation will become increasingly relevant to world business as a whole. Location decisions will be driven by global strategies, with the UK a component part of the Europe region. 'Hot spots' will develop within global regions as well as within national boundaries (Hsia and Green, 1991), and this will increasingly affect investors' portfolio strategies.

4.13 Conclusions

The rationale of the current consideration of non-domestic real estate investment by domestic pension plans has several parallels with the rationale for the initial investment by US pension plans in US real estate. These include higher historical total returns, reduced operating risk through vacancy and real estate portfolio diversification opportunities.

In addition, other reasons for investment in non-domestic real estate have been recognised. First, on a prospective basis, non-domestic real estate may represent an attractive alternative to local real estate given the current weakness in real estate fundamentals in certain markets, including the US and the UK.

Secondly, the emergence of multinational pension liabilities may lead to more active consideration of non-US real estate to offset the local inflation risk of those liabilities.

Third, the investment markets are globalising. The wholly domestic investor will increasingly face a risk of comparative under-performance, and the benchmark will shift from domestic to global measures.

These issues will affect all assets, including real estate. Successful real estate investment requires an understanding of the importance of location even more than other assets, emphasising the importance of the globalisation process for real estate even further.

A three-region world economic geography will at the same time increase the necessity of, and simplify, the global investment strategy. The theoretical case for global real estate investment is more powerful than ever.

5
The Future

5.1
Introduction

This section concludes by drawing upon the above material to speculate on the likely future property investment behaviour of UK institutions. It examines whether property will become more or less attractive, whether developments, fundings or joint ventures are likely to be more or less popular, and discusses the impact of globalisation on investor strategies. It also examines the way in which the current indebtedness of the UK property sector might be converted to equity, and briefly considers some implications for UK property markets.

5.2
Trends for the 1990's

Pension funds will become increasingly mature as the age structure of the UK population changes to include a greater concentration of pensioners. Pension funds will continue to disinvest in direct property and only the very largest funds in stable or growing industries will maintain significant percentages of their total assets in property.

On the other hand, insurance business will continue to grow, with insurance companies outstripping pension funds as the largest investor group. Personal pensions managed by insurance companies and life-associated savings plans will increase in importance. This trend is well understood by the insurance sector. After the current downturn has run its course and when the supply crisis is seen to have been brought under control, life funds will increase their property exposure

The election of a Labour government would help to create initial confidence in the property sector through an expectation of tighter supply policies, while the implications of the return of a Conservative government would depend greatly upon the extent to which environmental issues guided its manifesto.

While the 1980's was a decade of debt, with relatively little new equity issue, the 1990's will see a massive swing back to equity as the corporate sector attempts to wind down its debt and as overseas institutional investors provide a source of equity finance. This is dependent upon prices of both domestic and overseas markets. UK equity prices may soon fall to a level at which they appear cheap to overseas investors. The UK equity market will recover before the UK property market turns, but the returns of the 1980's will not be seen in the 1990's. Overseas markets will generally recover from their present doldrums.

5.3
Competition for resources

There are several sources of competition for the institutional funds which might otherwise be directed at UK and overseas property. Other drains on funds will include overseas securities, which will take up to 35 per cent of all UK institutional assets by the end of the decade.

The possibility of more index-linked and conventional gilt issues and of successful securitised loan markets (including residential and commercial mortgages) will create a leakage of resources which investments by overseas institutions will be expected to replace. This is expecting a lot. UK property does not appear cheap by global standards, unless it is compared with Tokyo: see Table 5.1.

Table 5.1 Notional property values: offices (per square foot, US$, 1990)

City	Rent	Cap rate	Value
Kuala Lumpur	12.0	4.0	300
Brussels	20.0	6.0	333
Chicago	33.0	8.3	398
San Francisco	26.0	6.0	433
Washington DC	32.0	6.3	508
New York	35.0	6.5	538
Toronto	34.0	6.3	540
Taipei	30.0	5.0	600
Sydney	52.0	5.0	1040
Milan	60.0	5.0	1200
Frankfurt	56.0	4.5	1244
Madrid	63.0	5.0	1260
Paris	87.0	4.5	1933
London	131.0	5.3	2472
Tokyo	197.0	1.0	19700

Source: Prudential Real Estate Investors/Real Estate Strategy Limited

5.4
Innovations

5.4.1
Introduction

Innovations will be essential if the UK property market is to retain the interest of domestic and global investors. These are likely to include a form of syndication/ securitisation; swaps and joint ventures between investors of different domiciles and between institutional and corporate sectors; and there are plans for a property futures market.

5.4.2 Liquidity

Lack of liquidity in property is a particular problem for institutional investors who habitually use tactical moves in and out of sectors to attempt to boost performance in the short term. Tactical asset allocation is impossible to achieve in property because of a lack of liquidity, specifically the lack of an identifiable secondary market (Baum and Crosby, 1988; Baum, 1989). If this were to be achieved through some form of securitisation then the attractiveness of property may increase considerably. The effect on the market will be to improve efficiency and increase the amount of trading but will also increase the volatility of property.

Possible initiatives include the return of unitisation, the introduction of property futures and a significant expansion of the secondary market in property-related debt instruments.

5.4.3 A property futures market

A property futures market is ready for launch in 1991. It is not likely to be a success in the short term. However, if it were to be successfully launched, it might just improve the attractiveness of property to the smaller institutions by allowing them to offset the risk of a lumpy (poorly diversified) property portfolio.

5.4.4 Joint ventures

There are strong reasons for institutions and the corporate sector to pool resources in property. Typically, institutions are not equipped to develop successfully and consistently. Neither are they placed to invest successfully outside the UK. This should, if corporate rivalries permit, lead to joint ventures between UK and overseas institutions; between UK institutions and UK developers; and between overseas institutions and overseas developers.

5.5 Where will the equity come from?

The above analysis leads to four possible areas of growth in equity finance available for UK and overseas property. These are as follows.

UK life assurance funds

As suggested in Section 3, property is attractive to life funds. Its function is to aid competitiveness by providing long term real returns, and to produce diversification by acting as an equity alternative. As one or two move overseas, more will follow and benchmarks will shift, exposing those who remain at home.

Overseas institutions

European, North American and Pacific Rim pension plans and financial services groups will develop global real estate portfolios which will recognise the three global zones and see the UK as a significant and pioneer component of a European portfolio.

Property unit trusts

The arguments in favour of property unit trusts are persuasive. New UK-based vehicles will be developed, and specialist international trusts will mushroom if and when legal difficulties can be overcome. These are crucial issues: see below.

Equity-financed property investment companies

The debt overhang currently clouding global property markets will eventually be cleared by converting debt to equity. Equity financed property investment companies will grow as banks and indebted property developers are forced to sell at low prices. This will provide an asset backing for existing lowly-geared companies and for the new breed which will eventually enable more debt to be raised. The outlook of many of these players will extend beyond domestic markets and they will be driven primarily by cheapness, in other words by high expected returns.

5.6 The impact of globalisation

5.6.1 The attractions of global property

The impact of globalisation upon the investment behaviour of the UK institutional investor should, in conclusion, be considerable. Non-domestic property is attractive in terms of risk, return and diversification. Those investors with overseas liabilities will use overseas securities as the main liability match but may build overseas portfolios of property for similar reasons. As competitors increase overseas portfolios, benchmarks will change and increased exposure for those in competitive businesses will become necessary.

A market for both UK and overseas property will exist among UK life assurance funds, overseas institutions (European, North American and Pacific Rim), property unit trusts; and a new breed of equity-financed property investment companies.

5.6.2
The problems of global property

However, three factors stand out.

First, property is seen by institutions as an equity asset with the potential to hedge inflation risks.

Second, property is lumpy, indivisible and illiquid.

Third, because overseas investments are unlikely to exceed domestic weightings, overseas property is unlikely to exceed 5% of total assets.

The result is that the momentum for a global property investment strategy will have little impact on the property strategy of any institution with less than (say) $US20 billion of assets, because it will be essential for most institutions that they attain reasonable diversification of the overseas property portfolio. This would limit the number of UK players to around five (see Section 2).

Hence, while the increasing and globally-based securitisation of property-based debt will satisfy some demands, the securitisation of property as an equity asset is essential. It is inevitably tied up with globalisation, as a solution in this area would free up world property markets and world property investors; without it, activity will be limited to the global strategies of a very small number of players and a variety of uncomfortable and complex joint ventures.

The implications for property as an asset class would then be miserable. Condemned to remain in domestic property markets while benchmarks in all other asset types shift to global measures, UK institutions and other property owners will regard property as even more different, even more difficult and even more risky as an asset class. Unless an effective means of dividing or sharing the property asset is developed, property may disappear completely as an institutional asset class for all but the biggest of world players. Property would become the preserve of only the mightiest of institutions and the risk-seeking corporation.

It is well accepted that the timing of a resurgence of interest in UK property is likely to be delayed by the election in 1991 or 1992, by the current supply crisis, by the current recession and by depressed equity prices. World property is largely affected by some of the same issues.

Beyond 1992, there are signs that new equity money may become available. The next phase for markets around the world will necessarily be driven by global strategies, but will depend vitally upon success in developing forms of shared equity ownership.

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Part Two

Procurement and Construction

Information Technology

COMPUTER AIDED DESIGN: RESEARCH NEEDS IN QUANTITY SURVEYING AND CONSTRUCTION MANAGEMENT

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Abstract

The use of computer aided design (CAD) systems by designers is reviewed. Techniques employed by them are discussed with reference to the different geometries adopted and the extent to which useful data might be extracted. Developments in CAD are examined in terms of how these are stimulating innovation and a wider use of such systems amongst construction professionals. Areas of research and development need are described and the action required of quantity surveyors and construction managers is outlined.

Keywords: Computer Aided Design, Architecture, Structural Engineering, Quantity Surveying, Construction Management, Modelling, Simulation, Animation.

1 Introduction

The author has described, at length, the technology of CAD, its application within design and the opportunities for quantity surveyors (Atkin, 1987; Atkin and Davidson, 1990). It would add little to our understanding of the subject if the contents of the above publications were reproduced here. There are, however, instances where further developments have occurred and where comment is necessary in order to appreciate the arguments advanced in this paper. These arguments are concerned mainly, though not exclusively, with matters of research. Thus, the primary purpose of this paper is to discuss research and development in the field of CAD as it relates to the needs of quantity surveyors.

In this, we must take account of the wider interests of quantity surveyors beyond the preparation of cost estimates and the generation of production documentation. Those employed as construction managers have, if anything, a greater need to harness the power of CAD systems. Construction method, resources and time are key factors in the provision of economical buildings of the required quality. Put simply, construction method and the resources that are consumed over time determine construction cost. The relationship between these factors is rarely straightforward, yet must be reflected in the price paid for a building. From whatever aspect the problem is viewed, the client should receive the best advice on cost/price, time and quality. If CAD techniques can be evolved to help provide better advice to the client, we should encourage the requisite research and development effort.

For the purpose of this paper, the term quantity surveyor is taken to mean the client's independent consultant on matters principally of cost/price; a construction manager is taken to mean the client's independent consultant on construction-related matters, namely method, time, resources and cost.

2
CAD and building geometry

2.1
Classification

A person's understanding of CAD is often muddled by the different approaches taken to 'describe a building to a computer'. Advice can be contradictory such that the would-be user—let alone the complete novice—can be easily confused. The classification of 'CAD geometries' holds the key to understanding which approach is best and why?

There is, to a large extent, a natural gradation of geometries from the purely symbolic 2-D to the 'solid appearing' 3-D. The following list places the most commonly used geometries in order of complexity and proximity to the real world:

1 2-D sketchpad.
2 2-D drafting.
3 2 1/2-D drafting.
4 3-D wireframe.
5 3-D box geometry.
6 3-D spatial and physical modelling.
7 3-D object-oriented modelling.
8 3-D solids or Boolean modelling.

2.2
The two dimensional trap

Traditionally, buildings were portrayed by a paper-based collection of flat, orthogonal views. Occasionally, three-dimensional projections were included to enhance visualisation and the appreciation of space, form and arrangement. The difficulty in originating more than just a handful of projections meant that a number of orthogonal views had to be assimilated by the reader before the implications of three-dimensional space and detail could be comprehended. The full extent of a detail might not be revealed until several fragmented views have been examined. A particular instance of an object may be partially revealed on two, three or more separate views. If this traditional approach is replicated by the computer, the problem of assimilation and comprehension becomes exaggerated. Since each flat, orthogonal view is represented by a separate file, two or more files may need to be examined before the complete picture is grasped. This difficulty becomes all the more pronounced when one has to extract data for post-processing. Procedures can be contrived to solve this problem, though it would be better if the problem did not exist in the first place. The idea that a three dimensional object such as a building can be adequately 'modelled' by a set of fragmented, two-dimensional views cannot be taken seriously. But does this contradict the evidence from practice where many designers are wedded to 2-D drafting systems?

The answer to this question depends very much on the answer to another question—what precisely is being designed? If it is three-dimensional space, form and arrangement then the use of such systems is, indeed, flawed. However, the use of a 2-D drafting system to add detail, that is to embellish views with information which will communicate the designer's intentions, is entirely justified. Another way of looking at this issue would be to decide whether or not the use of such a system was confined to drawing something that had been designed already. In such a case, the 2-D drafting system's approach is justified and can, if handled correctly, lead to the provision of more consistent design information.

As if seduced by the architect's love for 2-D drafting systems, many quantity surveyors are now investigating how it might be possible to measure directly from them. Such investigation is wasteful and misses the point. The objective should be to extract data from the basic model of a building at the early design stage. The cost, time and quality of a design become fixed—within certain limits — from an early stage. Getting the design right from the earliest point is far more important than worrying about the later measurement of trivia. Successive iterations of design generation-synthesis-analysis at early design enable the design team to converge on an acceptable solution quicker and more reliably with the quantity surveyor's involvement than without it. Therefore, it makes little sense for quantity surveyors to commit valuable resources to researching ways of linking with a particular architect's drafting system at the production documentation stage when cost, time and quality have become almost a foregone conclusion. Whilst reporting in great detail on what has finally been included in a design may still be required, it is not something which will secure the future of the quantity surveying profession.

In all of this, we must not lose sight of the fact that the quantity surveyor is an equal member of the design team and has a duty to advise the client on the most effective way of implementing CAD. Left to their own devices, some architects will simply foist their particular choice of CAD system on everyone else. Choices are bound to be tied to the architect's organisational needs and may not therefore coincide with the client's project-related needs.

2.3
Modelling the product not the process

There are other reasons for adopting a three-dimensional approach to describing a building (or part thereof) to a computer. If a model is composed entirely of 3-D objects and if these objects can have properties, even knowledge, associated with them, it is possible both to assign and extract data according to users' preferences (Björk, 1990). This is the thinking behind the move towards building product modelling. In essence, product models are structures that specify the kind of information used to describe buildings. The central concepts are objects, properties and the relationships between objects.

A structure has been proposed by Björk which involves the implementation of an abstraction hierarchy. This is intended to help designers deal with the subdivision of a building model into meaningful systems and parts:

> Building—containing attribute data about the site, total size of the building, type of building, construction cost, local weather etc..
>
> System—general information about the systems that constitute the building, the spaces that form a system, loadbearing components to form a system etc..
>
> Subsystem—used to divide the above systems into functional parts, such as floor, hospital ward and so on.
>
> Part—the vast majority of objects in the product model belong to this level, being tangible, physical components and devices.
>
> Detail—subdivides parts into basic objects, such as the individual objects which go to make a window or door, although much of this information might be held in general databases provided by material and component manufacturers.

The above approach should be contrasted to the present practice of using CAD techniques to replicate manual processes or methods of working, where the integration of project information is an intractable problem. Building product models, on the other hand, enable the evolutionary nature of the design to fit more closely with the needs of different contributors to the design and construction process as they change over time (Yamazaki, 1990). Much research and development is, however, needed before working systems are in routine use, for instance in determining how to manage knowledge-bases and databases, and in devising an efficient technique for capturing the history of construction projects.

The pressure to bring about such changes is supported at the international level through ISO/STEP and at various national levels. An international building product model standard is inevitable at some point: it is largely a matter of when. The substantial commercial gains from authoring software to support it will stimulate the leading vendors, Autodesk, Intergraph and McDonnell-Douglas, into action. Lesser, but nationally significant, vendors will be forced to follow suit. In such a scenario, the extraction of graphical and non-graphical data will simply happen: designs composed from 3-D objects dramatically reduce the need for human interpretation. As a result, the intelligent interrogation of a building's design will be possible, as knowledge about the objects from which it is composed can be associated with the objects themselves.

3
Current application of CAD and trends

3.1
General

The term computer aided design is ordinarily taken to mean the use of graphics-based systems. For some designers, the use of a computer to aid design activity does not necessitate graphics, though it can make it easier. Structural engineers, for instance, do not have a history of using computer graphics in design. Engineering design is analytical by nature, relying on the manipulation of mathematical functions. Detailing is an exception, where computer aided drafting has proven time and cost effective. Architectural design is different from engineering insofar as it involves, amongst other things, the manipulation of shapes, spaces and form. Additionally, structural engineering is concerned with a building's performance under conditions of load: resultant forces are both static and dynamic. In other words, the structural engineer must simulate those conditions which might be encountered once the building is under occupation. This represents a wholly different proposition to that encountered in architecture where one is concerned with static conditions only. In this respect, simulation is usually taken to mean the ability to generate successive views of a building model rapidly from different perspectives, so as to create movement through or around the building. Real world objects—people, trees, cars etc.—might be added to the model and animated to bring the illusion to life. Whilst our first reaction may be to dismiss this work as electronic wizardry, it cannot be denied that architecture is about art and what we are experiencing is a new form of art. If this leads to better buildings by design, it must make sense. Equally, CAD systems that enable engineers to visualise deflection and distortion in structural members help to bring science to life.

3-D modelling is not confined to architecture and engineering. In construction, the design of production and automation systems requires kinematic simulation of the systems in their working environment. Most, if not all, recent developments in this area have at first been simulated by computer before any prototype is constructed. From an economic standpoint, the cost of prototyping can be an order of magnitude greater than a desk-based design study. Computer simulation bridges the gap between the two and reduces risk for the developer of the system.

Graphics is the primary medium for the work of many designers, but its emphasis can vary dramatically with application. These differences are now discussed.

3.2
Use by architects

Until about five years ago, architects used predominantly 2-D systems for detail design and drafting. Few architectural practices had the wherewithal to design in 3-D. Limitations in hardware meant that 3-D modelling was possible only on expensive, timesharing minicomputer systems (Atkin, 1987). Computer aided drafting was justified mainly by those practices with a high and steady workload. The advent of microcomputers with 16-bit processors and multi-megabyte storage in the late 1980s changed all of that. Small practices could now afford computer aided drafting, though few could seriously buy into 3-D modelling—most had to wait for 32-bit processors and low cost, high-resolution, colour monitors.

The position today is that no small to medium-sized architectural practice could be without some form of CAD support on grounds of cost. For many, however, the term CAD is still to be interpreted as computer aided drafting. 3-D modelling systems for design are not widely used, even though there has been steady growth in sales over the last two years. For those who have invested in 3-D systems, CAD provides the power to visualise the building in its environment, as well as from within. Architects have always constructed physical scale models of their proposed buildings to show how they might appear, but the ability to visualise interiors was rarely easy and, in many cases, impractical. 3-D modelling has opened up considerable potential for architects to visualise and animate their designs. This will soon be possible in real-time.

Despite these excursions into the world of 3-D, most architectural practices use 2-D drafting systems for mundane reasons, like increasing drawing productivity and reducing labour costs. CAD in this sense is confined to the production documentation stage. The use of 3-D modelling systems at early design is evident, but could not be regarded as significant. Nevertheless, the trend is upwards and will continue until the vast majority of current users of 2-D drafting systems are also users of 3-D systems.

Interest in CAD may therefore be considered at two stages: early design using 3-D modelling and production documentation using 2-D drafting. However, traditional (manual) design activity is spread over several stages, as prescribed in the RIBA Plan of Work. A blurring of these previously distinct stages of work is already apparent with the emerging dominance of the two stages described above. If anything, this makes matters easier for the quantity surveyor and construction manager, as it focuses on the point at which cost, time and quality are determined, that is early design.

As far as software products are concerned, AutoCAD enjoys in excess of 70% of the market for architectural CAD software, taken in terms of numbers of sales. Most users are working in 2-D, very few are working in 3-D. Whilst this is likely to change, there is a growing base of users of 3-D modelling software running on the Apple Macintosh, a computing environment much favoured by architects. Presently, the majority of routine 3-D modelling in practice is to be found on the Apple Macintosh.

From the quantity surveyor's point of view, this fact is a mixed blessing. 3-D modelling permits more of a building to be measured. At the same time, however, some software contains utilities which enables cost and other data to be integrated into the building model, leading directly to the production of cost estimates. Thus, architects have the facility to generate cost reports and some have done so.

The automation of architectural design and detailing is a topic of renewed debate. Software is now available that can, with a little perseverance, automate routine detailing. Examples include the insertion of windows and doors in external walls and stairs between floors, where openings are trimmed automatically. In these examples the rules that govern the design of a staircase and the closure of a cavity wall around a window or door are well defined. Competent users are able to write small programs, known as macros, to prompt for basic design data which are then used to construct the relevant detail. Observation of manual methods would show that much effort in detailing a design is concentrated at the junctions of components. The embodiment of best practice within a CAD system, for instance on how to deal with commonly occurring details, would not only improve productivity but would also help to ensure a consistent approach.

A demonstrator has been developed at the University of Reading to show that it is possible to automate part of the design process. In this case, the design of cladding is accomplished by an implementation of AutoLISP, the artificial intelligence programming language within AutoCAD. Menu-driven commands lead directly to the rapid generation, synthesis and analysis of a building's cladding from a few, basic, design parameters. Doors and windows are automatically incorporated and the results output in the form of detailed elevations (Figs. 1a and 1b).

The demonstrator has been programmed with a range of cladding types. So long as the user is able to input basic data about a given cladding panel or system, the demonstrator will be able incorporate this in its next iteration. A list of parts is automatically produced at the end of each iteration, together with costs and estimated time for fixing on site. Approximately 10,000 lines of code and data have been written. Drawings may be output in DXF (drawing interchange file) format for importation into other systems. The demonstrator runs under UNIX on a Sun Sparcstation and has been supported, in part, by SERC funds.

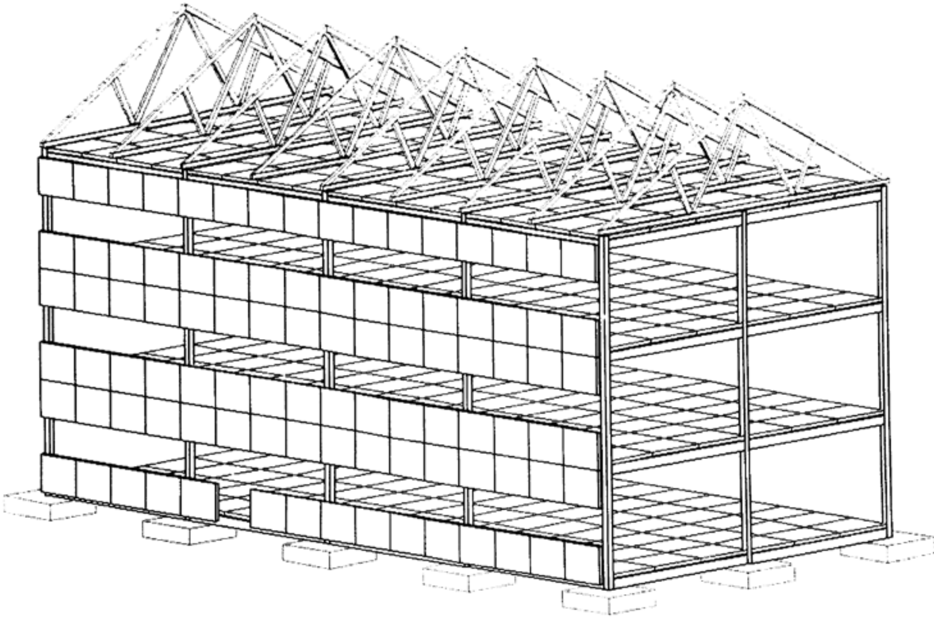
3.3
Use by structural engineers

The use of computers in structural engineering offers an interesting insight into how technology might be used to redraw the boundaries of responsibility between designers and other contributors. The design of multi-storey, reinforced concrete structural frames is a case in point. For slabs and beams, design calculation is more tedious than time-consuming, but for columns the time taken may be out of all proportion to that expended on other members. Engineers would almost always use a computer to analyse the proposed design, that is each member in the structure in turn. A 2-D drafting system might then be employed to detail the design. Little other computing would be used, nor would it be available.

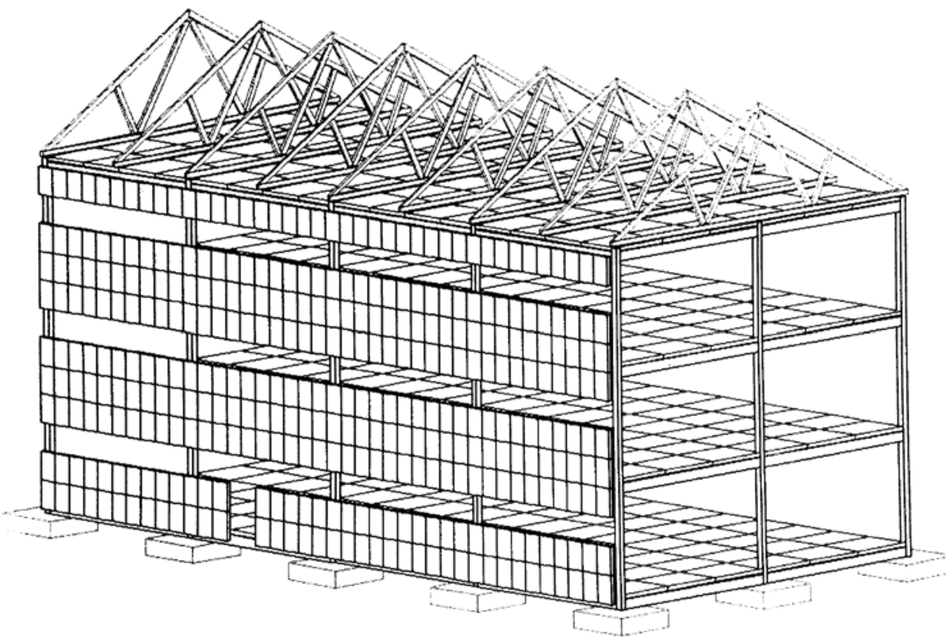
Designing a structural frame is like other design activities that begin with a concept. This may be defined by someone else, typically the architect, or might be something over which the engineer has control. Usually, the size of building, number of floors, floor height and grid size are the starting point; occasionally, three dimensional sketches might be provided. Since the particular material is specified and because design must comply with relevant British Standards and Codes of Practice, it is comparatively easy to define the problem. Loads on the building can be ascertained—by calculation or assumption—and an initial size selected for each member. Analysis of the structure is now possible, leading directly to its design. Software is widely available to handle analysis, design and subsequent detailing, but no software can handle the whole process from concept through loading, sizing, analysis, design and modelling to detailing. This necessitates the handling of both graphical and non-graphical data and the creation of a building product model (database) containing properties of all designed objects.

Software is being developed to do precisely this and has already passed the half-way stage. A joint venture between Laing Technology Group and the University of Reading, funded in large part by the SERC and DTI, is developing a graphics-based system to take the engineer from concept to detailing. The second stage will involve cost optimisation and quantity take-off of the proposed design, an exercise that is trivial in comparison to the demands of engineering design. The result will be that an economical structural frame can be designed and detailed in less than a day.

The system has been designed to interface with AutoCAD and other software using the ADI (user interface) and DXF format. In this way, it will be possible for the structural engineer to take notional design information from the architect and to return a fully worked-up design for the supporting structure. Naturally, changes are likely to most designs and therefore iterations between engineer and



Figs. 1a and 1b. Example screen images of cladding design from a demonstrator using AutoLISP within AutoCAD



architect will take place at intermediate stages. With this kind of computing at the disposal of the engineer, the quantity surveyor will have to be more proactive than ever before. This can begin with a closer interest in design economics, for instance, in looking at structural frames. After all, structural engineers are not cost engineers and are unlikely to acquire such expertise. They need the help of quantity surveyors to make sure that their designs are, indeed, optimal.

3.4
Other designers

It is important not to forget the contribution of other designers. The environmental services are, in many respects, the most challenging aspect of a modern building's design. Environmental services engineers must work hand-in-hand with the architect and structural engineer. They do not have the luxury of being able to design the services once the architecture and structure have been designed. Services are integral with finishes and contribute enormously to the aesthetics of a building's interior. They can also be used to considerable effect in shaping the external appearance of a building as, for example, in the case of the Lloyds Building.

The design of the environmental services might be considered in two, almost distinct, parts. First, the behaviour of the building and its occupants that gives rise to a particular servicing requirement. Second, the design of the many individual installations to satisfy that requirement. A mix of client needs, environmental science and architectural treatment will point towards an environmental services solution for the building. CAD offers exciting opportunities for the services engineer in supporting the ability to simulate many conditions which the occupant might experience. For instance, it is possible to simulate the effects of lighting—both natural and artificial—and air flows inside and outside the building; it can be used to identify hot spots and, likewise, cold bridges. By simulating the conditions under which the building will operate, the engineer is better equipped to translate needs into actions in the form of designed installations.

3.5
Use by constructors

In the UK, the responsibility for undertaking detail design has shifted away from the architect towards the specialist contractor. This, coupled with the increase in design and build contracts, has extended the market for CAD systems. Unfortunately, this tends to imply that contractors are newcomers to design when, in fact, several of the UK's leading contractors have long established design offices. In one or two cases, the amount of work supported by CAD compares favourably with some well-known architectural and engineering design practices.

The pressure for single-point responsibility (Bennett et al., 1989) points to even greater adoption of a design and build approach (N.C.G., 1990). With those responsible for construction having an increasing say in design it is highly probable that constructors, both general and specialist, will represent a growing market for CAD systems. Evidence from Japan makes it very clear that CAD is no longer the preserve of designers and that constructors have, if anything, more to gain from employing graphics-based systems. The so-called Big Six Japanese construction companies have invested large sums of money in CAD and the results are impressive. Taisei Corporation have developed a number of systems which include the following features:

Presentation—
Animation.
Ray tracing.
CAD/Modelling—
Schematic design.
Architectural design.
Structural design.
Environmental services design.
Ground modelling.
General drafting.
Simulation—
Structural analysis.
Fluid dynamics analysis.
Production and distribution.
Costing.
Feasibility.
Facility design.
Production—
Working drawings.
CAM.
Robotics.
Project management.
Database—
Building model database.
General database containing building objects, equipment, weather information, demographic information, construction history.
Expert System—
Construction planning.
Costing.

The relationships between the above systems and stages of design and construction are shown in Fig. 2.

Shimizu Corporation, the largest of the Big Six, have developed a CAD system which promises optimal design solutions from an integrated approach to design and construction. The system is noteworthy because of the way in which it

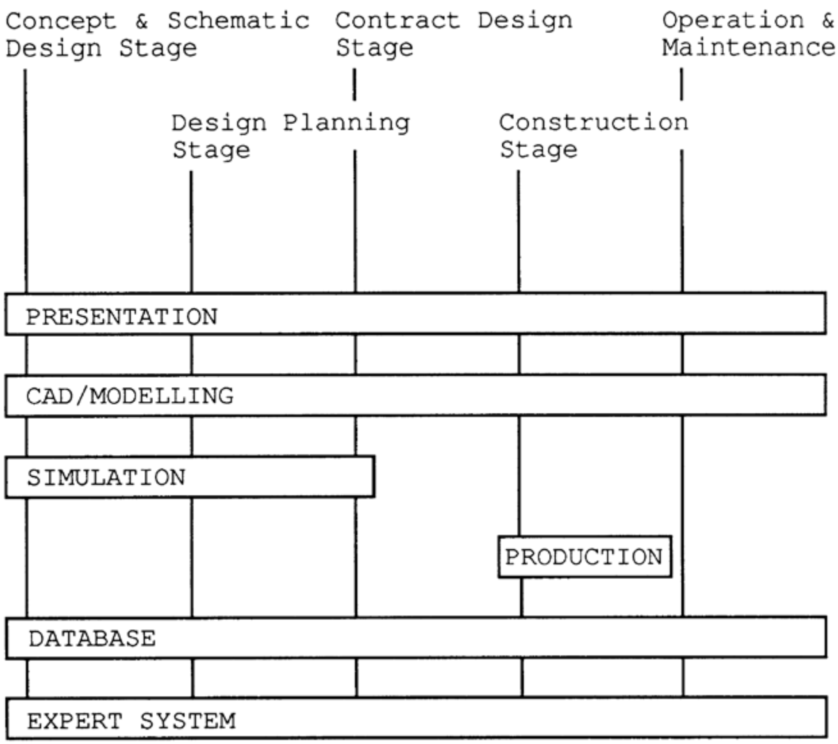


Fig. 2. Relationship between CAD-based systems and stages of design and construction—Taisei Corp.

divides the design process into three parts: concept and schematic planning; planning and simulation; and construction documentation. Planning and simulation is concerned with ensuring that the requirements for safety, comfort, durability, economy and building design can be evaluated. That these factors should figure so significantly is evidence of the Japanese commitment to providing quality and value for money. Testing or simulating the performance of the building before moving ahead with the generation of detailed documentation is intended to improve the quality of the design and lessen the risk of expensive mistakes in its realisation. Its use is by no means routine, but will grow to the point where it leads to a competitive edge for its users.

An example of the use of graphics-based computer simulation of construction processes is shown in Fig. 3. Kinematic simulation is helping in the design of a robotic manipulator for positioning cladding panels. Cladding positioning is a difficult and potentially dangerous task that cannot be performed in windy conditions. An automation system that removed operatives from the work-face and allowed them to control the manipulation and positioning of cladding panels remotely would lead to a safer and more efficient process.

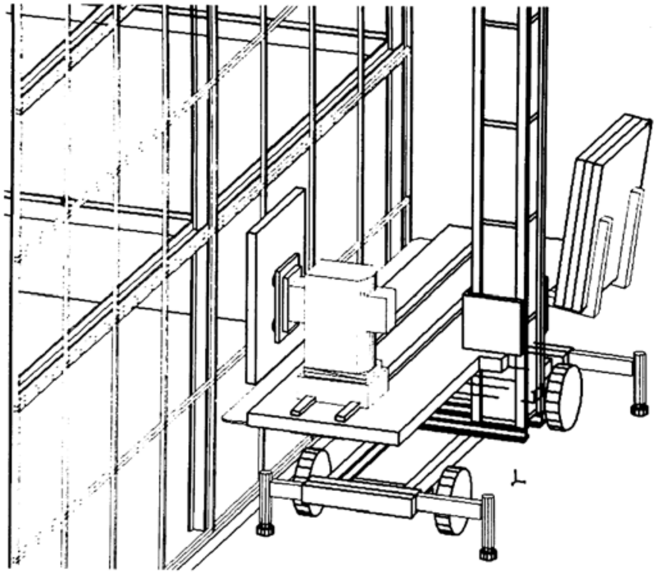


Fig. 3. Screen image of a cladding positioning robot using kinematic simulation software

The work is being undertaken at the University of Reading under the financial support of the SERC and has been directed towards the design, testing and specification of a cladding positioning robot and several other, prospective, automation systems. The findings of this work are due to be reported shortly.

3.6
Integration

The word integration is a cliché in the field of computing and is used in the same carefree way as 'system' and 'model' A simple, straightforward interpretation of integration is that it is concerned with bringing people together. In the context of construction this means the architect, engineers, quantity surveyor, construction manager, specialist and trades contractors and so on. It is achieved by identifying the information needs of each contributor to the process and the most appropriate structure by which information might be held for manipulation and subsequent exchange amongst contributors. But as discussed earlier, information must relate to the product if it is to represent an unambiguous and coherent description of the building. At each stage in the process of design and construction there will be a team of contributors whose composition will change over time. There has, therefore, to be some means for ensuring continuity, hence the attraction of building product models.

Another way of looking at the issue of integration is to regard the design and construction process as comprising a matrix of stages and contributors. At each stage, there will be a team of contributors with complementary skills being used to solve local (as opposed to global) objectives. We might refer to this as the horizontal integration of complementary skills, by stage. Likewise, we might use the term vertical integration to refer to the process by which one stage succeeds another over time.

Quantity surveyors surely recognise that integration has both a horizontal and a vertical component. Even so, they seem to be preoccupied with ensuring that information is available to permit the next stage to begin. As always, there is pressure to move ahead with the project, even though important earlier work may not be finalised. The iterative nature of design necessitates the bringing together of complementary skills at each stage. These skills should be brought to bear on solving problems local to that stage before releasing information to the next. To ensure this, the quantity surveyor and construction manager, where appointed, must have access to the building model. The architect may originate most of the model, but does not have the right to exclude the other members of the team who have a joint responsibility to see that the design 'works'.

3.7 Convergence of technology

Mention has been made in this paper of the recent history of CAD and how limitations in hardware precluded many architectural practices from its exploitation. Today, there are few practical differences between the powerful desktop microcomputers of Compaq and Apple and the workstations of Sun and Apollo. Multi-user environments like UNIX allow workstations to tap into a vast library of software and shared databases, but networked microcomputers can also share databases and peripheral devices.

In the early 1980s it was important to differentiate between main frames, minicomputers and microcomputers as the capabilities of each were quite distinct. By the mid-1990s, hardware will have developed to the extent that real differences in performance for the 'average' user will be of academic interest only. Yesterday's problems of storage and speed of processing will be something to talk about on cold, winter evenings. Technology will have finally provided the solution. Now we must be sure to understand the problems that we want it to solve.

4
Research issues

4.1
Completing the triangle

A fundamental principle of project management is that projects should be considered in terms of their cost, time and quality objectives. Each factor must be defined for the project if the design and construction team is to know how to satisfy the client's requirements. The relationship between cost, time and quality can be shown by a triangle where these factors are positioned at the vertices. Clients may well insist that their project is to be located at the centre of the triangle, that is representing the optimal solution. This is, however, an unrealistic proposition as not all factors can, at the same time, be optimal: one factor alone must be optimal. Thus, there is a relationship between the factors that determines the outcome of the project, that is the design of the building.

It is hard to imagine a building cost appraisal not being sensitive, in some way, to the time taken for construction. As this is determined by construction method and the resources that will be available, an understanding of the construction process is important if the quantity surveyor is to provide balanced advice. That time should be a factor which can expand or contract for no good reason cannot be used to dismiss the justification for its evaluation. Construction cost, which quantity surveyors believe they can predict fairly accurately, must be based on some assumption of construction method and the resources consumed over time. To suggest otherwise is nonsense. Furthermore, we can extend our definition of time to cover total project time and likewise would deem method to now include procurement approach.

Quantity surveyors are paid to be experts in cost and what this means in terms of quality for a given building or part thereof. There is a dire need to take account of the time factor and to explore its relationship with cost and quality. But in order to establish the time for a project one must appreciate the construction implications of a design. Quantity surveyors acting as construction managers understand this simple fact; others acting as the client's independent consultant must do the same.

4.2
Developing the expert systems theme

Research has already considered the applicability of expert systems to CAD in dealing with the 'intelligent' estimation of cost and time (Brandon et al., 1990) . The aim is to infer the cost and time of a building design from its supporting CAD database/knowledge-base. Preliminary work would be needed in gathering sufficient time-related data to demonstrate that reliable results could be obtained. Such data are not generally available in the form that is probably required, though much would undoubtedly exist in other forms. The gathering of data is likely, however, to be a continuing process whose purpose would be to refine the quality of the answers given by the system. The development of an intelligent knowledge-based (expert) system, one that supported 3-D object-oriented modelling, would enable the design team to converge on an acceptable design solution sooner than is currently possible. By its very nature, this approach would help to create greater horizontal integration. Further discussion of this concept is to be found in sections 4.3 and 5.4 below.

4.3
Areas of research and development

There is much work that could be done, far more than could or should be initiated by the quantity surveying profession alone. Outside commercial interests will tackle the more general, technology-related issues, but important work will remain for the profession to undertake itself. This is not to suggest that large sums of money should be directed into research using the already limited funds of the RICS and its membership. But it does mean that a contribution must be forthcoming as proof of commitment. Before there can be talk of money, there must be agreement on what should be done. The following is an attempt at mapping out the topics to be addressed. Nothing should be taken, at this point, as being fixed.

Topics for research have been organised into four areas, corresponding to the separate stages of a single research and development programme:

1 Determining the extent to which current CAD systems are able to support the extraction of graphical and non-graphical data for use in cost estimating and construction planning.
2 Defining a database/knowledge-base structure and mechanism that could capture the proposed and actual chronology of construction from a building product model and support the transfer of data to construction planning (project management) systems.
3 Defining a database/knowledge-base structure for commonly used construction plant and equipment.
4 Intelligent interrogation of CAD databases/knowledge-bases.

Each stage is now described, together with an indication of what would be delivered by way of tangible outcomes.

5
Research and development projects

5.1
Extraction of data for estimating and planning

It has already been established that a 3-D object-oriented approach to design is necessary, when using CAD systems, if meaningful data are to be extracted. The extent to which designers are able to support this requirement must be investigated, as must the capabilities of the database structures adopted by current, commercial CAD systems.

It would be prudent, therefore, to investigate the use of third party, relational database management systems, as a means for integrating and exchanging non-graphical data for cost estimating and construction planning. Part of the approach would involve determining the degree of detail of individual objects which would need to be captured by the system.

The results of this stage are required before any developmental work could be undertaken on the transfer of design data. The research for this stage would be a highly useful exercise in itself, in so much as the findings could be published and disseminated to a wide audience. This could be used to publicise the benefits to designers and others from adopting a common approach to the representation of graphical and non-graphical data, using object-oriented (building product) models.

Outcome: A comprehensive report on the extent to which current CAD systems (hardware and software) can support the integration and exchange of graphical and non-graphical data for use by quantity surveyors and construction managers (for cost estimating and construction planning); and the procedures which designers must adopt to ensure that such data can be made available.

5.2
A mechanism to simulate construction

This would involve devising a mechanism that could simulate the progression of a construction project as one might observe on-site production processes. The approach is analogous to the combined effect of time-lapsed photography and animation techniques, and would use commercially available software. It assumes that the building models created by the designers, on the CAD systems investigated and identified in 5.1, could be transferred to a computer workstation operated by a quantity surveyor or construction manager.

The mechanism would require that the sequence(s) of on-site production activities be identified by constructing the building on the workstation's screen. This 'Legoland' approach would be recorded by the system and then replayed as many times as are necessary to arrive at an acceptable sequence. A default sequence of activities could then be used as direct input into a construction planning system to provide a rapid means for analysing the proposed building's construction time and, subsequently, its construction cost. The capabilities of current project planning and control software (project management systems) would need to be investigated to determine the extent to which graphical data and non-graphical data could be taken as input.

Outcome: A handbook on the procedures required in order to devise a mechanism for determining, recording and replaying sequences of construction against an existing model of the building; and an assessment of the suitability of current project planning and control software to take graphical and non-graphical data from such a model as direct input. A demonstrator, that is an example system operating on a computer workstation, should also be provided.

5.3
Database/knowledge-base of plant and equipment

The ability to superimpose construction plant and equipment onto a building model and to test their performance dynamically using simulation techniques would enable operating parameters and conditions to be defined well in advance of arrival on site.

The approach requires that the most commonly used construction plant and equipment are identified and their characteristics—as they influence the decision-making of construction managers—are defined. Other, less commonly used plant and equipment could be added at a later date. Part of the approach would involve determining the degree of detail which would need to be captured by the system with respect to items of plant and equipment. This would then enable a database or knowledge-base to operate on the building model to provide a realistic picture of the construction process.

Outcome: The specification of an interactive database management system (or knowledge-based system) that would maintain performance characteristics of items of plant and equipment, enabling operating parameters to be defined. A demonstrator, that is an example system operating on a computer workstation, should also be provided.

5.4
Intelligent interrogation of CAD

The ability to provide rapid answers on the buildability of a proposed design solution would guide designers and their clients towards better design solutions. The establishment of a database/knowledge-base that could acquire the history of previous construction projects could be used to assist designers at early design.

The approach would involve inferring the construction process from the CAD database/knowledge-base. This would require that sufficient data relating to construction plant and equipment and the creation of temporary works were in place. It would involve the development of a database/ knowledge-base of construction methods that would help in providing answers to heuristic problems associated with planning temporary works. In this way, algorithms might be developed in the future and fed into systems such as those developed under 5.2 above.

Outcome: An intelligent knowledge-based system that would interrogate CAD databases/knowledge-bases to determine the most appropriate sequence of construction activities, including the generation of detailed resource schedules, and the means for exploring the relationship between cost and time.

6
Action required of QSs and CMs

Any research and development proposal can be labelled ambitious if the level of resources to be committed to it fall short of what is really needed. Discussion must take place with eyes firmly fixed on what the profession as a whole wants to get out of it. Whilst the cost of funding any research will be of immediate concern to some, it is hoped that energy will be concentrated upon deciding what precisely needs to be done. In this regard, cost should be relegated to a later stage when the full implications of the research and development programme are know. This will avoid dissipating vital energy into solving problems which have yet to be defined.

At the RICS level, discussion should begin on what needs to be done. This must involve leading quantity surveying practices as well as academics. The proposed topics in section 5 would be a sensible place to start. At the individual practitioner level, everyone should do their best to ensure that clients are fully briefed on the implications of taking a particular line on the use of CAD on their projects. Quantity surveyors acting as construction managers can reinforce and develop their position through a close look at the potential for using graphics-based systems. There are enough precedents for doing so. Quantity surveyors not involved in construction management must acquire the education and training necessary to become experts in cost and time. Here, the educationalists have a duty to broaden the curriculum. Learning about construction processes is not something which can, or should, be left for post-qualification training. A thorough understanding of technology and the management of the processes of design and production/construction is needed in addition to the more obvious subjects of economics, law and quantity surveying practice.

7
Conclusions

This paper has reviewed the use of CAD systems by designers and others, and has identified practices that have a bearing on the work of the quantity surveyor. The various techniques employed by users of CAD systems were discussed and account given of the significance of different geometries.

Developments in CAD were examined in terms of how these were stimulating innovation. Several examples were given of where new developments were shaping the construction industry of tomorrow. Client expectations are likely to be influenced by these developments to the extent that construction professionals generally will have to be equipped with the appropriate CAD tools. Several topics for research and development have been proposed, but these need discussion outside this Conference. They have major implications for the future education and training of quantity surveyors.

8
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MODELLING AND EXPERT SYSTEMS IN PROPERTY AND CONSTRUCTION

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Abstract

This paper provides a general critique of current models used in property and construction and suggests that there are advantages in harnessing the benefits of expert systems to provide an improvement. It describes some of the advantages of expert systems and the domains for which they are suitable. It then looks at the problems and limitations of such systems before outlining some possible future developments.

Keywords

Expert Systems; Modelling; Problem Solving.

1 Introduction

This paper attempts to outline some of the key issues related to the development and use of expert systems in property and construction applications. It will be appreciated that in a relatively short paper it is not possible to do justice to a subject which is growing at a very fast rate indeed. The interest in knowledge based systems in all aspects of human decision making, has surpassed the interest shown in practically any other research topic in recent years. As the subject begins to mature so it becomes of less interest in its own right but gains interest as one of a series of useful tools able to solve, or partially solve, difficult problems. The hype is over (Brandon 1990) but the benefits remain. The next phase will be one of evolutionary development based on incremental improvements in software and hardware.

Expert systems are in one sense just another form of programming and they suffer from some of the limitations of conventional programmes. Their task is to model human decision making and they suffer in the same way that all models suffer. They are representations of reality, and as representations, are almost by definition simplifications of that reality. Models, whether enshrined in a formula, expressed in a drawing, constructed in balsa wood or found within the mind of an expert, contain imperfection. The complexity of the world does not allow us to allow for every eventuality in the future or every possible new juxtaposition of traditional ideas. Our aim in modelling must be to get as close to reality as we can by combining the strengths of the model with the power of human thinking. To divorce one from the other will cause problems in use, acceptance and performance. Models which are sympathetic to human decision making and which support the human in his search for a solution offer much in the way of improvement. One of the strengths of expert systems is that, in their attempt to replicate and mimic human decision making, they give psychological support to the human problem solver. Other benefits also make them attractive as we shall see later. Before looking at these benefits it is worth noting some of the deficiencies of current models.

2
Mechanistic Nature

Almost by definition mathematical models are mechanistic in nature. Indeed some mathematicians see the world in this way and endeavour to reflect this view in their philosophy and in the models they use to support their beliefs. The danger with this approach is that the models they develop can become 'clockwork' replicas of a constrained view of the world and with little or none of the uncertainty and chaos observed in reality. Statistical models trample the uncertainty to death in order to abstract a trend, and simulation models, once in operation, find it difficult to model the behaviour of human beings in managing uncertainty.

Where the forecasting of future events is involved or where human behaviour is being modelled then mechanistic models are bound to run into difficulties.

For example regression analysis for building cost forecasting was very attractive to many in the 1970's. A large number of models were constructed and appeared to work well when forecasting within their own data set. When applied to new projects, however, they could not reach the same level of confidence. There are many reasons for this but a major factor was their inability to react quickly to external change. If a constant supply of data is not available (allowing the model to at least keep pace with the present) then error quickly creeps in. The regression models related to estimating should have attempted to establish time and cost relationships. However in order to simplify the problem the time factor was often ignored and cost became merely a function of a quantitative measure of design. Immediately this was done, all the factors affecting labour, productivity, political change, and other external issues which can change rapidly over time, were suppressed. The mechanism of the model could not handle the uncertainty of time related and inter-dependant events.

Perhaps the most obvious example of a mechanistic model is the traditional approach to Life Cycle Costing. Here a pattern of events for the life of the building is laid out, costed and then discounted to present value. If a computer is used (Bird B, White K and Morris I (1987)) then the computational method used, often follows the pattern without deviation to produce an answer. The uncertainty and lack of predictability over the lifetime of the building is ignored. In reality no client or tenant presses a button and then lets his building conform to a predetermined pattern, without intervention, over a year and certainly not over its lifetime. The mechanistic approach needs intelligence to be built in if it is to respond to the effects of uncertainty, the effects of inter-relationships acting together, the clients management policy and all the many external factors.

Some of the more advanced simulation models for the construction process also take a ‘clockwork’ approach. Ormerod and Bennett (1984) produced a very sophisticated model in terms of the simulation of construction activities. However the modelling of management intervention and employee response was not included and yet this would have a major impact on cost and time. Of course even if you could include the management response then which manager do your model—the good, the bad or the typical? Very few contractors would be willing to admit (or know) that they are placing a bad manager on a site and is there any such thing as a typical manager?

3
Black Box Nature

Associated with the mechanistic nature of mathematical models is often a concealing of the mechanism itself, usually as a by product of the nature of the model. If vast quantities of data have been analysed and a single equation derived then it is difficult for the user to regain the contextual data from which the model has been created. Nor is it always easy to bring the experts’ own knowledge, experience and understanding of the problem to bear on the result. Information is entered at one end, results appear at the other and no intervention or modification by the expert is possible. The implicit assumption must be that the model is perfect—which of course we know it isn’t.

Beeston (1984) raised this issue in the context of estimating but it applies in many areas of building modelling. Where there is stability in the knowledge and the thing being modelled is determined by physical laws then this may not be a problem. Some structural and energy calculations are of this nature and their level of performance may not be appreciably enhanced by human intervention. However where the model is attempting to represent a very complex object, or human behaviour, or an object or process heavily influenced by the economic, political or other external environment, then we have to ask whether it is realistic to expect good performance without human intervention. The strength of the human brain is that it can assimilate vast quantities of information, from all the bodily senses and draw a conclusion from its previous knowledge and experience. This assimilation is a continuous process, which is unbroken, and which provides a never ending modification of the ‘world’ model held in the expert’s brain. Current technology does not allow us to emulate in this way. We should therefore be looking for transparency in our models with sensitive interaction with the user so that the strength of model and user are harnessed for the benefit of both.

4
Value Assessment

The purpose of most models is to provide better understanding or better decision making on behalf of the user. In terms of the latter, the objective is to improve the result of the decision as viewed by the beneficiaries. In other words the user is seeking to improve the value to himself or his client. Value is a complex judgement involving the prioritising and weighting of needs and wants and balancing these against the costs and resources required to achieve them. Inevitably it involves compromise and this is difficult to incorporate in conventional models unless there is a common unit of measurement for all factors of the value equation. In the past, models which have attempted such a feat have been heavily criticized and are now largely defunct. Perhaps the prime example is that of Cost Benefit Analysis, particularly when artificial values have had to be placed on human life or human behaviour. The possibility of hospital circulation layouts being designed to minimise the consultants time rather than the patients, because of the differential in salary, is a case in point!

Construction and design activity is an extremely complex and poorly understood form of human activity. One person’s response to a building will differ from another. One manager’s approach to the construction process will differ from another. The value systems which each individual brings to the problem will incorporate cultural, aesthetic, religious, economic and other systems which in terms of content, or at least emphasis, will vary from person to person. The actual ‘process’ of achieving value will vary and it has been suggested, for example, that designers themselves may fall into one of five broad categories in terms of their approach (Brandon P and Powell J 1984). Each will be trying to solve the same problem but from a different standpoint and technique. The recipients of the final design will be even more wide ranging in their criteria for assessment. It is to the credit of good designers that they manage to achieve solutions which satisfy so many people over such long periods of time. Again the question must be asked as to whether it is possible to build useful models to establish ‘value’ for whole buildings or complete construction processes. It may be useful to have this as a long term objective but to integrate all the subsystems to provide value judgements is unrealistic. Even at the sub-problem level it is often difficult to handle the large number of variables which determine optimal solutions. The argument for a sensitive interaction between the decision support tools and the human brain is even stronger with an issue such as ‘value’. In developing models this interaction between model and human should be at the forefront of the model builder’s mind from the beginning.

5
Risk Assessment: Aversion or Seeking?

One of the most common calls for model improvement at the present time is to include risk assessment in the process and final result. The days of the deterministic model are thought to be over and the new orthodoxy of risk appraisal and risk management, recognising the uncertainties of the real world, is now in vogue. There is much to commend this approach despite the fact that, in the UK at least, clients still appear to want a firm figure on cost and time with which they can work. In most modelling techniques involving risk and uncertainty an assessment of variability from the past is determined, or a distribution is created from subjective expert opinion, about the present. This works quite well providing the past and present reflect the future. However a distribution of time or cost, for example, does not necessarily help in making the decision. The decision maker still has to determine what risk he is prepared to take and perhaps more importantly what faith he can place in the simulation model.

Where the time span of the simulation is extensive and projecting far into the future then he should be wary of the distribution before him. If he is planning the performance of a building over time then the number of interdependencies both internal and external to the building are for all intents and purposes infinite. The external economic situation, for example, will affect the behaviour of the building owner and his financial situation. This in turn will affect the amount spent on maintenance, refurbishment, general management etc, which will in turn effect the manner in which the building degrades. The level of degradation can affect the performance of the workforce, the behaviour of the tenants, the nature of the built environment in the area and therefore the obsolescence of the building. Each facet of this cycle will have many systems working upon it and will owe more to chaos theory than organisation theory (see Gleick J 1988). This vast range of interdependent events are almost impossible to model and users should be wary of those who claim special dispensation to forecast the future in this way.

The next question is whether we should model the decision making process of the user in order that the machine can reflect his preferences. Some models already do this but not usually in an overt manner. Life cycle costing models use discount rates, for example, to model the users 'opportunity cost' of foregoing the return he would receive if he placed the money in another type of investment rather than into the capital and running costs of the building. However this view of the problem may not, and probably does not, reflect the decision makers' thinking process. He will be assessing risk. The time span over which he views the problem will vary from individual to individual (Templeman—Platt 1986). In addition his attitude to decision making will vary and he may be risk seeking or risk averse (Bon R 1986). In turn this attitude may vary over time. Is it possible for a model to take issues like these into account over an extended period? The answer is almost certainly no.

6
Matching of Models

Fundamental to our understanding of the model is the objective or target at which it is aimed. The definition of a model as a representation of reality is fine providing we know what is meant by 'reality'. Of twenty six cost estimating techniques listed by Skitmore and Patchett (1990) more than half were attempting to model the reality of someone elses model rather than the reality of how cost was incurred on site or elsewhere. In general, up to the point of tender, estimating techniques are attempting to predict the lowest tender in a competitive bid (Ferry and Brandon 1990). All those attempting to estimate prior to this point are attempting to match their model with a more refined model to be used in the future. Even the tender document is a model which does not relate to cost occurrence on site but to finished artefacts in a building. It is subject to the vagaries of the contractor's estimator, his management board and the economic climate. All the early estimates are trying to second guess the successful tenderer despite all the variability which that tenderer has at his disposal. It could be argued that this process owes more to psychology than to scientific method. However the similarity between models from sketch design to tender ensures that the same concepts and culture is used by all and provides for some uniformity and consistency in this complex matching process. It becomes a refining process and huge leaps in model structure are avoided. These leaps tend to occur after a contract has been awarded when an attempt is made to reconcile the contract programme in the form of site operations with a tender document expressed in terms of design artefacts. Often it can mean starting again with a different set of assumptions. However while the culture exists it is possible to build compatible models and with the advent of expert systems allow some interpretation between models. It should also be possible to interpret between one culture and another, e.g. from design artefacts to construction activities providing the rules for the interpretation can be captured and defined.

7
Expert Systems

These and other issues suggest that if improvements are to take place then we must address the man, model, machine interface. We must attempt to define what is best done by the machine and what is best done by the human expert. At the same time we need to discover which aspects of human decision making can be undertaken by a machine, without detriment to quality, in order to make the human more efficient and release his time for more creative or managerial activity. It is in addressing these issues that expert systems begin to play a major role. In mimicking decision making processes they gain the confidence of the user and allow a strong relationship to develop which increases acceptability of the model and at the same time allows critical judgement by the human expert because he understands the process. The dangers lie in blind acceptance of the expert systems approach and this is of course exaggerated when the user is a non expert. The rest of the paper will address the nature and use of expert systems.

8
Nature of Expert Systems

The British Computer Society—Specialist Interest Group in Expert Systems define Expert systems as:-

> 'The embodiment within a computer of a knowledge-based component from an expert skill in such a form that the system can offer intelligent advice or take an intelligent decision about a processing function. A desirable characteristic, which many would consider fundamental, is the capability of the system, on demand, to justify its own line of reasoning in a manner directly intelligible to the enquirer'.

A key feature of an expert system is that the knowledge is separated from the processing of information, i.e. the knowledge base is kept separate from the algorithm which acts upon it. In conventional programs the two facets are integrated in the same program.

In use expert systems have their own characteristics. For example they can:-

- Explain and justify their reasoning.
- Operate with incomplete information. Handle uncertainty.

In addition it is usually easier to add, omit or modify the program largely by altering the knowledge base of the system. The 'reasoning' or inference mechanism merely acts upon the knowledge and does not usually require major modification.

These features are immensely helpful and can assist in overcoming some of the problems identified with earlier models. For example, the fact that they can explain (at least in part) their reasoning process, begins to answer the problem of the 'black box' nature of earlier models. The ability to handle incomplete and uncertain information allows qualitative reasoning and human sensitivity to be applied to mechanistic processes. Even value judgements can be attempted although the changes in value systems may be difficult to monitor and update within the knowledge base. The probabilistic features of expert systems allows risk to be evaluated providing the risk can be assessed against some universal or personal standard that can be defined. Finally the matching of models may be possible through a reasoning process allowing ease of refinement. It may also be possible to link one model to another of a different nature if the rules of interpretation can be defined.

The above statements are not meant to imply that expert systems are a panacea for all our problems. They are not. What they do provide is a vehicle for incorporating some aspects of human decision making in the machine, the ability to efficiently, accurately and consistently process information and to allow human interaction with the model in a sensitive and understandable manner. (The latter point is important because the acceptability of expert systems is high because they mimic the process the human would adopt. There is therefore no 'turn off' caused by an unfamiliar technology). These are important steps forward. They provide therefore a new perspective for modelling which includes:-

- the ability to make conventional models more transparent and open
- the improvement of diagnostic processes within the model derived from the 'reasoning process'.
- the ability to make reasonable assessments (default values) based on captured expert experience where information is not complete
- the ability to weigh one argument or set of circumstances against another within the model.

In addition they have all the attributes of conventional computer programs including access to databases, spread sheets and other standard software.

9
Nature of Problem Solving

Property and Construction problems and particularly those associated with design are usually open ended and are sometimes categorised as 'wicked' problems (Rittel 1966). Newton (1987) defines the characteristics of construction problems as:

- many often conflicting criteria
- ill-defined goals which change over time
- no singular metric by which to evaluate or compare alternatives
- effectively an infinite potential solution space

So how then do we actually solve problems in property and construction and resolve the difficulties associated with these characteristics through expert systems. The short answer must be that we *don't*—at least not with the present technology at our command. We cannot solve the multi-facetted complex problem of development, particularly creating a new design, without human input.

If we try to exclude the human input we would see:

- a succession of stereotyped solutions

- an enforced method of approaching the problem which may exclude potentially more beneficial approaches
- a single view of the problem

Every expert system, except for very well constrained simple problems, should therefore be seen as a support for human decision making and not a replacement. The danger of creating an oppressive tool which because of its attractive qualities (speed, consistency, explicitness etc) and which by its very purpose is intended to be used many times over by many different people with varying levels of understanding, is very real. Humans do have multiple views of the problem which can arise from their previous experience.

This allows them the potential to adapt to new situations, correct errors, discover new pathways for resolution through bisociation (Koestler 1976) and modify the model in relation to their own model of the world.

These are powerful skills and although in theory these could be used to modify any expert system that is developed, the time scale to execute the change is usually too great.

Much of this human power arises from the ability to use analogies as Minsky (1987) puts it'…by representing each new thing as though it resembles something we already know'. He goes on to say that the use of these analogies (signals, symbols, words and names) 'lets our mind transform the strange into the commonplace'. By this method we can extend and adapt our knowledge and improve our understanding of the world.

This facility is not yet open to expert systems so we run the risk of stagnation of our current thinking. However to be fair to the machine some people have this problem as well!

The opposite view to this more pessimistic commentary on expert systems is that they make available, the routine knowledge of experts, already elicited and formalised, to a much wider audience. One of the perennial problems of developers, designers and constructors is keeping up to date with, and using, the information already available to them. They are swamped with new products, new statutes, new byelaws, guidelines and codes of practice. Discerning what is relevant, assimilating the information and applying within the context of the problem in hand is now a major task.

If this knowledge could be codified and made easily available through an expert system then this would provide a major breakthrough in decision making. If at the same time the system can add the other attributes of consistency, explicit reasoning and ease of modification then there is a significant role to be played. As with any other modelling system there should be an awareness of the limitations. However many manual methods are also used blindly (Powell J and Russell B (1982) by inexperienced and sometimes experienced consultants and contractors —it is the scale of the repercussion of an error which is different in a universal computer program. By its very nature it is designed to be used many times over.

10
Expert Systems Domains

It may be helpful therefore to list some of the criteria which have been suggested by several authors in selecting suitable domains for developing expert systems.

The knowledge should involve a relatively small number of concepts (e.g. 50–300)	These 'concepts are the major building blocks of the system, which may in themselves contain routines and goals. Too few of these and the expert system is better undertaken by a human or conventional programme—too many and it is difficult to handle particularly when the concepts are inter-related.
The knowledge should already be well organised and formalised	This will speed the development of the system and in particular the knowledge elicitation process. However, a well structured and universally agreed framework may be sufficient if the experts are articulate about their subject.
The majority of the knowledge should be documented	Again this assists in development. If the knowledge has been written down, well usually it has to be organised and structured, which assists in defining the method of knowledge representation.
There should be a consensus on what	Knowledge engineering involving multiple experts can be difficult unless all agree
constitutes the domain knowledge	on what knowledge is required to be in the machine and the 'knowledge culture' which supports the decision making process. Homogeneous groups support each other and are prepared to listen to each others argument.
The knowledge should be and well tested	Knowledge related to fashion and stable political opinion and other matters which change rapidly does not provide a robust knowledge base and is expensive to maintain. It is best to identify unstable knowledge from the

	outset and either identify this for human decision making or include in a separate systems database which can easily be updated. Transitory knowledge is often difficult to test because of the short time scale over which change takes place.
The problem should be well constrained	Open ended problems are difficult to handle. It is important to set boundaries which allow the problem to be self-contained, i.e. it should be able to produce an acceptable solution from within its own knowledge base with the assistance of the user. It is critical that the scope of the system is constrained within what is technically and economically feasible.
An explicit model or methodology should be available	The strategy for solving the problem, like the knowledge required to solve it, should be agreed by all concerned and if possible already documented.
Large problems should be able to be split into sub-tasks	The mechanics of creating the knowledge base can be extremely difficult if the problem cannot be broken down into modules or sub-tasks. In more complex expert systems it may be necessary to design the product in a similar way to some of the information engineering tools available.
Experts should be to explain the steps they take to arrive at a solution	This is an obvious requirement for able knowledge acquisition but not all experts can articulate the manner in which they solve a problem. However one of the skills of the knowledge engineer is to extract latent knowledge where possible.
The problem should be worthwhile in terms of investment, i.e. not trivial	Many prototype expert systems in construction seem to address problems which are either not significant in the decision making process or rely on information which is not suitable for

the current technology (e.g. obtained by vision) or require enormous input of resources to produce a relatively small return. As with all investment the cost/benefit calculation needs careful consideration.

Very few problems associated with management decision making comply with all the above criteria but nevertheless the list gives guidance as to where to look for a productive return.

11
Property and Construction Applications

In line with the general growth of interest in expert systems the property and construction research institutions have begun to explore the possibilities they offer. In the UK several reports, papers and compilation volumes have been produced to explore different aspects of the applications of expert systems to building management and economics.

Lansdown (1982) took an early view of the potential for expert systems and their scope in the Construction Industry. Newton (1985, 1986) investigated their use in Quantity Surveying and in design decision making. Wager (1984) explained the nature of Expert Systems and their possible future use while Allwood et al (1985) investigated the use of expert system shells for construction industry applications. Hamilton and Wager (1982) edited a volume of papers detailing expert systems for Construction and Services Engineering. Several other conferences also examined the nature, use and practice of building such systems as part of their subject matter including Brandon (1987), Lansley P R and Harlow P A (1987).

Other countries are also active in studying the field including Finland (Kankonen 1987), Israel (Warsawski A 1987) USA (Maher M L 1987). (Pohl J 1988) and many others. The CIB W55/W65 symposium in Sydney Australia had 29 papers specifically related to expert systems (Ireland V 1990). This focus on one aspect of computer technology is probably unprecedented in the field of building research and indicates the importance and perceived potential of such systems to the future of those engaged in property and construction. However, most of the publications seem to focus on the techniques employed in developing expert systems or concern themselves with informing their readership of the potential benefits. Very few address the problem of developing a commercial system or use case study material from the construction industry to illustrate their point.

A few systems have been developed and reported, e.g. BRE damp (Allwood et al 1988), Crane selection (Gray 1985, Harris 1986) House estate Planning

(Formosa and Brandon 1990) and the Royal Institution of Chartered Surveyors ELSIE system (Brandon et al 1988). From these early attempts to produce useful expert systems it is possible to distil some lesson for the future. However, the UK experience has suggested that very few of those systems developed have been commercially viable. Indeed at the time of writing the ELSIE system appears to be the only product which has sold well with full support facilities and is continuing to be developed.

This is not uncommon and the UK Alvey Directorates community club scheme which had a budget of well over two million pounds covering nine industries did not produce another commercial system other than the ELSIE system in the first two years after completion. It would appear that in this early stage of the commercial development of such systems some hard lessons are being learnt about which domains are suitable and how to tackle system development. This should not provide grounds for pessimism however as the operating environment, declarative languages and software shells are continuing to be improved.

[For a full discussion on the lessons learnt from developing a commercial expert system, see the author's paper (Brandon 1990) at the CIB W55/65 symposium in Sydney].

12
Problems and Limitations of Expert Systems

There is a danger with any new technology that expectations rise above the level of what can be delivered. The association of expert systems with artificial intelligence has allowed a hype to develop which could be counter productive to their early acceptance and research support. Expert systems represent a first step on a very long ladder reaching to the replication of human intelligence and beyond. Many of us would challenge whether it is a good thing to progress too far up this ladder in any case! At present, expert systems are much closer to conventional programming than to human intelligence. Humans are very good at handling unstructured information coming through the senses. Machines are not. Where the problem can be defined clearly and where a proven structure exists for solving the problem (e.g. a mathematical formula) then machines are superior. As time goes on and the technology improves so the machine will be able to cope with more of the unstructured information and solve more open ended problems. At the moment it would be wise to avoid such analogies as 'thinking', 'intelligence' and perhaps even 'reasoning' when discussing a machine's attributes. We are still at the embryo stage and the shortcomings of these systems are all too evident. However these shortcomings are not only a commentary on the inadequacies of hardware and software, but also, in the case of expert systems, on the imperfections in our knowledge of the brain and mind. (For a discussion on these aspects see Minsky (1987) and Hofstadter and Dennett (1981)). We are presently addressing what it is possible for us to understand and use to our benefit, not what is necessary to reproduce a human clone or indeed any form of 'super intelligence'.

13
An Example

It is possible to illustrate some of the limitations through an example. The development process is central to property and construction problems. One way of classifying the knowledge used might be to consider the knowledge as:-

- entrepreneurial, where the developer looks for the best opportunities existing in the market
- creative where the designer attempts to change the environment
- mechanistic, where there are proven techniques which can be adapted to help solve the problem.

As far as expert systems are concerned there are grave difficulties with the first two of these. Entrepreneurial activity requires a thorough understanding of the market. This understanding comes through reading the newspapers, digesting the technical press, listening to radio and television, receiving the pronouncements of politicians, gossip among those 'in the know' and many other sources of ad hoc information. It requires an understanding of future possibilities as well as past and present successes and failures. It also requires a technical knowledge base which supports and interacts with this diversity of information. It is self-evident that machines do not have this ability at the present time.

Creativity is another problem area. Where do the new ideas for a new building come from? Undoubtedly the lessons of the past, the knowledge of 'good practice' and the help of design guides and regulations obviously assist in deriving a new solution. However concepts such as imagination, art, beauty and function are also involved and can involve emotional responses and future predictions of public reaction. The act of designing a building is a very complex decision making process which includes philosophical, sociological and physical concepts acting together. It involves visual and other assessment of the site and its surroundings and can involve political judgement and compromise. Except for very simple stereotyped buildings it is unlikely that a machine will be able to cope with these issues or the undoubted complexity. At a much simpler level the artist Harold Cohen has attempted to use machines to draw in his own style. However the criticism made is that the drawings, although original, are stagnant stereotypes and offer little in terms of evolutionary development. It would be difficult for a present day machine to take a change of direction and go through something like Picassos 'blue' or 'pink' period of its own volition.

The mechanistic processes involved in development do offer more opportunity for expert systems. These processes tend to be well structured and well constrained. It is possible to build some of the routine knowledge currently used by consultants into the expert system thus allowing the consultant to concentrate more on the creative and entrepreneurial activity. However, again, all we can reasonably expect is decision support. To take a very simple example, that of estimating, it is possible to see the problems. In simple estimating, the cost of an item is based upon the formula:

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Total Cost of Item = Quantity of item x Unit cost.
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The knowledge required to provide inputs into the formula depends on what stage of the development process the estimate is being provided. At an early stage with no drawn information from the Architect, considerable call is made on past experience, knowledge of the client, assessment of the impact of the site etc. The consultant takes the bare skeleton of facts available to him and expands this core of information to develop a set of assumptions which he considers to be appropriate to the problem in hand. Such experience is by no means easy to capture and is subject to matters which are of a 'local' nature and which cannot be easily provided in a universal programme.

These include the impact due to the choice of members of the design team, visual assimilation of the site and the nature and motivation of the client. These factors will affect the design and consequently the quantitative and qualitative information which provides the inputs to the equation. The quantity will be based on mass and form and the cost by choice of specification, production method etc. The degree of expertise required will depend on the level of information provided. For cost estimating, the more information the less the level of expertise.

It would be quite wrong to expect, at the current stage of the art, for every factor to be considered in such a simple exercise by an expert system. Indeed the assessment of many of these factors in conventional human decision making is also ignored because the human model on which the estimate is based is not sensitive to them (e.g. items are measured as placed in the building and not in terms of production resources), or the problem is too complex to model effectively, or time is too short to give due consideration to each factor. (For a more detailed discussion of these matters see Brandon et al 1988).

The question of complexity and time are important issues. It is almost impossible to predict what any individual on any given site is doing at a precise moment in time. Studies such as those undertaken by the UK Building Research Establishment in the early 1970's have shown that workmen on a building site spend the majority of their time doing things other than that for which they are employed. This is largely due to the onsite production process involving many interacting trades. There is a parallel here with observations made in sub-atomic physics where matter appears to move in a chaotic fashion and even appears and disappears without apparent reason (Davies P 1980). Yet at the level of the object to which those particles belong there is apparent order and form. Observing building activity at the level of the individual workmen might suggest chaos but at the level of major groups of activities it is possible to find order and purpose. The level at which the expert works and his choice of model, i.e. his knowledge representation, will depend on his experience, education, culture and the time at his disposal.

This flexibility is difficult to build into a computer program and until machines can 'learn' effectively from their own and other experience it is unlikely that the full range of human decision making can be encapsulated in a piece of software.

Even so, compared with conventional models, expert systems do represent a significant advance. In comparison with the problems identified for conventional models and computer programs earlier in this paper, they do:-

- Allow judgement to be incorporated into mechanistic processes although it should be realised that this judgement is exercised in a mechanistic way.
- Provide transparency in their operation which alleviates the 'black box' problem. However the level of explanation is limited and is usually confined to a trace of logical paths and/or a statement of assumptions.
- Allow some aspects of 'value' judgements to be incorporated and can prompt the human operator to consider value options. Their 'understanding' of the world is however severely limited and it is important to consider the system as decision support.
- Provide for easier inclusion of risk assessment into the model through their probabilistic functions. However the individuals view of risk cannot be properly modelled in a universal program without tailoring the program to the individuals personal characteristics.
- Enhance conventional models by increasing their transparency, modelling characteristics and ease of use.

Programs such as ELSIE (Brandon et al 1988) provide a quick and efficient way of getting to a first solution but it must be recognised that some human input is required to get this first solution. Human expertise is also required to modify and interpret the result. For this reason all expert systems should be designed to allow a high degree of human interaction enabling the human strengths to be integrated with those of the machine in a complementary way. The expert system must be seen as a support mechanism and not a replacement for human expertise.

14
Future Developments

In the past two years there has been a dramatic fall in the cost of expert system software and this has been coupled with a major increase in computer power for the same hardware cost. The expert systems themselves have become more sophisticated and the development environment has improved enormously. The net result is faster development with improved performance and better human/ machine interface. This is not only for the developer of the expert system but also the end user. Links to conventional external software, improved graphics facilities and exploration and archiving functions are now common place. It can be expected therefore that expert systems will cost less to produce, be of better quality, more versatile and be able to integrate more fully with other systems in the years that lie ahead. The impact could be large on the more mundane work undertaken by consultants.

In the context of the discussion within this paper, however, the same problems remain. It is the utilities which have improved but the limitations as to what knowledge can be captured are still there. At the present time it is only possible to speculate as to what breakthroughs might occur which would begin to resolve our present problems. Possibly the two major developments, presently in their infancy, are parallel processing and neural networks.

Parallel processing allows multiple functions to be performed simultaneously. This increases the speed of the machine considerably and may allow the more rapid development of such things as computer vision and natural language understanding. These facilities, coupled with powerful analytical and synthesising functions, could allow greater emulation of human decision making. In time it could allow the machine to read a newspaper, watch television or hold a conversation. However it is then the processing of these functions which becomes critical.

The view is now held that so-called massively parallel computers, modelled on neural networks, would be far better at many functions of intelligence than conventional (Von Neumann) computers. There are major basic differences between biological information processing systems and conventional computers. The biological systems are based on neurons, and memory in neural networks is thought to be distributed through the structure, not localised at a particular place as it is in serial machines. Moreover, in biological networks, memory usually takes the form of strengthened or weakened connections between neurons rather than of stored binary symbols. Current belief is that either through inate properties or through learning, biology's networks are, in effect, tuned to respond to specific stimuli. It is possible for example, that every person learns to construct 'elephant detectors' that are activated by the right combination of features such as largeness, greyness and four-leggedness. In such distributed memories, each neuron is its own decision maker and its own store of memory. One advantage of this arrangement is that it does not become severely damaged due to a fault in a neuron as it would if a transistor went down in a serial computer. A more important advantage is the characteristic called 'content addressability'. Instead of being assigned to a memory cell, with an arbitrary numerical address, each piece of information in a distributed memory is filed and retrieved according to its content. This allows associations to develop which allow people to recall or reconstruct their detailed knowledge from different and varied sources of information. It may be that the thinking process is a matter of 'spreading activation', a kind of chain reaction in which activity in one network stimulates associated responses in others. Projecting forward it may be possible for such systems to learn for themselves by exploration, observation and trial and error and do things not easily taught by any programmer. However these possibilities are a long way from practical and commercial use despite the existence of neural network software and much experimentation by artificial intelligence researchers. It is a question of waiting and watching developments and taking advantage of them when new tools arise. Ian Flood (1990) of the University of Singapore is already doing some work in this field for construction estimating and no doubt others will follow. Whether, ultimately, these systems can achieve the performance of the 100 billion neurons in the human brain remains to be seen. A machine which is self-referencing and which has emotions and can respond as humans do may be a possibility in the very long term but there are many who warn about the social and ethical dangers of such a concept.

For the time being expert systems have sufficient meat in them to test the property and construction researcher in his search to provide better decision support systems for the industry. The improvements they provide in solving problems will see remarkable advances over conventional models in the years to come. It is the responsibility of all of us to ensure that these systems are developed and used exclusively for the benefit of mankind.

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MULTI-MEDIA INFORMING TECHNOLOGIES TO SUPPORT BUILDING DESIGN AND CONSTRUCTION PROFESSIONALS

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Abstract

Advanced informing technologies now enable decision makers from the building industry to inform themselves and their colleagues better. Many progressive practices now do this fairly well with general office automation and computer based practice management facilities (electronic mail, word-processing, spread sheets, d.t.p., billing, critical path analyses and specification writing, etc.) and by making use of computer aided drafting/design CAD) techniques now commonly available at all levels within the industry. This paper assumes a knowledge of this now conventional use of information technology and turns its attention to currently emerging technologies. It discusses the potentials of exciting new developments in voice recognition, networking, massive database access and especially interactive multi-media. With respect to the latter interactive media, there is a particularly full discussion of the comparative merits and performance of interactive videodisc, compact disc (CD-DA, CD ROM and CD ROM—XA and CDI) and Digital Video Interactive. An attempt is also made to show how each of these different informing systems could be used to improve busy building professionals' understanding of technical/social issues, as well as improving the communication between themselves —to make the technology truly an informing part of their building team lives. At the seminar video and videodisc presentations were used to give practical demonstrations of the different systems.

Keywords: Interactive Multimedia, Informing Technologies, Decision Makers, Networking, Massive Databases, Compact Disc Interactive, CD—DA, CD ROM, CD ROM—XA, Digital Video Interactive, Interactive Videodisc, Communication.

1
Context

Information is now, more than ever before, fundamental to all activity in the construction industry. “Decision makers today are more interested in ensuring value for money than ever before. Control is the key word: management and control of time, cost and quality to meet objectives are the key issues. Procedures and capital investment programmes are becoming more sophisticated and complex each year. Quality Assurance (QA) and Quality Control (QC) have emerged to meet the generally perceived need to improve the quality of work in the construction industry.” This summary extract from a report by the Management Group Board of the Institution of Civil Engineers (1988) highlights the need for efficient management of construction information.

We must not underestimate the task of properly informing an industry of such a scale and fragmentation—for instance in 1986 there were approximately over 8, 000 component manufacturers, 170,000 private contractors employing less than 7 people and 3000 architectural practices employing less than 4 architects—and one made up of such various and disparate professional groups. For, as they attempt to achieve organisational effectiveness, efficiency and viability for their own practices, these building professionals are forced to operate in an extremely complex and almost “wicked” environment, amidst a mass of inchoate, conflicting, shifting perceptions and problems. Uncertainties exist because the information upon which they have to make judgments often pertains to endemically uncertain estimates of what their client, and even their co-professionals, actually want or say they want of any building. In particular this often leads to undefined, ill-defined and often disordered information flowing around the industry, sometimes not in the directions required. This puts great demands on the industries communication or information networks and, according to the ICE (1988), “increases the risk of misunderstanding, misinterpretation, malfunction and dispute”.

So what sort of building information actually flows around the system. It takes a variety of forms and is stored in many different way. A fully integrating information system has to cope with information as different as printed documents, photographs, on-line bibliographic surveys, Ordnance Surveys, video ‘walkthroughs’ of buildings, British Standards, spatial information in many forms, BRE data sheets, product information and the like. This large and complex database can be held on paper, on microfilm or fiche, on 35mm slides, on video, on hard disc, on optical disc, as software, in bubble memory or can even be computer hardwired.

It is against this context that emergent information technologies such as interactive multimedia has to work miracles.

2
The Role of Informing Technology

Now, partly as a result of the above, in almost every sphere of their working lives, all in the construction industry have become used to enjoying substantial benefits of at least some advances in information technology, especially those relating to the collection, interpretation and transmission of data. Indeed it is hard to see how construction could now cope without IT. For instance, using video based photogrammetry techniques, surveyors can capture precise three-dimensional data about a building and, using currently available CAD tools, create appropriate repair or refurbishment drawings. Many architects now readily design, from concept to minutest detail, far away from their old drafting tables on advanced CAAD systems. Accurately digitised images, created as a result of either new design work or refurbishment, can be simply used to automatically 'take-off quantities, schedule and cost schemes and even work out optimum construction programmes. In the construction offices itself, site and contract managers can have their ideas immediately word processed, copied and loaded into sophisticated document processing systems. Without ever leaving their desks and using simple typewriter keyboards, they can 'fax' these ideas to almost any other person in the industry, anywhere throughout the world, enabling easy, fast and accurate communication. As an inexpensive but extremely useful form of technology, which causes minimal disruption on the mode of office working, the fax has had a rapid uptake. Users readily adopt IT when they believe it offers an effective solution to their needs. In this respect the 'fax' is the perfect exemplar to IT system providers of the sort of informing technology our industry actually requires.

Unfortunately, the converse is also true. A recent survey undertaken in the use of information technology in general British industry (Aris et al,1990) strongly indicated that **the** most important problem posed by much of the new information technology arises from the rigidity of its human interfacing or lack of user friendliness. When this is the case it is easy to see why people won't use it. Clearly systems are needed that will give fast and easy access to massive databases of 'guaranteed' information and can also cope with the sort of informality, ambiguity, and/or even evasiveness which is so often crucial in the effectiveness of the work of building professionals. For information systems to become more fully used they will have to reflect the needs of all building professionals. This in turn demands improved information systems giving decison-makers greater autonomy in their use. In short information systems must be user friendly, *truly informing* and *enabling,* rather than disabling.

The previously mentioned Aris survey showed many users are beginning to demand *standard user friendly and informing systems* having standard operating systems and standard interfaces. The standard they require with respect to data bank handling and human-system interfacing relates to its *stability* and *familiarity* as far as they perceive it. These factors have therefore become the key design generators in for instance the emerging technology of interactive multi-media systems. It is for this reason that I believe such systems, as with the fax, will be rapidly taken-up by the building industry and are therefore worthy of discussion here. Many of these emerging systems appear “open”, transparent or even semi-intelligent to users, almost recognising their needs and acting accordingly in a sort of dynamically ‘bespoke’ way. Standards in this sense are of great importance and good to see that our industry is beginning to move towards commonly agreed standards at least for interfacing and data transportability.

On the interface side, WIMP (window-icon-mouse-pointer) and hypertext/hypercard based systems are rapidly becoming a ‘de facto’ standard, since they are industrially more appropriate. Such interface environments are now commonly quoted as being helpful to the inexperienced user, while not hindering the expert. In particular the mouse, a device for positioning a cursor on the feedback computer screen, is preferred as an information control mechanism by an increasing number of building professionals. Used in conjunction with HyperCard, which portrays data on the screen as a familiar index ‘card’, the mouse can activate ‘buttons’ within each card linking it to other cards in a ‘stack’. In effect a HyperCard system tries to emulate the free association characteristics of human thought and allows users to create, access and customise information held in digital form on the information system’s hard disc. In use the information system feels like a controlled wander through a computer based library. Its success in effective information handling is reflected in its wide and increasing use.

Such intelligent or semi-intelligent knowledge based interfaces and data-handling systems are beginning to provide the sort of ‘openness’ all users are now demanding. In the past the HyperCard based system’s major limitation related to the restricted nature of the computer databases open for its recall. However, new video adaptor cards and associated software—Videologics’ DVA 4000 and IBM’s M-motion—now open HyperCard access to mass storage of text, graphics, animation, stills, moving video, sound, music and numeric elements all held on optical disc. The video adaptor boards simply digitise the incoming signals, both analogue video and audio, so they can be used as simple information on the index ‘card’. The boards also allow certain special effects so the user can superimpose graphics over video or stills, they can change the size or position of stills or video on the screen, they make a ‘button’ of a still and use it to call other cards, and they can simultaneously view several different video images. Both video adaptor boards will accept signals from the variety of sources, such as videodiscs, VCR’s and compact disc, that increasingly hold the massive databanks of our industry.

We therefore now have the capability to handle, in a user friendly and appropriate way for the construction industry, both the interface to, and interaction with, many different storage mechanisms. Between them they could eventually hold all the massive and differently recorded databases of the industry.

All that is needed now is the confidence and the resource to produce a fully developed system given access to all necessary information.

In the next section I discuss in some detail the potentials of the key hardware and software which will help to make the above multi-media informing system a reality for the construction industry. In particular, and in turn, the discussion will cover developments in voice recognition, networking and massive database access especially to interactive multi-media.

3
Detailed Consideration of the Relevant Key Information Technologies

3.1
Talking to the System—Voice Recognition

One of the most successful information technology tools in every practice office is the telephone and, indeed, voice communication is clearly the mainstay of the entire construction industry. Furthermore, it is also clear that those responsible for the telephone network are endeavouring to add value to their systems in terms of local area and wide area networks. I believe intelligent applications of the voice-processing technologies, especially voice recognition in combination with advanced data processing will significantly affect the use of all IT and thence construction information handling and communication. My personal use of a simple and inexpensive (£900) 1,000 word voice recognition system linked to my Apple Macintosh computer—known as a 'Navigator'—has already indicated to me the power of such systems. Voice navigation of systems will soon be an integral part of every office work environment and through electronic data exchange will extend dialogue beyond practice boundaries.

One example suggested by Catalano (1990), in an extremely useful, complete and recent discussion of voice technology, might indicate the full value of speech recognition in our industry. As already suggested the most convenient input to IT systems today is seen to be the mouse-pointer controller used in conjunction with a keyboard when complex input commands are necessary. However, as one practitioner observed by Catalano making use of voice recognition said, 'to use both keyboard and mouse at the same time is difficult. If I need to use the keyboard I need to take my hand off the mouse. In no time I become pretty fast with one hand. However, a voice recognition system changes all that. With voice recognition my right hand does not need to leave the mouse and my left hand hardly ever touches the keyboard, and because I do not need to remove my eyes from the screen, my concentration in the problem in hand goes undisturbed.

'When it comes to writing specifications it is hard to beat a combination of voice control and favourite word processor. This is particularly true for those of

Fig. 1 Two Terminals Linked by Fax Communication

us that do not enjoy typing. Now I can cut and paste, insert and delete blocks, merge files like never before, without touching the keyboard unless I want to.

'I have access to CAD and Wordprocessing commands readily available and some macros. I plan to keep adding my most-used specification notes for insertion on drawings from spoken words. One word can pull in a paragraph and I have already developed a library of my favourite site symbols. For example, I say "column-thirty" to trigger a sequence of commands which will place a 30 in. diameter column on the plan, all without switching screen menus. As a result of all this I would say that my productivity has gone up by 30 percent'.

This response is no longer fiction but just one example Catalano reports from a designer in a progressive American practice. While voice recognition is not yet used much in the UK, my own office is making use of a speech recognition expansion board to develop a speech controlled 'fire command and control simulation' for fire brigade officers. The member of staff designing the graphics for that development is using voice recognition in precisely the way it is commonly used in the United States to improve his efficiency. Within the next few years our workstations will automatically gather the information construction professionals need, will 'switch back and forth between different jobs effortlessly by voice, keep track of appointments, make the right phone calls while sending design documents over the phone by fax. Mention of the fax again indicates the importance of getting the networking right.

3.2 Networking to Enhance Communication and Knowledge Base

The fax board added to an information system terminal is the most important development to date with respect to networking. Workstations can now both send and receive digitised images and data communications over conventional telephone lines at facsimile rates. As already mentioned such fax communication boards, see Fig. 1, are being 'plugged into' nearly everyone's computer to aid efficient and effective data transfer. With this in mind let us return to another of Catalano's reports from a principal of another practice. 'Our small firm has increasingly organised itself around an electronic network linking it to clients, consultants, manufacturers, and other firms, according to project needs and workgroup's deployment.

'Our designers work up schematics of new elements, a new part let's say, and through their networked systems, discuss it with our consulting engineers in terms of adjustment of specifications, review and eventual reshaping of the new part. When the design is done, a fax is sent back and forth for final approval and signature. At this point we fax the results to the manufacturing firm. It is now up to the firm to decide whether to make the whole part itself or subcontract portions of it to one of its suppliers, all of whose skills, current capacity and work in progress has been logged. As often as not, it chooses a supplier and sends the specification by fax, along with supplementary design information. The supplier, also a member of our electronic network, using advanced numerical control tools, makes the part, often in a matter of hours.

'Certainly, our firm's use of multiple layers of contractors and subcontractors in an external network allows extreme forms of specialisation in particular skills which, in turn, provides both flexibility and speed in response, and the potential for cost savings. Finally, let me add that, from an information creation point of view, the electronic network is also useful in compiling statistical trends and spotting consistent manufacturing problems, since quality of information from every workstation is placed into a computerised databank from which members can draw.'

Many construction people are intimidated by networking partly because of the jargon that surround it—bandwidths and bridges, twisted pairs and topologies—and partly because it provides so many sharing options. The best way for the industry to conquer its fear is to start small and add new capacities at it needs them. At the lowest local level simply networking to a laser printer adds economic value to an expensive peripheral. Llnking to others in the office enables you to simply share ideas and information. Adding *file server software,* enables you to store, in one place, files everyone needs to access—client databases, downloadable laser printer fonts for special presentations, or templates for frequently produced documents. Using *electronic mail software* you can send messages and files to colleagues. With *multi-user software,* everyone can access the same files without the need to store separate copies on each machine and without fretting over whose version is the latest. The logical extension of networking is the development of a global network, acting as a world wide conduit for all types of information. Xanadu, shown diagrammatically below in Fig. 2, is an ambitious Hypertext based networking project. It will presently allow information providers to send ASCII, and other data, to all corners of the globe, over the X.25 packet-switch network, for as little as £1 per hour. Xanadu aims to be a 'world archive', allowing users to tap into the system whenever they need information. It will encourage people to use the system as their own personal repository of information. If costs are kept low it might eventually replace conventional back-up.

Finally, fully networked systems, having voice recognition, linked to satellite and good interfacing can be used for *teleconferencing,* that is if the systems are properly configured and understood.

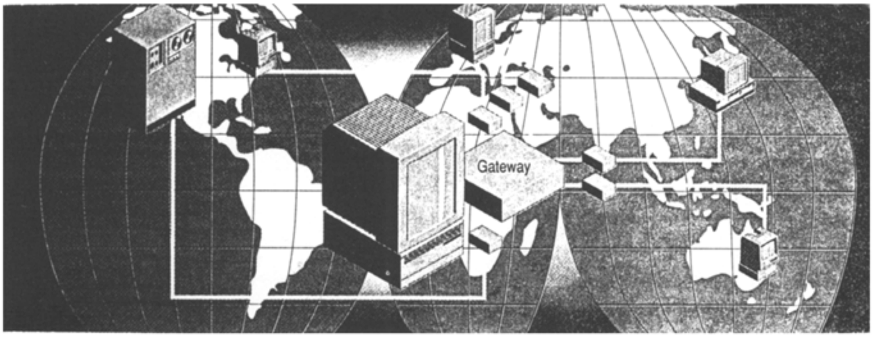

Fig. 2 The Global Xanadu Network

If the potential of networking in the construction industry is to be truly exploited one crucial factor needs to be made clearly apparent—there are two parallel levels of language to be enabled through such connection. The nature of the industry shows this by the way it emphasises an amalgam of products and processes. There is a formal language which enables the manipulation of products through agreed rule orientated definitions—'I altered it because it exceeded the safety standard'—but, there is also of equal importance a cultural discussion of things ephemeral and in the process of becoming—'I altered it because it seemed aesthetically wrong'. Any network which does not support both these languages in tandem will fail (Robinson, 1989). Electronic data interchange is now well adapted to communicating in formal languages —a digital design held within a network of connected CAD terminals can be dynamically changed by many users in remote locations simultaneously. However, without the communication of the reasons for change or the facilitation of a design conversation chaos can ensue. A typical response of a construction professional might be:-

'You are working on a screen when there is a flash as the design reconfigures as some else changes what you are in the middle of. You don't actually see it coming as you would in a normal meeting.'

The advent of teleconferencing for real-time designing with remote contributors and voice mail annotated digital sketches for time delayed design collaborations are potentially set to equip networking with the capacity to handle double level languages.

Once the interfacing is right, and the networks sound, all that is needed to fully complete a useful system is access to the huge databases of useful industrial information. This needs us to adopt the right standard for information exchange with these databanks and to store the various configured data on the appropriate mechanisms. The next sections deals with these issues.

3.3
Massive Database Access and Standardisation

Organisation of and access to massive databases are perhaps the most fundamental concerns faced by the construction industry. Unlike a physical library where every book has a spatio-temporal location and competent individuals can easily build and retain a mental map of where required items are, the black box syndrome of an intangible mega storage unit can become an offensive Pandora's box. However, many of the new interfaces already mentioned access massive databases in a manner similar to the way professionals think about, design and make a construction itself. Point and click on a roof component of a drawing and this 3-D object, held in the CAD system, becomes the search string which retrieves structural characteristics, manufactures' specifications and optional products, etc. In advanced systems such objects are automatically recorded and any updates (e.g. by dynamic links to manufactures' source databases) are communicated to the designer by colour changes in the relevant components.

To enable such system databases accessible to all requires standardisation. The NEDO Working Party (on CAD data and other information exchange in the building industry) recognised this and recommended the DXF format as a standard for at least graphics. This originally pragmatic intermediate solution for graphics has now evolved towards the more widely embracing European STEP standard for the exchange of all types of building/construction data. One of the unifying ideas to emerge from STEP is the concept of life-cycle within information model any standard system; this will lead to as-planned, as-designed, as built and as-used models in all data sets. The ISO STEP (1988) standard seems likely to soon be adopted, at least within European, so that translators can be written which will transform data from a given application into the standard and from the standard into a new application. In this way the standard will act as a vehicle for the passing of information between databases.

Armed with a good interface, a worldwide networking capability and a reliable data exchange standard for the construction industry, all that now remains is to have appropriate storage mechanism for the industries databanks. The next section concentrates its attention on optical disc technology—the most useful forms of storage to emerge to cope with the variety of database formats currently used in the construction industry. Clearly, traditional floppy-discs, hard discs and magnetic backup are also important forms of data storage; they are not thought worthy of discussion here since they are now so well used and therefore known.

3.4
Optical Disc Storage

Optical discs are in effect the 'new papyrus' of the publishing and information handling industries. Basically all the optical storage media allow fast, easy and

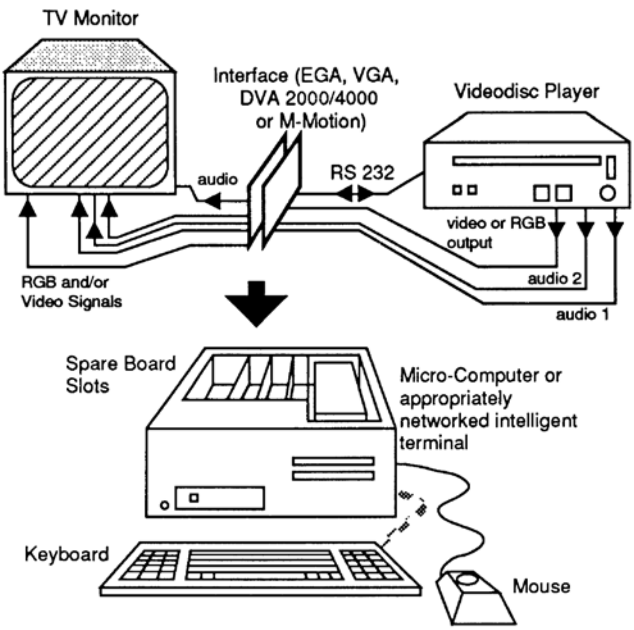

Fig. 3 Typical Interactive Video System configuration

reliable computer access to a range of often unstructured moving video, still images, graphics, sound or pages of text. Different systems allow cost effective storage of different types of information. The following sections describe the relative merits of the key optical media currently available to the UK construction industry.

Interactive Videodisc (IV)

Imagine combining 15 hours of audio with over 55,000 still images or 37 minutes of moving video, all in vivid colour. For this is the extraordinary capacity of a single 30cm video disc. All available at random access within seconds or split seconds of demand, comparing favourably with the rate of retrieval from a purely computer-based archive, or material stored on conventional videotape. The videodisc can offer such enhanced retrieval because of the unique method by which video information is accessed. Information is stored in the form of tiny pits ‘burnt’ into concentric rings on a thin aluminium membrane held within the disc fabric and is retrieved by a well-defined low density laser beam trained onto the disc’s reflective surface. A protective tough plastic coating on the disc surface, combined with the friction-free playback mechanism, provides a low maintenance robust system. Eventually this information is distributed to output devices such as a monitor. See Fig. 3 below for diagram of the system.

Team the rapid reflexes of the videodisc player with the organising, calculating, text and graphic powers of the computer and you have interactive videodisc—a system that can respond instantaneously to the different needs of the user. All professional videodisc players are equipped with an RS232 serial communication port. This communication facility is the same as that provided on many personal computers to enable them to be used with printers, modem and so on. Basically it allows the information to be sent and received serially as a 'string' of data statements. Theoretically it is possible to use different makes of videodisc player on different computers and make them work satisfactorily. The most common way of achieving this is with a video interface/overlay card/board which plugs into a spare slot in any computer. EGA and VGA cards were the early ways of achieving, on the same screen, a combination of (digital) computer text and graphics with (analogue) video signal. However, as already mentioned, some interface/overlay boards now enable a great deal more than this and both the M-motion or DVA 4000 video adaptor cards have replaced the simpler ones as standard cards. They have done this because they offer many functions which originally had to be undertaken in expensive video editing suites.

Under computer control, the videodisc can take on many roles—simple database, trainer, educator, salesman or entertainer. Quite simply interactive videodisc has the ability to provide access to an almost exhaustive library of audio-visual information shown in dynamic and compelling ways, at the highest quality, without degradation in use. It has so far been used in the construction industry mainly to provide training programmes in the areas of site safety (CITB and CITA), manufacturers information on bricks (Building Centre), in Energy Conserving Design and in Quality Assurance (CUBE). It has been shown to reduce training costs from £250 per man day to less than £13 per man day, and this includes the cost of purchasing the original IV hardware. There are also a portfolio of videodiscs available for the general management training in the construction industry, on topics ranging from 'assertiveness training', 'telephone answering skills', 'financial management to 'customer care'.

Videodisc players can now cost less than £1,000, video adaptor card approximately the same and, for multiple copies, disc as little as £20. A weakness of this medium is its analogue form and the fact that it is tied to incompatible broadcast standards adopted by different countries. Thus videodiscs made to the PAL standard used in most of Europe are not compatible with ones made in North America in NTSC, or in France in SECAM. The next optical medium discussed does not have this drawback.

Compact Discs General (CD-DA. CD RQM. CDI and CD ROM—XA)

Compact disc technologies offer another compelling optical disc storage mechanism. These include CD-DA (Compact Disc Digital Audio) for high quality audio, CD ROM (Compact Disc Read Only Memory) for mass data storage, CDI (Compact Disc Interactive) for complete interactivity with pictures, text and data, and also CD ROM—XA (enhanced CD ROM) to enable storage and retrieval of standard images, graphics and sound as well as text. Like videodiscs, compact discs are based on the reflective optical disc. However, they are only 12cm in diameter and the data is stored on the disc in digital rather than analogue form. Fortunately, there is a common standard between all forms of CD, so such optical discs can be used anywhere throughout the world. Unfortunately, the problem with existing forms of CD is that it is impossible to store more than a very small amount of moving video on each disc. To produce high quality video images, data must be displayed on a screen at a rate of nearly 15 Mb per second. Such a video transfer rate is well beyond the reach of most low cost systems. As we shall see later some CD systems try to overcome this using compression and decompression devices.

CD-DA (Compact Disc Digital Audio) is the most familiar form of CD technology. It delivers up to 72 minutes of broadcast quality stereo audio on a relatively cheap and durable player. It is remotely produced in a factory environment to a physical format conforming to standards set out in the "Red Book". Interactive CD-DA players can cost as little as £200 and individual discs only £2 when cut in multiple copies.

CD ROM (Compact Disc Read Only Memory) have evolved out of CD-DA and have the same physical characteristics and specification, as laid down in the "Yellow Book". Unlike CD-DA, CD ROM store only large quantities of digital data—up to 600 megabytes—of various forms. Each disc can store the equivalent of up to 200,000 pages of text, enough storage to contain the information on all 18 volumes of the telephone directories of Switzerland. Like videodisc it is 'read only memory', being made in a factory environment. It can be easily interfaced with existing databases, on most computers, and is now being increasingly built in as a standard facility in the higher level PCs. Now, at a cost of less than £500, it is becoming the preferred storage technique for distributing mass software.

In August 1990, Poulter Communications introduced a 'turnkey' information system for the construction based around a slightly adapted CD ROM, an IBM compatible with a 100 Mb hard disc, a large colour monitor and a laser printer. On this they are presently storing 6500 manufacturers' data sheets and publicity. Material is indexed by manufacturer, product category, Sfb classification and trade name. It can be simply retrieved for comparison purposes and the viewed page can be enlarged or laser printed. Also provided is a word processing package for free form enquiries, but standard ones can be prepared, automatically filled in with the producer's and user's details. These letters can be laser printed for sending by 'snail mail' or sent via the autodial modem to the suppliers fax machine. Poulter are renting their complete system for a subscription of £2765.

CDI (Compact Disc Interactive) simply extends CD-DA and CD ROM into a multimedia platform. It offers the same data or audio storage as its forbears, but can also handle up to 6000 high quality still images, 20 minutes of quarter screen broadcast video or 20 minutes of 42% screen VHS quality video. The technology is not yet sufficiently advanced to provide full screen full motion video. The higher levels of audio or video produce the best results but take up more disc space. The Phillips "Green Book" sets down a complete systems specification including how data is laid down on the disc, the disc content and the CDI player itself. Once again players will retail for around £500 in the UK. CDI is mainly intended as a consumer product.

CD ROM—XA (enhanced CD ROM) extends the High Sierra specification of CD ROM to add interleaved audio and video. It will not add much to the cost of a conventional CD ROM drive, but will slightly extend certain features of CDI. It will include quarter screen motion video and graphics with simultaneous audio tracks. According to Bayard-White (1990) 'CD ROM—XA achieves the bridge with CDI via two audio processors on the CD ROM drive interface card which compresses audio data. The XA standard also overcomes the problem of playing sound by interleaving blocks of audio data at regular intervals between blocks of text, image or programme data. This means that it is possible to synchronise a text display with any audio output—to see and hear them simultaneously—critical for example in developing foreign language learning programmes. Like CDI, XA offers different audio quality from mono speech to stereo sound and two audio channels. The physical form of CD ROM—XA is a plug-in adaptor card to a PC mainly aimed at the professional world. Aside from the conventional PC with VGA display and an ordinary CD ROM drive, the only hardware needed is the XA interface. The XA card has been specified to allow existing CD ROM software to run on XA hardware and CD ROM-XA software to run on CDI. As an intermediate technology XA lies just short of the more complex full motion video systems, although even this constraint may not remain as XA has been designed as a subset of other systems including digital video interactive'.

CD ROM—XA has only just hit the market but it is forcing publishers to think seriously about it as a cheaper replacement for IV. For instance, in 1991 Poulter Communications, mentioned in the CD ROM section, are for instance hoping to extend their manufacturers data system to add a training function by making use of the XA enhancement card to incorporate the extra and necessary audio-visual dimension needed in learning support.

Digital Video Interactive (DVI) is similar to CDI but offers 72 minutes of full-screen full motion video, 20 minutes of motion video with 7 hours of voice over and 5,000 high resolution still, or 2 hours of quarter screen video with thousands of textures and 3D objects. It also offers 360 degree panorama views. It has been developed for the PC market and can make use of CD ROM, Hard disc or WORM storage. Bayard-White again, 'DVI is an evolving software based process. At its heart is Intel's 1750 chipset, the most powerful custom processor chipset yet developed for the PC. Perhaps most importantly, the chipset is programmable from software. In short, users will therefore not have to purchase new hardware with every new version of DVI. It provides compression and decompression of digital data (see above) on any IBM compatible computer, whatever the storage medium'.

Many new applications are being developed for this extremely new optical retrieval mechanism. In comparison with Interactive Videodisc it still has a problem in coping with fast acting sequences especially with large colour changes. However, its flexibility, versatility and usability—it will be able to handle multiple video signals—give it an advantage over other optical media, including IV. Eventually, I expect the developers to overcome its existing fast data handling problems. So far there are few practical applications of this device in the UK and none in the construction industry.

The Benefits of Optical Storage for the construction industry are myriad. First and foremost it can store all forms of data and information of our industry, to a consistently high standard at any level of detail. The medium is extremely versatile and highly durable. The quality of audio-visual presentation from massive databases are always clear and cogent, to broadcast standard or any lower standard required. Presentations can appear personalised, or factual and can be presented at a convenient time and place, to meet a variety of needs. Images from the system are so good they grab attention and are very persuasive. Hardly surprising, therefore, that Poulter Communications have convinced over 2,500 manufacturers to sell their products by means of optical storage. Relatively speaking optical storage is also an extremely cost effective way of storing high quality images of many different sorts. In conjunction with the right computing technology, both control and interface hardware: they can act extremely patient, but remote and private, teachers; they can provide consistent messages for remote training in the use of standards and codes; they can provide remote help in an intensely human way; they can provide a realistic context for role playing simulations; they can provide a quality sales environment and many more benefits. Finally, they seem to motivate people to want to use them, what better reason for incorporating them into all new information systems for the construction industry.

4
Conclusions—Management Responsibility for Implementation of IT

It becomes clear from the above that those in any organisation responsible for selecting and implementing its informing systems enjoy, momentary at least, positions of great influence. In this respect they must, therefore, take care over their choice and consideration of eventual use and control. For one possible outcome is that the information system can come to reflect and consolidate only one organisational viewpoint at the expense of allowable others, even though the managers are not consciously aware of this situation. In this former case the users' experiences of an information system may oscillate between an euphoric sense of security, power and efficiency when assumptions in the system mesh with their own immediate objectives, values and interests; and intense frustration, insecurity and paralysis when they do not. The Aris (1990) survey showed this fairly forcefully and suggest to me that a key factor in whether or not *informing systems* has proven organisationally constructive or otherwise have related to the **autonomy** they have afforded the users. But, how flexible can the 'official' information system be (how flexible can it afford to be?) to autonomous local definition of relevance and goals in information definition and use. This is an important issue for all management to face when choosing and implementing an *informing system*. They need training and better information to make a sensible choice in this matter.

Top/senior management should play an active role in setting up and supporting such systems. In this respect they should therefore have a personal, close and complete understanding of the organisation's informational needs and from these be able to define, for themselves, the organisation's *informing system* requirements. A further requirement, to motivate and then train senior managers for this role, should not be underestimated. Indeed, I believe it is the key component to successful *informing system* choice and implementation.

Informing systems can be an instrument for beneficial change, if building professionals are motivated to understand their true potential. Let us hope the emergent user-friendly interactive multi-media databanks are more actively used by our industry

5
Two Glimpses of the Future

Let me leave you with two glimpses of the future as seen in a report by a principal building designer in one of Catalano's case studies. 'Our 12—person firm represents an example of a totally electronic, computerised design practice increasing its value as a small business through commitment to state-of-the-art information technology, from network computing linking us with clients, consultants and manufacturers, to voice controlled CAAD and related technologies, to in-house developed software for solid modelling and animation, to expert and decision support systems, to multi-media. Our computerised design firm is a structurally flexible, knowledge-based organisation where the emphasis is placed on information creation. Here, work is performed by computer experts, brought together electronically in spontaneous work groups that reach well beyond the boundaries of the firm'.

A final diagram, figure 4 below, shown a graphic by Roy Castle of how architects in the future might have a surrogate wander through a building they have designed without even leaving their desks.

6
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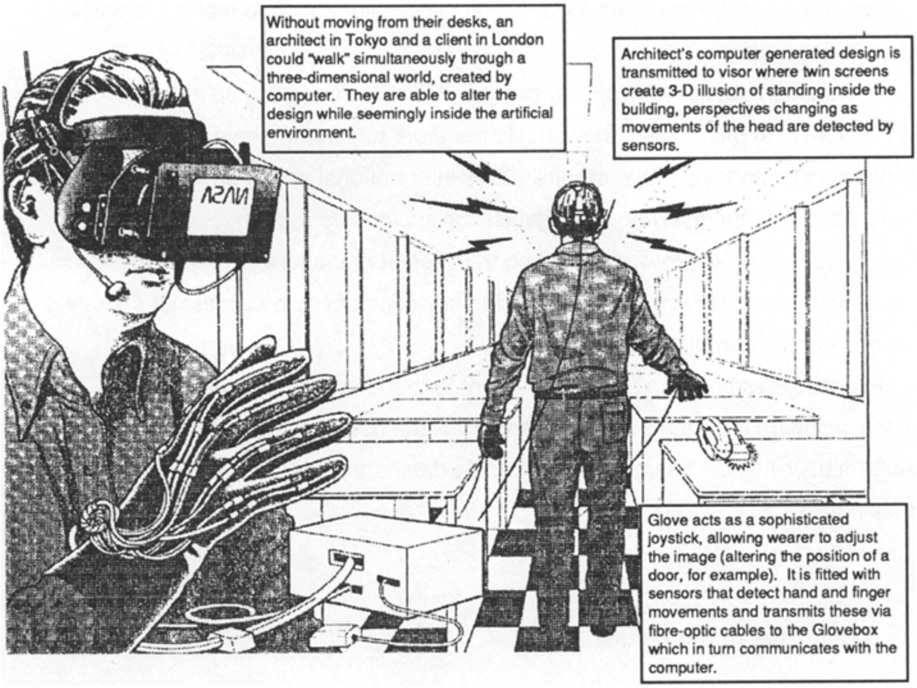

Fig. 4 A Graphic by Roy Castle (1990) showing an Architect's Surrogate through his Designed Environment

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Management

PROCUREMENT AND CONSTRUCTION MANAGEMENT

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Dearle and Henderson, London, England

Abstract

This paper considers the current pressures being exerted on procurement decisions within the construction industry, looking in particular at the factors influencing the decisions and their implications. Its puts forward a number of suggestions for areas where further research and investigation is needed.

<u>Key-words;</u> Procurement, Joint-venture vehicle, Contracts.

1 Introduction

My task will be to set the scene for subsequent discussions by providing a practitioner's view of some of the current issues relevant to construction procurement. My fellow speakers will provide papers on some specific issues related to management practice in general and construction management.

In the time available to me, I have needed to be selective as to the number of items covered by my paper. Since the prime purpose of this conference is to focus on research aspects, I have concentrated on areas that I feel are worthy of current consideration. Not surprisingly, these are those which exert the greatest potential for becoming problem areas.

This may leave the impression that I have little that is positive to say about the industry's ability to manage effectively its procurement and construction. This could not be further from the truth. During the past ten years much has been achieved by the industry in terms of improved efficiency; all that this paper will attempt to do is to highlight a personal view on where there might be room for improvement.

2 Definition and scope

Any paper needs to set out its definition and scope.

First—definition. Only one is needed, namely:-

2.1 Procurement

Today I use the term "procurement" in its broadest sense to cover teh collective action required to acquire the design, management and installation inputs for a construction project or some related aspect of the built environment.

I will not be attempting to offer anything new in terms of defining procurement systems or methods. I feel the contruction industry has a vailable to it a range of techniques and procedures capable of being assembled to suit most project circumstances.

Taking this to its logical conclusion one could state that there is no such thing as a procurement system. I prefer to use the term "procurement arrangement" whereby various parts are brought together to match a client's objectives. However, the industry would seem to be comfortable with some broad classifications of procurement routes or arrangements and it will be convenient for me in this paper to refer to them. Hence the table below represents my classification.

Within the four broad classifications above a range of alternatives are available to which the industry as attached titles. I have selected two points from each classification to illustrate the range. I do not propose in this paper to list the many permutations of titles currently circulating within the industry since many of the points I raise below are universal and are rarely amended by some subtle change of emphasis from one arrangement to the next.

Within each of these classifications a number of choices need to be considered and determined. In some cases the selection of the arrangement or the form of contract may pre-empt such decisions. I shall return to this aspect later when discussing the role of procurement advice.

2.2 Scope

Next the scope of my paper. In answering this one I am tempted to ask the question "Why the Spotlight on the management of procurement?"

After all buildings and construction projects of one type or another have been in demand since the need was identified to shelter operations and people…in other words a long time ago.

With such an ancestry it would be reasonable to presume that as an industry we should have ironed out most of the procurement and management issues and problems by now. This is not the case.

Whilst there have been periods of stability in the evolution of building and construction procurement such periods have been somewhat short lived especially since the Second World War.

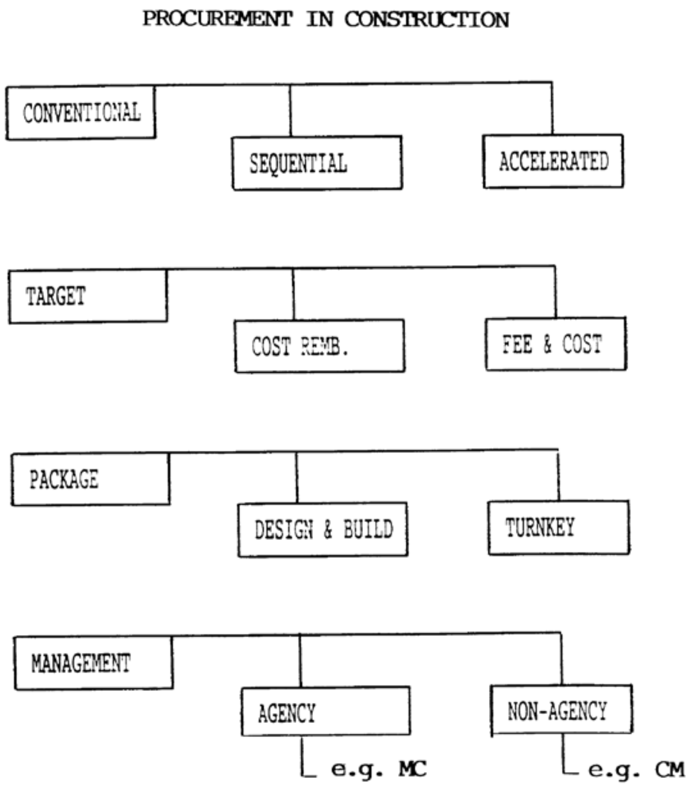

Table 1

A good indication of this lack of stability is provided by the RICS JOQS survey of contracts in use which has been usefully interpretated by James Franks (1). This is reproduced below.

Statistical information for 1987 onwards is patchy (for example the results of JOQS 1989 survey currently are not available) and hence my assessments are shown in broken line. Also Construction Management as a form of contract is not shown separately in the table and this may distort my assessments. Despite these imperfections the table shows that although conventional arrangements (represented by the FBQ lump sum figures) are still used for around 48–50% of the schemes sampled (which I believe is about 10% of current projects) large variations have occurred over a relatively short time span.

Hence it is only when we start to examine the reasons for this volatility or lack of stability that we can start to address the issues involved.

Therefore, I propose today to first look at the key factors influencing procurement decisions and some of their implications. Next I will focus on a few specific issues that are a feature of the current procurement scene.

Finally I will make suggestions for future action.

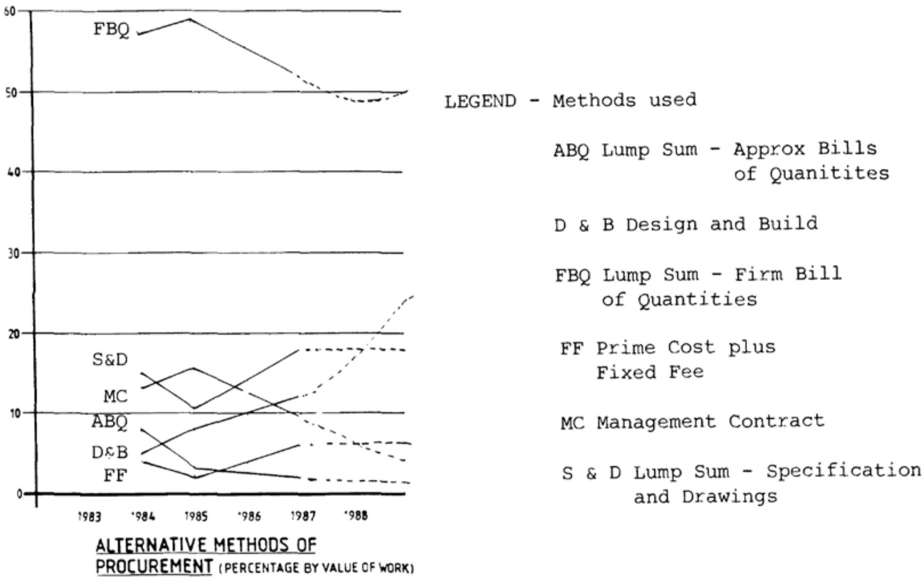

Table 2

(1) Procurement James Frank 'CQS' 1989

3
Factors Influencing Procurement Decisions and their Implications

3.1
First Principles

My first point is somewhat obvious but its importance is not diminished. Some of the difficulties associated with procurement within the industry stem from an individual's experience acquired during the first vocational/degree level education.

Generally each of us is instructed/lectured by, mainly, academic establishments using as a thesis the so called traditional or conventional approach to procurement which in turn envisages a world that is orderly and sequential. Above all, this thesis assumes that things happen when in theory they are meant to. Also within this premise it is assumed that every party to the process knows the limits of his or her duties and the responsibilities of others. There is usually a tendency for the tutoring to relate to new build and greenfield situations.

In reality the procurement process in construction is a bespoke assembly of parties and procedures put together to achieve a unique end product and the best that any party to this assembly can hope for is that there will be sufficient commonality with past experience.

Many will claim that no-one (even the most naive) believes that traditional arrangements as defined in conventions and standard documents within the industry are meant to work precisely as defined. Instead such statements of convention or standard practise are meant to be a base line from which to judge the implications of departure.

This is a fair comment but perhaps we should now redefine the base line. The NCG (2) has in its commissioned report "Building Towards 2001" a similar view although I depart from the report on matters of detail.

(2) National Contractors Group

If some of our current procurement problems stem from the industry's base training these can appear insignificant when compared to the effects created by other factors.

I tend to see these as falling into two broad categories, namely:-

(a) External pressures
(b) Internally generated pressures

As with any classification many factors are mutually dependent and the distinction between cause and effect is sometimes blurred. This is the case here.

4
External Pressures

Turning to the first group—external pressures—I consider the following to be most relevant.

4.1
The Construction Industry as an Economic Regulator

Published figures show that the GB construction industry's output over the last few years has averaged between £30 and £46 Billion. (Refer Table below). Even with the currently predicted fall for 1990 the figure is substantial. Of this between £16 and £27 Billion is in new work and the balance in repairs and maintenance. Around 50% of this total was funded by the public sector or commissioned for public ownership.

VALUE OF CONSTRUCTION OUTPUT—GREAT BRITAIN

EXTRACTS FROM THE HOUSING AND CONSTRUCTION STATISTICS GREAT BRITAIN HMSO

Table 3

Year	1986	1987	1988	1989
Actual Values				
New Work	£16 286 M	£19 066 M	£23 420 M	£27 315 M
Repair & Maintenance	£13 837 M	£15 515 M	£17 125 M	£18 859 M
Total	£30 123 M	£34 581 M	£40 545 M	£46 174 M
England %	87	88	88.5	89.3
Wales I	3.5	3.5	3.5	3.7
Scotland %	9.5	8.5	8.0	7.0
Value Indexed at 1985 Price Levels	£28 757 M	£31 022 M	£33 269 M	£34 684 M
Year on % Change	–	+ 8	+ 7.25	+ 4.25

With construction output representing something in the order of 10% of gross domestic product and with the public sector itself amounting to around 5% it is not surprising that the industry is used as a regulatory target. At times, “stop-go” policies have been applied to the industry, particularly the public sector, with those responsible for such decisions sometimes demonstrating a lack of awareness as to the expenditure flows associated with construction procurement.

All construction projects especially those utilising arrangements of a sequential nature require a considerable amount of professional effort to be commissioned in order to achieve efficient and timely construction expenditure.

In an effort to combat the adverse effects of temporary moratoria and the like, accelerated or “fast-track” methods of procurement that enable expenditure to progress quickly once the moratoria have been lifted have been developed and adopted. Hence, management contract/package deal/design and build arrangements which are seen as methods enabling the commencement of operations to occur more quickly than the sequential approach have been used. In some cases these methods have been used inappropriately leading to inefficiency of expenditure. Some counter balance has been instilled with some responsible for procurement decisions accepting the risk of continuing with the professional effort involved in sequential arrangements. Good news, but examples of poor decision making continue to surface.

Take, for example, the current situation regarding Housing Corporation (aka, mainly Government) funding of Housing Association capital programmes. At the very time when a growth in Housing Association activity would create not only a boost to an ailing property/construction sector whilst satisfying a major objective of Government housing policy we are advised that a cash flow underestimate for previous years means that the committed funding for future years will need to be rescheduled i.e. stretched.

Bearing in mind that this cashflow miscalculation was principally a result of misjudging the financial effects of the new procurement climate for Housing

Associations one is bound to question what assessment was placed on procurement implications.

If Governments wish to use the industry as an economic regulator then a far more sophisticated approach towards assessing the effects of decisions made on the resources of the industry must be adopted.

4.2
The Emergence of the Joint Venture Vehicle

Although more strongly evident in the development sector and major undertakings requiring private finance there has been a dramatic growth in joint venture vehicles for construction projects.

Some joint ventures have been borne out of a desire of contracting organisations to generate turnover for contracting businesses with the benefit of a possible profit from the end value of the enterprise. For example some contractors have created development sections for this purpose. Others arise from the creation of an ad-hoc operator formed amongst leading construction companies and suppliers (e.g. Channel Tunnel).

These joint ventures have had the effect of confusing or at best blurring the industry's understanding of responsibilities and procedures within the procurement arrangements used in such joint ventures.

An example of a typical joint venture for a commercial development selected at random from my Practice's project list is provided below. No doubt similar examples can be found in every quantity surveying office in the UK. This example concerns a relatively small value project but is illustrative of how relationships amongst parties can be organised so as to create the potential for conflict. For international projects involving multi-national joint ventures this potential becomes magnified.

I would submit that the industry has yet to come to terms with some of the practical implications of joint ventures especially where a single party has a potential conflict in terms of beneficial interests. For instance, where contractors fulfil the role of principal contractor together with that of party to the profit share some agreements do not recognise this potential conflict other than through informal/chinese wall arrangements.

Should the trend towards increasing joint ventures be maintained especially involving internationally based consortia then the potential exists for some parties to be disappointed with the level of protection their interests receive. Whilst it is always within the power of an individual party to appoint its own independent advisors and monitors or obtain duty of care agreements or collateral warranties the opportunity to do so may be missed or overlooked at critical times.

It strikes me as a sad paradox that the investment the industry has made in developing and policing procurement procedures that attempt to maintain high standards of administrative discipline and propriety risks being squandered by a failure in some areas to develop similar standards in the joint venture field.

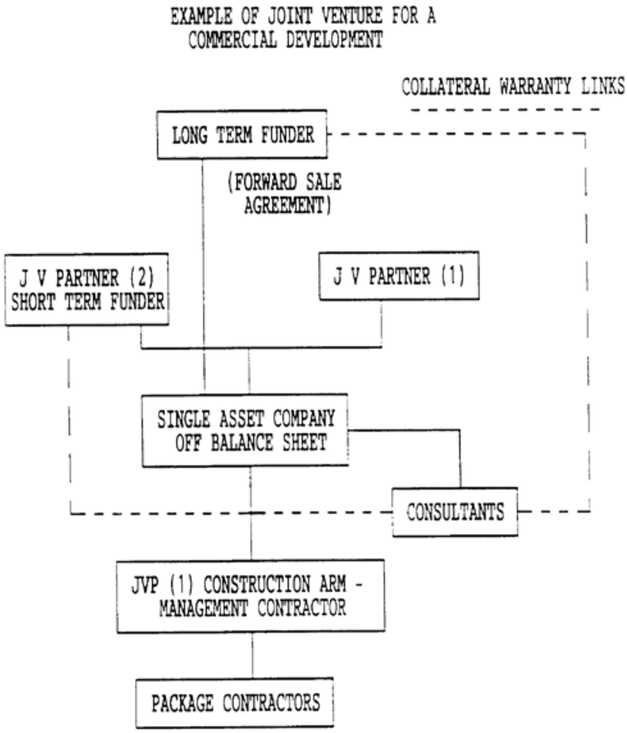

Table 4

4.3
Globalisation of Property and Construction

This represents a massive subject in its own right but suffice it to say here that world trade in construction activities has increased to the extent whereby indigenous clients are being persuaded to adopt the procurement methods exported by organisations from other countries. Studies such as CIRIA's (3) recent series on UK/Europe and Reading's (4) UK/USA comparisons have shown that differences in procurement methods between one developed country and another are in the main superficial and need not be feared if amended to suit local situations. However, such amendments do not always happen in practise and in some cases this has lead to the inappropriate use of certain arrangements.

If construction activity is heading towards true globalisation…perhaps initially through the European Single Market, then greater research is needed to provide a common basis or vocabulary for all parties to this process. As a first stage such a common basis could concentrate on administrative procedures, financial basis for contracts and codes to encourage fairness and probity. Quaint local practises may add to the "colour" of a particular country but seek only to confuse.

5
Internally Created Pressures

5.1
Re-positioning by the Players

Although I cannot prove this point statistically I recruit from the experiences of those whose opinions I respect. From these I conclude that some changes in procurement techniques are internally generated by the genuine or panic concerns of participants within the industry where they see their traditional work base is in decline. Whether this decline is real or apparent is not always researched to a sound conclusion.

For example, the current surge in design and build arrangements is often held to be client demanded following the failure of low risk forms such as management contracting and an increasing

(3)	Construction Industry Research and Information Association
(4)	University of Reading

discontentment with traditional arrangements. I am not convinced that this is necessarily the sole cause. A cynic might suggest that some contractors, quantity surveyors and architects have seen design and build as better suiting their organisational structures, or the position they wish to achieve in the procurement process, or a way to reduce liabilities and have thus promoted the form.

As I stated at the outset of this point it is difficult to ascertain whether market making by the participants is a cause or an effect but I cannot believe that it has not been a significant contributor in promoting change in procurement practise.

This must persuade me to make one valid if obvious comment. Procurement arrangements must ultimately serve the objectives of the commissioner of a construction project (i.e. the client). In the current climate of enterprise perhaps tinged with an atmosphere of "deregulation" can those responsible for advising on procurement always be sure that an unhealthy measure of secular self protection does not form the basis of some current arrangements. Conversely I do not believe that clients should be granted a dictatorial position…whatever way the economic pendulum swings but equally the industry has a duty to serve its clients in an even handed way as practicable.

5.2
The Great god "Consumerism"

It is debateable whether this is an external or internal pressure. I place it on the internal list since every industry has a degree of choice as to how far it will accede to the general mood or sentiment of an economy.

No one can deny that during the 1980's through a mixture of protective legislation and better public education and information we have seen the power of the consumer increase to a dominant level. Except in fields such as medicine or some highly esoteric activities where professionals and advisors maintain a degree of control (sometimes exercised through creating mystique) most other areas of commercial activity have succumbed to the "consumer rules" syndrome.

I do not claim this to be a bad thing since none can deny that we have all benefited but with such a syndrome much can be reduced to the level of the lowest common denominator.

Hence, in some quarters the production of buildings has become equated with the production of, say, motor vehicles. By this I mean that it is taken for granted by the client/customer that quality and fitness for purpose and function will be of the highest standard with only time and cost aspects remaining variable. This mood of taking as read good design and proper installation is not universal and some clients maintain an acute understanding of the part that individual and team skill can bring to these elements.

However the current consumer climate has several implications. First, designers in particular can feel threatened if they judge there to be an over emphasis on time and cost without due regard to design and function. This can set up antagonism amongst the team and the client where such a client is in no mood to be persuaded that he needs to invest excessively in design aspects. This is often the case where contractors are given the responsibility for the management of design information to be prepared by existing client appointed design consultants. This situation can lead to inefficient management of the process.

Second, the audience today will no doubt acknowledge that there are some aspects of building procurement which cannot always be reduced to the level of automation associated with the production line or the purchase of a consumer durable. Where a sensitivity towards aspect, planning and aesthetic is required this must be accommodated within the procurement process. Those advising the client must ensure that the arrangements recommended enable such inputs to flourish. I am confident that within the industry those who earn their return from the management aspects of procurement would not wish to see 'design' regulated to the level of an "also ran".

Nonetheless and despite how circular you wish to make this debate clients are increasingly impressed by those procurement arrangements that offer certainty of time and cost. These same clients are not always convinced of the argument that in some circumstances design and function may be disadvantaged by the adoption of procurement arrangements that provide the tightest control of time and cost aspects.

5.3 Client Preferences

Ephemeral subjects such as management, procurement and even finance these days are regarded by some of the industry's clients (especially informed clients) to be totally within their understanding and capability without recourse to sound advice. Whilst these same clients will in most cases accept without question advice they receive on issues such as design, engineering, planning and so forth… if the structural engineer advises a client that he needs 10 metres of concrete under his building he will rarely challenge this…this is not the case when it comes to procurement. Hence, clients will ignore or counter procurement advice.

Next, some clients having once been persuaded or forced into adopting a particular procurement arrangement attempt to apply this universally and preferences can become tablets of stone.

I illustrate from two case studies which I suspect are typical.

The first involved a private client for an industrial warehousing/distribution scheme who at the first full briefing meeting of the professional team under the item on the agenda entitled "Tendering and Contractual Arrangements" stated the following:—

"We are going to negotiate this job with Blanks Limited who has just completed a project for us in another part of the country. The contract will be JCT 63 and the contract period 14 months".

This might seem a fair request…a client clearly taking an active part in procurement arrangements…but further facts may be useful in assessing the validity of the instruction.

The meeting took place in 1985 by which time the JCT 63 form had been superseded by its equivalent in the JCT 80 range. Also, in 1985 we were only just beginning to see an improvement in the output of the industry and it was difficult to judge what sort of result might be achieved in competitive tendering. The preferred construction period was proffered before any consideration of the overall development period. Also the clients reasons for wanting to negotiate was his belief that he could commence site operations quicker…no consideration had been given to a two stage approach or even a management contract to achieve the same end. Finally in this example the client had undertaken no research into whether the contractor had the resources to adequately service the project in this different locality. (It subsequently transpired that the contractor was a smallish local firm and was unable to take on the project).

My second example concerns a government funded complex refurbishment project whereby the standing financial orders of the funder had been based around the sequential traditional arrangement. The direct client (a local authority) had been recommended to adopt a management form together with a pilot project to be awarded on a cost reimbursement basis in order to test designs and so forth. You can appreciate that such procurement arrangements played havoc with the funder's approval stages. For example, the standing orders required that approval to appoint a contractor could only be granted once a lump sum price had been obtained in competitive tendering. Here it was proposed to appoint a contractor following a limited tender (management fee and some on-costs only), for just one part of the works and on a cost reimbursal basis.

The direct client was caught in the middle, not wishing either to upset his consultant team whose advice he respected but also not wishing to alienate his funder.

In the end the client stepped back from this situation and pitched his procurement advisor in direct consultation with the funder. In essence the funder was advised that in the opinion of the client's consultants the recommended procurement arrangements would enable the client to achieve his objectives within the budgets available. If the funder was prepared to accept responsibility for budgetary control then its preferred procurement arrangements would be implemented. If the funder was not prepared to accept that responsibility then it should accept the arrangements proposed by the client's consultants.

The funder eventually accepted the consultant's advice on procurement but I would suspect that in many situations the reverse would apply.

The above highlights a serious point that should be made. In essence procurement advice can have an equally dramatic impact on a project's performance when measured in terms of cost and time as can design and engineering advice on a project's performance when measured in terms of function and quality.

6
Other Procurement Issues

The previous section of this paper has highlighted what in my opinion are some of the key factors currently influencing procurement decisions within the construction industry and which have the potential to create difficulties. From this I conclude that there are areas worthy of further research and investigation, some of which I have referred to later in this paper.

However, whenever a snap shot is taken of the industry with the purpose of identifying major or underlying issues there are likely to be exposed a number of specific or secondary issues which the industry is currently debating.

I would suggest the following fall into this category.

6.1
Managing the Interface of Specialisation within the Industry

The increasing complexity of construction aided perhaps by a climate of litigation, has meant that the industry has compartmentalised itself into a myriad of specialisations. Whilst some players in the market maintain an umbrella type organisation whereby they are prepared to commit to a project the vast majority of the specialisations that make up the whole this may not necessarily be the most suitable arrangement.

Procurement methods and in particular their management should recognise the nature of the industry in order to obtain the optimum efficiency principally in terms of cost and time but in some cases design. I believe that the development of management contracting and consequently construction management are arrangements which come close to accommodating the structure of the industry. Where these arrangements principally failed was that they were used too rapidly and too extensively for the industry to cope adequately. In many cases old adversarial positions were maintained and the practise of "buck passing" management responsibilities through the system gave rise to excessive preliminary on-costs within the arrangement due to the duplication of management teams.

We owe it to ourselves and our clients to ensure that the current shift towards one-stop procurement arrangements does not preclude the use of arrangements that achieve better returns from the industry's output.

What I suggest is not necessarily some superficial review of procurement methods but a fundamental examination of the interface of specialists within the construction process and once that has been quantified for there to be amendment to procedures as necessary.

However, again let us not simply devise a new name backed by a few principles which the industry then attempts to flesh out "on the hoof". In essence what we should do is take the best of known practise and amend as necessary to reflect the organisational realities of the industry.

6.2
Design and Build

The growth in design and build arrangements in the UK together with the projections made over the next few years for its continuing increase means that the industry will need to devote as much cerebral activity and energy to this form as it has in the past to traditional arrangements and more recently management contracting.

The market share for design and build is generally reported as being between 22–25% of new building works. However in some sectors especially for example, industrial building most commentators put the market share at 36% and rising.

Against this background I feel the industry should focus its attention on several matters.

First I contend there is a need for the industry to establish some form of base model or framework for the implementation of the arrangement. Standard forms of contract such as the JCT 81 have been helpful in establishing roles for the construction phase in terms of the employer, the design and build contractor and the employers agent. However this is only part of the management framework and with notable exceptions such as the NJCC (etc) code for selective tendering very little codified procedure has been established for pre construction activities.

In developing such a framework several topics will need to be addressed, for example,

(i) ground rules for novation of architectural and other design services
(ii) the degree to which supervisory services should be employed by the employer before it impacts on the integrity of a design and build contractual liability
(iii) common understanding of the limitations of the employers agent duties by clients and
(iv) establishment of procedures that will reduce the cost of competitive tendering…generally reckoned to be around 3–5% of the cost of the works as compared with 1–2% for conventional arrangements

Examples of good practise in connection with these and other aspects are available from the market place. Research organisations and professional bodies have attempted to marshal such good practise into clear advice for clients and participants alike but more work is needed.

Next there needs to be more emphasis placed upon a clients ability to assess the value for money (VFM) aspects of construction projects procured under design and build. This could be accommodated within the framework mentioned previously but in its absence the industry needs to address the problem. One way of aiding the assessment of VFM is by the granting of more time and the obtaining of more information before a contract is committed…however this may be held to work counter to one of the benefits of design and build, namely, speedy pre-construction timescales.

Finally, the industry should guard against the arrangement attracting the types of 'gimmicks' that have accompanied other newer procurement arrangements. For example, guaranteed maximum price and shared savings schemes must not end up as thinly disguised low risk management forms.

6.3
Risk—Its Management and Transference

Recent work by research organisations and similar have been instrumental in raising the awareness of not only the identification but also the management of risk within construction procurement arrangements. My own practice was first asked by a client to assess risks and estimate their effects in probabilistic terms in the early 1970's. Like others we have steadily increased our range of advice and experience in this field but I contend that the industry has still some way to go before the topic is established as common vocabulary.

I note other speakers at this conference are to speak on the subject. Suffice it for me to say, therefore, that I trust this aspect of procurement will achieve as equal a standing within management considerations as other procurement criteria.

This is particularly important given the growth of design and build and other 'one-stop' shop forms of procurement. These are held by clients to be less riskier than other forms. Better risk management within other forms of procurement might easily persuade clients otherwise.

6.4 Works of Renewal

By the above I mean any form of construction activity which seeks to replace, renovate, repair, refurbish, maintain, alter and adapt any part of the built environment.

In the UK the value of works represented by this umbrella expression accounts for something in the order of £14–19 Billion although due to its piecemeal nature I suspect not all works are captured by measurements of statistics. Also, a big market exists in the DIY and black economy for this sector.

Despite these imperfections the renewal market is large and on a cyclical basis has the potential to increase as society looks to re-cycle its output.

However, I feel the construction industry has not developed appropriate procurement techniques to a level warranted by the importance of the renewal sector. Arrangements and documentation used in the sector are based usually upon amended versions developed for new build projects.

Again as with other 'cinderella' topics, some good work has been produced but it is patchy. For example the RICS BCIS has a system for collecting and analysing maintenance cost information but it needs a greater input from those actively involved in the sector such as building surveyors and facilities managers.

Also, schedule of rate tenders, term contracts and so forth provide valuable assistance to those procuring renewal works but further work is needed.

7 Suggestions for Further Action

In view of the time constraints operating on me today I feel I should now close my list of factors and issues. Within the text I have discussed areas worthy of research and consideration. Here I highlight some areas which if addressed by the research community will lead to benefit for practitioners and clients alike.

7.1
Promote the Prominence of Procurement Advisor

As I have intimated in my previous discussion I contend that procurement advice is too often paid scant regard. I consider it essential that the role of procurement advice is given an equal prominence as other consultant inputs and at an early stage of a project's development.

As a quantity surveyor I feel not unsurprisingly that my profession has a signifcant part to play. I am not particularly concerned who is appointed procurement agent or advisor. What is more important is that he/she is suitably trained and experienced to advise upon and implement a set of arrangements that achieve all the objectives of the client within a balance of priorities.

It is not just a case of picking a well known name of a procurement route and assuming a 'system' will take over. A procurement advisor needs to be able to guide his client and team through a series of choices and criteria. My personal check list for this task is provided in the table below and is by no means exhaustive.

Also I mentioned earlier the growing number of construction projects under joint venture arrangements involving "hands-off" parties. Even with singleton arrangements there exists parties such as funders, headlessors and so forth, whose interests can be materially influenced by the decisions made on procurement.

I am concerned that such organisations have not always received proper advice (not only on procurement but other aspects).

7.2
Research into Time and Costs

I feel the balance of research is now weighted too much towards pure design and engineering matters. There needs to be some redress of this situation with increased research into management and procurement aspects of construction and especially how these impact on time and cost aspects.

Some good progress has been made in this field and I will leave it to my academic colleagues to beat that particular drum when they present their papers. However, I would contend that the current work available is not sufficient and more importantly not properly translated into useable intelligence for those in the market place attempting to advise their clients on procurement.

7.3
Whither the Public Sector—Meeting the Gap

I purposely left this item out of previous parts of this paper since I am unclear in my own mind as to how I view the dismantling of the public sector in the context of the development of procurement. The construction industry has benefited from

PROCUREMENT METHODS AND TECHNIQUES

ACTIVITY		CHOICE/CONSIDERATIONS		
Management		Executive		Client
		Design		Consultant
		Construction		Contractor
		Risk		
Design by:-		Employer (design consultants)		
		Principal contractor		
		Sub-contractor		
		Supplier/Specialist		
Selection of Contractors by:-		Price in competition		
		Reputation		
		Experience		
		Capability		
		Combination		
Tender				
	Method	Single stage	-	Open competition
			-	Selective competitive
			-	Negotiated
		Two stage	-	Combination of above
		Serial		
	Price basis	Fixed price		
		Fluctuating price		
	Pricing media	Firm Bills of Quantities (BQs)		
		Approximate BQs		
		Schedule of Rates		
		Pricing Summary for Drawings and Specification		
		Pricing Summary for Specification		
		Combination		
Contractual basis		Lump sum (usually with reimbursables)		
		Cost reimbursable		

Figure 5

the investment made by the public sector in the development of procurement arrangements established to stand the tests of public accountability.

Fairness and discipline may to some seem as creating a climate that lacks innovation and energy but without properly defined and well tested rules the industry would become inefficient. The rules developed by largely the public sector has served the industry well and in some cases has given it the confidence to experiment with new procurement arrangements.

By way of example the early attempts by the British Property Federation to re invent the procurement wheel by the publication of its system needed an industry to be well grounded in conventional arrangements in order to develop the fleetness of foot required under its system. Even so there has not been a large take-up of the BPF system even by its own members many of which adopt systems whose roots can be traced back to arrangements developed by the public sector.

As an industry I do not think we have faced up to the impact that the removal of a large proportion of the public sector will have on the future development of procurement techniques which are well regarded throughout Europe and other parts of the world.

7.4
Base Education

I feel I have made the case in the context of procurement for a fundamental review of professional base education and training up to the acquiring of a first degree or similar qualification. Whilst many would argue for the retention of the current technologist grounding we continue to jeopardise the future efficiency of the industry by not paying as equal a regard to management subjects.

Although a personal view I trust the above has provided representatives of the research community with an indication of a few of the concerns of practitioners within the industry in the field of construction procurement.

CONSTRUCTION MANAGEMENT—Delivery and Discipline

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Abstract

This paper looks at the development project procurement methods over the recent years and argues the case that this has resulted in a great array of different approaches now being available. It describes the various approaches, looking in particular at the factors in the more traditional approaches which have encouraged the growth of the Management paths of project procurement. However, confusion has risen in peoples' minds as to the true nature of the Management approach and, in response to this, the Construction Management Forum was established in 1987. The Forum has produced its final report, which presents to the construction industry a clear picture of why and how clients can choose and practice the Management path of procurement. It describes the processes involved and suggests the future implications for the various parties involved.

Key-words: Construction, Management, Procurement

1 Introduction

Methods of project procurement had evolved in the UK over many years and now presented an often bewildering array of choice to the client. In the mid-1980s a National Economic Development office publication—"Thinking about Building" (National Economic Development Office)—suggested that there were four different paths that a client could follow in procuring a building project. These were the Traditional, Design and Build, Design and Management paths. The first two were fairly obvious in their method in that the Traditional route had long established forms of contracts and conventions—i.e. a design was measured and priced for production by various contractors, the winning one being supervised on behalf of the client by the designer—and the Design and Build was where a single contractor—or joint venture of designer and contractor—contract with the client to provide the complete building for a guaranteed workmanship, cost and time. Design and Manage was a softer version of Design and Build in that a single organisation offers the client total management responsibility for the project delivery, but without necessarily guaranteeing workmanship, cost and time.

In the first two paths the client could expect the contractor to be responsible for the work of the works contractors—as they were his sub-contractors—but in the third path the contractor might or might not be responsible depending on whether he acted as a "contractor" or an "agent". This confusion could also arise in the fourth path of procurement —the Management path—because although the "management contracting" version had the works contractors as sub-contractors to the management contractor he was not ultimately responsible for their workmanship, cost or—unless professional "management" negligence could be proved—time over-runs of their work (Powell-Smith V., Sims J. 1988). The alternative version available in the Management route was "construction management" in which the works contractors route had direct contracts with the client and it was obvious to all participants that the manager was not ultimately responsible for the works contractor's workmanship, cost or time. However, because in practice "management contracting" was set up within the traditional JCT contractual framework, the impression could be given, and indeed by "amendments" to the standard form could be created in actual practice, that the management contractor was actually taking the risk for the client of the works contractor's workmanship, cost and time. In fact, "Thinking about Building", actually stated that the "management contracting" version of the Management route was where the contractor did guarantee the cost and time, if not the workmanship, of the works contractors

2
The Construction Management Forum

In order to clear up this confusion for clients surrounding the Management path of procurement, a "Construction Management Forum" was set in motion in 1987 following a joint initiative by the University of Reading and Wimpey Group (Department of Construction Management/Winpey Group 1987). From its Inaugural Meeting, a Steering Group and five Working Parties of leading client, consultant and contractors representatives were formed to discuss five key issues of concern when considering the "management contracting" and "construction management" versions of the Management path. Five separate Working Parties addressed Duties and Contracts, Briefing, Specialists and Quality and it became clear after the results of the Duties and Contracts Working Party discussions that, for a number of sound reasons, the "construction management" version was to be preferred if a client wished to follow the Management path of procurement. When these interim results (Construction Management Forum 1989) were presented to an Open Meeting in 1989, the Forum was asked to coordinate the results of all the Working Parties' discussions, clarify the arguments for the "construction management" preference and, in particular, determine how the works contractors could be appointed to the satisfaction of the client.

As a result of a series of Steering Group reviews a final version of the Report of Forum's discussion was refined and edited resulting in its Report and Guidance (Centre for Strategic Studies in construction 1991), published in January 1991. The Report and Guidance now presents to the construction industry at large a clear picture of why and how clients might choose and practice the Management path of procurement. One of the important aims of the Report and Guidance is to ensure that the client is fully aware of the involvement to which he must be committed and the risks he is carrying when following the Management—as opposed to the Traditional or Design and Build—path of procurement for his project. It also provides outline guidance documentation to support the preferred Construction Management Version of this procurement path as a basis for good practice in terms of selection of and agreements with Designers, Construction Manager and Works Contrators and controlling mechanisms for the evolution of the project from inception to commissioning. The detailed arguments from the Working Party discussions support its recommendations for the preferred Construction Management version, guidance documents, short-term training and longer-term education needs.

3
Construction Management as a method of procurement

The detailed arguments and guidance are best found in the Report and Guidance itself (Centre for Strategic Studies in Construction 1991), but the implications is that a method of procurement is being proposed that has some very distinctive features in comparision with the more familiar Traditional and Design and Build based methods. Those distinctive features benefits and pre-requisites can be defined as follows:

a) **Construction Management is the "management" method of delivering a building project that—**

- gives the Designer and Construction Manager equal professional status,
- gives a direct contractual relationship between the Specialist Works Contractors and the Client,
- gives the Client a direct responsibility for his project and flexibility in procuring the various "specialist design and construction services in terms of time and relationship.

b) **As a method its advantages are—**

- clarity of roles, risks and relationships for all participants, including the Client,

- there is only **one layer** of overall "management" responsibility for project realisation (—hence avoiding the numerous layers of "Managemet which can occur with the "project management" and "management contracting" approaches—), even though each participant remains responsible for the management of their own particular contribution,
- the management of the construction is considered concurrently with the evolving design at the earliest possibility in the project process,
- the client has distinct obligations in resolving conflicts between quality, cost and time criteria,
- within reason, the brief can be developed throughout the detailed design stage of the project,
- the essential cause of the "adversarial" attitude in all other forms of contract is removed.

c) **As a method it relies on—**

- a positive and continuous involvement by the Client,
- a positive attitude, teamwork and mutual respect and trust from all participants,
- a set of procedural controls that ensures clearly defined requirements through complete and timely information,
- meticulous and continous cost programme control.

d) **The Construction Manager must be able to**

- contribute postive construction advice and guidance from concept stage onwards,
- have sufficient knowledge of building design technology to manage the integration of the Designer's and Specialist Works Contractor's design output for production,
- keep to a cost plan and programme through anticipation rather than reaction,
- meticulously plan and control the interface of activities of all participants, including the Client, and not just act as a "postman",
- take responsibility for cost and time in conjunction with the Designer taking responsibility for performance and appearance for the final building.

e) **As a discipline, Construction Management demands an understanding of several bodies of knowledge and skills :**

- project process control through the application of quality management systems,
- integration of Designer and Specialist Works Contractor design output,
- communication, organisation, leadership and team-building,

- contractual arrangements between the Client and Designer, Construction Manager and Specialist Works Contractor,
- cost planning and control of the work of the Designer and Specialist Works Contractors,
- programming and time,

and

- project information management through the application of information technology.

One major advantage of the Construction Management method over all others is that by clearly distinguishing the roles of all the project participants—the Designers design, the Manager manages the construciton which includes the Designers' output for production and the Works contractors provide the physical elements—risks can be clearly defined and carried by those best suited to manage them.

This in turn can lead to more harmonious and less adversarial relationships as the confused roles and risks of other methods—especially the "management Contracting" version of the Management path—which are the basic cause of distrust have been removed. Also, the Works Contractors will be given more encouragement and incentive to further develop their own technical and managerial skills and knowledge as "specialists because of their direct contractual role with their client.

4
Implications for the future

What all this could mean for the future of the UK construction industry's traditional professions is that, given that "Client", "Designer" and "Construction Manager" all represents teams rather than individauls—

- **architects and engineers** will continue designing and being responsible for the overall design, performance and appearance of the finished building—although most would wish to be "Designers", some may wish to become part of "Construction Manager" and possibly "Specialist Works Contractor" teams,
- **quantity surveyors** could find positions in either the "client", "Designer", "Construction Manager"—and possibly "specialist Works Contractors"—teams as expert cost advisors, auditors, or managers,
- **builders** could find positions as advisors in the "Designer" or controllers in the "Construction manager" teams or in "Specialist Works Contractors" firms.

Construction management as a method is suitable for all type projects and not just the large development projects for which it was first evolved. Its choice is dependent on how the client wishes to understand and control his project and his acceptance that it may not be possible—nor desirable - to have a "lump sum" price when construction begins. Detailed specification change may need to occur during the construction—especially in a "rehabilitaion" project—and by having the direct involvment of the construction Management method, the client can be in a better position to make "value for money" judgments on choice that he alone can reasonably make.

However, it is important to stress the fact that both Designer and construction Manager must have equal and direct access to the client without any additional "Project Manager" in between acting as both a barrier and filter for effective design and construction decision-making. Depending on experience, the client may wish to have additional external advice in carrying out his duties as a client, but that person must act only as the client and even then not detract for the client's own executive decision-making role.

5
Conclusion

The essential recommendation of the Forum's Report—that the "construction management" and not the "management contracting" version of the Management path of procurement—should be the preferred has drawn some adverse reaction from both academic (SERC Research Project, 1990) and industrial (Ridout G., 18 January 1991) quarters. However, the only justification both seem to have for the "management contracting" version is that it suits the client who does not want to be as involved as he should be in the project if he chooses the Management path.

In an industry brought up in the adversarial and distrustful environment created by the Traditional path of procurement, changing attitudes needed for construction Management will be no easy task. Whole areas of legal and cost skills have emerged and become established to deal with the "claims for redress" atmosphere caused by the Traditional path of procurement helping to support those attitudes through vested interests.

Construction Management as a method of procurement both demands and provides for the continuous and informed involvement of the client in his evolving project to his and all the other participants' ultimate benefit. Educating and training both the client and the other participants in the meaning and methods of Construction Management approach through a joint programme is the one way to ensure that the changed attitudes necessary for the effective application of the Construction Management method in practice are instilled in the traditional construction disciplines.

6
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CONSTRUCTION MANAGEMENT—THE WAY FORWARD

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Abstract

The pace of change in construction practice has imposed additional demands on construction management which require a more analytical competence than was previously the case. During this period construction has undergone a metamorphosis. An industry which was characterised by robust technologies and familiar practices is now one where the technologies are complex and composite and the practices transient and expedient. Contemporary construction management is therefore concerned with the management of a complex and volatile process where technological sophistication and project complexity exists in an uneasy and demanding symbiosis. Increased competition for a share of a reducing market requires higher levels of productivity, greater managerial efficiency and decision making ability. Construction managers with responsibilities for the physical project and the construction process are often forced to make important decisions based only on intuition and experience. These changes require a redefinition of professional functions and by extension, professional training. There is ample evidence to show that the quality and efficiency of the construction process is functionally dependent on the quality of the construction manager. Among other things this has led to development of the professional construction manager bringing with it a new set of contractual relationships.

Keywords: Construction, Management, Decisions, Control, Time Cost Relationships.

1
The Construction Industry

The construction industry embraces building, civil engineering and large mechanical plant installations, all three often occurring in an individual contract, eg. a chemical plant with a related range of buildings and roads. The financial value of contracts can vary from as little as a few hundred pounds for small domestic extensions to multi-million pound installations for manufacturing, generating and other large industrial undertakings.

The construction industry also covers a wide range of practical and professional skills. These skills are usually subdivided between design and production. The design is usually undertaken prior to the appointment of a contractor (and therefore without consultation), whose job it is to translate the design into a finished building. Design skills include the functions of architecture, engineering and surveying. These skills are often duplicated on the production side and, in addition, there is a requirement for additional functions such as planning, estimating and a wide range of management skills. The situation is further complicated by the fact that a construction project involves a large number of independent trade contractors.

This type of fragmentation is a feature of the construction industry and influences, to a large extent, the way in which it operates. A further distinguishing feature of the industry is the fact that virtually all construction projects are unique and "The power of decisions is nearly always spread over several different interests and is remote from the scene of operations" (Harper—1978) In the opinion of the writer apart from its economic vulnerability many contracting failures result directly from the inadequate information on which management decisions are taken. This is exacerbated by the competitive bidding market in which the construction industry operates.

The construction industry is therefore often criticised for "poor management". The picture emerging is one of intuitive decision making based mainly on experience in a situation of uncertainty. Uncertainty in relation to work load, production methods, resource availability and profitability, amplified by the less than deterministic environment which usually surrounds the construction project itself. Organisations responsible for production are often criticised for poor management in terms of the optimal use of resources, inadequate planning and control procedures and an inability to determine accurately, project costs and duration times. The inability to appreciate the relationship between the time and cost parameters and model this relationship is also of considerable significance in terms of management decision making.

The pace of change in construction practice since the early 1980s, has imposed requirements on the construction manager which demand a more analytical competence than previously. During this period, construction has undergone a metamorphosis. An industry which was characterised by robust technologies and familiar practices, is now one where the technologies are complex and composite, and the practices transient and expedient. Contemporary construction management is concerned with the management of a complex and volatile process. This is most apparent in the activity of building where technoligical sophistication and project complexity exist is an uneasy and demanding symbiosis.

These changes have resulted in a re-definition of needs and demands which can only be satisfied by changes in professional functions and by extensive professional training. There is ample evidence to show that the quality and efficiency of the construction process is functionally dependent on the construction manager. Construction management is effected in a dynamic and complex environment in which the skills of communication, co-ordination and management are the catalysts which, through the agency of construction technologies, allows buildings and civils works to be created, and maintained in a functional state.

2
Management Decisions

Decision making, although one of the principal aspects of the manager's job, is one in which he is frequently faced with uncertainties. In such cases, the decision maker must base his deliberation concerning outcome possibilities on subjective opinion and the subsequent decisions become predictive in nature. Predictive decision making is widely practised in the construction industry and highly expensive resources are often committed in this way. The efficiency of this commitment cannot be ascertained unless the accuracy of the decisions can be determined. Given a satisfactory method of measuring and evaluating predictive decisions it is apparent that the objective nature of the information should be as accurate as possible to ensure effective analysis. Note must also be taken of individual behavioural traits in terms of possible variations that exist between optimistic and pessimistic predictors. There may also be differences between the predictive decisions of particular groups of specialists i.e. site managers and planners. Evidence suggests that predictive accuracy of site personnel over long periods tends to be poor and erratic, although in the short term, say a maximum of three weeks from the event, results are very much improved. In most cases results are best for activities which the predictor regards as critical and for which he has immediate responsibility. It is also likely that the accuracy of predictions will vary with the type of work being undertaken on any particular site.

The magnitude of a decision at a specific level will normally be judged in terms of the resource commitment its implementation will require and the risk factors associated with this commitment in relation to the expected outcome. As the level of management becomes higher the accent on decisions of greater magnitude increases. Jacques (1976) describes this phenomenon as the 'time span of discretion', suggesting that "each manager has the discretion to make certain decisions and that it is the time period between their implementation and the resulting outcome which determines the responsibility that manager bears in his job". Higher management tends to have a longer time span of discretion than lower management, thus their decision making is, perhaps, more important. It is as well to remember however, that all managerial personnel are given some discretion, all make decisions, and by doing so all contribute to the well being or otherwise of the organisation they serve. An improvement in this function at any level can provide only benefit, both to the individual and the corporate body.

Decisions, once made, commit a company's resources. Accurate decisions where actual outcomes are as predicted will encourage efficient use of these resources, inaccurate ones obviously result in waste. However, without a method of evaluating a decision there can be no check on this and the firm may well be sustaining unnecessary losses of which it is totally unaware.

In the construction industry there is often a conflict in management between the entrepeneur who traditionally makes his decisions on the basis of intuition and experience, and the technologist who seeks a deterministic solution to the problem, that will hopefully provide the one correct answer. However, given that managers will always wish to arrive at a rational decision, the answer often lies in combining the intuition of the entrepreneur with the analytical ability of the technologist. The objective being to provide a quantitative basis for taking decision where problems occur in conditions of uncertainty. It is appropriate at this point to distinguish between certainty and uncertainty in that decision making can take place under either of these conditions.

Decisions under Certainty—Possession of objective information concerning all the variables connected with a certain problem should generally result in an accurate decision. The return to be expected from each alternative strategy developed for solving the problem must be determined and then the decision taken as to the strategy that gives the highest return in terms of the original objectives. The main task will be in calculating possible outcomes from the information available. These outcomes should be sufficiently accurate to allow for effective comparison. In the context of this paper, the term certainty is not taken to imply a precise knowledge of all the factors relevant to the situation. It does mean however that they are sufficiently well known to allow a high level of confidence to be placed in accuracy.

Decisions under Uncertainty—In most situations full objective information is rarely available and uncertainties will exist—this is more often that not the case in the construction industry— particularly when no accurate means of analysis is available. When uncertainties exist, as they invariably do, and there is an absence of objective information, the manager will naturally draw upon his experience or judgement. This general lack of objective information and methods of analysis often results in construction managers placing too much faith in subjective decision making when dealing with uncertain conditions. It is not, in fact, unusual for decisions to be made on an intuitive bases, even when full objective knowledge suggesting a contrary course of action is available. Many managers would argue that a subjective element exists in all decision making situations.

It could be argued that in the construction industry nothing is totally predicatable therefore the concept of certainty is totally unrealistic. It is important to realise however, that we are not concerned with problem areas where it is possible to predict exactly the outcome, but with activities where we can forecast with some considerable confidence what is likely to happen. For example, it is nccessary to forecast reasonably accurately the cost of a particular activity on a construction site, without being exactly sure of the final cost. Decision theory does attempt to quantify uncertainty through the concept of probability. This is not simply a descriptive term that indicates whether an event is highly probable or impropable but is a measure of the real likelihood of its occurrence.

Most construction problems require consideration of a combination of separate activities each of which have their own distinct probabilities. Furthermore, different combinations may apply, for instance, in a planning situation, different probabilities are combined to determine the project completion date. However, because of the number of activities involved and the fact that each separate activity that makes up the total project network will have a probability distribution between two extreme limits, i.e. a shortest possible duration and a longest possible duration, we can only determine the most likely project completion date.

A further factor that must he taken into account is variability. Statistical variations and variants are specific terms with very precise meanings. It is also important to note that when all the inputs to a system appear to be constant the output may still vary. What must be accepted is that variability does occur and furthermore that it may be possible to measure it.

The concept of risk refers to the chance of unacceptable losses arising at some point in time is obviously also very relevant to the construction industry. Risk which is most frequently associated with cost, will be viewed in different ways by different organisations. Where cost is the factor at risk the attitude will obviously be influenced by the amount at risk. The amount of profit likely to accrue from risk taking will also have a significant effect on the decision maker. There are other factors that may relate to risk such as contract duration, decisions to tender, client attitudes etc. The decision maker will be required in a situation of risk to evaluate alternative courses of action. Irrespective of the nature of the risk the objective should be to base decisions on as much quantitative information as possible.

The making and implementation of decisions is therefore the means by which a manager seeks to achieve specific objectives. However the ingredients on which decisions are based are the types of information available. Ross in dealing with information systems states that "an organisation simply cannot survive without the critical element of information nor can the functions of management be performed unless a flow of information is provided to decision matters". This is particularly true of information relating to time and cost. Ross concludes "The task is to upgrade many of these systems from the historical variety to the type of specific application that will provide better decisions and information for planning and control". Examination of a decision/information system within a company will show that the two are inextricably linked.

The quality of decisions made will be affected by the availability and ease of access to information, its accuracy and pertinence to the problem, and the skill and judgement of the manager in using it.

Information can he classed into two principal types—Objective and Subjective. Objective information is that which is factual and related directly and truthfully to the object in question. It is 'hard' information and is completely divorced from the opinion, judgement or intuition of the individual. Subjective information is that which exists within the mind of the individual and relates to, or reflects his thoughts or feelings. In an industrial sense it is based upon the knowledge, experience, intuition and judgement of the individual and as such is 'soft' in nature and difficult to quantify.

If all information were purely objective, decision making would be a much simpler process. However, in practice and particularly in the construction industry this is not the case and there is always a high element of subjective information. As with the majority of things in the industrial world there is very little black or white but mostly varying shades of grey.

It is extremely difficult to instigate control procedures where a high percentage of decisions are subjective in nature. It is generally too late to judge the effectiveness or otherwise of a decision when an activity or project is complete. This is particularly true in an industry where risk and uncertainty are, to an extent, inevitable. The manager's aim should, therefore, be to seek optimum or near optimum solutions, based on objective data or information wherever possible. Many well informed people in the industry hold the view that this is impossible and argue that subjective decision making is acceptable due to the high level of uncertainty.

3
Planning and Control

In many instances, the ability to plan and evolve effective control procedures may mean the difference between survival and liquidation/bankruptcy for many construction organisations and many, even the large ones, have been forced into liquidation due to the financial difficulties encountered on a single project. It is considered that these difficulties could often have been anticipated and possibly avoided, had an adequate control and feedback system been in operation to provide early warnings to management.

As the time span of a plan increases its accuracy will tend to decrease accordingly. It is necessary to adjust plans frequently and to measure the effect of these adjustments on future events. There is a need, therefore, for a balance to be struck between relying totally on imperfect information and postponing a decision until perfect information is available. Continuous comparison of a project plan with actual performance enables the manager to instigate the control necessary for early correction of deviation.

The actual cost of planning must be balanced against the likely benefits to be obtained at the completion of a contract. It must, however, be emphasised that planning is not a luxury but a prime necessity for any organisation that wishes to operate effectively. The cost of planning must be offset against the cost of such things as false starts, the inadequate allocation and utilisation of expensive plant, equipment and labour that will inevitably result when planning has not been undertaken, i.e. it must be judged against the losses that may be incurred if it is not undertaken. It must be remembered that planning is a means to an end and not an end in itself, and more effective ways of implementing and controlling the plan must be continually sought.

It is becoming more common for a contract to be awarded not purely on the basis of the lowest price but also on the ability to complete the work in the shortest time. It is important therefore to ascertain whether the client's prime objectives are time or price, or a combination of the two, in terms of identifying the most acceptable tender. It should also be noted that in practice, the duration of a contract is not always directly related to its value.

The assumption that "the earlier site activities are commenced, the sooner the contract will be completed", must be avoided because in almost all circumstances the reverse is much nearer the truth. Failure to plan carefully and accurately before work commences on site will invariably delay completion and result in additional costs. It is essential that the client is aware of the implications of this approach when making a decision on the next appropriate starting date. While the ultimate decision on a starting date will be influenced by the size and nature of the contract, nevertheless this general premise is applicable whatever the size of the contract.

4
Time—Activity and Project Durations

Costs are usually calculated in considerable detail, while the time for an individual activity or a project as a whole is often nothing more than "a gross estimate based on similar projects". This situation probably derives from the fact that the success of a tender is still judged to relate directly to the competitiveness of the tender figure submitted.

Research suggests that the most significant single factor affecting activity duration is weather conditions. This factor is, however, often cited when the underlying cause relates to lack of adequate planning and control, nevertheless weather conditions do present a considerable problem and it is recommended that allowance is made at the end of clearly defined phases of a contract, e.g. after the ground works have been completed, with a special allowance for those individual activities identified as most likely to be affected by weather conditions.

The findings of other researchers, particularly MacGrimmon and Ryavek and Klingel raises grave doubts as to the reliability and accuracy of stochastic models, such as PERT, when applied to the analysis of the time parameter. It is considered that many of these difficulties stem from an unsuccessful attempt to build simplicity into a sophisticated, probabilistic model. Bearing in mind the clear preference for deterministic "one time estimates"on the part of the planners and site management, it seems logical to conclude that the deterministic approach is certainly the most acceptable and probably the most appropiate for the majority of construction projects. Furthermore, it can be seen that the introduction of the costs parameter in an attempt to optimise the relationship, so complicates the issue as to make the use of probalistic time estimates unrealistic.

5
Characteristics of Construction Costs

Costs not only vary from organisation to organisation but also from contract to contract within the same organisatron—a conclusion substantiated in discussions with a number of construction companies. However, the fact the "there are certain factors that remain constant" whatever the situation did also emerge. This latter factor is worthy of further research.

Information required for costing, either for estimating or planning purposes, must be accurate and preferably based on work measurement reflecting the expertise of the particular company and should be easily retrievable. It is essential that actual production costs can be ascertained quickly and accurately during the progress of the contract itself and that planned and actual costs can be easily compared. The differences between actual results and the standard set requires careful analysis and may be expressed in the form of variances which would identify where the responsibility for such differences lie.

Action in high cost areas can often produce what appear to be immediate benefits, however an initial saving may in fact change the critical activities for the contract as a whole, with the result that characteristics of uncritical activities are changed in such a way that they, in turn, become critical. Such a variation may change the emphasis in terms of resource requirements necessitating a change of policy and, in the end, result in an increase in cost.

It is essential to the manager that the level of monitoring detail which should be reported is judged to be that which allows action to take place where and when the actual situation and the cost plan diverge. Information is required rapidly and in a form that is easily digestable. The monitoring system can be simplified and made more effective in two ways (a) delegation of authority and (b) reporting critical or key ratios only, using the exception criteria.

The majority of activities in a construction project fall logically under the heading of forecasting and these forecasts are generally time dependent or dynamic activities. It must be recognised therefore, that unless estimates are properly prepared and relate to time factors, the monitoring of costs and their comparison with estimates is often invalid. It is considered that efficient cost control is dependent on:

i the preparation of a realistic estimate expressed in terms appropriate to control once the contract is actually under way.
ii monitoring commitments entered into against original estimate.

iii detailed cost control of individual activities with particular emphasis on critical activities allowing the exception principle to be operated and closely relating time and cost in such a way as to optimise performance.
iv quick and effective feedback showing deviations from plan and highlighting critical activities
v the rapid comparison of alternative courses of action allowing informed decisions to be taken quickly, based on objective information.

In the main, individual activity direct costs will decrease as the activity duration increases. The project duration is found by summing activity durations along the critical path. Conversely, indirect project costs will tend to increase with an increase in project duration. This increase will normally take place in a piecewise linear fashion.

6
The Time Cost Relationship

From discussions with construction companies it can be concluded that the time parameter is carefully planned, often in considerable detail and controlled using networks or bar charts, etc. In addition, these organisations consider themselves to be cost conscious and confirmed that their major objective was to complete all projects at the least possible cost. They did not, however, give serious consideration to the relationship between these two parameters and its significance in terms of decision making. Accepting that for any activity or for any project there is a range of possible durations, their difficulty was to determine which duration should be selected in order to arrive at the optimum cost for an individual activity or for the project as a whole. As there was no adequate facility available their only recourse was to intuition and experience. There is no way in which the time cost relationship can be analysed in an intuitive way. In fact it is virtually impossible to identify the time induced critical activities in this way, let alone the significance of simultaneous variations in the time and cost parameters and the dramatic way in which this can change and increase the number of critical activities. The intuitive approach does not therefore represent a suitable basis for decision making. It is impossible to compute the variety of possible combinations manually for the highly complex set of activity relationships that exist in the normal construction project. It is generally accepted that to decrease the duration of any project more money must be invested and this invariably implies the allocation of additional resources. What is not appreciated is that additional resources need only be allocated to critical activities, i.e. those that directly affect the overall project duration.

Indirect costs are particularly significant in situations where the early completion of a project will have a profound effect on the client's maximisation of his investment, e.g. completion of factory design to manufacture a new and more effective commodity such as micro computers. In this case, the later the project is completed, the smaller will be the client's short term or even long term share of the market. Factors such as this may be of considerable significance and may well warrant the crashing of a project even though the initial project cost is increased. It is necessary to balance these factors in order to achieve an optimum return on investment, and, therefore, to identify an optimal relationship between indirect costs and the duration of the project. Cusack (1987). The optimisation of the time cost relationshipcan be of great significance to the client in highlighting the effect of the early completion of a project on the maximisation of his investment. Construction management can also see the value of analysing and seeking an optimum or near optimum solution to the time cost relationship problem. However, this cannot be accomplished manually due to the range and variability of the highly complex activity analytical models. Earlier attempts to model the time cost relationship failed due to the complexity of the models produced and the consequent need for high levels of computational power available, only on the large main frame computers, to solve them.

Heuristic models have been developed—Cusack (1987)—to exploit the advantages of the micro computer and although adopting a simple and more direct method of analysis to derive project cost curves, it can be concluded from the tests undertaken that the results obtainable are demonstrably comparably, in terms of accuracy, with the more precise integer linear programming models. The model also retains and integrates the role of managerial judgement essential to the construction process and so highly prized by construction management, thus allowing it to be viewed more as a valuable aid than as a potential replacement for the decision maker. It can be concluded therefore that the concept of optimality although achievable in strictly mathematical terms (it must be remembered that an element of mathematical accuracy is sacrificed in heuristic models), may not be of major significance or even desirable from the viewpoint of the practicing construction manager. Near optimality may well be a more appropriate and socially acceptable concept for project evaluation.

The outputs obtained using the micro computer meet user requirements in respect of the precise form and level of detail required by decision makers operating at different management levels by allowing the output to be obtained in both abbreviated and detailed form, including a full data listing where appropriate. The input can be simplified where only approximate solutions are required with a consequent effect on computational limits and speed of decision making. Amendments can be easily input into the system without destroying the existing data base thus enabling the logic of alternative strategies to be examined at any stage and the consequences involved in changes of plan to be evaluated.

It could be concluded that the deterministic framework assumed in the models precludes consideration of factors that are probabilistic in nature, e.g. weather conditions, multi time estimates, breakdowns or unavailability of plant or other resources. This is not the case and probabilistic factors can, in fact, be built into the models. The models however, do not in themselves cater for the analysis of these factors. The choice to include or not to include them is therefore a matter for the individual decision maker.

By enabling time and cost to be related and near optimal solutions to be obtained, the models allow the decision maker to finally evaluate decisions in purely monetary terms—"the only criteria readily acceptable to construction management", who see the final outcome as "the optimisation of profits". This conclusion is substantiated by Howard—1966 who makes the point that "A good decision is a logical one…one based upon the uncertainties, values and preferences of the decision maker. A good outcome is one that is profitable or otherwise highly valued…, we find no better alternative in the pursuit of good outcomes than to make good decisions".

7
Construction Management—A New Profession

The introduction of cross-functional professionals to make up a project team is long overdue. Such a move would represent an evolutionary approach to the development of new organisational structures ie: to be effective the total project must be considered on the basis of team work and skills rather than rigid functional structures. Inherent in this approach is the need for discipline and goal orientation as opposed to crisis management and inappropriate leadership roles. Construction management should be orientated towards enterprise rather than bureaucracy. This means breaking down mechanistic organisations where the emphasis is on a rigid management hierarchy with management skills and techniques geared towards the achievement of overall objectives. Construction management is about attitudes as much as about skills, techniques or procedures. Techniques should be used in a purely supportive way to achieve the ultimate objective ie: a high quality product delivered on time at the least cost.

It can be seen therefore that one of the major problems facing construction management is who of the various parties involved is the most suited to the leadership role. It is often argued that leadership is more a factor of personal skills than functional background. While this may well be the case the leadership role may well vary depending on the type of project and the stage of completion ie: procurement, design or production. Conflict often emerges in that construction management includes not only line managers but technical and functional specialists. It can of course be argued that construction management is in itself a function area as is marketing procurement or finance.

Clearly the leadership role will appeal to someone who likes the challenge of change and the excitement of turning entrepreneurial ideas into the reality of a completed building or structure. This must be linked with the ability to manage or delegate the detailed planning and control of resources, particularly the human resource. It is essential that the techniques and working methodologies of the other members of the team are clearly understood. Preferably from the outset of the client brief.

Of all the resources required in construction the human resource is the most difficult to manage. This is often linked with the fact that the ability to achieve project goals is seen as being dependant on the successful attainment of forecasted productivity and manpower levels—Anderson & Woodhead 1981. However, it is suggested that the achievement of project goals really comes about through the effective utilisation of all the resources, equipment, materials, manpower, finance and management, al] of which compliment one another.

Construction Management implies an understanding of the inter-active effects of resource utilisation on project completion time and costs. Flowing from the above a new profession has emerged bringing with it new forms of contractual relationships. The key features of "construction management" can be summarised as follows.

Construction management is increasingly recognised as a logical and commercial by attractive alternative to traditional tendering under this contractual arrangement the construction manager forms part of the clients team from the outset, with responsibility for co-ordinating on his behalf the construction, planning, management and execution of a project on a fee negotiated in advance. It creates an identity of interest between members of the design and production team and because of involvement from the outset, design, tendering and construction periods overlap with potential savings in time and cost.

Construction is the only major industry in the UK in which design and execution are divided. Using the construction management approach, client and constructor operate together from the outset and the real cost of the project is identifiable at an early stage. In this way the most economical methods of design, construction site procedures, material handling etc can be attained. The project is broken down into trade elements and trade contractors selected by competitive tender.

8
Responsibilities of Construction Management

Architectural, quantity surveying, structural, mechanical and other consultancies are selected and appointed directly by the client as in normal traditional tendering. Construction management is responsible to the client and his professional advisors for the entire project including construction planning, execution and contact. Buildability is a key issue as is early completion and the most competitive price for each element.

The construction management supplies extensive pre-building services to the professional team, these include:

1 the assessment of design from the point of view of construction management
2 feeding of real cost information to the design team

3 the assessment of design alternatives from cost, time, value engineering, ease of construction and quality viewpoints
4 the preparation of precontract network
5 the establishment of the availability of materials and labour
6 planning and management of the project

In this way the construction management team is totally integrated with the professionals from the earliest possible date. AI1 parties are aware of what is expected of them in practica] and contractual terms.

The construction manager's role is one of control and co-ordination of all activity on the site and is not therefore influenced by the profit motive. In collaboration with the quantity surveyor he will police the cost plan and maintain up to date records. This will enable the preparation of the final account to "take place quicker and without conflict, in that potential conflict points are sorted out at the time of occurence. Design leadership and ultimate responsibility remains with the the architect but the main burden of executive effort falls upon construction management during the construction phase.

Construction management is engaged on a consultancy fee basis divided into two parts—precontract service, and managerial and co-ordinating roles undertaken during the project thus the client can terminate the arrangement if necessary.

During the evolution of the design a list of tenderers is drawn up under the management control of the construction manager. Tenderers for each major package are interviewed and a short list prepared. A tender analysis recommendation is made to the client who will place the order. The procedure allows scope for the appointment at the most commercially acceptable time ie: early or late in the contract.

The final account includes the management fee, site preliminaries, common services and trade contractors agreed final accounts. There are no profit elements added to trade contractors quotations. The construction management fee is not an extra, it is part of the total construction cost.

The process of construction management evolved from the responsibility of the main contractor for the overall completion of the project through the use of sub-contractors. The main shift in emphasis being the removal of effective legal responsibility from the main contractor for the difficulties arising with sub-contractors/suppliers. Accepting the function of construction management as a key part of the development team is the major psychological change of emphasis from traditional methods.

9
Construction Managers Liability

The basic principle of construction management is that the client engages direct the trade contractors who are responsible for carrying out the work packages including design where appropriate. The construction manager is engaged to manage the work of the trade contractors.

Construction management has no contractual relationship with the trade contractors ie: responsibility rests primarily with the defaulting trade contractors and the remedy is directly reinforceable by the client—assuming that the construction manager has performed his duties adequately eg: The Duty of Care -duty to the recipient to use all reasonable skill and care in what he is engaged to do. The Tort of Negligence—to be negligent is to commit a civil wrong ie: it exists wholly separate from any contractual relationship between the party and any other party—there is little likelihood for the success of a claim against the construction manager based on liability in The Tort of Negligence.

It may well be, however, that the client having paid a substantial fee to the construction manager may not he content when facing multi-million pound claims for a failed project to accept the philosophy of no risk management ie: the contractual arrangements in this area are not sufficiently developed as yet to allow a clear picture to be drawn.

Evaluation

RISK

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Abstract

This paper concentrates on what formal assessment of risk involves and associated benefits. It uses as a framework a method developed by the author to assess schedule risk for BP projects in the North Sea, subsequently adopted by BP for major sensitive projects world wide. It uses examples to illustrate the benefits drawn from experience with a number of major projects. It relates these benefits to what might be achieved in lower risk smaller projects, and how the approach might reflect the need to balance benefits and costs.

Keywords: Risk, Risk Analysis, Risk Management, Procurement, Construction, Evaluation.

1 Introduction

The cost of constructing or procuring a building and the life cycle cost of a building can be estimated in a variety of ways, as earlier papers in this session by Skitmore (1991) and Raftery (1991) indicate. Traditionally, such evaluations are deterministic point estimates: single value estimates obtained by combining other single value estimates. However, formal consideration of risk is a key agenda item for future research.

To many people, formal consideration of risk implies measurement of uncertainty associated with component estimates and probabilistic combination of component estimates to provide a measure of the uncertainty associated with overall construction, procurement or life cycle cost. To this author, formal consideration of risk may involve this measurement process, but it may not, and whether or not it does this is only one aspect of a risk management process which is quite subtle and diverse in its aims and benefits.

During the middle and late 1970s, the author developed a risk management approach to planning and costing for BP International, initially for off-shore projects in the North Sea, subsequently adopted for all major sensitive BP projects world wide (Chapman, 1979) . This approach, referred to as SCERT (Synergistic Contingency Evaluation and Review Technique), was later adapted to risk management associated with reliability and availability (Chapman, Cooper and Cammaert, 1984) and technical choices (Chapman, Cooper, Debelius and Pecora, 1985). Related approaches have been developed for quite different fundamental design studies (Chapman, 1988) and assessment of contractual aspects of risk allocation (Chapman, Ward and Curtis, 1989), with a range of applications in between, including ongoing work in a variety of contexts.

In its original form, SCERT is the most detailed and sophisticated formal approach to project planning and costing risk the author is aware of, a substantial generalisation of Generalised PERT and its derivatives (Moder and Philips, 1970). It was worth developing such an approach for offshore projects in the mid 1970s because the technology was not familiar, the environment was hostile, very large sums of money were at stake, and conventional approaches were not performing adequately.

Most aspects of most projects of interest to this audience will not justify such detailed assessment of risk. However, the principles apply in the context of any project, and a range of simplifications are possible (Chapman, Phillips, Cooper and Lightfoot, 1985) to capture key issues when and where they arise at an effective and efficient level of detail.

Comprehensive discussion of such approaches (Cooper and Chapman, 1987) would require consideration of:

models,
methods,
computation procedures,
computer software,
method design,
management issues.

This paper focuses on methods and some key management issues. It considers key steps of the method developed for BP, in the sequence employed by this method. It illustrates what is involved drawing on experience with BP, with offshore projects involving other companies, and with a number of other studies. In relation to earlier steps, the emphasis is on what is involved for detailed studies and how the process can be simplified. In relation to later steps, the emphasis is on the benefits of such a process. The intention is a brief introduction to formal risk management processes, in terms of how others have used them successfully, to what ends, and how the present audience might achieve related benefits from a related approach.

The structure of the paper follows the outline of the structure of the method, as follows.

Qualitative Analysis	Scope phase	Activity list Risk lists Response lists Secondary risks and responses
	Structure phase	Risk and response links Minor and major risks Specific and general responses Simple and complex decisions
Quantitative Analysis	Parameter phase	Where and when to quantify Quantification of uncertainty Combination of risks
Risk Management	Interpretation of results and development of alternative approaches as appropriate	

In practice, the process is iterative to a considerable extent, and quantitative analysis may not be appropriate.

2
Scope Phase

The scope phase begins the qualitative analysis process. It is concerned with documenting what is involved in a form which provides some initial structuring of this information. The discussion which follows will concentrate on SCERT treatment of duration or schedule risk, but the approach can be generalised to also consider cost and other criteria like performance.

2.1
Activity list

The first step in the scope phase involves decomposing the project into a set of component activities, and documenting what is involved in each. Project cost risk may use these activity durations plus associated cost rates or a separate cost item structure. Life cycle cost may use these structures for initial cost, plus an operating cost per time period associated with components or other aspects of the structure and its support systems.

The key to successful risk management is keeping this breakdown as simple as possible, so we do not “lose sight of the wood because of the trees”. Even a £1, 000,000,000 offshore project might involve only 20–50 activities for SCERT risk management purposes. For example, fabrication of a platform might be one activity, laying a 120km pipeline from the platform to shore another. The procurement cost of a major office block might involve only half a dozen key components, like:

site cost,
design and approvals,
foundations and shell,
services,
decorations and furnishings,
management.

The rationale for separating components is a set of sources of risks which are largely different and unrelated, the responsibility of different people, realised risks amenable to different responses or solutions, and other rules of thumb of this nature.

2.2
Risk list

The second step in assessing project duration risk using SCERT involves identifying sources of risk associated with each activity and the project as a whole, and documenting what is involved. For example, laying an offshore pipeline might have sources of risk identified like the laybarge arriving later than planned, not operating as quickly as planned, encountering bad weather, experiencing a pipe buckle, and so on.

The key to successful risk management is not overlooking any important source of risk. In the pipelaying context this might mean forty or so risks as indicated above need separate identification and documentation. In the context of a major office block, “foundations and shell” might be associated with two key risks, “ground conditions” and “new construction technology”, with all other sources of risk being associated with a single “residual risk” pool.

2.3
Response list

The third step involves identifying responses for each source of risk, and documenting what is involved. Four different kinds of responses are possible. For example, consider a pipe buckle: the smooth “S” shape the lay barge attempts to maintain as new sections are welded to the pipeline and the extended pipeline lowered to the ocean floor develops a buckle, the pipe fractures, water rushes into the pipeline, which becomes too heavy for the barge to hold, ripping itself off the barge unless it is released quickly.

One kind of response is purely after-the-fact using readily available resources: the buckled pipeline can be repaired. This involves sending down divers to cut off the damaged sections and put a "cap" on the pipe containing valves. A "pig" is then sent through the pipe under air pressure from the other end, to "dewater" the pipeline. The pipeline can then be picked up and pipelaying recommenced.

Another kind of response is after-the-fact, but requires essential prior actions: the buckled pipeline can be abandoned, and a new pipeline started. If the buckle occurs before very much pipe has been laid, and sufficient additional spare pipe was ordered in advance, this is a cost effective solution because of the time saved.

A further kind of response is a prior action which mitigates the implications of an after-the-fact response: a more capable lay barge will allow a buckle repair to be completed in less time, capability for this purpose being maximum wave height conditions for safe working.

A fourth kind of response is a prior action which reduces the chance of a risk being realised: a more capable lay barge could also serve this purpose.

The key to successful risk management is not overlooking any key responses of all four kinds for any key sources of risk.

In the context of projects of interest to this audience, relatively few risks may deserve the attention given to pipelaying in offshore projects, but where risks are important, the same principles apply to their management.

2.4
Secondary risks and responses

The final step in the scope phase involves identifying secondary risks and responses as appropriate, and documenting what is involved. For example, if "repair" is the response to a pipe buckle, an important secondary risk involves the "pig" running over a bolder or other debris, becoming stuck. A secondary response is to send down divers, cut the pipe behind the pig, put a cap on the shortened pipeline, and try again. Another secondary response is to increase the air pressure, hoping to pop the pig through, with the tertiary risk that the pipeline may fail to withstand the additional pressure some considerable distance back from the stuck pig.

The extent to which it is worth identifying and documenting these higher order risks and responses is very much a matter of judgement, necessarily dependent on a variety of issues. The key is not to overlook any important issues. For example, do not assume a fixed price contract for a specified quality or performance necessarily means the fixed price will be the final cost and the performance or quality will be achieved, even if significant penalties are involved and the organisation is financially sound. One organisation which made such an assumption discovered claims made against such a contractor would be passed on to a sub-contractor which was owned by the organisation initiating the claim, an unusual but devastating secondary risk.

2.5
The value of documentation

For a major offshore project the description of activities, risks and responses as just discussed might run to six or seven hundred pages of text, using a hierarchical numbering system: responses within risks within activities. For a major office block or similar project, one or two hundred pages may suffice. But the importance of this documentation is difficult to overstate, for four reasons.

First, the discipline of explaining clearly what is involved clarifies the thinking of the person initially preparing the documentation.

Second, communication is an important aspect of the planning process, documentation of this kind reducing the risk that different people will have a very different understanding of an issue.

Third, projects often suffer from staff turnover, documentation of this kind making it much easier for someone to pick up where another left off.

Fourth, without documentation of this kind, corporate expertise poured into one project is not readily available for the next similar project. Captured corporate knowledge is a very valuable asset.

3
Structure phase

The format of the information gathered in the scope phase provides initial structure, but further structure is the purpose of the second phase. This additional structure is sought while maintaining a qualitative approach.

3.1
Risk and response links

Many risks and responses involve important interdependencies which need to be identified. For example, a response to one risk may effect the chances of another risk—responses to industrial relations difficulties often have such effects. If the analysis cannot be structured to avoid such links, it is important to consider their effects where they are significant.

3.2
Minor and major risks

At some stage in any analysis we need to decide what is and what is not important, and a related but different issue, what needs care and attention in terms of analysis, what does not. There is a natural tendency to make these judgements as quickly as possible, failing to even note potential difficulties dismissed as unimportant. The discipline associated with leaving such judgements until this stage is useful. Once primary responses and secondary risks and responses are clear, and risk and response links, it is easy to dismiss some risks as minor because effective responses exist, major risks being identified as a residual. It is possible to pick up those risks which at first glance seemed minor, but have no effective response. It is also possible to distinguish between major problems which have only one simple and effective solution, requiring no further attention, and those for which appropriate responses do not involve obvious choices.

3.3
Specific and general responses

Some responses are specific to particular risks: for example, "repair" in relation to a pipeline buckle, or "abandon and start again", as discussed earlier. Others may be identified in the context of a particular risk, but offer a solution to a wide range of risks. For example, the delay associated with a pipebuckle can be recovered by using a second laybarge working from the other end, and a submarine connection to join the two parts of the pipeline, providing an option on a second barge is in place if it is needed. But this response will also recover time lost due to bad weather, equipment failures, delayed start to pipelaying, and a wide range of other difficulties, including some which may not have been identified.

The key is to be aware of any particularly useful general responses, and ensure they can be implemented if necessary. If, for example, completion of an office block later than a contracted date involves very high cost penalties relative to the cost implications of being early, it may be worth starting early and working to a target completion date much earlier than the contractual date, a simple but very effective general response.

3.4
Simple and complex decisions

An efficient and effective risk management process does not involve gathering all the facts and defining all the options and then making all the necessary decisions simultaneously. The analysis and management process has to start with relatively simple decisions, and then move towards relatively complex decisions, within the context of starting with strategic level planning, and then moving towards the tactical. For example, assessing how much extra pipe should be ordered to allow the "abandon and start again" response to a pipe buckle to be implemented is a simple decision relative to whether or not to take an option on a second lay barge, so they should be considered in that order. More generally, there is a need to plan the process of analysis to follow at this stage in the process.

4
Parameter Phase

Quantitative analysis, using probability distributions to further aid our understanding of uncertainty and how best to manage it, is the third phase of the SCERT process.

4.1
Where and when to quantify

Formal risk management procedures do not necessarily require any quantification or uncertainty. If an organisation is not able or prepared to take any significant risks, the risk management process will be concerned with avoiding or transferring risks, and measurement will not be appropriate. Usually some degree of quantification is useful, but quantification of any aspect should be in response to a considered view that it would be useful to quantify that aspect of uncertainty.

For example, when considering an offshore pipeline, sources of risk like weather, equipment breakdowns, pipe buckle and so on, all lend themselves to useful quantitative analysis. However, if the planned pipeline route might be changed if drilling for oil in a nearby area proves successful, keeping to the proposed route might be best identified as a condition current plans depend on, without attempting to embed the possible changes in route in the current plan. Similarly, if a pipeline has to be laid across other pipelines, involving a significant chance that lay barge anchors will damage the other pipelines with very serious consequences, it may be best to identify preventative and contingency responses in detail but keep this issue separate from the “base plan”.

Similar issues for an office building or similar project arise in relation to planning permissions and force majeur incidents like a major fire during construction.

4.2
Quantification of uncertainty

Some uncertainty is relatively easy to quantify based upon very appropriate data. For example, North Sea average wave heights have been recorded by sea area by month for many years. This makes estimating the effect of weather on equipment whose operational limitations are defined in terms of wave height conditions relatively straightforward.

Some uncertainty requires important subjective adjustments to data based estimates. For example, in the late 1970s the number of kilometres of pipe laid in the North Sea and the number of pipe buckles was known, providing a simple estimate of the probability of a buckle per kilometre of pipelaying. However, it was known that the equipment was improving rapidly, and the operators were becoming much more experienced, so a very important subjective adjustment needed to be made to the historically based estimate.

Some uncertainty is very important, but appropriate data is not available. Some people argue formal analysis is a waste of time if good data is not available. This author argues lack of data makes analysis more difficult, but more important, as there is no other way to deal effectively with uncertainty.

Consider an extreme case. A few years ago the author was asked to advise on the risk of sabotage associated with a pipeline which had suffered one unsuccessful sabotage attack. The client needed an analysis which would stand up in court should the analysis suggest it was not worth spending money protecting the pipeline but it was subsequently attacked successfully. A situation like this requires turning the issue around—avoiding the question "what is the chance of a successful sabotage attack?", and asking "what does the chance of a successful sabotage attack have to be to make it worth spending money on protection?". In this case, the most likely point of attack was identified, the most effective response to this attack was identified, this response and the consequences of a successful attack were costed, and the resulting analysis suggested successful attack every couple of years would be necessary to justify the expenditure. The case for not spending the money was clear and defensible.

4.3
Combination of risks

To the extent that uncertainty is quantified, individual sources of risk must be combined to appreciate their joint impact. The key point here is the need to avoid putting all the numbers in to a black box, turning the handle, and getting a result which is difficult to interpret. It is important to be able to see how the effect of each source of risk contributes to overall uncertainty, as illustrated by Figure 1.

Figure 1 curve 6 shows the joint effect of six sources of risk on one activity. Curve 1 shows the effect of the first risk on its own, curve 2 shows the first plus the second, curve 3 shows the cumulative effect of the first three, and so on. The gap between the curves clearly portrays each successive contribution, providing built in "sensitivity analysis". We can tell at a glance where and why the serious problems are likely to arise.

Starting at an activity level, we can build up pictures like that of Figure 1 to consider the joint effect of a sequence of activities, the effect of project duration and other factors on total capital cost, the effect of total capital cost and other costs on life cycle cost.

5
Interpretation of Results

The final phase of this formal risk management process is directly concerned with the management of risk given the insights provided as a result of the earlier phases. At this stage, the iterative nature of the process becomes more pronounced. Interpretation of results based on all the assumptions inherent in our base plans and contingency plans will generally leave us uncomfortable in some areas, and lead us to revise our plans. For example, if the 15% chance (0.15 probability) of achieving the base plan date indicated in Figure 1 was not acceptable, we would have to reduce the uncertainty by more effective responses, or start earlier.

At this stage the bottom-up approach to building up our understanding of the risks and responses is used in a top-down manner. Where final consequences at the life cycle cost or total capital cost level are unacceptable, we have to examine our analysis to deduce the best way to improve the situation. The understanding of the relationships between risks and responses developed earlier is essential to allow effective and efficient management of risk at this stage.

In section 2.5 the value of documentation was discussed, an important feature and benefit of formal approaches to risk management. However, it is at this stage in the overall process that the central benefits are realised, and it is at this stage in this paper that they will be addressed.

5.1
Risk efficiency

In technical terms "risk efficiency" means a minimum level of risk for a given level of expected cost, or a minimum level of expected cost for a given level of risk, or a comparable position in relation to profit, performance or other criteria. "Expected" values are our best estimates of what should happen on average. Doing things better in terms of risk efficiency is the central role of formal risk management.

Consider an example. An offshore project involved a hookup, connecting a pipeline to a platform, with a target date in August, using a 1.6m wave height capability barge. Risk analysis demonstrated that August was an appropriate target date and a 1.6m barge was appropriate in August. However, because this activity was late in the overall project, and there was considerable scope for delays to earlier activities, there was a significant chance that the hookup would have to be attempted in November or December, and might not prove feasible until the following spring, with severe cost implications. A revised analysis was undertaken, assuming the use of a 3m wave height capability barge, costing about twice as much per day. This analysis indicated the more capable barge avoided the risk of going into the next season, and it involved a significantly lower expected cost, a significant increase in risk efficiency. The base plan was changed, and this one change paid for the risk analysis study many times over.

Most of the projects of concern to this audience may not involve such dramatic chances to improve risk efficiency, but chances are there for those who look for them.

5.2
Risk/expect cost balance

Had the numbers been a bit different, the expected cost of the 3m barge in the example just cited might have been slightly greater than that associated with the 1.6m barge. In such a case a reduction in risk is possible, but a tradeoff is involved: reducing risk requires increasing expected cost, or vice versa.

Reducing risk or reducing expected cost where appropriate, making such tradeoffs, is a central role for formal risk management procedures.

5.3
Distinguishing different types of estimates

It is important to set targets for durations, costs, performance and other criteria which are achievable if no significant difficulties are encountered, but "lean": as free as possible of "fat" associated with unspecified contingencies. If people are given unspecified contingencies they will tend to use them, whether or not this is necessary.

It is important to identify contingency sums associated with all significant individual risks and a residual contingency for other unidentified risks to allow controlled adjustments from target figures to realised figures. As part of this process it is important to relate these contingency sums in an appropriate manner to expected outcomes, to budget or commitment outcomes which have an appropriate chance of being achieved, and to outcomes which will or will not happen.

For example, one project the author was involved with recently had a contingency provision associated with the expected cost of poor ground conditions given such conditions were realised, available to the project manager only if poor ground conditions were realised, a contingency provision associated with the unconditional expected cost of other sources of risk, and a further contingency provision associated with an uplift to the expected cost to provide the project manager with a reasonable chance of staying within budget. Corporate reserves set aside for this project based on unconditional expectations excluded the uplift which should not be needed on average, but included an expected cost provision for poor ground conditions.

Suitable target, expected and commitment values may involve successive uplifts to targets by 30 to 50 percent or more. Very different numbers are involved. Formal risk management procedures clarify what is involved. Without such procedures, there is considerable scope for confusion. This issue is every bit as important in the context of projects of interest to this audience as it is for major offshore projects.

5.4
Culture change

Controlled adjustments from target figures to realised figures as just discussed has important corporate culture implications, as does the explicit understanding of risk efficiency and risk/expected cost tradeoffs discussed earlier. They allow a clear distinction between good management and good luck, bad management and bad luck. For example, the hookup activity discussed in section 5.1 actually took place in late October during a period of good weather. Had the project manager argued for a 3m barge on quite sound intuitive grounds, his career might have looked quite different than it did in the light of the formal analysis, which justified the 3m barge decision and also made it clear he had done very well to achieve the hookup by October. If people have reason to believe they will be punished for being unlucky, they will not take risks, which will lead to higher expected and average costs than may be appropriate. Formal risk management processes ought to facilitate greater risk taking, to reduce expected costs and increase expected profits. This aspect alone may prove the most important benefit of formal risk management approaches.

5.5
Contractual arrangements

Contractual arrangements between a client and a contractor are concerned in a very central manner with who bears the risk associated with their joint or separate perceptions of what will happen over the life of a joint project. Formal risk management processes ought to be able to assist with the appropriate choice of contract, for reasons developed at length elsewhere (Chapman, Ward and Curtis, 1989). The author has yet to observe an example to cite, but this would seem a particularly important area for future research and development.

5.6
Clarifying “the big picture”

It can be very important to relate analysis of a specific choice to broader concerns of the organisation. The importance of such relationships may not be recognised if formal risk management procedures are not adopted.

For example, several years ago, the author was asked to assess construction cost risk associated with one method of recovering off-shore oil (say method A) with a view to comparing this with a relatively low capital cost but much higher operating cost and reduced revenue approach (say B). What soon became clear was the cost risk for A in itself was not an insurmountable problem, but approach A with a cost in the upper end of the likely range, in conjunction with a reservoir size at the lower end of the likely range, in conjunction with an oil price at the lower end of the likely range, could mean disaster for the whole organisation, not a reasonable possibility for approach B. The organisation managed a reduction in these combined risks for approach A, rather than choosing B. But the point being illustrated is they may have become aware of their overall risk exposure too late had they not adopted a formalized approach to what turned out to be only a component of their overall risk exposure.

5.7
Opportunities as well as threats

Common reactions to the possibility of imposed formal risk management procedures are "we will be overcome by doom and gloom", "we will suffer paralysis by analysis", "we will frighten ourselves to death, and never do anything". Properly conducted, formal risk management procedures should not produce these effects. They should be very much concerned with the identification and management of opportunities as well as threats, upside risk as well as downside risk. This is not just a question of taking more risk, as suggested earlier. It is also a question of identifying opportunities more effectively and more efficiently.

5.8
Creativity and lateral thinking

Further common reactions to the possibility of imposed formal risk management procedures are manifestations of concern about a mechanistic process which is boring and lacking in interest. Properly conducted, formal risk management procedures should not produce these effects. They should allow scope for creative and lateral thinking, searching out better ways to avoid or respond to risks well in advance of such risks being realised. They should allow the proper management of risk rather than the management of crisis. Put another way, if a formal risk management process isn't fun, it probably isn't being done properly.

6
Conclusion

This paper outlines what is involved when formal risk management processes are used, and indicates the nature of the benefits. It makes no attempt to explain how such processes should be established, and what is involved at a detailed level. These issues are dealt with elsewhere—for example, see Chapman (1990) or Cooper and Chapman (1987) as a starting point.

A crucial issue when adapting the approach developed for BP as described here to deal with an office block, a factory, a housing estate or some other project of direct interest to this audience, is where and how do we simplify, to reduce the effort and associated costs, without losing key benefits. Some guidance is offered in this paper, more in a paper specifically on this topic in a project planning context (Chapman, Phillips, Cooper and Lightfoot, 1985).

However much you care to read, or take advice from consultants, the first time you implement formal risk management will involve a lot of learning. To develop procedures which are efficient and effective over the entire range of your activities will involve movement down a number of learning curves, with important costs. However, the chance and the consequences of too much effort in this direction are negligible by comparison to the chance and the consequences of too little effort. Those who continue to do nothing at all will be most at risk.

Research in this area to provide guidance to the community as a whole cannot be theoretical. It must be applied, involving experimentation by those who are willing to try new ideas and approaches. To the extent that such research provides competitive advantage, those who undertake it might not be willing to share what they have learned. However, the author's experience with those developing new approaches to risk management in other areas suggests this should not be a problem. Indeed, if you start a special interest group in this area to encourage dialogue, communication should not be a problem at all. Another device you might consider is a sponsored research project concerned with one organisation's approach to one kind of situation as a demonstration of what might be done, or a small set of situations like this, with all interested parties funding the study.

7
Acknowledgements

This paper is based upon a presentation developed for IBM UK Limited, presented to their senior management as part of the 1989–90 Forum 2 programme some 50 times, initially by the author, subsequently by the author or departmental colleague Stephen Ward. A similar presentation has been adopted as the opening session for a one day seminar on risk management by PERAC for MOD Procurement Executive project managers. This is the first written version of the material.

Figure 1 is reproduced with the kind permission of John Wiley and Sons, from Chapman, Cooper and Page (1987) .

8
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WHICH ESTIMATING TECHNIQUE?

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Abstract

This paper presents a unified view of the relationship between (1) quantity and (2) price generating mechanisms in estimating individual prime construction costs/prices.

A brief review of quantity generating techniques is provided with particular emphasis on experientially based assumptive approaches and this is compared with the level of pricing data available for the quantities generated in terms of reliability of the ensuing prime cost estimates. It is argued that there is a trade off between the reliability of quantity items and reliability of rates. Thus it is shown that the level of quantity generation is optimised by maximising the joint reliability function of the quantity items and their associated rates. Some thoughts on how this joint reliability function can be evaluated and quantified follow.

The application of these ideas is described within the overall strategy of the estimator's decision—"which estimating technique shall I use for a given level of contract information?"—and a case is made for the computer generation of estimates by several methods, with an indication of the reliability of each estimate, the ultimate choice of estimate being left to the estimator concerned.

Finally, the potential for the development of automatic estimating systems within this framework is examined.

Keywords: Estimating, Generation, Reliability, Techniques, Automatic Systems.

1
Introduction

It has often been said that the straightforward use of computers to simply replicate manual processes may not always be the best approach to computerisation and automation in any field. In order to examine the possible consequences of this in the computerisation of cost evaluation activities it is necessary to consider in greater depth of the underlying concepts and structures of construction cost/price estimating techniques (CCPETS) generally. Two recent independent analyses (Newton, 1990; Skitmore and Patchell, 1990) aimed at classifying CCPETS arrived at quite different results, indicating a lack of theoretical basis and the general need for more work in this area.

The aim of this paper is to develop some of the more obvious ideas contained in this previous work, in terms of the perceived present structure of estimating systems as they have evolved from older manual approaches, into a generic model of CCPETS for use (a) in providing an initial theoretical structure for understanding the fundamental nature of existing CCPETS, (b) to enable the identification of potential new CCPETS, and particularly (c) as an aid to selecting the most appropriate CCPET for a particular estimating task.

2
Design economics

Prime cost estimating is considered here as a part of the general domain of **design economics,** which is essentially an investigation of the general model:

$$ED = f(B_i, DB_i) \qquad DB_i \le A \qquad (1)$$

where ED represents an economic design objective (profit maximisation, satisfactory returns, etc.), B represents the perceived benefits (income, satisfaction, etc.), and DB the perceived disbenefits (expenditure, costs, dissatisfaction, etc.) accruing from design alternative i, subject to the DB being less than or equal to the level of affordability, A.

For practical purposes, B and DB are usually considered to be on a continuum, represented by a single scalar (eg., utility analysis) or vector of measures (eg., Multi Criteria Decision Making).

Difficulties surround the type and estimation of the measures that are appropriate for all the terms in the equation, DE, B, DB, A and f the objective function. In particular cost evaluation, as one of the relevant DB elements, suffers from an apparent informational paradox. In the early stages of design, when the major cost significant decisions are made (eg., floor area, plan shape, number of storeys and orientation) is a time when least information is available for compiling cost estimates. As the design progresses, information is released to the estimator and so estimates become increasingly reliable.

Fig 1 illustrates the position where both cost and value are being estimated as the design evolves. Value is recorded as a positive benefit, costs as a negative benefit. Here the reporting system informs on the likely consequences of design decisions as they are being made. Fig 2 indicates the expected level of reliability of the cost estimates involved. In the very early stages a typical coefficient of variation (CV) is 30%, narrowing to around 10 to 15% at tender stage.

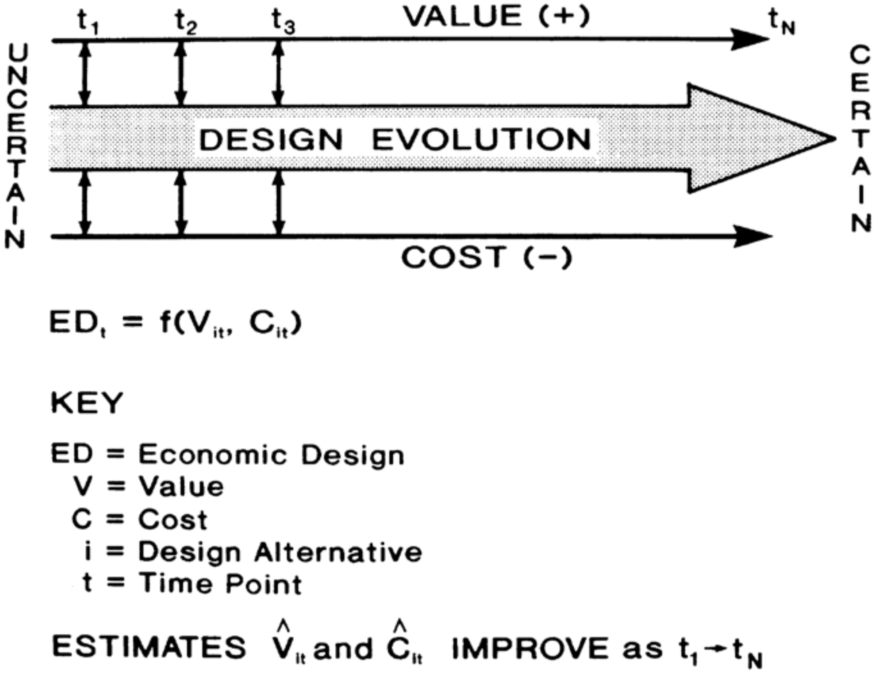

Fig. 1. Cost and value estimation

The importance of the paradox is that the highly important decisions made very early in the design, based on unreliable estimates, cannot easily be changed at a later date when more reliable estimates can be made. What is needed is a means of achieving greater estimate reliability in the early stages of design.

Two approaches are obvious (1) developing entirely new estimating techniques, or (2) using detailed estimating techniques (eg., bills of quantities, process based) in the earlier design stages. The second of these approaches is developed in this paper.

3
A general model

A convenient starting point is the basic building blocks of all formal CCPETS—items, quantities, and rates—which provides the model

$$P = \sum_{i=1}^{n} q_i r_i \qquad (2)$$

where P represents the total cost/price, q and r are the item quantities and rates respectively, and the subscripts (i=1, 2,…, n) denote the items involved, with n being the total number of items.

Clearly the calculation of P depends on two main factors, (1) identification of the items, i, and (2) estimation of the parameter values, q and r. This implies that

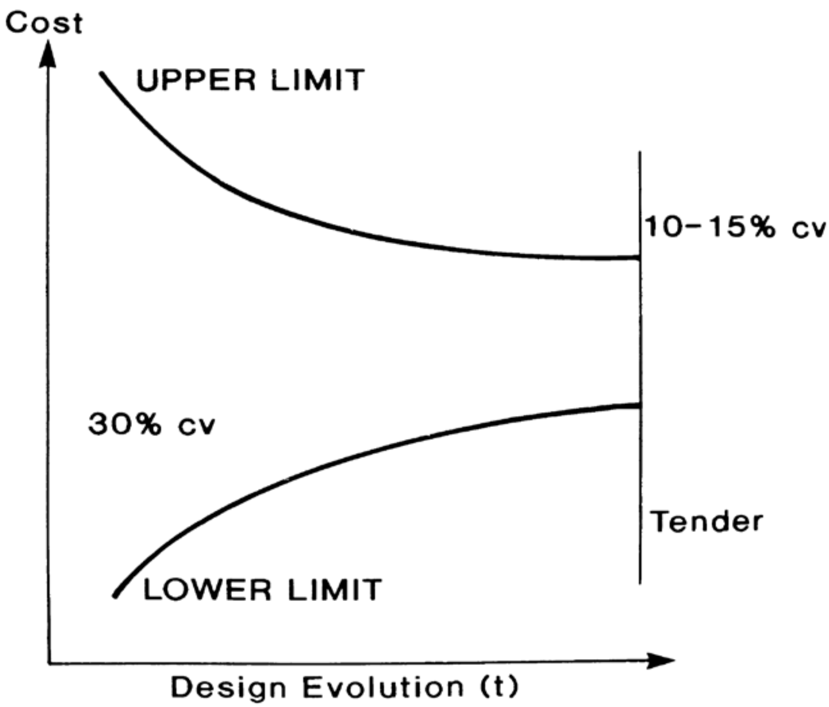

Fig. 2. Reliability of estimates

the accuracy of estimates of P are dependent solely on the combined accuracy of these two factors.

The emphasis in standard texts is on the accuracy of item quantities as the determining criterion for CCPETS selection, on the principle that all estimates must contain near perfect item quantity estimates. What is clear from the foregoing argument however is that the accuracy of item rates should also be taken into account. Very accurate quantities combined with very inaccurate rates for example may well produce less accurate total estimates than fairly accurate quantities combined with fairly accurate rates.

Another possibility is that the use of greater numbers of items may result in accuracy improvements, even when combined with inaccurate quantities and rates. Indeed there are some strong statistical arguments in favour of just this approach (Beeston, 1983).

The implications for computer aided estimating centre on the processes by which these items, quantities and rates are generated.

The next section describes some of the relatively recent advances in these fields.

4
Estimate generation

4.1
Item generation/identification

The standard manual approach to item generation is prescribed at length in many text books on the subject. These may be either 'work in place' (product) or resource (process) based.

4.2
'Product' based methods

UK practice is dominated by various product based 'Standard Methods' of measurement which are usually set within the legal framework of the construction contract. Modern computer 'taking off' systems use a 'menu' approach, which requires the user to select items from a menu provided by the computer—an essentially manual process. Several computer systems currently perform this function either semi automatically (eg. Calculix™) for a full range of building types, or fully automatically (eg. Holes and Thomas, 1982) for a restricted range of 'system' type designs.

Problems however start to occur when design information is incomplete, a frequent occurrence in UK practice. In this situation, a popular manual approach is to generate items by making an informed guess at the likely design decisions in advance of their being made. An automated version of this approach is the ELSIE expert system (Brandon et al, 1988) which is capable of assuming such design features as the number of storeys, type of H&V system, etc., from very basic design data.

4.3
'Process' based methods

Several process based item generating systems are currently under development (Hendrickson *et al,* 1987; Bremdal, 1987; Ibbs and De La Garza, 1988; Navinchandra *et al,* 1988; Alshawi and Jagger, 1989; Formoso and Brandon, 1990) using expert systems technology, although very few are available commercially as yet. Some of these systems attempt to generate plans of construction' site activities from basic design data, usually in the form of 'elemental' information concerning walls, floors, roofs, etc. Compared with product based systems such as ELSIE, these advanced process based methods are essentially second generation systems, relying on (1) the conversion of design data into elemental format, and (2) the conversion of this elemental data into production activities for subsequent scheduling.

4.4
Quantity generation

Quantity generation is perhaps the easiest task of the three considered here, certainly for a computer. Digitizers, provide the simplest form of mechanisation but of course they need a literally big helping hand from the user. All the item generators mentioned above have quantity generation, although ELSIE is the only system which makes informed guesses of this nature.

Some early work on automatic quantity generation from drawings is by coordinate referencing (Ferry, 1970) although this was restricted to concrete work. Recent developments in CAD estimating however suggests this to be a major growth area.

Another type of quantity generator for process based estimates is the stochastic simulation system (Bennett and Ormerod, 1984) in which time quantities are obtained by repeated random sampling from either empirical or subjective probability distributions. The need for the user to input estimates of the distribution parameters makes this less than a fully automated system, but the facility to model uncertainties in this way makes the system unique as a quantity generator.

4.5
Rate generation

The most popular form of manual rate generator is the product or process based 'price book' or data base, where the estimator simply matches the item description in his take off with an identical one in his data base. The problems with this approach are well known. Costs for identical products and processes vary from project to project depending on a host of circumstances, and contract prices are influenced greatly by work loads and general market conditions.

Despite a substantial amount of research in the UK at least, very little progress has been made to establish a suitably reliable mechanism for generating item rates. This has lead to a greater current emphasis on the investigation and modelling of reliability itself usually through stochastic simulation of product based rates (eg. Wilson, 1982; Baxendale, 1984).

A further problem is that cost-price databases are as yet insufficiently comprehensive to allow fully automated of rate generation. What seems to be needed is a set of algorithms that will generate rates without having to build a vast database. The little research on this problem that has been done to date is encouraging and suggests that fairly accurate rates (ie similar to standard 'product' type price books) may be generated with a relatively small data base (Skitmore and Smith, 1990).

5
Quality of estimates

Before considering the combined effects of the reliability of the three estimate components outlined above—items, quantities and rates —on overall project estimates, some mention should be made of the known factors that influence the quality of estimates generally. Five types of influences have been identified (1) the type of project, (2) the information used, (3) the technique used, (4) the estimator himself, and (5) the feedback system (Skitmore *et al,* 1990). Each of these five influences have an effect on each of the three estimate components.

Remembering that we are concerned here with estimate reliability or accuracy rather than estimate generation, Table 1 summarises some of the connections that have been made. The availability of information concerning a new project clearly affects the reliability of item selection and its quantity. Little is known however of the effect of the characteristics of the project, estimator or feedback on the reliability of item and quantity generation.

The reliability of item rates, on the other hand, are known to be significantly effected by the characteristics of the projects (eg. rates for office blocks are more variable than, say, factories), information (eg. out of date cost data bases are less reliable than current databases), estimators (different estimators have different views on the most appropriate rates), and feedback (better feedback is usually considered to provide more accurate rates).

The effect of estimating techniques on the reliability of the estimate components is a little different. As it is normally recommended to use a technique which fits the information available, item selection and quantity generation is considered to be totally accurate, the only source of inaccuracy being in the rate. This immediately suggests an anomaly—why should the technique, of all influences, be different? There seems to be no theoretical reason why this should be the case. The attempt to reduce risks in the technique by restricting the use of the technique to apparently non risk situations, although a good practical expedient considered in isolation, is certainly questionable when the estimating process is considered as a whole.

Table 1. Estimate components and influences

Influence	Component		
Item	Quantity	Rate	
Project	?	?	X
Information	X	X	X
Technique	X	X	X
Estimator	?	?	X
Feedback	?	?	X

x known influence, o supposed influence, ? unknown influence

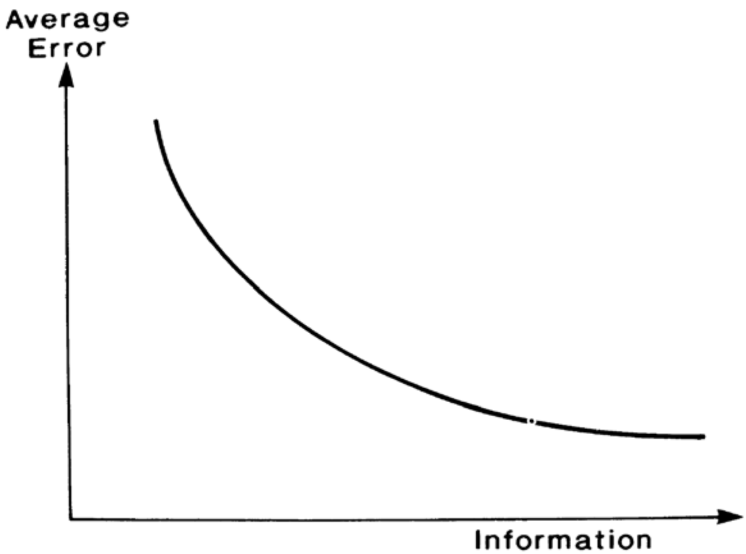

Fig. 3. Effect of design information on estimate accuracy

To consider the situation as a whole involves the examination of the combined effects of the influencing factors—projects, information, techniques, estimators, and feedback systems—on the combined estimate components—items, quantities, and rates. Of course this is not an easy task as there are 5×3=15 combinations of influencing factors and estimate components even assuming they are independent. To take into account interdependencies would involve a further (5+3)=8 factorial (40320) possibilities, a logistically impossible empirical investigation!

For the moment we will consider just one set of combinations—product based techniques, information, and the total estimate. Fig 3 shows the well known relationship between the level of information known about a project and the average estimating error in terms of the percentage difference between pretender estimates and lowest bid received. Here the average error reduces asymptotically with the provision of further information.

However, it is apparent that the estimating technique changes stepwise as the level of information becomes appropriate to that technique. Fig 4 shows the situation. The more cruder techniques such as the UNIT method are used where design information is minimal, but progressively increasing in accuracy as more information becomes available. As further information is received, the estimator switches to a more refined technique such as the FLOOR AREA method, which again produces increasingly accurate estimates with further information. This then switches to an even more refined technique such as APPROXIMATE QUANTITIES, with similar effects. Finally the BILL of QUANTITIES (BQ) provides the most accurate of all product based techniques, but still dependent on

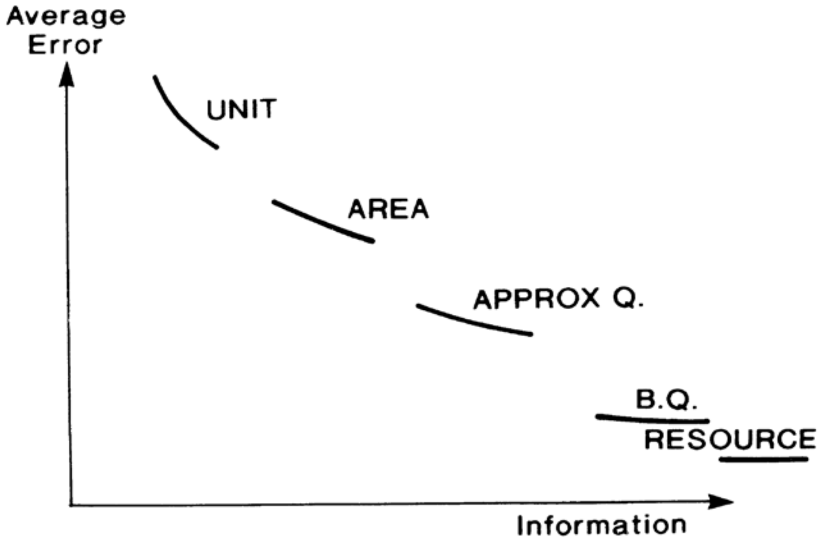

Fig. 4. Effect of estimate technique

the level of information provided. As a result, the smooth curve shown in Fig 3 is seen to be really more a series of discrete smaller sub-curves, each related to the technique used.

Of course we have very little data which allows us to predict the accuracy of a technique if it was used outside its usual information level range. Conventional wisdom suggests that each technique is used optimally (Fig 5) so that the best possible accuracy is obtained commensurate with the level of information available. By extrapolating the sub-curves outside the usual range of application, the optimal range is denoted at the crossing points of the curves. An alternative view is that shown in Fig 6 which suggests that, with more optimistic extrapolation, techniques normally associated with high levels of information may be optimal much earlier than is currently imagined.

The lack of data on the subject certainly restricts our judgement on the choice between Figs 5 or 6 at present, although it is clearly an empirical issue that can be tackled experimentally, if not in practice.

At this moment we have to rely on analyses at the estimate component level as illustrated in Fig 7. This shows the accuracy of rates (R1, R2, R3, R4) and quantities (Q1, Q2, Q3, Q4) for the UNIT, AREA, APPROXIMATE QUANTITIES, and BILL of QUANTITIES techniques respectively. The accuracy of the rates for each technique can be treated as constant irrespective of the level of information, hence their representation as horizontal lines in the diagram. The accuracy of the quantities however, generally unknown outside the usual field of application, are shown here as smooth shallow curves. The crucial combination of the two components—rates and quantities—is all that remains.

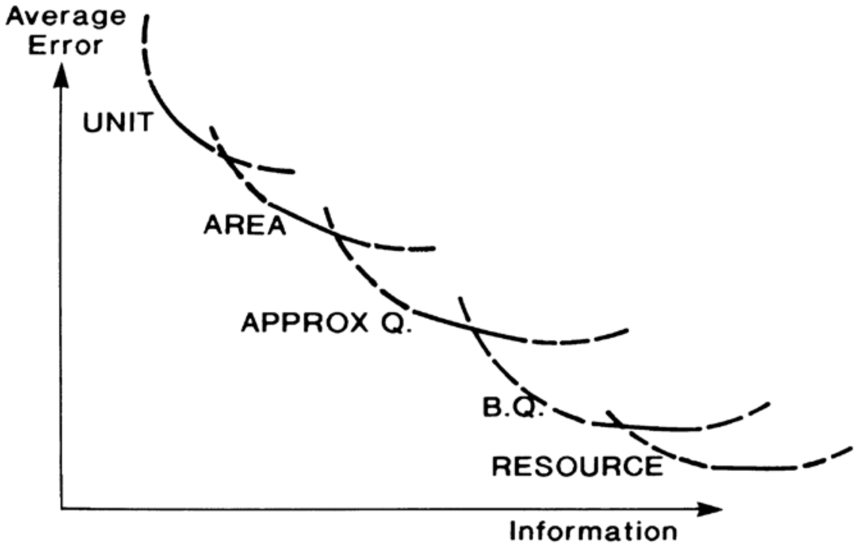

Fig. 5. Extrapolation (1)

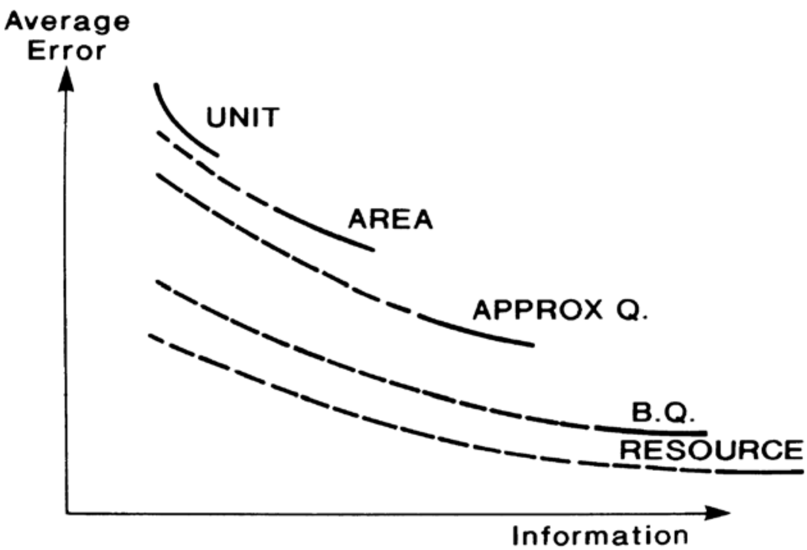

Fig. 6. Extrapolation (2)

6
Reliability

Supposing all estimating techniques were currently being used at all levels of information, how could each technique be assessed for reliability? Standard multiple regression analysis (MRA) provides one approach. As discussed above,

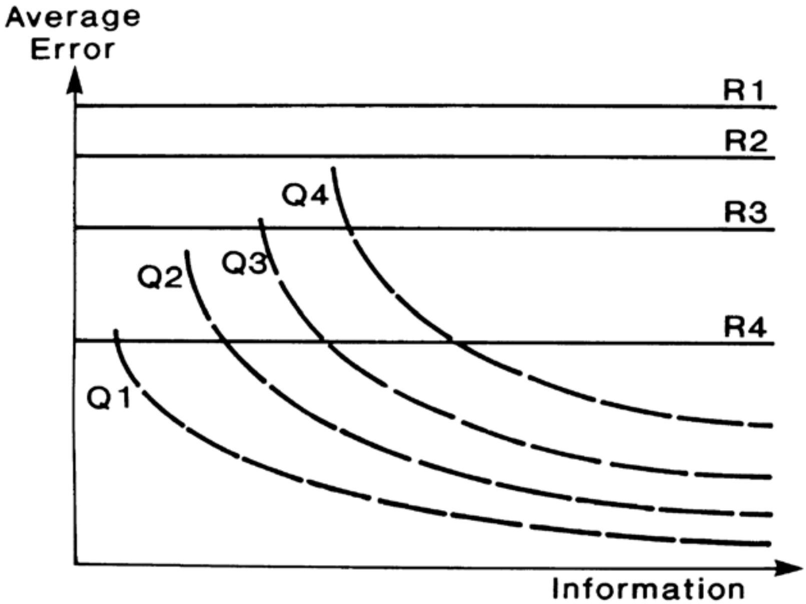

Fig. 7. Accuracy of quantities and rates

analysis of this kind is greatly inhibited by logistical problems created by the vast number of possible combinations involved. Fortunately, MRA has the capability of variable reduction by statistically identifying 'significant' and non 'significant' effects. Omitting non 'significant' variables form the equation should lead to a fairly simple equation of the kind:

$$E = a_0+a_1T_1+a_2T_2+...+a_nT_n+a_{n+1}I+a_{n+2}J_1+a_{n+3}J_2+...+...etc \quad (3)$$

where E is the expected error of the estimate, T_1, T_2, etc are the estimate techniques, I is the level of information available, J_1, J_2 etc are the type of project, etc. Therefore, given the estimate technique, level of information, type of project, etc., it should be possible to predict the likely resulting error.

Depending on the measure of accuracy used (eg. percentage error, mean deviation, root mean square, standard deviation, coefficient of variation), the prediction may be one of bias or consistency. In general, consistency is harder to handle than bias, but iterative methods are available if required.

7
Automatic estimating systems

Some suggestions have been made recently (Gilmore and Skitmore, 1989) concerning the discrete nature of the various estimating techniques used in practice and the resulting discontinuities between techniques and associated rate data bases. Considered at the limit, **it is now certainly technologically possible**

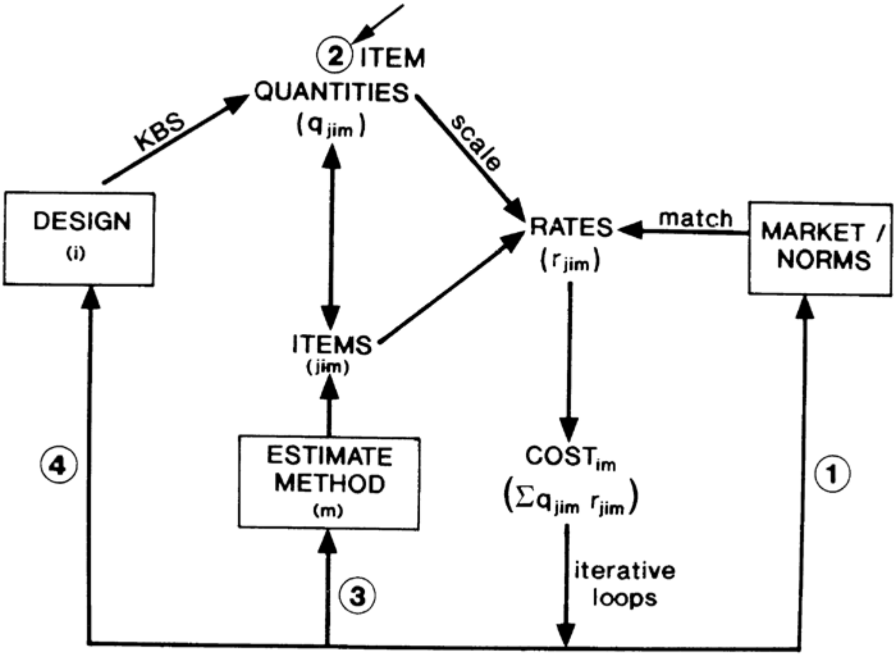

Fig. 8. Automatic estimating system

to conceive a system which automatically generates process based estimates directly from minimal design information (Marston and Skitmore, 1990). As yet we have no evidence of the reliability of estimates that may be produced by such a system but, if approached in a non deterministic way, reliability measures will be easy to obtain.

Fig 8 illustrates the general form of automatic estimating systems. For a given design, i, a knowledge based system (KBS) generates items and quantities for a given estimating method, m. These are matched to a data base of market or norm rates, adjusted for scale, and the results summed to a total contract price estimate. To gain an impression of the reliability of the estimate, rates can be sampled by stochastic simulation, as also can the quantities. This process may be repeated for further estimate methods for comparison, and for further designs in search of an optimal or best solution.

8
Conclusion

The main conclusion of this analysis is to urge the use of various estimating techniques, especially detailed estimating techniques, in different circumstances to those currently recommended. The use of computers means that a battery of techniques may be applied to the same estimate at very low cost to the estimator. Research in expert systems shows that assumed items and quantities do not necessarily result in poorer estimates than the usual early stage estimating techniques. The reason is that detailed estimating techniques use more reliable rates which, when combined with even very approximate quantities, can still produce reasonably accurate results.

The title of the paper suggests that the selection of the 'best' estimating technique is possible and of interest. Though by no means a simple task in itself, an approach has been outlined which may make this possible. By inputting the type of project, level of information available, the estimator, and the feedback system used, it is theoretically feasible to predict which technique will give the 'best' figure. Furthermore, if, instead of one estimate, several estimates are generated, each with an indication of its reliability, it should be possible to devise a means of combining estimates to one that is even more reliable than those generated individually.

More importantly however, for researchers in the field, the approach described should lead to a better and more analytical treatment of the subject by standard empirical research methods.

9
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Part Three

Building Performance

Evaluation

FACILITIES MANAGEMENT

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Abstract

Facilities Management is a term which has been defined in several different ways. The definitions express a growing concern that the management of large, complex buildings, or stocks of buildings requires a comprehensive view of the costs and benefits stemming from the occupation of the stock.

The achievement of operational efficiency, and fitness for purpose, are fundamental aims of the Facilities Management role, which can consequently be potentially very broad.

The paper discusses some of the background to Facilities Management, and its growth worldwide. It presents an overview of the scope and aims of Facilities Management and discusses the nature of data required to discharge the Facilities Management role effectively. Attention is drawn to the inadequacies of many current property information systems, and suggestions are made to improve the effectiveness of the management of built assets.

Keywords

Facilities Management, Property Management, Estate Management, Life Cycle Costs, Built Assets, Maintenance.

1
Introduction

Facilities Management is a term which encompasses a wide range of activities involved in the effective management of built assets. Facilities Management has already achieved recognition in North America as a profession and, in a short space of time, has been taken up in Europe and the Far East. In some countries the previous absence of a clearly recognised property management professional body has been a major factor in the adoption of the concept of Facilities Management. However, in some other, particularly European, countries the management of property has been recognised as a coherent professional function for some time. What has not tended to be acknowledged is the potentially comprehensive view of property management which is at the root of the Facilities Management concept. I am indebted to Kreon Cyros of the Massachusetts Institute of Technology Office of Facilities Management systems for pointing out the following definition of Facilities Management.

> "The practice of co-ordinating the physical workplace with the people and work of the organisation, integrates the principles of business administration, architecture and the behavioral and engineering sciences."
> (US Library of Congress 1988)

This definition is very broad but it relates to many of the people 1 have met who practise Facilities Management in North America, who come from a business management, architecture or plant engineering background. I have also noticed in other countries that Architects have been amongst the first people to realise the potential of Facilities Management, although it is fitting that in the U.K. context this paper is delivered to a Chartered Surveyors' conference. Whilst surveyors are clearly in a good position to discharge the Facilities Management role, I believe that this is a field which resembles Project Management, insofar as the background of potential practitioners is not limited to one profession. Like Project Management, successful Facilities Management needs a wide scope of knowledge and experience, and an appropriate range of personal qualities.

I have been conducting a survey on Facilities Management for the international research body C.I.B. and I was interested to receive a letter from the Euro FM group which gave a definition of Facilities Management. As I have had this translated from the German I hope that it truly reflects their views:—

> "Overall strategic framework for co-ordinated programmes in order to complete buildings, their systems and contents, keep them functioning and adapt them to varying organisational requirements. Thus highest quality of use and maintenance of value will be achieved."
> (Euro FM 1990)

This is interesting as it gives greater prominence, than the previously noted definition, to the building and its functioning, related to long-term value. Dr. Frank Duffy of DEGW Architects, London, in comments to me believes that the growth of Facilities Management has been spurred by demand-side thinking, related to the deficiencies observed by building users; and that a supply-side property orientated viewpoint is not necessarily the major interest for Facility Managers. However, whichever definition of Facilities Management we favour, and of course there are others, it seems clear that Facilities Management provides an umbrella term under which a wide range of property and user related functions may be brought together; and I shall seek to indicate in this article some of the factors which might raise its profile in the U.K. and the rest of Europe.

2
Why Facilities Management?

The suitability of buildings for their purpose is becoming more important to employers as interaction between buildings and people becomes more overt. Large, highly serviced, even "intelligent" buildings operated in expensive locations, in many cases by multinational corporations, have focused more interest on their efficient operation. Departments which are being charged by top management for the space they use are becoming more aware of quality and performance of their accommodation; and the growth of technology in business operations has focused attention on the building as a resource which should be adaptable to changing space and servicing needs.

Many consultants are thinking in terms of life cycle costs of property operation as being the main concern of their clients, and I would like to briefly examine this viewpoint.

Although property costs are not necessarily high when compared with other costs in an organisation, particularly the staff salary budget, they nevertheless can be a significant item of expenditure. The running costs of property may look like the undernoted: -

	Percentage
Energy	26
Maintenance	14
Cleaning/caretaking	34
Rates and rent	20
Other costs	6
	100

Source: Audit Commission/SCALA report

Thus, measures designed to optimise energy consumption, maintenance, and cleaning and caretaking costs, may impinge upon three quarters of the running costs. Improvements may not be expensive, but might result in improved efficiency with significant cost savings. The existence of active Facilities Management may help to identify potential problems with maintenance and running costs before they result in component breakdown and even temporary shutdown of buildings.

To consider factors as tabled above is only part of the Facilities Management equation, particularly where salary costs are relatively high and the potential contribution of property to overall efficiency of the organisation may be hidden, but possibly much greater than expected. Layout, adequacy and servicing of space clearly has production and efficiency implications for manufacturing industry, and it is being increasingly realised that similar considerations apply to office and other types of workspace. The messages that space and its planning, furniture and equipment, together with staff amenities, send to staff can be powerful, even if not always understood by management. Also, the goals and priorities of management are not necessarily reflected in the way they allocate and manage space. Additionally, we know that at the level of day to day management of buildings, the existence of problems such as poor electrical socket location, inappropriate insulation, lack of ventilation, poor maintenance, dampness and inefficient lighting, are often contributory causes of VDU strain and sick building syndrome, poor morale, sickness and reduced efficiency in staff. Such inefficiency can be expensive to a large employer.

The aim of Facilities Management therefore is not just to optimise running costs of buildings but to raise the profile of the management of space and related assets for people and processes in order that the goals of the firm may be achieved at optimum efficiency and cost.

3
Growth of Facilities Management Internationally

At the first International FM Association Symposium in Washington D.C. in May 1989 [1] delegates attended from the United States and Canada, Australia, United Kingdom, Japan, Netherlands, Switzerland and Germany. In the U.S.A. and Canada two organisations were identified, the IFMA of United States to which Canadians also belong, and the Federal Inter-Departmental FM Association of Canada. There are a number of Facility Management training programmes available in the U.S.A. and undergraduate and master degree programmes in Facilities Management are being established, in some cases supported by vendors and design consultants. There is a branch of the International Facility Management Association in Australia formed in 1988, and in 1987 the Facilities Management Sub-Committee of the National Committee for Rationalised Building organised a Facilities Management Conference which stimulated developments in that country.

In the case of Japan, personal observation suggests that they are taking the FM function very seriously. The Ministry of International Trade and Industry helped to promote a New Office Promotion Association in 1987 which carries out research into office environments and design. The Japan Institute of Architects and Building Contractors Society have formed Facility Management Study Groups and the Ministry of Construction organised an Intelligent Building Research Committee. The Japan Facility Management Association has undertaken investigation into the provision of courses for Facilities Management and NOPA has also been energetic in this respect.

In the case of Germany, as in U.K. and the Netherlands, it was felt that the situation was not the same as some other countries in that many of the FM functions are already carried out by existing professionals. Therefore it was felt by some people that perhaps an extra professional was not required but there was a need for a recognition by top management of the integrating nature of Facilities Management functions. The Netherlands Facilities Manage-ment Association was founded in 1989 and has helped to set up Facilities Management courses. The emphasis is strategic as opposed to tactical, it being less concerned with questions dealing with techniques of how to design, implement or run facilities.

In the United Kingdom the first British Facilities Management Conference was held in June 1984 and discussions subsequent to this led to the foundation of the Association of Facilities Managers (which is not the only group with interests in the topic). As far as Facility Management education in the United Kingdom is concerned, there is a gradually increasing interest in the pro vision of short courses and post graduate work. At the conference on Facilities Management at the University of Strathclyde earlier this year a decision was taken to link some European Facilities Management bodies together in a group called Euro FM. Increasingly, Strathclyde University together with Bristol Polytechnic and one or two other institutions, as well as providers such as Facilities Training of London, are providing education in the field. I would therefore expect to find Facilities Management forming part of a property related module in many undergraduate courses in the relatively near future in the United Kingdom.

I hope that I haven't offended anybody by omission because it is clear that there are other organisations in different countries and other definitions of Facilities Management which I haven't mentioned.

4
The Scope of Facilities Management

A comprehensive Facilities Management strategy will involve all of the elements which many practitioners in the United Kingdom might see as coming under the heading of strategic property management, plus some other essential elements. It will require an understanding of how the corporate mission might be translated into an overall view of the operations of the organisation, which in turn must be considered in relation to the use of property and related services and equipment. Therefore effective Facilities Management cannot be undertaken in the absence of a corporate strategy, based upon a mission and goal statement which leads into medium and long term planning for the use of property. It also requires of course a system for the monitoring of the use and efficiency of the property and in many large organisations this also involves the identification of needs for additional property, or the identification of redundant property which can be disposed of to the benefit of the cashflow of the organisation.

A significant problem which has been addressed by many large organisations not least being County Councils and large Housing Authorities, is the problem of access to data. In many cases data on property are held by a variety of departments in an organisation and thus planning of the future use of accommodation according to demographic or expected business trends will not be related to a clear view of the operational costs and expected life of existing property. This problem is addressed in the next section, but the scope of Facilities Management can be gauged by means of typical checklists which can be found in much of the literature [2] and frequently involve broad headings such as noted below:-

Mission statement and goals.
Forecasts of direction of company business and staffing.
Consequent long term space forecasts.
Medium term space need forecasts.
Financial forecasts and projected budgets for space.
Property acquisition and/or disposal plans, planning of moves.
New build, rehabilitation, and conversion plans.
Equipment planning.
Annual maintenance and conservation budgets including work in respect of health and safety.
Planning and re-planning of interior spaces and workplaces.
Interior finishing and furnishing.
Business support services such as telephones, fax, reprographics, word processing networks, internal mail, security, and day to day building maintenance.
Monitoring management and staff/customer satisfaction with environment.

5
The Scope of Data Required for Facilities Management

The nature and extent of data required for comprehensive Facilities Management is such that they are not necessarily going to be held in one department. However, the discharge of the Facilities Management function does require that data are compatible and capable of exchange between holders and different levels of management. It is likely in setting up a Facilities Management data system that organisations will build on existing data systems. There is much to be done in this respect and as an example the author has proposed a diagram [3] in Figure 1 which illustrates the desirable relationships between building maintenance budgeting, the recording of cost data, and the property file and condition file systems. These relationships are currently the subject of a research contract which is being undertaken by the author and colleagues [4].

Property managers will recognise the difficulties of achieving compatibility between the elements of the system illustrated without necessarily extending the system further.

However, in any organisation with a high turnover of the use or ownership of space, referred to in the U.S.A. as a churn rate, it is generally recognised that the sensible way forward to plan the property file system is to use a computer aided

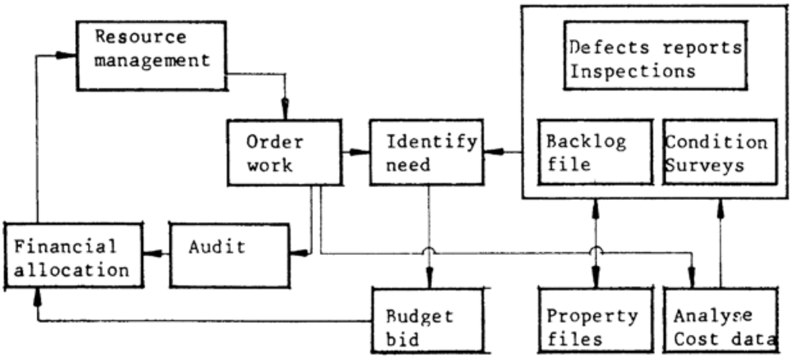

Figure 1

design system. Thus the use of space, the location of staff and equipment can be readily recorded. In this respect it is not uncommon practice in the United States to label all rooms and the equipment therein with bar codes so that these can be read with a light pen and hand-held computer, and inventory data may be put direct into a mainframe computer. Clearly the expense of undertaking regular suryes of this type would not be justified in many organisations, but where the policy of the organisation is to charge departments with space and equipment they use, it can provide a rapid means of updating information. Such data can then be co-ordinated with day to day maintenance and minor building work information to provide an indication of the outlay on an individual department or groups within departments.

A significant advantage of a comprehensive cost recording system is that it will be tied into the annual budgeting arrangements and therefore the use and costs of space will be reviewed at regular intervals. In order to obtain the necessary information the co-operation of staff is necessary at all levels. They must understand the objectives of the Facilities Management department or function, and must feel that they also receive a service from it. They should receive information on operational efficiency, energy planning and management indicators, such as comparative information on the use of space. One of the major objectives of Facilities Management therefore must be to assess staff satisfaction with their work environment and to take remedial action where this is possible and economical.

Because the aims of many large firms are to retain key staff, attempts have been made to construct staff satisfaction profiles in order to measure the rather elusive questions of quality of building and its environment. The question always arises, of course, as to who is to judge the quality of the environment: is it management, is it staff, or is it for instance the public who come into the building? Nevertheless, it is suggested that satisfaction profiles may bear some relationship to operational efficiency indicators in some industries and organisations. Such information may be valuable to an organisation, particularly where they are briefing a design team on new buildings or on major refurbishment, and there are already examples of intelligent or high-tech buildings where the staff satisfaction with the environment is extremely low. Research has shown that increased employee involvement is associated with greater satisfaction with their work environment, and with savings on alterations which might come later because staff consider the environment unacceptable. [5] It may be suspected in some cases that the undertaking of surveys of user satisfaction on a scale ranging from very satisfied to dissatisfied has actually helped to improve staff relations; and although quantitative data are notoriously difficult to collect in respect of what is normally thought of as qualitative factors, the effort may be worth while.

I have indicated in this and the previous section some of those areas where data need to be collected, clarified and used to improve the quality of management of the building. In my experience with management systems, each organisation is different and requires data to be collected and presented in a different form. This is also likely to be the case with the Facilities Management organisation, in that it will differ according to the organisation being serviced. Factors such as the size of the firm, whether its management is centralised or decentralised, whether the buildings are centralised or dispersed, their number and size, the financial position of the organisation and its priorities, are important. The use of in-house or outside Facilities Management consultants can be considered but in all cases the different functions to be provided by the Facilities Management service should be clearly delineated. The scope for Facilities Management, however, is not only limited to large organisations, but can apply to any organisation which manages property. The Facilities Management service may be provided in-house in an organisation which has a large number of units of property, however small and dispersed; or a consultant Facilities Management service may be offered to a number of separate organisations, each of which does not necessarily own a large amount of property. An example of the former is the position which might be developing at County Councils and this is examined in the next section.

6
Property Management in County Authorities

County Authorities in England and Wales are responsible for a large range of properties but, as has been pointed out, [6] the bulk of the costs of maintaining and running property in a County Authority relate to schools. A new factor has emerged because the 1988 Education Reform Act provided for each Local Education Authority, based in the County Council, to produce schemes for the local management of schools. Subsequently the Department of Education and Science [7] required each Authority to produce schemes for the devolution of certain budget headings to particular types of schools. This has resulted in all primary and secondary schools being allocated budgets based on formula funding in 1990 and the requirement by April 1993 of delegation of budgets to all primary schools of a certain size and all secondary schools. Thus whilst the Education Authority still retains statutory responsibility for the education service in respect of policy and resources monitoring, the Governors in the chosen schools will have to set objectives and sub-divide the allocated monies for the Head Teacher to manage. The Audit Commission [8] requires Education Authorities to develop computer systems for management of schools' delegated budgets. The LEA is to specify records to be kept by schools, to satisfy their management and audit processes, using coding systems which classify expenditure under headings to be specified, school by school. This of course builds on the Audit Commission's previous requirements for County Councils to improve the data recording of the whole of their property, using computers.

The system operates by the general schools' budget level being determined by the Local Education Authority who keep control of certain items which are called mandatory exceptions. There are certain other items within limits which may remain with the LEA, and the balance of the general schools' budget, which is called the aggregated schools budget, is allocated to individual schools by formula. Thus the aggregated schools budget will cover staff salaries, premises costs such as fuel, rates, rent, emergency maintenance and caretaking as well as pupil related supplies and services. The repairs and maintenance element which is devolved to a school usually includes glazing, decoration, internal and external finishes, certain items of internal joinery, and maintenance of gutters. This places a new requirement on schools to manage finances, and of course a large proportion of Head Teachers will not have had experience of the construction industry, nor of the ordering or monitoring of building work in progress.

Whilst the extent of repairs and maintenance delegated to the schools under the present regulations may not be extensive, it may be that devolution will be increased in subsequent legislation. Concurrently, County Councils are having to cope with schools which may be opting out of the LEA system and these schools of course will be responsible for a much wider range of building related management. If present trends continue, and even accelerate, it may well be that schools maintenance which is by far the largest part of a County's maintenance budget will slip from their control to a large extent. Thus the parts of the property departments which deal with management and maintenance of county property may find much of their workload has disappeared. They may of course become subject to a form of budgetary control which approximates to privatisation. In such a climate it is clear that many current LEA departments could offer a comprehensive service to individual schools, whether or not they have opted out, which covers not only repairs and maintenance but all aspects of the efficient running of property. Thus the concept of Facilities Management may appeal to County Councils, and they could operate a consultancy service, not only for properties which are within the County Council but also for other property owners within their region. It is unlikely that a comprehensive Facilities Management service would be bought by such clients, but I suggest that some progress in the direction of Facilities Management by County Authorities is likely.

7
Conclusions

Facilities Management is a term which is already subject to different definitions and thus may be subject to misunderstandings. However, there is world-wide interest in the Facilities Management concept and such an embracing term has attractions to building users, as well as property consultants.

It can provide a disciplined framework for the examination of many of the relationships between design decisions and the satisfaction of the end user of the property, whether in economic or environmental terms. It also provides a framework for the review of user satisfaction as business and other circumstances change.

8
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BUILDING MAINTENANCE POLICY: NEBULOUS NEVERTHELESS NECESSARY

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Abstract

This paper explores some of the strategic issues facing building maintenance decision makers. The pressures on maintainers to adopt a sound building maintenance policy are greater now than ever before. These pressures are coming from various quarters, for example from the aspirations inherent in facilities management and asset management and from the emphasis in the last decade on Life Cycle Costing and the concept of the economic life of buildings.

This paper explores some of the strategic issues and identifies the problems of arriving at a sound maintenance policy amidst the uncertainties that exist in the field. It goes on to demonstrate that whilst the maintenance policy may be based on rather abstract assumptions it has paradoxically an important role to play in maintenance planning at the operational level.

Keywords: Maintenance Policy, Economic life cycles, Standards, Objectives, Timing, Costs, Priorities, Financing, Planning.

1 Introduction

It is evident that there is now greater emphasis on building maintenance and the need to preserve, restore and improve existing buildings. Whilst we have not nearly arrived at the position where we can feel reasonably comfortable about the level of importance building owners and users attach to Building Maintenance we are at least seeing progress in the right direction. It could be argued that part of the problem is brought about through a lack of understanding of a very complex subject and consequently the inability of construction and property professionals to provide clients, owners and users with good advice on how to look after their buildings efficiently, effectively and economically.

The first step in providing effective building maintenance is that of formulating a reliable maintenance policy which BS3811 defines as “a strategy within which decisions on maintenance are taken". Those responsible for building maintenance are faced with enormous difficulties at the strategic level as they are concerned with the building itself, its operation, its pathology, its performance etc. and with the wider issues associated with buildings as a facility, as a resource and as an investment. These concerns span the utilitarian objectives being emphasised in Facilities Management and also the investment aspirations of Asset Management.

It could be argued that the increasing need for a more scientific approach to Building Maintenance has accentuated the complexity of the subject. The supply of more data and more information, instead of clarifying and simplifying the situation, has heightened the difficulties of comprehension.

This paper examines some of the basic issues and problems associated with formulating a maintenance policy and whilst the focus is centred around the building maintenance strategist it cannot be over emphasised that the need to liaise with other property professionals is essential. Equally important is the requirement to analyse the disparate influencing factors and preceptions in formulating an appropriate maintenance policy.

2
Building Maintenance Defined

Building maintenance has been defined in many ways and if ever a term needed re-naming to reflect new definitions this is one. The term building maintenance is viewed in different ways by different people and problems of perception has dogged the industry for years. Probably the most appropriate definition for the purpose of this paper is that recommended by the Building Maintenance Committee (1972):

"Building maintenance is work undertaken in order to keep, restore or improve every facility, i.e. every part of a building, its services and surrounds to a currently acceptable standard and to sustain the utility and value of the facility".

Prior to this definition there was a lack of reference to improvement as seen in BS3811 (1964) which concentrates on retention and restoration. Whilst the Building Maintenance Committee's definition refers quite rightly to improvement as an integral part of maintenance it has been subject to some criticism. For example the CIOB (1982) argued that "a currently acceptable standard" was a compromise between need and resources and should read "an agreed standard". The absence of any reference in the definition to resources or more importantly to the lack of them has lead to difficulties over the concept of sustaining the utility and value. Earlier definitions did make reference to resources for example the Woodbine Parish Report (1970) on Hospital Buildings amplified the BS3811 definition to having due regard to "…the requirements of the NHS and resources available".

There appears in all definitions to be a reluctance to extend the maintenance remit. This is probably due to its historical development, methods of financing i.e. revenue and capital allocations and inter professional demarcations. Observing the process it seems absurd not to encompass in the management and planning of building maintenance all processes of work to existing structures be that small repair items or major repairs, alterations and improvements. It may therefore be appropriate to amend the definition and exclude the objectives of maintenance embodied in standards, utility, value and management of resources and simply say what it is namely:

"Work to existing buildings, their services and surrounds". This may promote a need for some other title other than Building Maintenance to be postulated. So be it, but we should not limit the purview of what we mean because of problems over semantics.

3
The Maintenance Policy

It is eminently sensible that before maintenance is carried out at an operational level that some form of strategy is mapped out as a basis for decision making. In the past the policy was a short term document of crisis proportions which sought to allocate little resources to satisfy a substantial need over a limited time scale of between one and five years.

The advent of terratechnology, which pursues the economic life cycle of physical assets, has increased awareness amongst clients and design professionals of the need to evaluate in design the cost of buildings throughout their lifetime.

Emphasis on Life Cycle Costing has brought about the need to solicit from maintenance experts and researchers reliable data and information in order to make the cost models more reliable and more accurate. It has also had the effect of increasing the cognizance given to maintenance and the need to manage the cost-in-use resources efficiently. It is also a contributory factor in helping to shift maintenance management vistas from short term planning to life cycle planning or, as many maintainers prefer to call it, whole life planning.

Before examining what is believed to be the essential features of a maintenance policy there is a need to clarify that what is being addressed is a strategy document from which all other sub-ordinate planning or policy documents may emerge. It is accepted that the maintenance policy in this context would probably have to be supplemented by more detailed information viewed over a shorter time frame. However there has been an acute lack of interest in long term planning in its true sense and its importance is now being recognised. For example the Audit Commission (1986) encouraged local authorities to adopt longer term planning and more comprehensive strategies for their council house maintenance.

The maintenance policy has to start with an assessment of three criteria.

1. Time Frame

2. Objectives
3. Costs

The policy will focus on what is to be achieved, over what period of time and at what cost?

3.1
Time Frame

Clearly if we focus on property as we would on any other asset then it is necessary to determine the optimal life of that asset or in the case of an existing asset the optimal remaining life in order to fulfil the objectives of economic efficiency.

If cost is no object then most assets in the absence of physical obsolescence could be repaired and components replaced indefinitely. Since cost is an object then it is economics which usually determines the physical life of a building often referred to as the economic life. The RIBA (1987) describes this as "the period over which the occupation of a particular building is considered to be the least cost alternative for meeting a particular objective".

What is therefore the economic life of a building and hence the time frame in which maintainers have to plan? It could be based on the estimated life of a building as perceived at the design stage i.e. the calculated economic life which Alexander (1987) states is dependent on the flexibility for changing usage or its "robustness" (i.e. the ability of buildings to adapt and provide performance over time) It could however be based on a particular owner's or user's point of view or interest. Templeton Plat (1986) attempted to determine a relationship between this "period of interest" and "preferred calculated life" in order to help understand the decision making process of clients and identified considerable disparity. In some cases the client's interest is much shorter than we would normally associate with the life of buildings. For example the period may be under ten years for a chain of supermarkets and DIY stores.

The identification of the economic life and hence the maintenance policy time frame is problematic. It may not be simply a matter of considering either the calculated economic life of the building or the owner's period of interest but a combination of the two.

For example an owner's period of interest may be only ten years but the standards of maintenance must be based on a longer time frame if his interests in property values (assuming there is a residual value) are to be protected. We then enter the realms of assessing the impact of maintenance on property values which is equally difficult to assess.

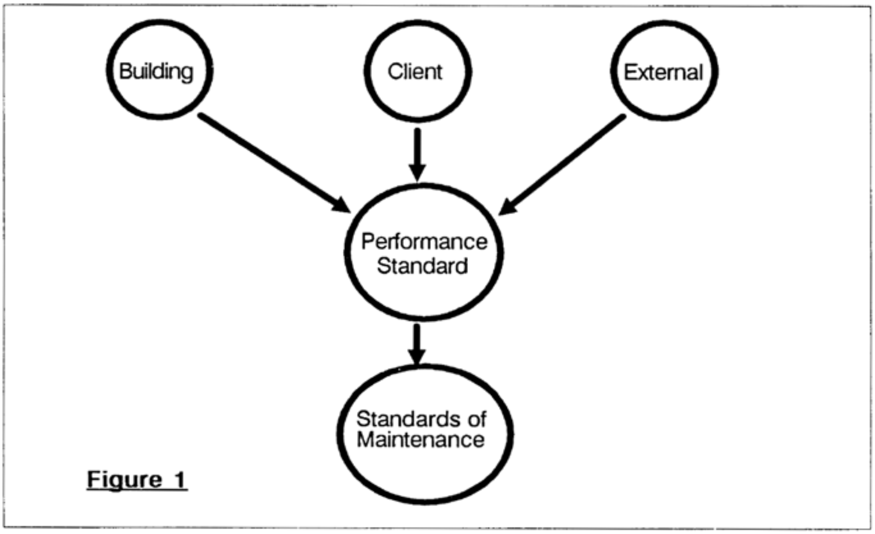

Figure 1

3.2 Objectives

The overall objective is contained to some extent in the various definitions as they refer to standards, utility, value and resources. What is required is work to existing buildings, services, surrounds etc. to achieve appropriate or agreed standards of performance at minimum cost. However before minimum costs can be identified the appropriate standard or standards of maintenance need to be determined throughout the established time frame.

It seems anomalous that considerable effort is given to assessing the suitability of a particular building design to meet specified objectives yet building maintenance continues to be carried out without a clear statement on what is to be achieved. This may have something to do with the pre-occupation with budget lead philosophies and trying to obtain maximum benefit from what is known to be insufficient resources. However if this situation is ever to be corrected it must start with a perceived goal, a "yardstick" on which to base existing and future levels of achievement.

Standards of maintenance is a difficult concept to grasp and needs to be housed in another, more tangible, notion. It is considered that this might well be standards of building performance which could be considered as the resultant standard derived from pressures from three sources—the building, the client and external influences. These are demonstrated in Figure 1 below.

Keith Alexander (1987) explores the need for an explicit statement of building performance at the outset of a conventional project and that the need for maintenance is the recognition of a shortfall in performance. He suggests that relating maintenance to building performance provides a mechanism for establishing priorities.

It is not possible in this paper to begin to attempt at providing a comprehensive list of considerations but a flavour of the considerations in each of the three categories is provided below.

The Building

The type and construction of each building will influence the performance levels through time. It should be borne in mind that we are not setting performance levels to design or re-design but attempting to set performance levels from within the constraints of an existing building. Certain works will need to be initiated if such levels are to be achieved. It is necessary not only to take into consideration the building elements, their design, technology etc. but also their functional performance i.e. what they provide to the user's environment. Lee (1981) identifies the "functional system" in regard to classification of maintenance costs. This may also be useful in assessing the functional characteristics of particular elements e.g. weather, security, safety, spatial etc. and their impact on desired performance levels. For example a small repair item such as a leaking rooflight may produce much higher indirect costs if rainwater damages a piece of processing plant than say a major structural repair with no indirect costs.

Client, Owner/User

Williams (1990) in referring to performance evaluation of office buildings refers to the client as the pivotal point which any evaluation must commence. It is vital that the maintenance policy recognises the client's objectives and understands what he is trying to achieve through his property. Williams (1990) suggests that a client profile should be determined taking into account his requirements associated with funding, cash flow, taxation and grant availability and suggests that client objectives may encompass: function; quality; image; flexibility; durability; energy efficiency; operating efficiency; cost. In some cases Facilities Management will represent the Client's objectives and input.

External Agencies

The external pressures outside the client's control and the nature of the building itself will need to be included in the analysis of building performance. For example availability of government grants may influence what is achievable in standards of accommodation through additional resources. The list of factors is again considerable and would include economic, political and social influences, legal and statutory requirements and restrictions etc. and taxation.

3.2.4
Analysis of Building Performance and Standards of Maintenance

Analysis of the required level of building performance to meet the client's value for money objectives requires careful consideration. The level of sophistication and complexity of analysis will depend on personal choice, resources available etc. and may involve detailed performance analysis modelling requiring the use of computers such as developed by BPRU at Strathclyde University, or it may be a much cruder and more subjective approach. For example the building appraisal may be a purely subjective approach advocated by Speight (1969) in his concept of a broad general appraisal of buildings but in this case it may be over a greater time frame than he envisaged.

The output that is required is an explicit statement of performance and standards of maintenance which will probably be a series of performances and standards when several buildings and several different uses are employed. Also what is needed is information on all maintenance works, cyclical, non cyclical, planned and preventive, as well as a yearly assessment for contingencies maintenance throughout the time frame so that whole life cost calculations can be undertaken.

Problems with existing buildings

It is appreciated that what may be described is feasible for a new or recently re-furbished building or even a building that has been adequately maintained. However if the condition of the building is already considerably below the required standard, i.e. in a backlog situation, then this will distort the analysis.

It is commonly accepted that backlog maintenance is better kept completely separate from on-going maintenance. To attempt to build-in the cost of bringing buildings up to standard may completely obscure the true maintenance resource requirements. It is also important not to base economic life demands on stock condition surveys. The Audit Commission (1986) recognised this and suggested that these, at best, could only provide an outline programme and cost estimate for, say, 10 years ahead and such surveys needed to be worked into a more comprehensive maintenance strategy.

The solution to backlog maintenance problems can only be achieved through additional resources. A separate strategy for dealing with back-log maintenance should be included in the strategic maintenance policy. Whilst it will need to be included in the same time frame senario and woven into the planning process the costs will need to be separate in that the policy needs to be explicit about two discrete aspects, i.e. what is needed to bring the buildings up to standard and what is needed in ongoing maintenance to achieve the standards required.

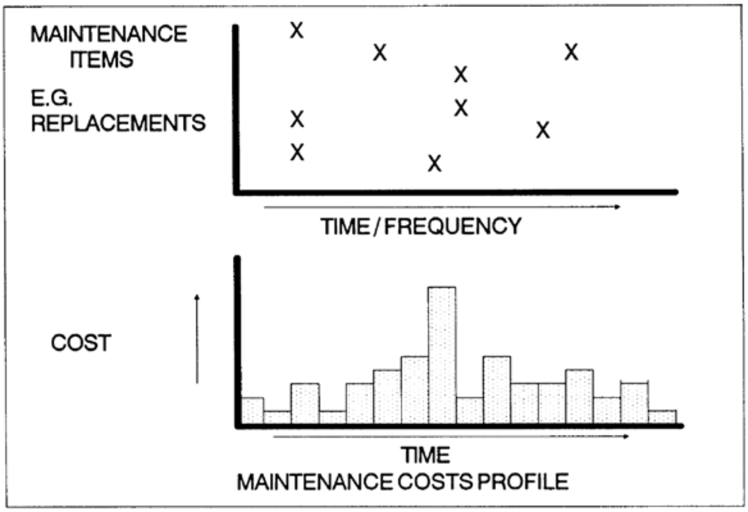

Figure 2

3.3
Costs

Having identified the performance standards and from this the maintenance requirements it is necessary to undertake whole life (economic life) costings. This is similar to life cycle costing in that all the anticipated maintenance works can be scheduled on a time frequency basis and a maintenance cost profile produced. See figure 2 below.

The cost profile can then be used to assess future costs and these can be discounted and annualised (annual amounts) as required to suit methods of financing. The same level of detail as life cycle costing and evaluation can be adopted in evaluation except it may be expedient to adopt a less precise method on the basis that the object here is not to compare alternative design strategies but to establish levels of maintenance financing.

Life cycle costing techniques are often criticised because of the difficulties in making assumptions on component performance, building life, inflation, taxation, technological changes, fashion etc. However it may be possible by moving away from the concept of initial cost, which life cycle costing in design cannot ignore to the notion of actual maintenance costs it may be possible to produce long term maintenance costs in the right regimes. This needs more work in research and practice and the author is very much aware that whole life costing can be seriously adrift. For example recent analysis of re-roofing work undertaken by the author showed that initial costs of components taken at todays prices can be a fraction of the maintenance work undertaken at replacement. See figures 3a and 3b.

It can be seen in figure 3a that the re-roofing costs were made up of 20% in remedying the inherent design problems in the building at parapet wall and roof

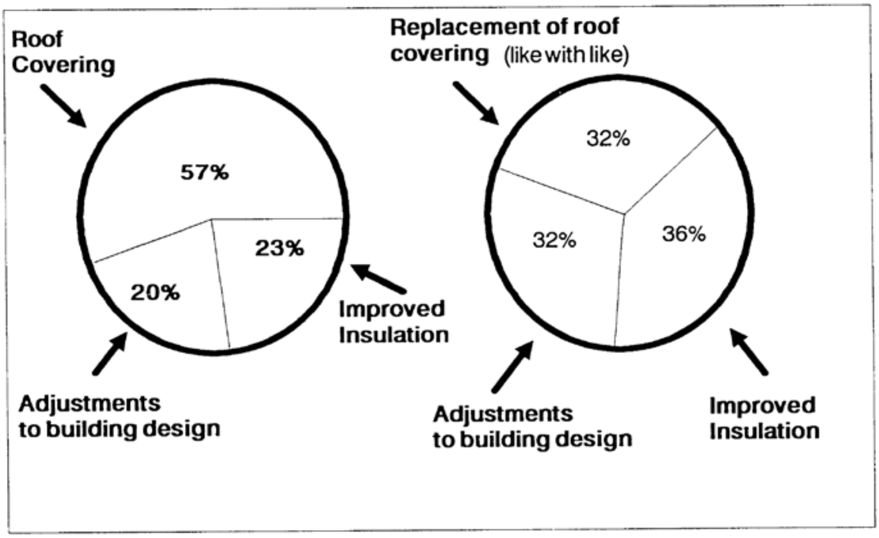

Figure 3a

abutment details, 23% was spent improving the thermal insulation standards of the roof and 57% on actual roof covering. However if we provide for replacing the roof covering with like for like, i.e. asbestos fibre based felts as against a polyester based, fully elastomeric system, then the replacement cost is much less significant in the total maintenance cost of re-roofing (see figure 3b). It can be seen therefore that concentration on initial costs for maintenance budgeting purposes would have been seriously inadequate.

Furthermore work by Mole and Stafford (1987) for Irwell Valley Housing Association on whole life costing identified that small recurring items of maintenance, often not included when looking at major elemental replacements, can be of considerable significance taken across the life of the building.

It may not be possible at present to provide a maintenance expenditure profile with any degree of accuracy, however with research work and examination of real maintenance costs, it should be possible to obtain an indication of maintenance costs through the life of the building with sufficient accuracy to enable realistic budgets to be identified. What is being aimed at is an analysis of trends rather than perhaps trying to be too pedantic about itemised costings.

Output

Having established the maintenance standards required, the time frame and the whole life costs it will be necessary to bring these together in an explicit form as a basis for planning at the operational level. It will be necessary to supplement the Strategic Maintenance Policy with an Operational Maintenance Policy. This is demonstrated in figure 4 below.

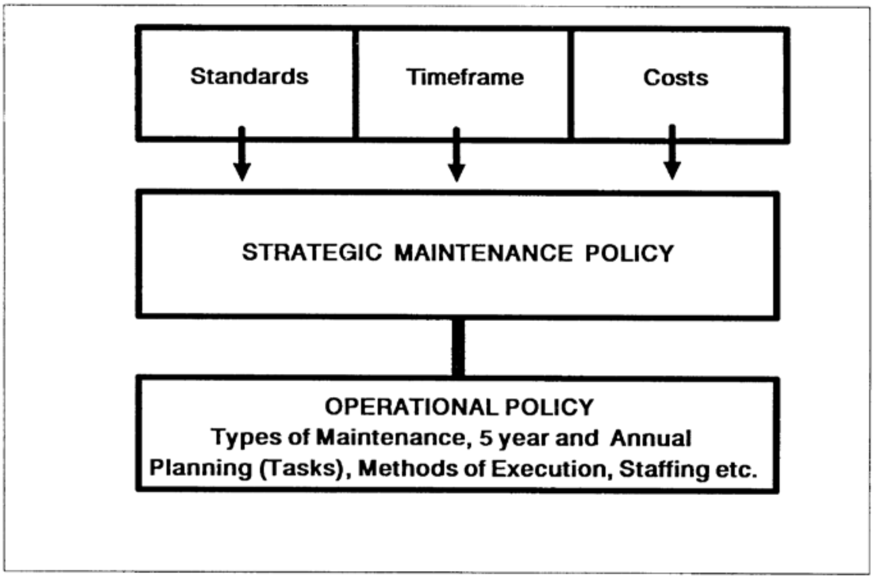

Figure 4

4
Maintenance Policy Applied

The preceding discussions are centred around the paradign that objectives, timing and costs can be analysed to produce a realistic maintenance policy. It can be seen that there are so many unknowns, so many variables, that such an exercise may be considered futile. Can such a policy realistically contribute to the operational management of building maintenance? What are the limitations in practice of such a strategy? These are examined briefly.

4.1
Establishment of Priorities

The maintenance policy should help to ensure that at operational level resources are allocated towards achieving "value for money" as perceived in the maintenance policy. So often there is conflict between what maintainers would like to achieve in ensuring that buildings etc. are in first class condition and where the client would like to direct resources. These issues would hopefully have been sorted out in the strategy document and would enable the building surveyor/maintenance manager to establish priorities using the maintenance policy.

The maintenance policy will need to be reviewed regularly and compared with actual performance. There will also be a need to recast the objectives, time frame and costs on the basis of feed-back and when different pressures arise. It may be sensible to look at a five yearly review to ensure that the strategy is up to date.

4.2
Maintenance Financing

The maintenance policy, albeit inaccurate and flawed with assumptions which may prove in detail to be unreal, may nevertheless be extremely useful in establishing projected levels of expenditure. Without such projections building maintenance will continue to be financed on an ad-hoc basis regardless of whether resources are available or not. The reason for this is that resources can seldom be increased easily to accommodate the changing demands in maintenance expenditure. The relatively low demands in maintenance expenditure of buildings in the early years of life are often fixed and then rolled forward with inflationary adjustment year in year out. Possibly the present backlog problems are attributable to lack of sound information on anticipated levels of expenditure as much as to actual lack of resources. It is therefore essential that maintenance managers plan within a realistic time-frame in order to make clients aware of maintenance expenditure requirements throughout the established economic life. If the requirements initially are quite low and the funders wish to provide a fixed annual sum adjusted for inflation. Then there will be a need for them to set such sums higher than is required at the beginning of the building life to allow surpluses to be invested to cover future increases.

It is less important for costs at this level to be accurate and difficulties in establishing realistic maintenance costs on what may be long time horizons can, provided they are in the right cost regimes, be appropriate. Detailed costing can be carried out when producing short term or annual programmes and by instigating sound budgetary control techniques provide the right level of annual expenditure.

4.3
Planning

The significance of the maintenance policy in postulating an economic life time frame in maintenance planning is probably very limited. It has been mentioned that the economic life is an estimate and the inability to predict it with confidence will prevent maintenance managers from accepting it as a basis for renewals and replacements.

If it was known with certainty that a building had an economic life of, for example, 60 years and that it would be demolished at the end of that period then it may be possible to plan elemental replacements (assuming of course that their life expectancies could be reasonably assessed). For example in this case it would be sensible for an element with a mid life expectancy, i.e. 30 years, to be replaced at that time irrespective of whether it needed to be. To prolong it would risk failure and increase the likelihood of a building being demolished with considerable elemental life remaining. The idea that it is possible to, as it were, provide a long term planning “bring up” system that prompts the automatic replacement of components is misplaced. So long as the economic life of buildings and reliability of elemental life cycle predictions remain obscure this will not happen.

For this reason the normal operational maintenance system of so called long term planning which may now be considered medium term (looking say 5 years ahead) is sound and it should not be considered at odds with the concept of whole life planning. What is taking place at this level might be termed “failure or near failure” planning which seeks to make decisions about elemental life cycles and subsequent replacement when there is reasonable confidence about when failure is likely to take place. Bargh (1987) suggests that the maintenance team should make decisions about an element when it has reached 25% effectiveness based on pre-determined effectiveness curves.

5
Conclusions

It is accepted that the concept of strategic maintenance planning over the building life may be considered unnecessary and a waste of resources because of the uncertainties that exist. Furthermore it may be felt that the level of detail required is beyond the realms of possibility for most organisations. However the author feels that building surveyors and maintenance managers should not be put off by the scale of the exercise as a simple analysis, however subjective, may make a considerable improvement in the organisation and execution of maintenance work.

What should also be considered here is not the removal of any existing maintenance policies and planning on which we rely but rather another supplementary activity that attempts to stand back and look at the wider issues. Perhaps more importantly strategic planning in this sense can begin to move maintenance away from budget lead philosophies that simply react to immediate pressures. It will help to enable maintenance professionals to establish realistic levels of funding and encourage funders to set resource levels that begin to ensure “value for money”.

It is accepted that much research and development is needed in this area to ensure realism and reliability but it is considered to be an area of utmost importance for the future.

Finally the strategic maintenance policy will help bring together all those with an interest in the built asset and help maintainers to appreciate the different objectives and different aspirations which has to bring considerable benefit through understanding.

It is accepted that much research and development is needed in this area to ensure realism and reliability but is considered to be an area of utmost importance for maintenance and should be supported wholeheartedly.

6
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ENVIRONMENTAL ISSUES FACING CONSTRUCTION PROFESSIONALS

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Abstract

This paper provides an overview of the environmental considerations pressing upon the UK construction industry and considers the actions that professionals and their organisations need to address. The role of the construction professional needs to shift away from the quantative toward the qualitative. Professional responsibility must expand to inform the client and occupants of the environmental options and consequences. The construction industry, particularly the professional organisations, need to improve research funding and dissemination. Research results need to be assessed and placed in a format that can be understood readily by construction professionals for the risks and compatibility of building products over time.

Keywords: Building biology, environmental issues, professional responsibility, research, liability, health, environmental standards, eco-labelling.

1 Environmental Considerations

Building biology is defined as the interactions over time between buildings, occupants and the environment. Building pathology is the study of problems in this system. It is more than mere eradication of building defects or failures, such as the well-known problems of condensation, rot, or ‘sick building syndrome’. It deals with prevention (always a better course of action than allowing a problem to develop and then having to take remedial action) through monitoring, assessment, and prediction. As the science of understanding the complexity of interactions between buildings, occupants and the environment, building pathology encompasses a number of diverse fields: facilities management—the ongoing administration, operation and maintenance of property over time; environmental health—the study of how environmental factors such as air and water quality effect health; materials science; psychology; and of course, the design and detailing of buildings.

Although no building can be totally ‘green’, environmental soundness can still be a relative term for the construction industry. The questions we can address are relative:

* which buildings create less pollution?
* which buildings consume less energy to provide us with a comfortable indoor environmental quality including heat, fresh air, light, and hot water? What is the energy source, its efficiency, and how much carbon dioxide and other pollutants are produced as a result?
* which buildings create less wastage of materials and what are the implications of the chosen materials on existing resources and reserves?
* which designs can respond to the changing demands & changing lifestyles of society over the years?
* which combination of materials and other substances are likely to cause risks to health?
* is the building suitable to its context and the overall environmental strategy for the particular site and its region?

2
Financial Implications

One misapprehension about an environmentally sound approach is that it costs more. Certain buildings actually cost less to produce than conventional buildings (for example, due to the substitution of natural ventilation for air conditioning). Other buildings with higher construction costs offer savings over the long term with decreased operating expenses or by decreased absenteeism through the creation of healthier environments. Environmental issues are part of a larger trend in shifting away from quantity toward quality.

3
Defining Environment

Before we go any further, it is worth considering the word “environment”. The word “environment” or “environmentally friendly” means something different to each profession. The best technical definition of environment is to consider a spectrum ranging from the macro to the micro level: from the global ecosystem down to the specific regional area, and down further again to the individual building and the rooms within it. Included within this spectrum are not only the major and minor effects on the environment but how the environment affects the health of humans. A building which presents health risks to it’s occupants, construction or maintenance crews is also not a ‘green’ building.

The impact of a building can be described on three levels-

Global: by the specification of products, the depletion of resources, and long-term effects on the ecosystem.
Regional: by the impact of local pollution and the influence on the immediate surroundings—noise, travel generation, air, soil and water quality, wind generation, etc.
Local: by the effects on the health and well-being of the people involved in the construction and occupation of the building.

It is widely accepted that science can assess, and to a certain extent, can predict the impact of pollution on global and regional levels.

To illustrate our industry's impact on the regional and global environment, even the specifier's choice of mundane items for a building have an effect. For example, the selection of chrome doorsets can effect the regional environment by the winning and manufacture of chromium. This can permeate into the ground water and the food chain.

4
Health Impact

It is worth spending a moment on the study of environmental impact on health. Medical research has two primary approaches to this topic. Toxicology is based on the study of exposure to chemicals and observing the medical implications. Epidemiology is based on the monitoring of a population to discern that a hazard exists.

The difficulty arises when a certain population has been identified as suffering from poor health and factors in their shared environment are thought to be the hazard or the trigger, such as in 'sick building syndrome', but the number of possible environmental factors is so great that it is hard or impossible to isolate and test each one. Indeed, some research is beginning to indicate that it is not a question of one isolated factor but a number of different environmental ingredients which combine to make a toxic cocktail. Most of the research that I am aware of in this area is epidemiological and therefore is based on identifying the environmental factors that people who are ill share in common. In the case of Legionnaire's Disease, the micro-organisms in the water supply have been identified and tests performed to prove the cause and effect. However, 'sick building syndrome' and some other environmentally induced health hazards have not yet been clinically identified which leads some sceptics to doubt its existence. A more reasoned view would be that although full medical and physiological knowledge is incomplete, current epidemiological evidence suggests that exposure to certain substances does present risks to health by reducing the well-being of the building occupants.

Going one step further in the argument, having identified either by epidemiological or toxicological methods that a substance or group of substances is likely to harm the body, it is then labelled as a hazard. Scientists have long lists of hazardous substances but the design team has little idea of these chemicals, let alone in which materials and products they occur. A plethora of information and standards exist, but these documents are written by scientists and intended for use by other scientists. Architects, surveyors, and others in the construction industry are not conversant in this scientific language, so there is a knowledge gap. Similarly, scientists are not conversant with the practical aspects and the chemical formulations of building products—curtain walling, carpet, and hundreds of others.

5
Defining an Appropriate Response

What we in the construction industry need to address are two fundamental questions. First, we need simple answers because we are not scientists and do not have the training to make sophisticated judgements concerning health or environmental impact. Second, we need to understand the context of use for hazardous or potentially hazardous materials. This is known more commonly as risk assessment.

Let me illustrate risk assessment with a small anecdote. I assume most of us here today had a cup of tea or coffee this morning. The caffeine in your drink is a known toxic substance and if taken in large quantities can have a serious effect on your health. If it is a toxic substance and it holds the potential to harm us, why is caffeine not proscribed? The answer is that we take in only small amounts of caffeine and most of us use it intelligently, not consuming twenty cups in one sitting.

To apply risk assessment to environmental issues is to understand how, when and where to use materials and the appropriateness of certain strategic decisions when assessing a design for its combined impact on the environment over the life of the building.

6
BREEAM

BRE has recently launched their Environmental Assessment Method for new office buildings, BREEAM. Its aim is to provide developers and agents with a certificate which recognises some of the many environmental aspects that have been tackled when the building is at drawing-board stage. The advantage of this scheme is that for the first time, many agents, facilities managers, and pension funds are being introduced to some of the criteria for ‘green buildings’ and that this avoids false claims of ‘environmental friendliness’. With this knowledge, it will be easier to discuss and raise the aspirations of our clients and the building occupants when designing buildings.

7
Consumption of Resources

Our industry has been described as a sleeping giant. It is a major consumer of raw materials, manufactured products and energy. The buildings and other engineering projects created by the construction industry shape a long term pattern of resource consumption to operate and maintain our cities and towns. As a major and conspicuous consumer of resources, it is inevitable that industry outsiders (government, consumers, environmental activists, the media, and foreign competitors) will critically examine the construction industry.

At present, we have no mechanism within the industry for assessing the rate of material resource consumption; the long term availability of resources nor any mechanism to determine if we are consuming them intelligently. As we all know, the choice and specification of products are multiplied hundreds of times within each building, and hundreds of times again over the course of a specifier's working life. This volume of activity may be depleting resources at a global level without our active recognition. One survey has estimated that copper is within 30 years of global depletion. This comes as all the more surprising that our industry is unaware of this particular impending problem and compounding the situation by leaving the discussion and plan for action until very late.

There are many trade-offs to be considered over the life of a building product—each product has its environmental strengths and weaknesses, but we have not begun to consider which situations are appropriate to use which product. This is an area of much needed research and dissemination to be carried out by our research and standards institutions: CIRIA, BRE, BBA, and our university departments.

This brings us to what I would like to think of as the next phase of greening our industry: asking the question of how to intelligently design, construct, operate and maintain new and existing buildings (and cities) that are less environmentally destructive.

8
Site Contamination

The site itself and the building that is proposed for that particular site are two primary perspectives to start with. The site itself may be contaminated from a previous use. It may contain waste, chemical and/or radiological seepage from its past or from another site. This is not surprising as most of the land in the UK has been employed previously for a variety of uses. Natural contamination is also possible from methane, radon, and sulphates. Depending on what the source of contamination is, it can present a risk to health, local plant life, and to building materials and fabric. The cost of remediation is often considerably more expensive than the site itself. At present, the existing legislation in this country has no provision for informing buyers of any known contamination, and therefore, it is the buyer who must beware. In the United States, a more onerous system requires that the owner must clean up the site which has caught out a few developers in the past for not ascertaining the hazards associated with the site before its purchase.

9
Radon

The site may also possess high levels of radon. Radon is a naturally occurring gas from the radioactive decay of radium 226. Radon can be emitted from soil and rock depending on the local geological conditions. Radon is also exuded from certain natural building materials such as stone. If inhaled over a period of time, some of the radioactive particles will settle in the lungs and may cause lung cancer—the risk increases with the amount of exposure. The health risk to building occupants is increasing as buildings are made more airtight to save energy. Much guidance exists for the alteration of existing buildings as well as the design of new buildings to mitigate the flow of gas into the building. The salient point for the construction industry is to increase the monitoring of the site and indoor air conditions.

10
Suitability of Context

Another important aspect of the site is its suitability for the intended use in terms of density and travel generation. The ultimate environmentally designed building may be situated in the wrong place. If it is not married to the context of its site and to an overall urban or regional strategy for density and communications, the building will generate a series of environmentally deleterious effects as a consequence. The suburban office park which relies wholly on the automobile is a good example of this.

As I have to be brief, let me mention two more important considerations relating to the site: Construction and Design. The many considerations for the construction phase include the impact of:

Noise
Dust
Vibration
Transport —how materials will arrive on site and the length of the journey

Timing Minimising waste and pollution, including water run-off and existing vegetation

In terms of the building design in relation to the site, many considerations arise including:

The massing, height and bulk in relation to the surrounding cityscape and landscape: how does the massing cast shadows, deal with solar gain, and create local wind effects?

Does the design of the building take into account the surroundings and does its landscape design work with both the design of the building and its surroundings?

11
The Long Term View

The building stock in this country is maintained for a long time and a considerable proportion of our buildings are over 60 years old. The buildings we create now should also be built with a view to exist over the long term. The buildings and structures we create are long-term investments, so it makes sense to consider not only the immediate needs of users and the current legislation. It makes sense to plan ahead and anticipate other problems before they arise. This will make our buildings easier to adapt over their life and allow our industry to gradually implement change in advance of legislation.

12
Liability and Legislation

Both EC and UK policy are increasing the liability for health and pollution risk. In the United States, a recent case of litigation involved formaldehyde off-gassing from domestic chipboard flooring. This created health problems in a new dwelling and resulted in a successful award of $16 m to one family. Such a high financial penalty, with other cases still pending, suggests that it is cost effective to prevent environmental and health problems from arising. Manufacturers, suppliers, contractors, developers and professionals need to have assessments of materials and products at their fingertips if they are to make environmentally intelligent decisions including the combination of different products and their location within or around the building.

Assessment of building products is likely to become a target of legislation and economic pressure. Although the COSHH Regulations (Control of Substances Hazardous to Health) provides a limited amount of information, it has not gone the full way of either fully labelling the ingredients and/or providing detailed information on the hazards to building occupants and the appropriate methods and places for use.

Let us look at the impact of the single European Market on one environmental aspect affecting the construction industry: building products. Much has been made over the last two years of 1992 and the harmonisation of markets in Europe leading to the removal of trade barriers. This harmonisation will also mean new health, safety, and environmental standards which will have a fundamental impact on the UK construction industry.

There are already over 100 Environmental Directives emanating from Brussels with another 50 or more in draft form.

The environmental standards set by the EC Directives will become a baseline minimum for professionals and products to achieve. I believe that competition will force companies to achieve standards far above the environmental baseline in the years ahead.

13
The Need for Independent Assessment

The lack of credibility in advertising claims and promotional literature and the limited availability of pertinent information has highlighted the need for independent assessment. Independent assessment confers both credibility and similarity of criteria for comparison. Certain aspects of materials such as strength, safety, durability, etc exist in a number of assessments (eg, British Standards, British Board of Agrement, etc). The environmental factors being assessed need to have a similarity of criteria to allow comparison between products.

14
Eco-Labelling for Products

Eco-labelling would not only benefit the design team—it would benefit manufacturers, contractors, and developers by overcoming the fragmentation of information and promoting dialogue within the industry. The question confronting the industry is how can we develop and adopt new design and working practices. This cannot be limited to the design team if it is to be effective. Manufacturers, contractors, developers, and suppliers all have an essential role to inform the conversation as well as discuss how their methods and approaches may need to be adapted and integrated into the whole construction process.

An eco-labelling scheme would not only help the specifier trying to make sense of many criteria, but would be of use to all of the construction industry by placing the environmental discussion on a rational, quantifiable basis away from the advertising and marketing people. From a manufacturer's and developer's view, a labelling scheme could provide incentive to improve the quality of their products and thereby remove the age-old chestnut about the economic risks involved with creating new products.

Although certain materials and product trade associations may feel besieged by current pressures, a comprehensive eco-labelling scheme could prove to be beneficial by:

* Displaying the overall cradle to grave impact of a product which may mitigate certain single aspects of a product. (For example, are energy intensive products justifiable if lower pollution and a longer life cycle were the trade-offs?)
* Shifting patterns of specification and consumption away from quantity toward quality. This provides impetus to 'value engineering' and improves business performance by consuming less resources.
* Providing a platform to launch new products
* Allowing industry to invest in a rolling programme of R & D to improve the environmental performance of their products. Eco-labelling could help companies and specifiers to shift away from reacting to legislation and 'pressures' toward an approach which anticipates and creates a leading edge and is rewarded appropriately.
* Becoming a tool for both analysis and synthesis. A sophisticated assessment of construction products could aid at the strategic level of the design stage. Both product design and building design teams can use criteria to model, test, and evaluate new designs before they are implemented.
* Providing a rational basis for government financial incentives for acknowledged 'green products'. The present difficulty in reducing taxes on green products and services is the lack of an independent system of verification.

The construction industry needs its own eco-labelling scheme which must be a more sophisticated and multifaceted assessment of products than other labelling schemes. The scheme we require will enable us to understand the appropriateness of a particular decision within the context of a specific project; rather than depend upon vague and sweeping generalisations which may be inappropriate to a particular scheme.

15
Climatic Processes

The major global issue facing us is the greenhouse effect. Changes in the gaseous composition of the atmosphere are causing more of the sun's heat to be trapped.

Scientists have not yet found a direct cause and effect, but there is no lack of scientific consensus— greenhouse gases are linked to global warming— anticipated between 1 and 4 deg Centigrade by the year 2050.

Carbon dioxide emissions currently contribute 55% and are the single largest contributor. The majority of CO2 production is from the burning of fossil fuels— coal, oil, gas.

In June 88, the United Nations conference on Global Warming concluded that the industrialised countries should set a target reduction in CO2 emissions of 20% by 2005— against the anticipated 24% increase if present trends were to continue. The UN has proposed a "carbon tax" to help achieve this objective— making fossil fuels more expensive and relating the tax burden to the carbon produced.

To reduce carbon dioxide production from fossil fuel burning, the following principles are required:

* promotion of conservation and energy efficiency
* growth of renewable and other energy sources
* use of best available technology for fossil fuel burning
* substitution of least damaging fossil fuels for the most damaging.

The implications for the construction industry are enormous. UK buildings consume 50% of the total energy. We must anticipate and plan for this reduction by developing buildings which consume less energy and use different types of energy. We should begin to consider the development of buildings for the post fossil fuel age.

16
Research

In light of the few examples presented in this paper, it is apparent that there is an even more basic need for research into the environmental issues facing the construction industry. What an opportunity exists for ETSU, BRE, CIRIA, and other research organisations to investigate the risks and compare the impacts of different environmental issues and trade-offs which beseige us. We should not expect a definitive answer on these issues, but we need to provide a sound basis for the design team, the planners, and the developer on which to base their decisions and on which to understand the environmental risks and consequences of their actions.

The more applied role of research is to test and warn of potential problems and to find better alternatives. Usually, environmental problems have been uncovered only after a product or method of practice has been in use for a considerable period. This is only partly true for CFCs which have been in production for over 50 years and were thought until recently to be totally safe and inert. When it became clear that CFCs had an impact on the ozone layer, it took 15 years between that discovery and the implementation of the Montreal Protocol. The effect of CFCs were discussed in the House of Lords Committee in the mid 1970s and recommendations were made to phase it out. The fact that the chemical and the construction industry didn't pick up on this, until after the eleventh hour, suggests we don't pay enough attention to our research scientists and that we invest too little in R & D. The professional organisations have a poor record of funding R & D, so it comes as no surprise that the professional organisations have little influence on what research is performed nor making that research accessible to their professional membership.

17
Conclusions

There are many things that we in the construction industry need to assess across a wide spectrum from the planning of towns and cities to the specifications and uses of building products, from energy efficient designs to the reduction of pollutants and waste. Some of these issues are being explored already. But one of the largest potential blind spots is the ongoing efficient use of buildings.

Changes to the construction industry take place slowly and time is needed to coordinate from policy level down to the construction site. The industry needs to anticipate client demands and government intervention in order to allow time and training for practical implementation which is well understood across the industry.

Professionals need to educate owners and users to take a more responsible role and long term view. We need training and information in a format that we can understand and apply to the assessment of environmental quality and impact before we are able to convey this to our clients and the public.

The environmental issues facing the construction industry are:

> The comprehensive assessment of building products that is in a format that can be used by the industry.
>
> The assessment of planned projects and existing buildings for their environmental impact as well as the alternatives for improvement. Concurrent with this must be the development of strategic urban and regional environmental guidelines.
>
> The divide between phases of a building's construction and operation must be bridged and professional responsibilities need to be extended to encompass this aspect. The monitoring of building performance and maintenance over the building's life by the provision of a user's manual and logbook is an essential aid to operation and maintenance.
>
> The ongoing assessment of building stock during occupation is necessary to determine what other factors may be influencing health, such as poor operation and maintenance. Sick building syndrome and

Legionnaire's disease indicate that the house-keeping and maintenance of buildings is a contributing health factor.

The promotion to government of an MOT scheme for buildings will ensure that safety and environmental standards are adhered to over the life of the building. It will also incorporate regulations which are currently absent.

A professional code of conduct to ensure that the environmental consequences are brought to the attention of clients.

An active involvement in the funding and development of a diverse research portfolio is essential if professionals want to influence what research is performed. The dissemination of research findings to members must be made in a more accessible format than present, and incorporated into CPD and educational curricula.

Information Technology

INTERACTIVE VIDEO: A SURVEYOR'S SUPPORT TOOL

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Abstract

This paper advocates the use of interactive video (IV) as a decision support tool for use by trainees and practitioners in building surveying. Unlike other computer based applications which use visuals as an 'add on', interactive video ensures a productive synergism between computer and video techniques.

The former part of the paper discusses the architecture of an IV system currently being developed at Reading University, which seeks to satisfy the holistic and subjective needs of a building surveyor. The suitability of IV as a decision support tool is discussed in the latter part of the paper. This is based on a consideration of the problem solving approach adopted by proficient building surveyors. Such an approach relies on a surveyor's capacity to interpret visual clues. Conventional expert systems which typically use a tree-like approach to problem solving, fail to exploit this subjective approach.

Keywords: Interactive Video, Building Surveying, Expert System, Decision Support System.

1 Introduction

Property owners are increasingly conscious of the financial savings that can be achieved from well managed buildings. Accessible, prompt and relevant information is seen as a necessary prerequisite for this.

On many construction projects, post-site-management and care of the completed building and its services will often pass to someone who may have had minimal involvement during the construction process. This lack of continuity produces several detrimental effects:

a) much of the data relating to the workmanship and quality of hidden construction will be lost.
b) the standard of care which future building managers achieve is dependent on their knowledge and experience of the building type and the materials used in its construction.

Conventional information transfer to an incoming manager occurs in two principal ways:

a) the provision of a maintenance manual that contains information on technical details and materials, assessed life cycles and servicing records.
b) variations on the original proposals by as-built drawings and recorded variations.

Often this supplied data may be all that is available for a manager to use in assessing how the finished structure and its services will perform. Even when sufficient data is provided, there can be no certainty about its eventual interpretation and use. This will depend on the manager's technical competence and experience with particular construction features and materials.

Maintenance manuals, as passive records, cannot reproduce the building condition or advise on probable causes of defects. Modern computer aided design (CAD) packages now provide intricate and realistic graphical representations of the building. Such developments have enhanced the information available to a maintenance manager. However CAD systems have one major drawback: they offer a representation of the building as it *ought to* appear rather than how it actually *does* appear. Factual rather than representative information is required for the diagnosis of defects in buildings.

2
Interactive video and surrogate travel

Interactive Video (IV) presents a method of record keeping which could be a tremendous asset to building operators. It enables the compilation of sizable audio-visual archives on individual buildings. This includes high quality still and moving video as well as sound. Interactive video is capable of retrieving this material almost instantaneously using laser disc technology. A personal computer is integrated with the laser disc to provide an intelligent and controllable environment for the user.

A disparate collection of photographic images obtained from a building is of little use to the building surveyor. The images need to be assembled in a meaningful way that relates to the total composition of the building. "Surrogate Travel" is an IV method that can achieve this by systematically recording and retrieving information. Photographs are taken at regular intervals (0.5 metre steps) during a traverse through the building of interest. Compilation of these images on a computer database is conducted so that subsequent retrieval of images produces an impression of movement through the building. This is achieved without forfeiting the quality of the still image or the flexibility of movement that would result using conventional video sequences. The resulting surrogate travel system allows the user to tour the building without actually going there; moving backwards and forwards, left and right, panning and zooming on chosen areas.

Further diagnostic information can be obtained during the travel. Endoscope images can be incorporated to indicate the condition within cavities. Thermal images can be used to indicate heat leakage from ducts or pipes. Such information would be obtained by clicking the component as it comes into view.

Providing a time dimension is another possibility. Visual records can be taken during the construction process as well as on completion. The surveyor is able to step back in time and examine the type and quality of construction which is concealed by subsequent construction operations. The current condition of a component which is subject to visible deterioration can be compared to previous conditions. This provides the surveyor with a time spanning impression of how a building condition arose.

3
The ROBUST advice system

A visual interactive model (VIM) provides a very effective front-end to a general decision support tool. A proposed project at Reading University will use surrogate travel in conjunction with an expert system shell for this purpose. This allows interactive enquiry about the maintenance or operation of a component that is observed during a surrogate tour. The surveyor can acquire formal information and advice as well as direct visual clues. Fig. 1 illustrates the general architecture of the ROBUST (Remote Observation of Buildings Using Surrogate Travel) decision support system.

One feature of the support system is the standardisation of meaning. The surveyor is shown what the expert system understands by terms such as “limited corrosion” or “widespread wind damage” using reference images. These photographic images illustrate a typical condition which falls into the particular subjective class. This overcomes the problem of visual interpretation, which is often a source of error when using expert systems for a diagnostic purpose. The support system is then used to assist in logical deductions from this input. It will give advice about possible causes, the appropriate repair actions and the effects of delayed action (health and safety; cost; knock-on effects).

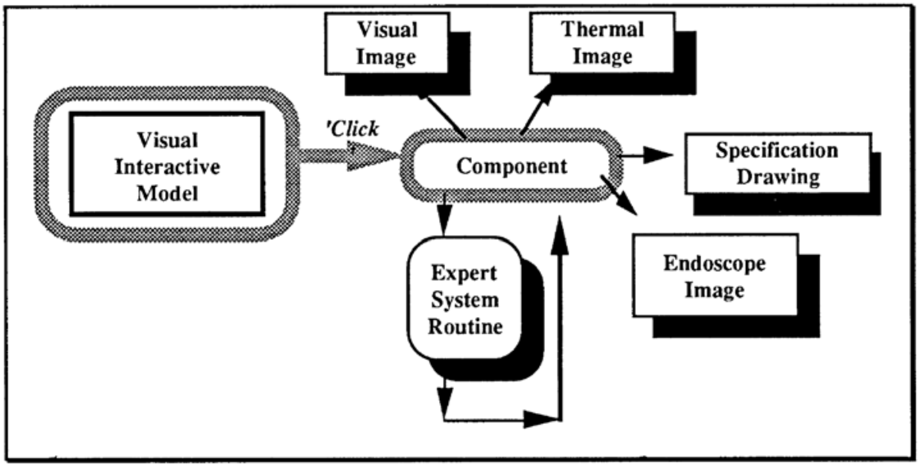

Fig 1: The architecture of the ROBUST system

4
Exploiting visual interactive models

The current cost of developing bespoke interactive models is undoubtedly prohibitive for conventional buildings. A single laser disc production requires a ball-park cost of fifty thousand pounds. However, several issues are likely to make such systems economically viable in the near future. These include:

a) the development of a series of generic expert system routines which can be easily adapted to the visual model of each building.
b) the targeting of particular building types which are best positioned to benefit from this form of support system. These include prestigious buildings, high-tech buildings, hazardous buildings and buildings in which down-time is costly.
c) the use of the same interactive model for several target audiences. These may include surveyors, maintenance managers, facilities managers, cleaning contractors and users.
d) the possibility of conducting group discussions between various experts in a conference setting. The interactive model serves as a vehicle for communicating the condition of the building.
e) cost reducing technologies which are likely to be realised in the next few years.

The advent of CD-I (Compact disc interactive) and DVI (Digital Video Interactive) promise more cost effective ways of combining video, graphics and sound. Read and write storage devices will also allow the visual records to be updated continually without the need for new disc productions.

5
Decision Support

Any support system must provide more than a passive record of information: expertise is also necessary. Modern buildings present complex variations in design detailing, materials and services. This complexity demands greater expertise, which is often scarce and multi-disciplinary in nature. To address this problem an expert system will be used to offer advice for non specialists on routine matters.

The user-friendliness of current expert system shells allows professionals from all disciplines to participate in the development of expert system routines. However, such expert systems rely on the integrity of the computer-user interface: the communication vehicle being the written word. Advice transfer by this medium has inherent limitations both in terms of scope and degree of expertise.

The support system encompassed in ROBUST must reflect the problem solving approach typically adopted by a surveyor. This is examined in the following section. The eventual configuration will be based upon a pilot knowledge base system that is discussed in the remaining sections.

6
The surveyor as a problem solver

The diagnosis of faults within buildings typically involves the association of effects with a range of broad causes. These broad causes are further divided into a series of related subproblems. When the subproblems have been identified they are then examined in turn to find out the specific cause of the problem and possible solutions. The surveyor will draw upon text derived knowledge and direct experience that has been obtained in similar situations. The human expert will thus use powers of recognition, knowledge and experience to determine both the broad and specific problem.

An example illustrated in Fig. 2 demonstrates this problem solving approach. A surveyor faced with the visual evidence of dampness at ground floor level near a skirting board will consider several possible broad causes including rising damp, condensation and penetrating damp. The surveyor will further identify from these broad causes the common construction defects that are usually responsible for them.

Information not immediately related to the problem may also be used. This may include the age of the property, type of construction, usage patterns and the standard of maintenance. This provides a holistic view of the problem, which immediately precludes many causes.

In reality the surveyor may not have access to much of the information shown in Fig. 2. Often the necessary information will be concealed within the building fabric. Such features as the condition of the junction between damp proof

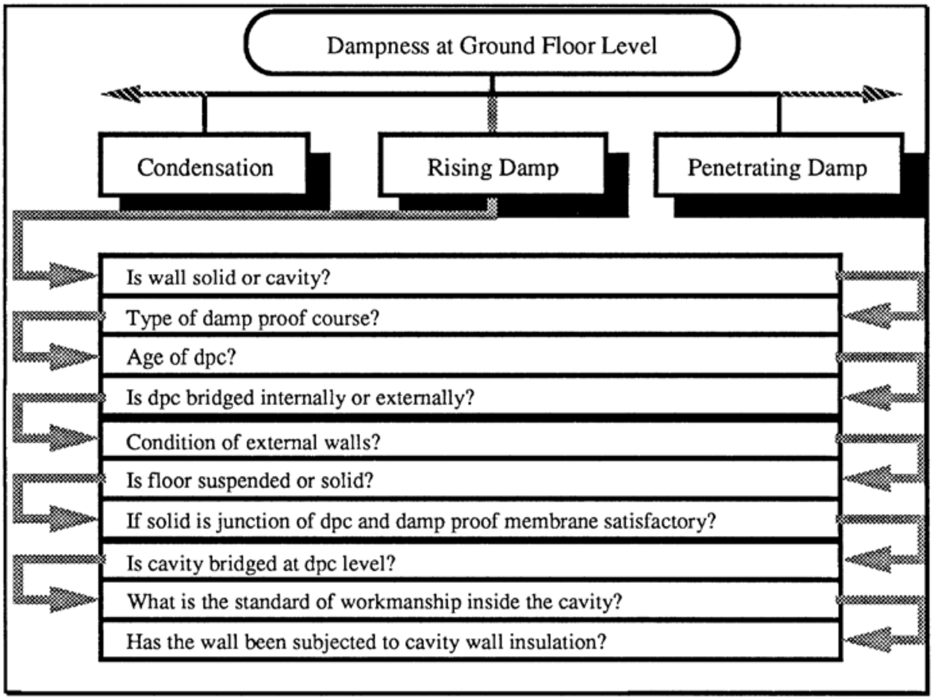

Fig. 2 Diagnosis of dampness at ground floor level

courses and membranes, the condition of the whole damp proof course and the workmanship of any cavity wall insulation will not be determinable without extensive and expensive opening up works.

The problem of diagnosing defects is further compounded by two additional factors. In the first instance it is common to find more than one broad cause. This may cloud the principal cause. Secondly, many defects dealt with in buildings, progress through several stages. For example, timber decay caused by fungi has various stages at which the visual characteristics will vary.

Clearly, the process of diagnosing building defects and functional problems is not a scientific process. It is a process that requires experience and expert judgment and, as such, is uncertain in nature. The expert will therefore tend to assign a probability, either explicitly or implicitly, to a number of possible causes.

7
Computer based advice

Work by Bright (1985) has revealed the problems of using conventional expert systems for surveying purposes. The Computer Assisted Training System

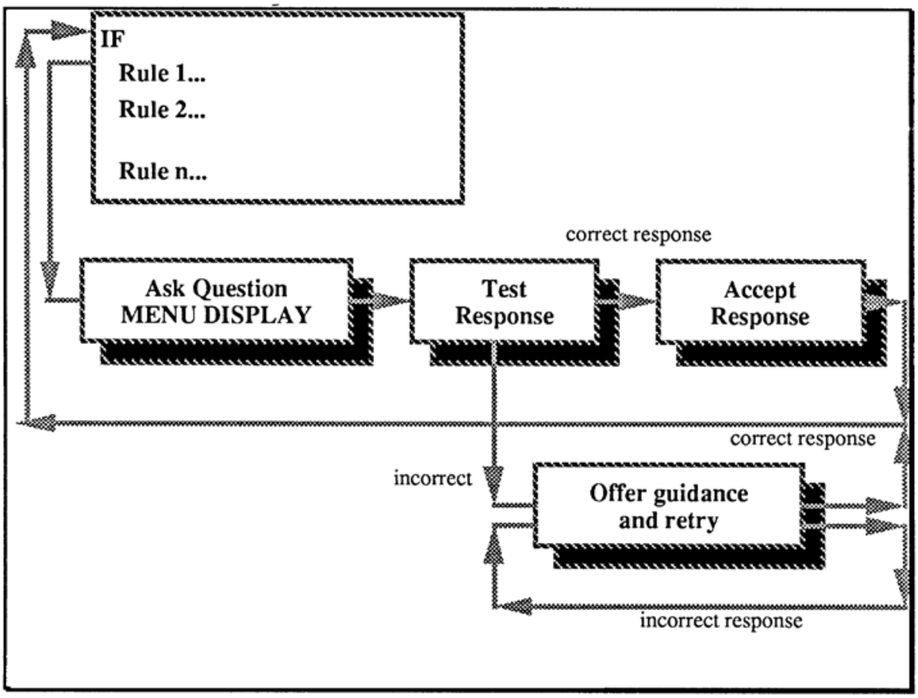

Fig. 3 Testing procedure used in CATS

(CATS) consists of a series of case studies, structured knowledge bases and tasks to test the user's understanding. The case studies have been carefully structured to represent plausible or actual surveying experiences. They encompass ambiguous and non relevant data that surveyors must decipher to form a correct diagnosis. Knowledge bases have been structured to produce two types of output. A correct response from the user produces confirmation of a correct diagnosis by the CATS system. An incorrect diagnosis prompts the system to offer advice. Each case study has a knowledge base and a unique set of rules, influencing the advice it gives and how it interacts with the user. The testing procedure is illustrated in Fig. 3.

The limitation of a 'Yes/No' response to questions was recognised early in the development of CATS. This approach to interrogation encourages guess-work and does not test the trainees understanding. The system therefore presents a menu of correct, incorrect and plausible choices. Alternatives have been carefully chosen to make the user think about the broad topic area. Interaction with the system is necessary for the user to progress further in the case study.

Diagnosing defects is a complex process that invariably relies upon the surveyor's experience. Whilst experienced surveyors will know that slight variations in evidence can lead to a different diagnosis, less experienced ones may be unaware. To address this, CATS has been designed to give advice even when the correct response to a question has been selected. This allows the user to acquire expert knowledge as well as factual data. The knowledge bases have been formulated around particular defects. Structured information is presented in the case study as well as the knowledge base.

In practice text book conditions are often absent from a survey or may be disguised by other problems. Furthermore, much of the information needed by the surveyor may be hidden within the structure. Therefore, surveyors in practice will tend to make informed judgements based on incomplete information. The step from a training tool to a support tool for the experienced surveyor will demand a capacity to deal with uncertain or incomplete information. Some expert systems address this by assigning probabilities on a numerical scale.

Earlier we suggested that a surveyor draws upon powers of recognition, knowledge and experience to determine broad problems and individual characteristics. Knowledge, in the written word, can be formulated into structured conditions to solve problems. Experience can be incorporated in a similar fashion to advise the user. However, based on trials at Reading University, we would suggest that:

(a) An expert system constrained by the written word is capable of representing only one facet of the surveyor's expertise.
(b) The process of *recognition* needs to be carefully considered in any support tool. Using visual images to assist in subjective assessment will provide a usable interactive advice system.

8
Conclusions

The two barriers to the development of visual based support system for buildings are; a) cost and, b) practitioner's unawareness of available multi-media technologies. The cost barrier is likely to diminish with cost reductions in all areas of multi-media production. However, the responsiveness of the Construction Industry appears limited. Practitioners need to question how these technologies can be harnessed most effectively. What applications are most appropriate? Which audiences should be addressed? It does undoubtedly provide an opportunity for surveyors to offer a value-added service to the client.

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THE INTELLIGENT HOME

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Abstract

This paper outlines the concept of intelligent homes and reviews the historical development of this field. The various current collaborative initiatives to develop standards for home systems are discussed. Finally, the paper outlines the various issues facing participants in this new industry, including questions about design and the housing stock, the role of housebuilders, the image of intelligent homes and the response from end-users.

Keywords: Intelligent, Home, System, Automation, Interactivity, Remote, Control, Programmability.

1
Introduction

Intelligent Homes have been portrayed by some of their more enthusiastic advocates as providing a potential driving force for consumer electronics in the 1990s. Pundits inspired by the work of futurologist Alvin Toffler have prophecied a revolution in lifestyles once home systems cut across existing product boundaries and offer many new control options.

Many of those who are developing such products have a more cautious assessment of the impacts of home automation, as do the more sanguine market reports. While there is a certain amount in the pipeline, the time scale before such systems become more widely available could well be in the order of 5 to 10 years.

Nevertheless, media coverage and regular conferences reflect the on-going and substantial worldwide commitment to set the scene for what in the medium to long term could be a very lucrative market.

2
The technology and its applications

Cheaper microprocessors have made feasible the development of a network within the home akin to the office LAN (Local Area Network) which currently links computers and peripheral equipment. ‘Smart’, chip-bearing household appliances on such a system could then intercommunicate via a variety of transmission media, including mainsbourne signalling, infra red, low power radio, twisted pair wires and coaxial cable.

In essence, intelligent home systems offer new ways of controlling appliances. This may be in the form of remote control from within or from outside the home or through enhanced programmability where several devices could operate in conjunction. An example would be where a system remembers previous patterns of appliance usage and can turn lights on, draw curtains and even turn TVs and radios on to convey the impression that somebody is home. Other examples include monitoring and controlling appliances via the phone, lights which are programmed to come on if intruders or smoke are detected, or washing machines which can start up when electricity tariffs are low.

While there may be instances where home systems reduce time or labour, by and large this is not the main point. These systems provide enhanced control, offering the consumer ‘benefits’ such as flexibility, convenience, various senses of security and the possibility of some cost-savings (eg in the case of electricity usage).

3
The development of intelligent homes

3.1
The origins of home systems

Ideas about some form of ‘automated’ or intelligent homes date back to earlier this century—especially in science fiction imagery. In practice, the option of remote controlling and programming appliances have been achievable for some time provided enough electronics and later computer power were utilised. But until the late 1970s, the cost of such developments were prohibitive as regards a commercial product. Nevertheless, the availability of the technology has spawned a range of demonstration houses over the last 20 years, at exhibitions through the efforts of enthusiastic individuals.

Discussions of possible homes networks or ‘computer homes’ have also been voiced for some time within a variety of firms. From the late 1970s, technical trends involving falling microprocessor costs and incremental improvements in expertise relating to transmission media such as mains-signalling and infra-red prompted a number of companies to consider that home systems might be a viable product.

Over and above the technical developments, there were also important market considerations favouring home systems. The intelligent home is potentially a strategic innovation, in the sense that this system consisted of more than a set of new black boxes which could be sold to the consumer. In the longer term, it enabled producers to add value to their existing products by incorporating new electronics into the traditional appliances.

Furthermore, once the network was established in homes, yet more value and functions could be added to the products, or other new products could be developed which could take advantage of this new network infrastructure. If accepted by consumers, intelligent homes could ultimately prove to be very profitable for a whole range of producers who could offer services relating to the system: such as brown and white goods manufacturers, builders, telecoms firms (including cable), utilities ect.

3.2
Home control and home computer products

The first well known domestic appliance control system to take advantage of cheaper electronics was the American X-10 system. In this system, a module which could be remotely programmed and operated from a control unit via mains signalling was inserted between the plug of an appliances and the wall socket. The system appeared in 1979. Within a few years, a range of North American, and some European, companies offered X-10 based products. The system is only now becoming available in the UK.

Shortly after the appearance of X-10, home control became one more application for the newly emerging home computer. By 1983, several small companies were offering products to link various home computers to X-10 systems. Either the micro could act as an input device plus display for a home control unit which then functioned autonomously, or the micro could be in permanent control of various appliances. The arrangement whereby the home computer is the centrepiece of home automation has continued to be followed by some, mainly small, firms in the UK and abroad.

However, as the domestic appliance producing multinationals have increasingly defined the mainstream trajectories of intelligent home initiatives, it appears more likely that the micro will find a role as simply a peripheral attached to a bus system for those who prefer keyboard and screen interfaces.

3.3
Subsystems, energy, telecoms and commercial systems

The late 1970s also saw the arrival of some precursors to more comprehensive home systems. These usually delivered particular subsets of the functions offered by the networks which are currently being planned. For example, in the brown goods field the Peritel/Scart plug and later D2B protocols were developed for connecting such equipment as TVs, VCRs and Hifis into what would now be called audio-visual subsystems.

Meanwhile, the electricity utilities in various countries have spent years running trials on systems orientated primarily towards load management (ie shifting domestic demand to even out electricity usage). The gas, water and electricity utilities are also interested in remote meter reading and billing. To achieve these various goals, these utilities have experimented with such features as radio, mains and telephone communications to the home, distant control of facilities such as heating systems, remote control of appliances from within the home and displays of energy usage. In Europe, the French gas and electricity utilities in particular have been promoting products with some home control functions, while US electrical utilities are involved in a range of intelligent home projects.

Another potential route into home systems is via telecoms' services. The EEC RACE programme and Japanese telecoms have discussed the model in which telecoms agencies might offer packages of intelligent home functions as an extension of the telecoms public network into the home. In practice, there have been limited telecoms initiatives in the US, Japan and Europe. However, both British Telecom and the communications equipment provider GPT continue to show an interest in this whole area.

Finally, we have players coming from the field of commercial building automation, the history of which covered in David Gann's paper. In Europe, two groupings of firms with experience in the environmental controls of 'intelligent building'—the Batibus Club and Association EI (European Installation) Bus—have proposed marketing their network designs to the home. The respective Batibus and EI-Bus systems were developed from industrial and commercial building applications, involve a single medium—twisted pair—and handle mainly heating, water, air conditioning, alarms and lighting.

3.4
Intelligent homes in Japan and the US

The major initiatives to develop more comprehensive home bus systems originate in the late 1970s. By the early 1980s, many Japanese firms had published their own home automation blueprints, and in recent years a number of proprietary systems have been launched to test market reaction. Those parties involved in the field include the big electrical appliance manufacturers, prefabricated house builders, smaller communications companies specialising in entry-phones and security services companies.

The first moves to achieve some form of standardisation date back to 1981, with greater effort being shown from 1984. This whole process took longer than many had expected, but a Home Bus System industry standard has been issued since September 1988. In the US, larger firms such as General Electric and Mitsubishi (US) have launched products, but despite expectations that these initiatives could open up the intelligent home market, their systems have had very limited success to date. Current attention in the field focusses on two rival programmes which started in the early 1980s: CEbus and Smart House.

The Consumer Electronics Group of the EIA (Electronic Industries Association) first examined the field of home automation in 1982 and commenced efforts to develop non-proprietary standards in April 1984. Their 'CEbus' (Consumer Electronic Bus), design was initially based upon General Electric's Homenet protocol. The initial 12 companies involved soon grew to 50, and now stands as about 200, including some Japanese subsidiaries.

Meanwhile, the National Association of Home Builders (NAHB) Research Foundation launched the Smart House project in 1984 and shortly afterwards set up the Smart House Development Venture. Smart House is a proprietary system which is licensed to participants who have paid to join the project. The initial focus was the development of a simplified and safer wiring system, but the initiative took on board the idea of home systems and, in particular, developments in energy management and conservation. Sixty-five manufacturers and 45 gas, telephone and electrical utilities are involved. The latest plan (following delays) was that 'Smart Ready', the cabling system, would be due in April 1991, with the full Smart House (products and system) being available in October 1991.

3.5
European initiatives

European firms such as Philips and Thorn first took an interest in intelligent homes at the same time as their Japanese and US counterparts, but there has been far less development of actual products, while collaborative initiatives towards producing standards emerged later in the mid-80s. It is only within the last few years that larger companies such as Thomson and Electrolux have launched subsystems of home automation. The most activity to date has been in France.

The first European wide collaboration to develop standards for a home bus commenced in 1987 with the 'Integrated Home Systems' project of the Eureka programme. In the course of 2 years, this project achieved its main goal of producing rough specifications for a standard. These efforts then fed into the two year Esprit 2 project on 'Home Systems' whose efforts culminate this month, January 1991. The aim has been to finalise and submit proposals for official standards as well as developing demonstrators of complete systems and disseminating information about these developments. A very recent initiative to emerge from the Esprit participants involves the launch of a European Association to promote home systems.

Meanwhile in Britain, the National Economic Development Office (NEDO) first set up a Task Force on 'Interactive Home Systems' in 1984. The discussions which took place in the Task Force established some consensus about general features of intelligent homes which fed into later Eureka planning. Carried out in conjunction with RMDP, the subsequent market research reports and conferences of 1987 and 1988 drew the attention of a wider audience to this emerging field. More recently, NEDO have formed a steering group to further disseminate information about home systems. A British association, to parallel the Italian and French home systems trade associations which already exist in this area, is currently being planned and should appear later this year.

4 Issues

4.1 Design

One central issue for the European thinking has been that differences between European, US and Japanese consumer demand might provide each with an advantage in their own market. Some diversity is regarded as stemming from cultural differences and lifestyles: for example, regarding the types of security which might be of interest in the different regions. However, the key differentiation revolves around the issue of national housing stocks.

Housing in Japan, and to some extent the US, is built to have a shorter life-span than European equivalents. Hence there are less new-builds in Europe. Whereas the emphasis in Japan (and in the Smart House Project in the US) is to design systems which could easily be installed into new houses, Europeans have focussed on the retrofit market. This difference has influenced systems designs and standards and so may often make home automation networks less exportable, offering a limited form of protection for the home market.

A second key difference follows from the housing issue. Japanese and Smart House programmes have predominantly been geared to installing a complete home automation package into new housing. In contrast, the emphasis on retrofits has meant that standardisation in Europe has been geared to systems which could be purchased incrementally. The Europeans have been working towards separately marketable sub-systems which would be able to intercommunicate and onto whose networks further products could be added.

4.2 Housebuilders

Some interest has been shown by British housebuilders in Smart House. Admittedly, the current housing slump is taking up much of housebuilders' attention at the moment, so intelligent homes are on a back burner. Even so, the House Builders' Federation has received various enquiries from builders as to whether there had been any progress on home automation in the UK.

One perspective amongst housebuilders is that home automation may provide a potential marketing advantage, allowing new houses to stand out and hence giving them added value. Therefore, any form of intelligent home technology has the potential to differentiate more sharply new housing from the old. The logic of this perspective leads some builders to favour restricting home systems to newbuilds—which would then also provide important showcases for a more total concept of the intelligent home. Clearly, this is at odds with the perspective of appliance manufacturers—a rift which was also experienced in the Smart House project and which led to delays.

Nevertheless, while most housebuilders are not going to be at the forefront of promoting intelligent homes, they do see it as important in the long term, and there are already links with particular appliance manufacturers to cater for both the 'early adopters' of home systems and those who want more sophisticated systems.

4.3
Standards

While many firms have decided to work towards official standards for the moment, product launches aimed at achieving unofficial standards have not left the agenda. Japanese firms involved in the standardisation efforts have periodically tested the market with their own proprietary systems, and some of the participants in CEbus are also in the rival Smart House scheme.

The networks which will be marketed to the home by firms traditionally dealing within commercial buildings also threatens to disturb the single standard which the Esprit partners have been so carefully preparing—although EI-Bus is to a degree compatible with the Esprit work. In the UK, the first major home systems offering will come in early 1991 from Creda. But even its 'Credanet' has evoked some concern in that the design was based on earlier Esprit blueprints before the standard proposal was finally formalised. The fear of those who have laboured on collaboration is that different proprietary systems, or different standards, might in the long term fragment the market.

4.4
Image

Home automation has cut across traditional product areas which has demanded new forms of coordination between divisions within firms and of cooperation between companies from different industry sectors. Because so many interests have been involved, the process of arriving at a consensus over standards has proved to be time consuming. Moreover the difficulties concerning multi-product systems also spill over into marketing. Some of those working in the field have noted the potentially ambiguous identity of multi-functional systems. It is already difficult enough to convey the idea of intelligent homes to end users without the potential confusion which may be caused by diverse firms portraying the concept in different ways.

Second, fictional images of computerised homes have existed for some time and still colour some of the media coverage of this field. Certainly, producers such as Thorn and Philips have been wary of science fiction images, and hope to avoid such connotations. They may not be able to do so. Intelligent homes have already come to be associated with futuristic trends and lifestyles—including dystopias. Market research, such as RMDP (1989), has repeatedly drawn attention to consumer fears of the home system as a dehumanising machine in control—or out of control. The challenge for marketing, design and PR departments is whether they can overcome such concerns.

4.5 Consumers

Ultimately, there is the question of whether consumers will perceive sufficient benefits in home automation or its subsystems. The evidence of past purchases which has been cited by more bullish commentators is problematic and has been open to a somewhat liberal interpretation. Just because certain previous consumer electronics have found markets is no guarantee of success on this occasion. And where the optimists see brand new markets, such as residential security, others who have lost money in this field are a little more sceptical.

There are some agencies, such as those charities operating on behalf of the disabled and aging, who have shown a particular interest in home systems because of the potential they can see for their particular clients. Enlisting their support in publicising intelligent home may well prove useful for producers. As regards the wider mass market, consumer research in such a new product area has to be treated tentatively. So far, the results of the research have been mixed. Some interest has been shown in particular aspects of home systems, with most of those involved in discussion groups liking some aspects of the intelligent home. But much less interest has been shown in whole house automation. So at the moment, such full-blown systems remain a vision in the eye of producers which may be realised only once the market has been ‘educated’.

5 Conclusion

Given these uncertainties involved, many producers are treading carefully and at least trying to prepare as much of the ground as possible in advance—by such initiatives as the development of official standards, conferences and reports to disseminate information and now trade associations. There is certainly considerable scope for losses for those companies who do not strike the correct balance of cost and product configuration. But since the field of intelligent homes covers such a broad range of products and functions, since it is being attended to, albeit cautiously, by a vast array of companies and since some signs of potential support has been indicated by end-consumers it is highly probable that some form of market will develop.

6
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THE DIFFUSION OF INTELLIGENT BUILDING TECHNOLOGIES

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Abstract

This paper examines the 'intelligent building' concept. It describes the growth in demand for such buildings which is associated with the rise of the information economy and the need for better environmental control. A key issue is how far the use of Information Technologies within buildings will diffuse from large offices to smaller buildings. The production, operation and maintenance of intelligent buildings is placing new demands on construction, leading to new relationships between those involved. Enhanced skills will be needed in a wide range of occupations at all levels to ensure that these technologies are implemented safely and effectively.

Keywords: Intelligent Buildings, Information Technology, Technological Change, Environmental Control, Energy Management, Building Automation, Office Automation, Telecommunications, Technology Strategy, Skills, Industrial Restructuring.

1
Introduction

The demand for 'intelligent buildings' is associated with the drive towards office automation, with the advent of the electronic office and increased use of telecommunications. Such demands are resulting in strong pressures for change in the construction sector. The construction industries are confronted with two principal requirements: to construct buildings facilitating the provision of enhanced communications services based on Information Technologies; and to provide more sophisticated environmental control. In consequence, construction is undergoing a process of restructuring in which new ways of organising building work are coming to the fore, and new technologies—particularly microelectronics and prefabrication—are being adopted. The types of firms operating in the sector are changing, together with the relationships between those involved in the building process, their skill requirements and their competitive strategies. One major implication of the development of intelligent buildings, particularly in offices, has been an increase in international trade.

This paper considers the types of technologies associated with 'intelligent buildings'; trends in technological developments; the potential for diffusion of these technologies; and some of the implications for skills and industrial structure in the construction sector.

2
Intelligent building technologies

The idea of the 'intelligent building' is to automate, control and monitor many functions within buildings through the use of computer management systems. The term is ill defined, but it is generally used to describe the application of microelectronics controls equipment in buildings. It was first used to describe offices developed in the US in the early 1980s, and the concept was adopted in Japan in about 1984. In its most far reaching use, the term relates to buildings which incorporate building automation, office automation and enhanced telecommunication systems. Each of these systems includes some or all of the following groups of technologies:

1. Building Automation
   Energy management, temperature control, humidity control, fire protection, lighting management, maintenance management, security management, and access control.
2. Office Automation
   Local Area Networks (LANS), electronic mail, data processing, word processing, management reporting, and other internal communications such as audio/visual.
3. Enhanced Telecommunications
   Digital PABX, routing cost analysis where the landlord acts as public utility for the building, and teleconferencing.
   (Duffy, 1987 p. 133)

Technological change is rapid in all three areas and research on systems integration is being carried out aimed at creating single intelligent building systems. Developments in computer technology—in particular the advent of the PC—have facilitated the introduction of building control systems to a growing market which includes smaller buildings. Yet sales of small control systems for buildings of less than 1,000 square metres currently account for only about 25 per cent of the market.

As in other areas of construction, the Japanese are carrying out a great deal of research in intelligent building technologies. A large area of Tokyo Bay Island has been designated solely as a site for state-of-the-art construction projects. Japanese involvement in intelligent buildings embraces large construction firms, who are spending more on R&D in collaborative ventures, as well as the activities of electronics firms and equipment manufacturers.

2.1 Building automation

Building automation is perhaps the most developed area of intelligent building technology. The aim is to create a 'wired' building in which a network links sensing, monitoring and control devices to computerised management systems. The energy crises of 1973/74 and 1979, linked with a growing concern over energy conservation, have promoted the need for energy efficiency in buildings: markets for energy management systems (EMS) grew rapidly, by 300% between 1981 and 1988 (Proplan, 1988). At the same time, energy generated by equipment installed in buildings is increasing, creating added pressures for better environmental conditioning and control technologies. Heat gains in office buildings are likely to double during the next decade.

Technical change is moving towards the wider use of direct digital control and programmable equipment. There are two benefits of using programmable controllers: they can control processes more closely to theoretical optima than can traditional hard-wired controllers; and they facilitate the collection of data, therefore, this equipment also permits a degree of self-diagnostics. The increased use of such systems has made it possible to operate and monitor the performance of buildings remotely. For example, energy use can be managed and monitored in several buildings using a central computer sited elsewhere, each building having its own semi-autonomous control unit.

The use of micro-electronic control systems has created pressures for manufacturers of other building equipment to provide their components with some 'intelligence'—the ability to respond to a variety of electronic commands—so that they can be connected to the control network. There are, therefore, technical changes in all types of equipment such as air-conditioning units and pumps, which have small micro-processors added: for example, the smart pump permits controlled flow rather than on/off switching. And intelligent lighting networks are being developed which reduce energy consumption by turning lights on and off automatically: low voltage lighting rings are also being used in conjunction with this. Non electronic components such as pneumatic sensors and actuators have been replaced by electronic devices.

2.2 Office automation

The market for office automation equipment has grown rapidly since the mid 1970s, particularly with more widespread use of desk top micro-computers and the growth of the Information Economy. In order to function as a system, such equipment is linked together using local area telecommunications networks

(LANs). Therefore growth in use of office automation has given rise to the need for the installation of network cabling and the need to develop new cabling architectures such as structured wiring.

2.3
Enhanced telecommunications

The third group of intelligent building technologies is associated with office automation and the need to develop better telecommunications infrastructures between the activities within a building, and those outside: thus the need to link LANs with wide area networks (WANs). The importance of developments in telecommunication infrastructures should not be underestimated as a driving force of change in building technologies.

Companies offering shared-tenant telecommunications service (STS) as a new business to increase the value added through intelligent buildings have emerged since the deregulation of telecommunications in Europe, Japan and the US. ISDN (Integrated Systems Digital Networks) offers the potential for many novel applications, such as sophisticated voice and data switching systems. Programmable Digital Multiplexors (PDMX), which distribute intelligence out from the switch and into the network, are superseding the traditional public exchange.

The installation of optical fibres in the long-distance telephone network has been continuing in Europe, Japan and the US since the early 1980s. Costs of optical fibres have recently fallen sufficiently to justify installing them in the local network—between the office or factory and the nearest telephone exchange —for high revenue business customers.

In Japan there are several major projects to develop 'intelligent cities' and teleports. Teleports are designed to combine long-distance communications media, such as satellite, optical fibre and microwave radio systems into a single project to provide a long-distance communications network for local business centres. The development of teleports is likely to lead to the construction of intelligent building complexes, and the refurbishment of existing buildings to accommodate new Information Technologies

2.4
The need for standards

One of the biggest problems in developing intelligent building systems is that of compatibility and the need to achieve standards that permit all components to interface. Problems associated with systems compatibility and pressures to provide better integration between LANs and WANs has given rise to the need to achieve standard operating procedures and protocols. In multiple occupancy buildings lack of common standards means that equipment installed by the landlord may be incompatible with that which the tenant wishes to install. The need to achieve standardisation is crucial if the intelligent buildings markets are to expand, and if systems compatibility is to permit uninhibited flows of information between different building complexes. Several different standards are currently being developed, and operate internationally: one standard for the US, one for Britain and Europe, and one set by Japan.

3
Demand for intelligent building technologies

The demand for intelligent building technologies is linked to the development of the Information Economy and the need for better energy control. The oil shocks of 1973/74, 1979 and the Gulf crisis together with growing awareness of environmentalism are leading to increased demand for energy control and building automation technologies.

Buildings can be viewed as the 'hubs' or nodepoints in the new global telecommunication infrastructure. In the 1980s, market growth in Britain was driven primarily by the needs of the financial services sector. Deregulation of the telecommunications infrastructure in 1984 and the City —Big Bang—in 1987 added further stimulus to demand for office automation systems. The retail sector and high-technology businesses such as micro-electronics, software, pharmaceuticals, and the IT industries are demanding more sophisticated buildings incorporating these technologies. There is growing evidence of diffusion of these technologies from their initial use in large scale buildings located in city business districts, to medium sized buildings in more provincial areas. This trend is likely to continue.

However, high interest rates and the collapse in property markets are slowing the pace of development of new-build projects, and it is likely that there will be an increasing shift in emphasis towards retrofit markets. But refitting existing buildings with intelligent building technologies is generally more difficult than new-build and this tends to slow the rate of growth in retrofit markets.

4
Construction

The production of intelligent buildings is placing new demands on the construction sector. The role of building services firms is increasing in importance and firms from outside the traditional construction industries are entering the market resulting in a process of industrial restructuring. New skills in building services and facilities management are required at all levels to meet these new demands.

4.1
Industrial restructuring

Specialist building contractors, telecommunications and other electronics firms are converging on the intelligent buildings market. For example, manufacturing firms involved in fire protection and security, process controls, and data processing are converging on construction in their search for new market opportunities. Large computer companies such as IBM have established intelligent building firms. New specialist high-technology firms are competing for the installation of equipment into buildings and playing a bigger role in the design and construction management processes. This new competition is causing industrial restructuring with a shift in power away from traditional construction firms. The trend is represented by the shift from craft based construction activities to engineering and assembly work, with a much higher proportion of the value of new buildings in mechanical and electrical systems.

Convergence is also occurring across national boundaries. The recent UK boom in office development has led British and Canadian developers to employ US design teams, international project management and suppliers from Europe, Japan, the Far East, and the US. Having gained experience in UK and European markets these firms are likely to maintain a presence in what was once a traditional, indigenous industry.

4.2
The need for new skills

In all high-technology industries there is a need for a highly skilled workforce. One of the reasons for the success of Japanese and German firms is their adoption of continuous training, and career development—essential in any dynamic innovative industry. Skills required to construct intelligent buildings are often very different from those needed in traditional construction. The industries supplying new technologies must address the question of where the skills to design, develop, manufacture, install and maintain the systems will come from. I have already argued that there has been a convergence of firms from different sectors—including telecommunications, electro-mechanical, electronic and software. In the provision of building services in offices, this technological convergence has given rise to the need for new skills in the contracting industry. But requirements vary depending on whether the work is new build or retrofit, and these skills diverge sharply from the multiple skills required in repair and maintenance. Inadequate training in this area is threatening to curtail the rate of growth, particularly in Britain.

Skill shortages and poaching at all levels are making it difficult for firms to plan their work loads. A building's IT requirements need to be defined at an early stage by competent designers. But the roles of IT practitioners in the building process remain unclear and this militates against systems integration.

There is a need for education of building or facilities managers. Users need to be aware of how their buildings function, the facilities that are available and how to maintain them.

5
Conclusions

The markets for intelligent building technologies could expand rapidly over the next decade, fuelled by the demands of the Information Economy and the needs for energy conservation. Current demand is leading to a shake-up in the construction industry, with new firms competing in the market. But if the construction industries are to successfully expand their roles in providing high technology buildings, strategies will need to be developed on two fronts.

First, there is a need for technology strategies involving collaboration in R&D across industrial sectors, coupled with the need to achieve standardisation, systems integration and compatibility. Second, there is a need for skills and training strategies with the objective of recruiting and training a skilled workforce in all areas from design through development to installation, operation and maintenance.

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COMPUTERISED SURVEYS AND COMPUTER AIDED DESIGN

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Abstract

This paper examines the technology currently available for the collection of various kinds of survey information. The distinctions between computer aided design and computer aided drafting are outlined and the basic features of computer aided drafting described. The possibilities for direct input of measured survey data into computer aided drafting programs are discussed.

Keywords: Data Logging, Hand Held Computers, Down-loading, Database, Graphical User Interface, Accurising.

1
Introduction

Affordable high technology has been available and in use by surveyors of all disciplines for the collection, recording and analysis of many different types of survey information for at least four years. Until comparatively recently and the widespread use of personal computers, this technology was very much the preserve of larger practices able to risk investing in unproven technology and academic institutions. Practices of all sizes and disciplines must now consider whether they can afford not to commit themselves to high technology and information technology (IT).

Much of the surveyor's output is either graphical or textual information, typically drawings and reports. It is on the quality of that information and the ability to identify and analyse it that surveyors are judged by their clients. The work of surveyors is heavily data intensive, whether it is the analysis of valuation comparables by valuers, collection of building condition information by building surveyors or cost planning by quantity surveyors, all surveyors must identify, collect, assimilate, analyse and present information. These are professional activities which rely upon a high level of knowledge and understanding by the surveyor, but often they are based upon largely mechanistic processes of information collection which may safely be delegated to others. Although this is not the case for all information collection activities, some of which require more on site analysis than others, a principal aim of automating the survey process is to free the professional surveyor from time consuming, monotonous work in favour of analysis and strategic thought.

High technology and IT are the key to increased accuracy and efficiency. IT is unique in offering professionals of all disciplines the opportunity to reduce costs, increase efficiency and at the same time enhance their professional services. This paper will examine a variety of survey automation devices and techniques which can be used by surveyors of all disciplines from agents and valuers to building surveyors.

IT and high technology provide no magical panacea for transforming the work of surveyors. They must be applied in the surveying environment by professional surveyors seeking to increase quality and efficiency if they are to be truly integrated into the work of the surveyor. The development of appropriate professional techniques is an essential prerequisite for successful use of new technology.

Surveyors have not always been quick to embrace new working methods and technological developments. However, in a highly competitive market for professional services in which an increasing number of firms are aware of the benefits of high technology and IT, those practices which continue to postpone the decision to utilise new technology, and which decline to accept the changes it will mean for established working methods and professional boundaries will become increasingly uncompetitive. The continuing development of technology brings with it an electronic imperative which the economics of the market place will not allow to be ignored.

2
Survey automation

2.1
The problems of automation

Many of the surveyor's professional activities rely on the ability to incisively root out relevant information and record it accurately. When collecting information, profitability is determined by the efficiency and speed with which information can be recorded for later retrieval. This is a complex process which can currently only be partially automated as it relies upon human intelligence, experience and the exercise of judgement. All surveys require such a combination of description and analysis.

Figure 1 is a simplified, generalised model of the survey process which implies the limitations to automation. The survey process is modelled as a sequence of activities, observation, recording and analysis. The model allows various possible scenarios for any part of the survey. The model is based on the

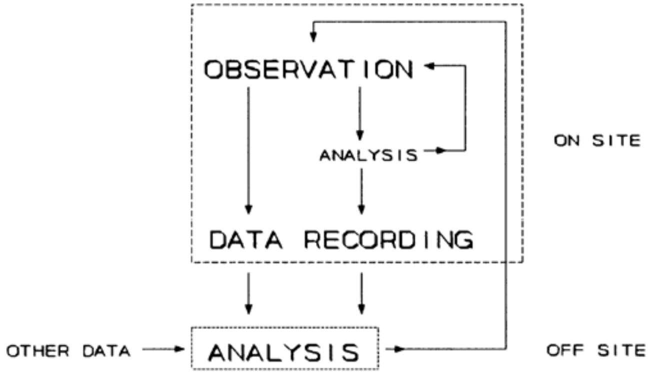

Fig. 1. Simplified survey process model

assumption that the survey is the basis of an off site analysis of a loosely defined problem and that the solution of the problem requires the collection of specific information.

In the simplest scenario, the surveyor observes factual data which may be a dimension, a structural feature or the use of a room and records it on site. In many cases however, observation leads to on site analysis for which the surveyor relies on experience of similar situations previously encountered. This leads to further, more detailed observation forming an iterative cycle of observation and analysis which eventually terminates in the recording of the relevant information.

This process elucidates data which is relevant to the solution of the problem, but the need for which may not have been originally envisaged. Off site, the surveyor may combine general reference and other material with the data recorded on site in the analysis of the problem. This may expose the need to return to site to gather further data to enable a conclusive analysis of the problem.

The model shows that the manual survey process is distinct and separate from the analysis which follows it. The quality of the analysis depends on the data on which it is based, yet the identification of required data may be dependent on informed on site analysis. The survey process would be more effective if it could be integrated by automation.

2.2
The benefits of automation

Automation eliminates intermediate manual processes and increases efficiency by streamlining information handling. Automation also enables validation tests to be applied to data to eliminate trappable errors. For example, impossible combinations of materials and elements may be excluded in condition surveys, and unacceptably high closing errors may be detected in measured surveys.

Automation enables large scale surveys for example, housing stock condition surveys, to be undertaken to a high level of consistency despite the involvement of many staff. This can be achieved by the use of predetermined numeric values to describe the condition of elements in place of subjective textual descriptions. This necessarily involves a degree of inflexibility in survey methodology, but is vital to enable the data to be input into a database for statistical analysis and report generation.

2.3
The current limits to automation

Future developments in expert systems may enable a much higher degree of automation than possible today. Currently however, survey automation goes little further than the electronic logging of data for subsequent down-loading to computer. A degree of data validation has been achieved for measured surveys and rigidly defined condition surveys using hand held computers as “intelligent” data loggers. A recently developed lightweight, keyboard less computer, capable of recognising characters written on a liquid crystal display (LCD) screen may enable a limited degree of on site analysis for certain kinds of surveys.

2.4
Portable data collection devices

There is a growing range of portable devices suitable for collecting and recording data on site. These can be categorised into measuring devices and data logging devices.

Sonic and optical telemeters have been available for about five years, the accuracy of both has risen and their prices have fallen considerably since they were first introduced. Reflector less laser range finders, which are highly accurate and capable of being used single handed are an important step forward in the process of developing a truly automated measured survey system. An optical telemeter capable of down-loading its data directly to a computer through an RS232 interface has recently been developed. Digital cameras are now available which enable photographic images to be captured then edited in pixel editor software, or reproduced at high resolution in word processed survey reports. Electronic measurement devices need further development before the majority of surveyors will consider them sufficiently cheap or reliable for general use, but devices for recording data such as hand held computers are in widespread use already.

One of the earliest attempts at survey automation was by machine readable preprinted forms. The forms must be designed specifically for each survey and consist of text indicating the data to be collected, and a grid of boxes for the data. The surveyor indicates his choice of answer to the questions on the form by putting a pencil mark in the appropriate box. The forms are fed into an optical mark reader off site which reads each sheet and down-loads the information into a custom designed database.

This method most closely emulates the traditional survey process, but validation is only possible after the forms have been machine read and the information down-loaded. Although ensuring consistency of survey methodology, this method is limited in its ability to accept unenvisaged data and is essentially non interactive.

Machine readable forms are still used, but hand held computers have the advantage of interactivity and on site validation. As the name implies, hand held computers are small enough to fit in the hand and are distinct from laptop and portable computers which have more conventional keyboards and display screens. Systems incorporating hand held computers are currently in use for collecting condition and maintenance data as well as measured survey data. A hand held computer can be used in conjunction with a bar code reader enabling the surveyor to enter information from pages of bar codes rather than by using the necessarily small keyboard. This makes these devices particularly suitable for use on site.

The limitations of small screens and keyboard data entry have been major obstacles to the more widespread use of hand held computers for measured surveys and text intensive surveys such as structural surveys. These limitations may be overcome by a keyboard less hand held computer which is now available. The computer is built around a large, LCD screen and is driven by software capable of recognising text written directly on the screen by the user. The use of an advanced graphical user interface greatly expedites data entry. If required, data entry can be in a format which closely resembles the appearance of the final survey report.

3
Survey data collection techniques

3.1
Housebuyers reports and valuations

Housebuyers reports are largely descriptive and based on standard forms, they are therefore in principal, amenable to automation. A graphics capable hand held computer can be programmed to prompt the surveyor to provide information under the headings of the standard form. Character recognition enables fast, free form text input. The surveyor need know nothing of computer technology to operate the system as it closely resembles the familiar manual process. The interactivity of the system is achieved by ticking check boxes and icon buttons on the screen. This gives the surveyor far greater freedom to fill out the report in the most appropriate order than non graphic systems which tend to lead the surveyor through a rigid series of questions. The survey information is saved to a battery backed up memory and can then be down-loaded to an office based computer for printing, or printed immediately on a portable printer.

3.2
Structural surveys

Structural surveys are difficult to automate because of the high degree of analysis which they contain. There is however a large element of description and standard clauses are used quite extensively for describing defects and outlining remedial action. Proprietary libraries of standard clauses are available commercially. The danger with automation is that following prompts and calling up appropriate descriptive clauses can lull the surveyor into a false sense of security, so that defects for which there are no standard clauses may go unnoticed or unrecorded.

Unlike condition and maintenance surveys, structural surveys tend to be automated through “intelligent” word processing rather than databases because of the need for extensive free form text input.

3.3
Mass condition surveys

Unlike structural surveys, condition and maintenance surveys tend to be automated through databases rather than “intelligent” word processing because the elements of the building stock can be fairly rigidly defined, condition can be described by a numeric scale, and measured quantities can be automatically related to a schedule of rates. There is little need for free form text input. This type of survey has been automated without using character recognition, graphics or large screens although these capabilities would undoubtedly enable greater freedom by the surveyor.

A typical condition survey program is based on a standard list of elements and sub elements. The program prompts the surveyor for information on each element. The surveyor enters the construction type and material by selecting from a range of predefined descriptions. Age or residual life is entered as a number, condition and priority as a numeric value within a set range. The extent of repairs can be specified in units which will be rejected by the system if inappropriate for the particular element.

The survey information can be saved to volatile or non volatile memory. The information is down-loaded into a personal computer database in the office. The information in the database can be sorted, analysed, illustrated by semi automatic production of graphs and reports can be generated. Repairs costs can be calculated automatically by relating the surveyed quantities to the schedule of rates which can be updated quickly and easily on the office based computer. Arithmetical errors by surveyors are almost totally eliminated by the system.

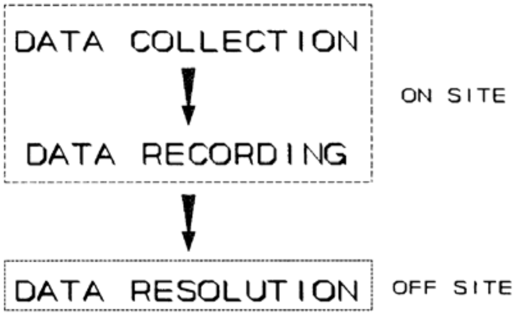

Fig. 2. Manual measured survey process

A variant of this approach uses a bar code reader and incorporates software which enables the surveyor to design the survey and print out the bar codes. The system supports multi choice and multi level questions, decisions and validation. The survey can be designed, tested on site and modified to incorporate any changes required in a few days with no knowledge of computer programming. The generation of reports does however, require some knowledge of databases.

Systems such as these can tend to reduce surveying to a mechanistic, mundane process and therefore can be prone to fairly high levels of human error. The inflexibility of some systems can discourage surveyors from undertaking a comprehensive examination of dispersed elements prior to recording data, thereby encouraging approximation. In general, it is a mistake to think that low calibre, unqualified staff can reliably be used to carry out mechanistic automated surveys.

3.4 Measured surveys

Figure 2 illustrates the manual measured survey process. The most essential part of the process, the resolution of collected and recorded data occurs off site. The survey process therefore becomes discontinuous and there is an increased likelihood of errors in resolution of the drawing.

Hand held computer systems are available for recording measured survey data as it is taken. These systems are intended principally for use in conjunction with computer aided design software. One system uses a bar code reader and a menu of symbols such as doors, windows, radiators etc. to build up a very complete record of the building being measured. A direction calculator is used to establish the correct format for data input. Text and other information can be added as the dimensions are taken.

A similar product dispenses with the bar code reader and simply uses keyboard entry of the dimensions, symbols and text. Angular walls are located by triangulation in the usual manner, and the trigonometry is calculated

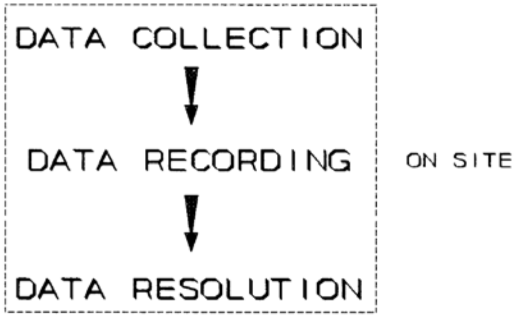

Fig. 3. Automated measured survey process

automatically by the system. Both systems check to ensure that any closing error is within acceptable limits. With both systems, the hand held computer is connected to a personal computer at the office and the information down-loaded into a computer aided design program.

The measured survey information is reconstructed automatically as a fully resolved measured survey drawing. Figure 3 illustrates the main purpose of survey automation.

The current generation of notepad computers with full aspect ratio, LCD screens and large amounts of memory may provide the means to view the drawing as it is drawn line by line whilst on site. Software is currently being developed which will enable the surveyor to sketch on screen the approximate relationship between two walls, then type in their lengths followed by a tie dimension to establish the correct geometry. The computer will respond by redrawing the walls showing their correct dimensional and spatial relationship.

4
Computer aided design and drafting

4.1
Definitions

Computer aided design and computer aided drafting are two aspects of the same technology and overlap to the extent that precise definitions are difficult to sustain. Computer aided drafting uses the computational power of the computer to maximise drawing output and efficiency and is mostly concerned with 2d drawings such as plans and sections. Some systems use 3d modelling techniques to further enhance the production of 2d drawings.

Computer aided design is principally, although not exclusively graphics oriented, but uses 3d modelling and other techniques to enhance the quality of the information available to the designer in the design process.

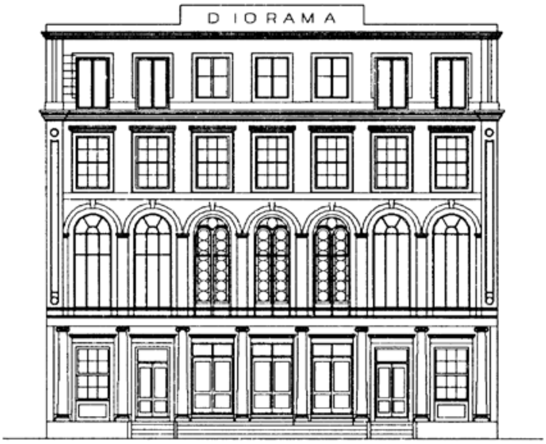

Fig. 4. Elevation produced from scanned original.

Computer aided design allows visualisation of building interiors and exteriors, assessment of massing and environment, and the possibility of experiencing internal and external environments through animation. Computer photo montage, which allows scanned photographs of an existing site to be combined with proposed 3d models is a significant development of 3d modelling techniques which further allows the designer to experience proposed changes to existing environments.

4.2
Principal advantages of computer aided drafting

Computer aided drafting allows drawings to be manipulated in infinitely more powerful ways than are possible manually. It is not only more efficient, but also more effective. Entire areas can be extracted from drawings, modified and used as the base for new drawings. Scheduling of components can be accomplished automatically, and revision consistency can be assured.

The time taken to produce working drawings can be greatly reduced. The highest productivity gains are possible when there is repetition in elements such as cores, staircases and column layouts which can be drawn once then replicated. Figure 4 shows the amount of repetition which can exist even in existing buildings. The elevation was redrawn from a scanned original. The drawing was built up vertically, mirrored about a central axis, and the entire elevation "accurised" to conform to known dimensions.

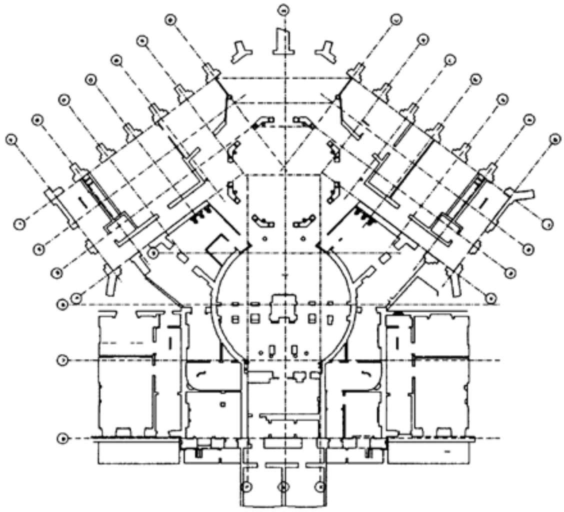

Fig. 5. Plan produced from scanned, vectorised original.

4.3 Symbols libraries

Furniture symbols, mechanical and electrical symbols, sanitary fixtures and drafting conventions, are entirely standard whether used for new build or refurbishment and their use alone may lead to valuable savings in drafting time. Symbols may be rotated, enlarged, reduced and distorted once inserted into a drawing. The brick buttresses in Figure 5 were not drawn individually, but a single buttress was defined as a symbol and inserted wherever required. Similarly, the sanitary fixtures in Figure 6 were retrieved from a library of standard symbols.

4.4 Drawing quality

Computer aided drafting results in clear, unambiguous drawings and a consistent drafting style. Any part of a drawing can be printed or plotted at any scale, with guaranteed dimensional and geometric accuracy. A wide variety of printers and plotters can be used to produce the most suitable drawing appearance for particular requirements. Line types, line weights and typefaces can be selected to give drawings the required drafting style.

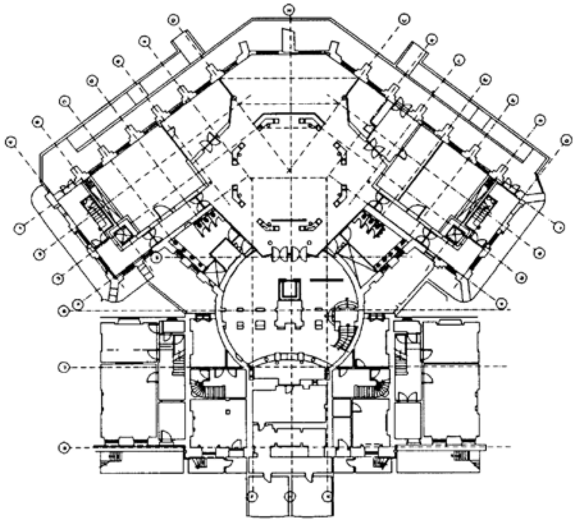

Fig. 6. Plan with all layers visible.

4.5 Accuracy

Computer drawings of existing structures can be as accurate as the survey information on which they are based. This enables highly accurate, semi automatic calculation of areas and perimeters, and obviates the need to re-survey parts of buildings in order to redraw them accurately at large scales. Dimensions can be determined with millimetric accuracy on screen, whereas scaling manual drawings is notoriously inaccurate.

The plan in Figure 5 was redrafted from a scanned manual drawing. A subsequent laser survey of the rotunda showed the drawing to be accurate to within 2 mm. Figures 5 and 6 were produced from the same computer drawing. The layers on which sanitary fixtures, stairs and windows were drawn were suppressed to plot Figure 5, and unsuppressed to plot Figure 6. As the two plans are generated from the same drawing, their consistency is automatically guaranteed.

4.6 Automation

Computer aided drafting can automate time consuming drafting tasks. Schedules can be generated automatically, and dimensioning becomes a semi-automatic process. Moreover, drawings can possess a degree of intelligence, associative dimensioning for example, ensures that dimension text is automatically updated when drawing proportions and dimensions are changed. Sophisticated drafting

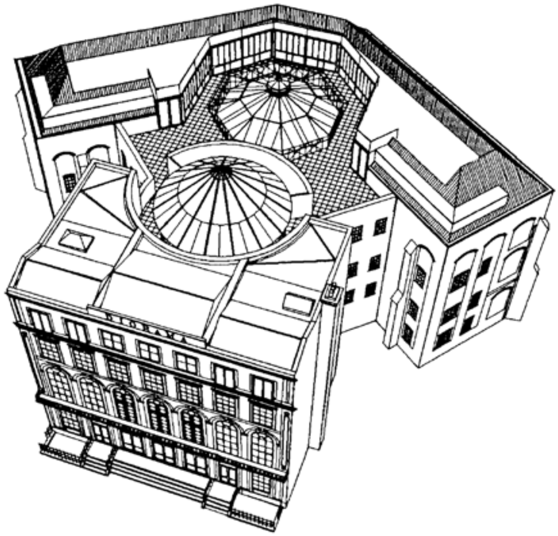

Fig. 7. Perspective view of 3d model.

systems can generate cavity or solid wall construction drawings from simple line diagrams. Door and window openings can be formed automatically complete with associated detailing. Symbols can be inserted on the correct layers automatically.

4.7
3d modelling

3d modelling enables a series of drawings to be produced from different viewpoints from a single 3d model. The simplest form of 3d modelling is extrusion. The system simply extrudes plans in the z axis of an imaginary graph. The heights of the extruded lines are specified when drawing the plan. Views can be plotted or printed as wire frame axonometric, isometric and perspective drawings with or without automatic hidden line removal. Hidden line removal may take hours for a complex model, but can be generated overnight.

4.8
Surface rendering

Surface rendering produces perspectives with the appearance of solidity, colour and texture. They are especially valuable in planning negotiations, as the area surrounding a site can be digitised from maps and then block modelled. The proposed building can be modelled in full detail, placed on the site and viewed in its proposed environment.

Figure 7 shows a perspective view of a 3d model with hidden line removal. The model was formed by suppressing all layers in the ground floor plan, except for the external walls and inserting a copy of the front elevation vertically on the plan. The walls were then extruded and the remaining detail added in a true 3d environment.

5
Computer aided drafting and existing buildings

5.1
Specific problems of refurbishment

In new design work, repetition exists within projects and also between projects of the same kind. Modular design and dimensional coordination can greatly simplify drafting. The dimensional idiosyncrasies of existing buildings and the lack of direct repetition can exclude these techniques and require a high level of thought and interpretation in refurbishment drafting. Potential productivity gains are therefore more elusive than in new design and the techniques to exploit them more complex.

5.2
Modified and direct repetition

The viability of computer aided drafting is not totally dependent on simple repetition, although there is sufficient repetition in refurbishment drafting to lead to increased productivity. Electrical schematics, reflected ceiling plans and furniture layouts, consist almost entirely of standard symbols. There are also however, elements in drawings such as window bays which vary only dimensionally and can be drawn once, copied to new locations then modified to make them dimensionally correct. Whether through direct or modified repetition, the potential exists in refurbishment for drafting productivity to be radically increased.

5.3
Cad techniques for existing buildings

Using computer aided design successfully for work to existing buildings means maximising potentially large numbers of marginal productivity gains. If the ergonomic efficiency of a drafting system is high, then the lack of direct repetition will not prevent computer drafting from at least equalling the speed of manual drafting. There are however, certain techniques which are quite specific to refurbishment work and which are essential to ensure sufficiently high productivity to justify the use of computer aided drafting.

5.4
Scanning

Raster scanners used in conjunction with vectorisation software enable manual drawings to be input into computer aided drafting programs. The process is not fully automatic, as the scanning process generally produces unstructured computer drawing files, which must be edited intensively to produce a layered, “intelligent” drawing. Scanning is however, a far more efficient technique than manual digitising.

The starting point for many refurbishment projects is often a set of factually and dimensionally inaccurate plans which must be used to produce an accurate set of as existing drawings. Scanning and accurisation techniques enable this process, which is fundamental to the development of effective design proposals, to be accomplished quickly and accurately. Scanning can also be used to combine the humane style of manual drawings with the computer’s flexibility to print information selectively at any scale.

5.5
Rectified digitising

Rectified digitising is a technique which allows photographs of elevations to be corrected for convergence and divergence as they are digitised. This technique is a worthwhile alternative to commissioning laser and rectified photographic surveys. Although the use of non specialist photographic equipment makes this technique less accurate, computer aided drafting is arguably the most powerful medium for incrementally increasing the accuracy of dimensionally inaccurate, distorted elevations.

5.6
Accurisation

Accurisation covers a range of techniques which enable dimensionally inaccurate plans and elevations to be made to conform to figured dimensions or check dimensions taken on site. Drawings can become dimensionally inaccurate through various causes such as, poor original drafting, paper stretching and shrinking, and reprographic processes. Even scanning and digitising can introduce a degree of aspect ratio distortion. Once existing paper drawings have been input into the system, they can be rescaled consistently or independently in both axes to conform to known dimensions. Millimetrically accurate measurement of drawing dimensions is fundamental to the diagnosis and quantification of areas of inaccuracy. Individual parts of drawings can then be stretched and compressed by precise dimensions.

5.7
Parametric symbols

Parametrics are symbols definitions which are adaptable to a variety of situations. Doors and windows for example, can be defined as a collection of related dimensions. An "intelligent" routine can therefore construct precisely the door or window required to fit an existing opening without distorting or descaling the symbol.

6
Conclusions

There is obvious potential for measured survey data collection methods to extend to proven methods of drawing automation. Data collection and resolution can already be automated, full automation of the measured survey process will only be achieved if measurement itself is fully automated. This may shortly be achieved by tripod mounted, rotating telemeters, programmed to take measurements at variable intervals and to down-load them as polar coordinates to laptop computers for immediate resolution. The automation of other survey types is less likely to progress significantly towards more complete automation until advances are made in expert systems and artificial intelligence.

7
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Technology

CONSTRUCTION TECHNOLOGY— THE DEVELOPMENT OF CONSTRUCTION INFORMATION

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Abstract

This paper suggests that the best way to improve the performance of the construction industry is to ensure that existing knowledge is more widely used, and addresses the question of how to achieve this. It considers the main types of non-project and project information used by the industry and the impact of the growing use of quality assurance systems and databases, and of the Single European Market. It describes the role of BRE in providing technical information and doing research into how it is used, and considers the impact of new technologies on the future development of construction information.

Keywords: Research, Information, Construction Industry, Information Technology, CPD, QA.

1 Introduction

There is no doubt that the performance of the industry, and the buildings it produces, would be improved with new materials and techniques, and with better understanding of the behaviour of existing materials, components and completed buildings. But many studies into the research needs of the construction industry of recent years have emphasised that the greatest improvements would be obtained by putting more effort into ensuring that the knowledge which already exists in the technical literature, in specialist research laboratories and in the best consultancies is more widely put into use. When asked to suggest research priorities, practitioners often come forward with proposals for work which has already been done, or say they do not want research but information that will solve their current problems.

I therefore propose to concentrate in this paper on how the information needs of the construction industry can be better met, particularly by new Information Technology. BRE is making and will, I hope, continue to make, an important contribution to this topic and members of the RICS are, of all the professions in the industry, the greatest consumers of information from BRE. I believe they are also committed to seeing improvements in this field.

My concentration on this topic does not mean that I think no research is needed into improved materials and techniques for construction. On the contrary, I am sure that such research is vital for the continued health of the industry. However, I believe it will prove difficult clearly to identify what is needed in many areas, and to mobilise the necessary funding, until there is a better perception by practitioners of where the frontiers of knowledge lie. This can only come from improved information from the existing knowledge base.

The construction industry has often been characterised as one which adapts the technologies developed in other industries to its own uses. Many areas of life are currently in the throws of an information technology revolution which some have compared in its potential for change with the advent of printing. However, in many respects much of the construction industry is as yet almost untouched by this revolution. The next 10 to 15 years promise to be a period of great change in this respect as the UK construction industry comes to terms with and exploits new information technologies which have largely been developed for use in other industries.

At the end of this paper I shall attempt to forecast the nature of some of these changes. But first I will briefly review the nature of technical information currently used by the UK construction industry, both that which is not related to specific projects such as regulations and standards and that which is specifically project related such as drawings and bills of quantities. Secondly, I shall describe the current role of BRE in providing technical information and in helping to evaluate and facilitate the changes which are taking place.

2
Information used by the UK construction industry

When considering information used by the industry it is useful to divide it into ‘non-project information’ and ‘project information’.

2.1
Non-project information

I will deal first with non-project information—the general background information which is needed by participants in the construction industry, such as clients, designers, contractors and subcontractors, manufacturers and building owners to help them design, build and operate buildings. It might be described as the ‘information infrastructure’.

With the approach of 1992, major changes are taking place in the mandatory documents which underpin the construction industry. Directives and regulations from the European Community are increasingly influencing the form and content of building regulations and other regulations in member states and the development of technical specifications such as standards, not only in member states but in the surrounding countries of EFTA and Eastern and Central Europe and, indeed, as far away as the USA and Japan. In order to demonstrate compliance with the Construction Products Directive for their products, manufacturers will generally require an EC mark, which will necessitate the development of a large volume of certificates related to accreditation, certification and test results. There is also likely to be a considerable growth of marks implying compliance with higher levels of technical specification such as those included in the non-harmonised parts of standards.

In addition to mandatory technical information, the construction industry in the United Kingdom and elsewhere has always called upon a large amount of non-mandatory information to help it in elaborating designs and managing the construction process. Increasing attention is also being turned to the management of facilities in terms of both their technical and their economic performance. Research and development organisations in government, universities and trade associations, as well as commercial publishers, produce large volumes of technical information aimed at this market, and I shall enlarge on BRE's role in this later.

A potentially valuable type of information which is increasingly in demand, but which is as yet not well developed, is feedback from activities downstream in the construction process to activities higher up. For example, feedback from sites to the design office on the buildability of designs, of costs in use and other facilities management information to both designers and clients, is often lacking because of the disaggregated nature of the construction industry and the absence of suitable financial incentives. Some changes, such as greater use of design and build and the growth of product insurance, may increase the flows of information of this type.

BRE together with several corporate owners of large building stocks have created a Building Performance and Costs in Use Club in an attempt to encourage increased feedback of this type. The BRE Defects Prevention Unit has taken data from BRE studies in housing defects and established a database of building defects. Information and advice aimed at completing the feedback loop are published in the BRE Defect Action Sheets and other guidance documents. This work is now being extended to other building types and new publications such as 'Good Building Guides' are now being produced.

Lastly in this section related to non-project information, I should mention the information generated by the growing use of quality assurance, not only in the manufacturing part of the industry but also in design offices and contracting companies. The development of quality systems for individual companies is itself generating large volumes of technical information within quality manuals as well as guides on the application of British Standard BS 5750 (ISO 9000).

2.2 Project information

In the above section I have outlined the main technical information activities in the construction industry which are not related to specific projects. As each project is developed it draws upon this body of general technical information and elaborates it. Increasingly, where the participants are themselves quality assured, quality plans will be developed for the project which include specific plans for the structure of project information for the project.

A vitally important stage in all projects is the development of the brief, and BRE has given guidance on this much neglected activity. Many of the general technical information sources mentioned above are incorporated into the project (for example, test certificates related to specific products), and the design intentions are passed from the designer to the contractor, subcontractors and manufacturers. These are still generally in the form of hard copy drawings, bills of quantity and specifications. BRE research has demonstrated the shortcomings in these areas and the major role they have in contributing to subsequent building defects. The result has been the development of the Coordinated Project Information initiative (CPI) which sets down standards for drawings, bills of quantity and specifications for the building end of the construction industry in the UK. The RICS played a full role in developing this initiative and BRE hopes to monitor its effectiveness later this year.

As with non-project information, feedback is also needed related to specific projects. For example, how buildable were the details produced, how well did they work, how does the building perform compared with the design prediction? These sort of questions are rarely answered or even addressed.

In this section I have attempted to outline the main types of project and non-project information. Much is still passed in the form of the printed word. However, other media are increasingly used, and I have outlined some of these in section 4 below.

Even before potential construction professionals enter the industry as practitioners, they require information as part of the education process. Increasingly, however, education is seen as not finishing once graduation or entry to a professional institution has been achieved. Continuing professional development (CPD) is now mandatory in several professional institutions, and many employers provide information and facilities to assist in the CPD of their staff, not only to help them with their personal growth but to ensure the continued prosperity and technical capability of their companies. The RICS has taken a leading role here in encouraging CPD among its members, and RICS members form one of the largest groups attending BRE seminars.

3
The role of BRE in providing and doing research into technical information

It is BRE policy that, wherever possible, the methods and results of the research we carry out should be published free of charge and openly in scientific and technical journals and through conferences to ensure peer review and international dialogue on scientific matters. However, we recognise that such papers are likely to have little effect upon practice in the construction industry. Much of our work for government is in support of regulations and standards, and we participate fully in the development of UK regulations related to the construction industry and in standards work, both in prenormative research, the development of drafts in committee and the development of test methodologies. This work thus finds its way into these fundamental and often mandatory sources of information used by the construction industry.

Beyond this, BRE is a major publisher of technical information and is now the largest single source of technical information used by designers in the UK construction industry. I am pleased to say that members of RICS and their firms are among our best customers. A regular monthly package of leaflets, which includes BRE Digests, Good Building Guides and Information Papers, is sold by subscription and individual reports and books are marketed through the BRE Bookshop and through other retail outlets. These publications combine the basic results of BRE work with knowledge of work carried out elsewhere and of the construction process. They are written in a variety of forms, designed to be used for education, in the design process, on the construction site and during the management, or in maintenance and refurbishment of buildings. Recent publications for practitioners include guidance on foundation movement and underpinning, tackling condensation, and assessment of housing for rehabilitation.

As part of our technical consultancy services, BRE provides an Advisory Service which gives advice over the telephone and by letter, office consultations and site consultations about specific building problems. We also run a full programme of seminars both to maintain contact with other researchers and to support continuing professional development. As I said earlier, RICS members are major users of our advisory and seminar services.

While we make considerable use of IT in the preparation of our publications, the medium most used by BRE for communication with the industry continues to be paper and print. However, we also have arrangements with commercial organisations who republish much of our material in microfiche and on CD ROM. We also produce software in the form of databases, calculation software, interactive training software and expert systems, and make some use of video disc, recorded telephone messages, and audio tapes.

Finally, we encourage the take-up of research findings by entering into licence agreements with manufacturers who may wish to develop products from prototypes made at BRE, and have participated in the design and construction of demonstration buildings. These and case studies based upon them or upon other prototype buildings can be forceful application media.

4
The future for construction information

The future development of construction information will depend both upon changes to the industry itself and changes to the information technology available to it. The UK industry faces considerable changes in its technical and socio-economic context through the development of the Single European Market. Demographic changes will force it to give greater consideration to education and training, both first-time training for new professionals and continuing professional development to help those already in the industry to adapt to the changing environment.

At the same time demands from consumers for improved quality in building products and in design and construction is resulting in the growth of quality management systems and third party quality assurance in all these sectors, and there is some evidence of a growth in project insurance in the UK which will give even greater impetus to these developments. Furthermore the increasing rate of change of technology in the construction industry is likely to mean that regulations and standards will have to be amended more frequently, which will place increasing demands by legislators, standards makers and standards users on information systems.

What solutions, then, can the information and communications industry offer to the construction industry in the face of this information explosion, tighter resources and demand for higher standards? Research by BRE has shown that, although print on paper is the favoured method for the production and consumption of technical information in the industry in the UK, the result has been large volumes of information, stored centrally within design offices and on site, which are not used, or only turned to when crises occur.

Computer aided design has hitherto largely been used only to speed up the drafting process. New generations of CAD contain design methods and algorithms which themselves are based on standards and regulations. The use of CAD systems incorporating such algorithms will no doubt increase, and ways in which CAD systems can be used to incorporate other assistance to, and constraints on, designers at the point of design will need to be developed. One such system in the UK is RIBACAD, where the CAD system contains images of products available to the designer.

In some fields it will be possible to develop CAD systems with an output direct to a manufacturer to control the manufacturing process (for example in some types of system building) or to the contractor or subcontractor to ensure appropriate schedules, orders etc (so called CAD/CAM or CAC). Expert systems to help, for example, with diagnosis or to advise on remediation, already exist in prototype and will be available more widely. Databases currently available on line will be made more user friendly and made available on CD ROM. They will need expert system front ends to facilitate their use by generalists rather than information experts, and, linked with video disc, could also present moving and still pictures. The use of hypertext to develop technical documents of all kinds will facilitate their adaptation to such IT systems. Electronic Data Interchange (EDI) is already being used between some construction companies to pass not only technical information but commercial and other information. There will no doubt be a growth of these systems together with electronic mail etc.

Studies such as Building IT 2000 in the UK, are helping to elaborate the needs of the UK construction industry for information over the next 20 years. These will inform the IT and communication industries of the construction industry's needs and also inform the construction industry of those tools which are already available, or likely to become available in the near future. There is obviously a need for dialogue between these two major industries so that the synergy which results can be used to manage the changes in both industries in a way that will lead to a safer and more prosperous future.

5
Conclusions

Studies by BRE into the quality of buildings have demonstrated that too often the problems are due to failure to apply existing knowledge. Other studies by BRE have shown that designers rely largely upon their own experience and do not make sufficient use of available information, either because they do not know of its existence or because of the cost and difficulty of finding the piece of information they require.

In the face of this, I have not only indicated the need for more information such as feedback on performance from site and from use, but also predicted an explosion of information due to factors such as the Single European Market and the increased availability of data bases. Increasing demands for quality, the implementation of quality management and changed liability arrangements will make it more important than ever that practitioners get a grip on information with the use of the necessary IT tools. BRE will be doing its best to respond to this developing information market and will continue to work closely with its more enlightened customers such as those in the RICS. I believe that only as the industry comes to terms with the information issue will it find its way to the frontiers of knowledge in a way that will enable it to engage properly in pushing those frontiers back by funding to a greater extent in other aspects of R & D.

6

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DURABILITY & DEFECTS

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Abstract

Our buildings are not as durable as they used to be and they demand much more of us if they are to remain useful. The more sophisticated we make them the more potentially defective they become. Different sub-systems of buildings age at different rates which affects our concept of durability. Usually the most seriously defective sub-systems are the building envelope and the engineering services and these should be considered and refurbished together. But the image of the building stock, and our most immediate benefit from it may reside in the more visible systems, and it may be these which determine how durable we want our buildings to be.

Key-words; Building defects, building sub-systems, durability building technology, maintenance.

1
Introduction

The link between defects and durability is either very clear or very obscure depending on the level on which we approach it. Clearly a defect can signal a loss of durability in the purely physical sense; unremedied defects will get worse and may ultimately threaten stability or useability. The connection becomes much more obscure when we decide to live with the defects because the remedial costs and disruption are considered too high.

Ideally our buildings should remain in good repair indefinitely even when subjected to changes of use and abuse. Maintenance and repair are costly, troublesome and temptingly easy to postpone. Older traditional buildings were subject to much slower physical decay and much less change of use, and these characteristics moulded our prevailing attitude to durability. Now both old and new buildings are under pressure from our increasing demands and expectations and still we have not revised our thinking about durability, how much of it we want and what it is going to cost to achieve it.

World War II formed the watershed between old buildings and new. The vast majority of pre-war buildings were of the old simple traditional kind, enduring but inflexible, while almost the entire post-war health building stock is of the new complicated kind, trying through innovation to meet our growing demands and frequently failing in some respects to do so. The concept of the building fabric has changed radically from the traditional simplicity of walls and a roof to the modern complexities of structure, envelope, environmental controls, partitioning, finishes, fittings and furnishing.

These systems interact in some very important ways in the design, construction and operation of buildings. The more we demand of our buildings the more dynamic they become. Every time we try to advance our building technology to achieve greater economy, comfort or a new aesthetic we risk introducing another crop of defects that undermine durability. For example, today's buildings are subject to greater movements within and between their parts, they contain a greater assortment of materials with widely diverse properties which may or may not make them physically or chemically compatible where they meet. Overlaying this complexity are the conditions created by the increased differences between the internal and external environments, further differences exaggerate in taller and more exposed buildings.

This all adds up to a different concept of building; instead of the traditional artefact which could survive our benign neglect for a hundred years and even appreciate in value, we are now faced with a building fabric which needs constant care, attention and renewal if it is to remain in service. At the same time as being our biggest artefact and one of our main support systems, the building stock now consumes increasing resources in its maintenance, renewal and growth.

Nor can we look forward to an early plateau of more durable building; too many vectors of change infect our culture to allow that to happen soon. There are pressures for faster, safer building continuing, innovations in material science, construction technology and information systems, the constant search for economies in initial costs and operating costs and ecological imperatives to save energy and preserve health in the choice of materials, the building's assembly and throughout its life-cycle.

This is the down-side of innovation, the price of advancement. If the price is not paid in initial construction or increased maintenance and repair it will be exacted as a progressive loss of quality in our built environment. And now—at last perhaps—there is the growing realisation that serious human damage can come from poor building and that conversely great benefits in health and happiness accrue from good, sound building.

2
Systems

We have said that in one sense durability may be defined as the absence of defects. Defects may be of several kinds; the wrong location can be a terminal defect in a building as can its inability adequately to fit its purpose or to accommodate a change of use economically, but it is technical failures, the breakdown of its physical systems, that we will focus on first. One way to approach the difficult question of durability is to analyse the building's systems. For example, for reasons of human safety the structural system must have very long-term built-in durability whereas systems of partitioning, fittings, furnishings and finishes are relatively transient, and in many buildings seem to be in perpetual change. Large refurbishment programmes are usually triggered by the need to do something serious about either the building's envelope or its environmental engineering. These two big systems, lying at the heart of major refurbishment, are so closely intertwined that the re-design of one should never be undertaken without at least a fundamental review of the other in order to explore possible benefits and economies and avoid the unplanned piecemeal measures that would frustrate future plans.

So to strengthen our tenuous link between durability and defects we will review defects under the same systematic headings.

3
The Structure

Structural elements should need little maintenance but recently some serious defects have been found in concrete structures; carbonation or excessive chloride content result in corrosion of reinforcement and spalling of concrete. Concrete repairs can be noisy and disruptive and must be executed by specialist firms using comprehensive systems of preparation and repair using modified cementitious mortars. After repair we are left with the problem of its continued protection; both new and old concrete should be given a protective coating to prevent re-entry of carbon dioxide and, where necessary, to conceal repairs and decorate the concrete. Coatings have to allow the envelope to 'breathe' and so avoid condensation on internal surfaces or interstitially, while at the same time preventing wind-driven rain entering the concrete.

4
The Envelope: Roofs

Roofs present outstanding problems and opportunities. Notorious as the areas of greatest heat-loss and the prime source of water penetration, they are also notable as the easiest areas to insulate and the possible sites of inexpensive extension by building an extra storey or habitable roof space.

Many pre-war pitched roofs are reaching the stage where they need re-slating or tiling along with new flashings, rainwater disposal systems and associated repairs to wall-heads and parapets simply to restore the status quo. Such work offers great opportunities for far-reaching improvements to the insulation, natural lighting and re-servicing of the building if the right conceptual effort is put into the design from the beginning. Care should be taken in placing insulation in positions where it can adversely affect the snow-loading that old pitched roof structures have been used to coping with, causing damaging movements at wall-heads.

Flat roofs have been a common characteristic of post-war buildings. The recent return to pitched roof forms was due in part to a desire to return to a more vernacular aesthetic (but not, it should be noted, the accompanying vernacular construction) but also because of the atrociously bad record of much flat roof construction during the ’60s and ’70s. Generally this was caused by the placing of insulation directly beneath waterproof membranes which were too weak to withstand the thermal shocks and cycles they were exposed to in that position. Flat-roofing technology moved on in the ’80s to overcome this problem with much stronger membranes and with closed-cell insulation that could be placed on top of membranes to protect them from the stresses of exposure.

These technical innovations have been extremely useful in the refurbishment of existing flat roofs, turning them into attractive, sometimes habitable decks. Of equal or greater interest is the growing trend towards the over-roofing of failing flat roofs with 1ight-weight pitched roofing systems that create valuable space for new engineering plant and service systems, valuable storage space or even habitable rooms. With any metal decks there is a risk of clear-night condensation and thermal pumping through lap joints so that, used wrongly, even trusty materials such as copper and lead can fail in a remarkably short time.

4
The Envelope: Walls

Apart from pointing and local defects such as the decay of old decorative stone, problems with traditional masonry walls are generally related to their thermal performance. Where adequate space is available, these may be dealt with by adding insulating internal linings, provided care is taken to avoid risks of condensation and cold bridging, which can be difficult. Elsewhere, traditional overcladding such as tile hanging may be appropriate usually with underlying insulation. This is not likely to be acceptable, however, on listed buildings or where vandalism presents risk of damage. The filling of existing cavity walls can be successful but is heavily dependent on good detailing and the degree of exposure to wind and rain.

The walls of many buildings of the 60’s show the defects that arise when materials that lack basic durability are compounded by lack of adequate maintenance. In the school building of that period there was a massive use of poorly seasoned timber, almost all of which is now rotting and in need of replacement.

Where there are no legislative constraints such as in listed buildings or conservation areas, windows may be replaced by more energy-efficient designs incorporating double glazing and thermally-broken frames. Where existing appearance has to be retained, secondary glazing may be added or, in some cases, post-applied double glazing such as the 3M Signa system may be added to existing glass.

Problems occurring in modern envelopes are likely to be more extensive and more varied than in traditional construction and to result largely from movement. Rendered or tiled surfaces spall and fall off, concrete supports deteriorate, panels break up or become detached, seals fail and windows have to be replaced. In the remedial design of envelopes there is often a choice between designs that replicate the original and the opportunity to update the building's appearance. Whatever approach is adopted, opportunities will exist to improve water resistance and thermal performance. Whether the old cladding is to be removed or retained will depend on the extent of detachment or deterioration, ease of removal and disposal, thermal value of the existing and any constraints placed upon design of new cladding by retention of the old.

Then it is necessary to decide upon the new cladding principle to be adopted: is it to be a rainscreen, a drained and ventilated cavity or a fully face-sealed system? This again will be influenced by the desired aesthetic and the degree of exposure.

5
Engineering Systems

Heating systems, ventilation plant, communication networks and movement systems of lifts and escalators all share the characteristics of heavy wear-and-tear and swift technical obsolescence. Past trends to integrate them with other systems, burying them in walls, columns and floors have failed to cope with the constant need to inspect, repair and replace defective or outdated systems. A better answer has been servicing zones, horizontal and vertical, that distribute services and access in a flexible manner largely independent of other systems. Although there have been many important technical improvements in building services this century there has been a sad lack of a conceptual approach in its integration into total building design. Not only have opportunities been missed in initial design but their lack of provision for change and growth has frequently inhibited later growth and change and so endangered the durability of not only the servicing systems but the whole structure.

6
Envelopes and engineering systems

The essential links between the remedial design of the envelope, the environmental engineering systems, energy efficiency and user satisfaction must be grasped from the outset. For example, the correct interpretation and integration of the findings of the various surveys that may be undertaken requires experience in assessing the total performance of buildings. It is essential that all members of the design team are involved at a sufficiently early stage to avoid false starts, problems during the course of the works or, worst of all, an unsatisfactory outcome to the job because of a lack of a comprehensive approach. That way lies missed opportunities and poor value for money. An energy survey will identify and quantify heat losses through various parts of the building, solar gain and the interplay of the envelope and services systems, which we have already seen to be of paramount importance in preventing defects and ensuring a more durable building.

7
Image

Without diminishing the importance of these big ‘serious’ systems of structure, envelope and services, no debate on building defects and durability can afford to underestimate the significance of the other image-making systems of partitions, finishes, furnishing and landscaping.

Most types of building exist to provide shelter and support for human activities. In many cases these activities can be costed and where this has been studied it has transpired that these functional costs far exceed the initial and operating costs.

The diagram Fig 1 illustrates this ratio dramatically in the case of offices and shows at the same time how the potential for economy in this area of building use far exceeds likely savings in initial or running costs.

While admitting that this is a world of intangibles where it is very difficult to link cost directly with benefits, it is clear, nonetheless, that there are great returns in human well-being—and therefore most probably in productivity—for money spent in creating and maintaining a clean, cheerful, colourful, 1ife-enhancing image in our built environment.

Recently this lesson has been taken to heart in the NHS where it has been demonstrated that improving the out-patient experience offers a huge return in patient and staff satisfaction for a very modest investment in image-enhancement.

The serious side of this is not only the immediate “bang for your buck” but what it says about our attitude to our building stock. Defects can often be ignored or the remedies postpones without threatening technical durability, but the resulting impoverishment of our buildings and the lives we lead in them can lead to that most serious of defects—corrosion of the human spirit. We may come finally to realise that our attitude to durability is determined by considerations that are frankly more aesthetic than technological.

Table I
Functional Use Costs: Total Long-term Costs (present value): Initial Operating/ Maintenance/Repair/Replacement, and Functional Use Costs and Functional Use Ratios for examples of three building use types.

Source Functional	**Initial Costs**	**OMR Costs**	**IN & OMR Costs**	**Functional Use Costs**	**Use**
Ratio **	%	%	%	%	FUR-
(I+0+FU)	I	0	I & 0	FU	
/I					
Offices					
Brill ’72 US (a) 50.0	2	6	8	92	
GenEle ’78 US (b) 11.8			17*	83	
Dinwid ’80 UK(c) 25.0			8*	92	
Brill ’81 US (d) 33.3	3	4	7	93	
Fuller ’82 UK(e) 25.0			8*	92	
GSA ’85 US (f) 25.0	4	3	7	93	
conservative	5%	5%	10%	90%	
average: ratio 20.0	1	1	2	18	
Hospitals					
Macedo ’78 US (g)	9	24	33	66	10.6
HavAIA ’79 US (h) 7.1	14	7	21	79	
MGH ’86 US (i) 12.6	7.9	6.1	14	86	
Mayo ’89 US (j) 11.0			16*	82	
Universities					
Fuller ’82 UK(d)	30	11	41	59	3.2

Table 1 Source: R Ward (MIT. Framework of Total Value)

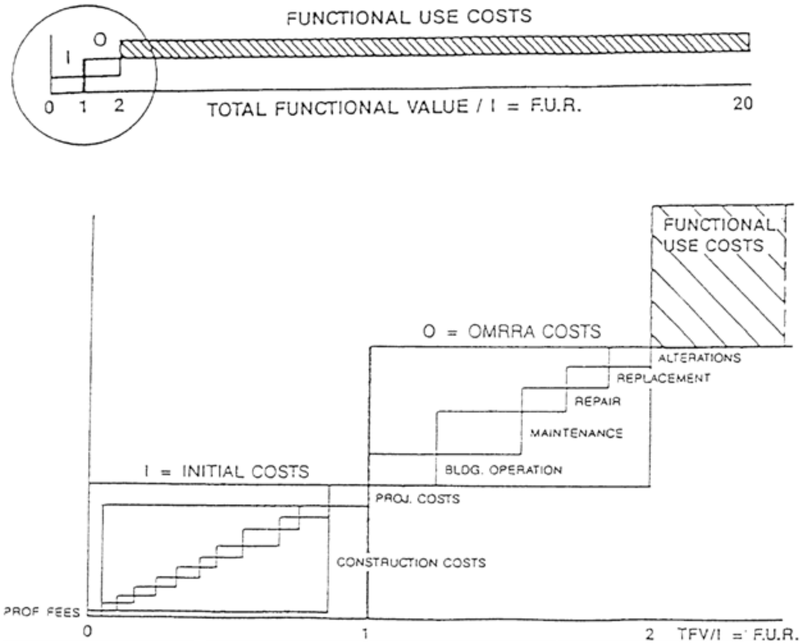

Figure 1

Figure 1 source: R Ward (MIT Framework of Total Value)

GROUND ISSUES—FOR SURVEYORS

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Abstract

This paper provides an overview of the various mechanisms which render land difficult or unfit for development. Aimed at property professionals involved in making decisions about the acquisition or development of land the paper seeks to demonstrate how surveyors can better inform themselves in such matters and having informed themselves provide their clients with effective derelict land management. Sources of information are mentioned together with the types of problems likely to be encountered and the potential solutions.

Key-words; Chemical contamination, ground conditions, mineral workings, reclamation.

1
Introduction

In the heady days of the 1988 property boom many developers in the frantic search for land, acquired sites either with little meaningful regard for the ground conditions or without being afforded sufficient time to examine sites properly.

The surveyor involved in land and property transactions is often in possession of local knowledge concerning site conditions, but fails to present this knowledge in a way which assists the client in reaching a decision about land.

Surveyors are called upon to undertake building surveys prior to acquisition of an office or house but such reports often omit constructive comment on the land upon which the property sits.

I hear you say already that this is somebody else's job and in some respects you would be right, but it depends upon how definitive you feel you need to be about ground issues. In today's litigious society it is essential to know more about the likely effects of ground problems on land. The surveyor is part of the team and possesses the ability to assist that team in respect of basic research about the land being dealt with.

2
Failure Mechanisms

A surveyor may inspect a house and see a crack in the gable end. This assists in reaching a decision about that house. If the crack passes into the soil or perhaps across the back garden there is also the potential that the surveyor might notice something amiss but given his survey is of a “desirable residence plus land” in some leafy part of rural England or Science Park on the edge of some university town what needs to be looked at in terms of the ground suitability?

The mechanisms by which land may be unfit for development fall into three main areas.

1. Naturally occurring ground problems.
2. Effects of chemical contamination or industrial abuse.
3. Mineral activity, past present and future.

3
Naturally Occurring Ground Problems

A variety of naturally occurring ground problems exist throughout the United Kingdom. These can vary from solution cavitation in the soft chalks underlying south-east England to heavy metal contamination from mineralisation of granites throughout much of what might be termed Celtic Britain. The current concern surrounding radon not only exists in Cornwall but in several other areas such as emission from the oolites to be found underneath Northamptonshire, Oxfordshire and the Cotswolds.

The range of more common problems can be summarised as follows:

1 Groundwater

- shallow
- fluctuating
- flowing

2 Solution in soluble rocks

- limestone, chalk, rock, salt, etc

3 Landslipping

- in glacial deposits
- in Coal Measures, Wealden clays etc

4 Compressibility

- alluvial deposits, glacial lake clays
- peat

5 Swelling and shrinkage of clay soils

- seasonal variation
- effects of trees

6 Frost susceptibility
7 Chemical Effects

- acidity, sulphates
- heavy metals and other contaminants
- gases—methane, hydrogen sulphide etc
- radon

There is a relatively close correlation between geological ages, specific types of problems and geographical areas. It is about his or her 'patch' will learn to recognise possible problems of this nature affecting land or property, the subject of report.

4
Chemical Contamination

Chemical contamination is not simply the result of past geological activity. Man's activities have created major ground problems as a result of past and present industrial use and abuse.

The industrial revolution the origins of which stemmed from the ability of man to recognise the potential of naturally occurring materials created continues to create, a legacy of dereliction.

Miles of abandoned railway lines and canals, disused factories and docklands, vast areas of spoil deposits and sterile land vividly testify to the need for better awareness of how such activity has influenced the future use and development of land.

A variety of uses have the potential to create chemical conditions likely to affect either construction materials used e.g. in foundations of houses or hazardous to construction workers, and also the end users of the property.

Thorough research is necessary into the past use of land, particularly in urban areas to identify what potential exists for problems. Typically any land having the following past use may present problems to the developer:-

1 Domestic tips
Iron and Steel works
Foundries

Polluted Site Thames Valley

Gasworks
Chemical Works
Tanneries
Shipyards etc

which create problems with:-

1 Fill
polluted industrial waste overfilling land often the site of past minerals extraction, concealing the tell tale signs of mining instability.
2 Hazards created by development on such sites include:-
Poor and variable bearing capacity
Buried obstructions and voids
Soil and water chemical toxicity
Odour
Gases
Pathogens
Expansive slags
Self-heating materials

The detailed investigation of such sites may not be the work of surveyors but again local knowledge and recognition of problems can and does allow the surveyor to better function as an advisor on the development of land. therefore the case that the surveyor having taken the opportunity to be informed

5
Mineral Activity, past, present and future

There has been a history of mineral working in the United Kingdom for almost two thousand years and perhaps even in Neolithic times. For example the Romans first worked for coal in the United Kingdom near Viroconivm at what is now known as Wroxeter in rural Shropshire. Agrippa Panhandulus the well known Roman prospector trudged the hills of south-west Scotland finding gold and other metals at Wanlockhead. As the easily won surface deposits became exhausted men started to burrow and, rabbit like, created vast systems of underground workings in the search for the mineral wealth which lay beneath the ground.

The underground working of minerals has not been confined solely to coal or to areas "somewhere up north". Underground workings for materials such as clay, limestone, chalk, flint, gypsum, ironstone and salt exist in regions as diverse as Norfolk, Surrey, Kent, Cheshire and Lincolnshire. Further afield metals have been worked in most of the Celtic fringes and tin continues to be won in Cornwall albeit on an ever reducing scale.

The impact of such workings, largely unrecorded until the late 19th century, has been extensive.

Types of workings:	Coal and related minerals
	Metalliferous
	Non metalliferous

Hazards:	collapse of shallow workings (void migration)
	subsidence from deeper workings fissuring
	mine entries (shafts etc)
	spontaneous heating of spoil
	chemical toxicity of spoil
	gas

Precisely how a collapsing mineworking affects the surface is a function of the depth and thickness of the seam, the associated geological structure, rock, soil and fill cover. In the case of coal mining where seams have been worked at or near the surface by underground methods the classic signs of failure to a building include severe cracking of the brickwork, elongation, compression or twisting of the structure. Land

will reveal "crown-holes" where voids have migrated through to the surface, often opening up, in some particularly inconvenience or dangerous place. More widespread, subsidence is also created by active underground mining where British Coal in exercising it's rights to mine coal removes a seam of coal in a particular neighbourhood. This can and frequently does affect properties at the

Exposed Shallow Mineworkings—"Stinking Coal" West Midlands

surface, particularly where no structural precautions have been introduced into their design.

6
Sources of Information

The surveyor in developing his or her awareness of the issues affecting the ground has many sources of information available. Standard geological information can be obtained from the British Geological Survey, information on past land uses can be easily obtained from examination of Ordnance Survey plans of both County and National Grid series. Records Offices and libraries around the country operated by county and local district authorities provide a wealth of data on land issues and past mining.

In respect of mining of coal, British Coal and private sector mining consultants offer services which help to identify mining interests in a piece of land. Other minerals information can either be found with operators, the mines record office, the British Library and several other sources. It is appropriate that surveyors take the time to better assess what they are dealing with.

Finding the solution

The surveyor in identifying a problem must also be prepared to assist in finding (AND FUNDING) the solution. The role to be played at this stage is in the co-ordination of what remedial steps might be necessary. Major problems connected with extensive tracts of polluted or undermined land will require a different approach to the open mineshaft discovered under the lounge of somebody's house.

Inner city dereliction has been recognised throughout the past decade as a major problem requiring, in some form or another, central government intervention and initiative. The Derelict Land Act 1982 introduced a Derelict Land Grant scheme which has become exclusively a scheme for local authorities to reclaim land through Department of Environment auspices. The private sector, first with Urban Development Grant then more recently with City Grant, has the opportunity of using a combination of public and private sector cash to make marginal developments happen. Many problems, particularly with naturally occurring geological conditions or chemical pollution, can only be solved by innovative schemes and enough cash but opportunities do exist for problems associated with shallow mineworkings to be solved on a very cost effective basis by means of opencast working of the mineral.

Reclamation—Modes and Philosophies

This brief examination of some of the problems associated with the ground would not be complete without mention of how engineering solutions can be achieved.

In dealing with weak natural or fill material at the surface a variety of methods exist depending upon the precise nature of the problem. Three methods of improving the load bearing capacity of weak fill are:-

1 Overdig—where the surface fills are excavated, selected and recompacted by means of, for example, a vibratory roller to a previously calculated depth and specification.

2 Vibro replacement—where a column of stones is placed and tamped by means of a large poker into the fills replacing the weak materials. Costs are dependent upon depth of fills and building size.

3 Dynamic compaction—where a large standard concrete or steel block is lifted to a predetermined height by a crane and dropped on the ground at intervals on a grid basis. This has the effect of pushing the air and/or water out of the fills thus reducing the small voids between particles and the ability of water to move through them. Costs are dependent upon depth of fills and building size.

In all cases any material classified as hazardous would have to be dealt with separately either by encapsulation on the site or clearance to a tip licenced to receive such wastes. Costs for this latter exercise have risen by over 100% in the past twelve months.

Overdig Exercise—Housing Estate County Durham.

Treatment of mineworkings requires a thorough knowledge of the nature of the workings and the type of development. Typically shallow mineworkings in coal are filled through boreholes with grout mixtures of up to 20 parts pulverised fly ash to 1 part of cement for workings and 9 parts pulverised fly ash to 1 part of cement for workings and 9 parts pulverised fly ash to 1 part of cement for mine shafts and injected under pressure at approximately 80 p.s.i. Depending upon the thickness of the coal seam this can cost of the order of £35/m^2. The area to be treated would normally be tailored to and a little wider than, the size of the units to be built.

Mineshafts where a full stabilisation programme is required of proving, filling and grouting the shaft column and constructing a reinforced cap at the surface can cost up to £15,000 per shaft plus the cost of the fill. If that mineshaft is under someone's lounge then costs will be a function of the difficult working conditions.

Underground cavities of varied types and scales exist. Room and pillar limestone caverns 5 to 7 metres high and several hundred metres across blight considerable areas of the Black Country, even where they may be 200m below the surface. These are filled by either sluicing waste sand through large diameter boreholes into the voids or by injecting a slurry mix utilising colliery spoil with PFA and lime additives.

However not all such problems require copious sums of cash to solve. Creative reclamation has resulted in some cases with real opportunities being identified for future beneficial use of sites at no cost to the landowner.

The Singing Cavern Tunnel in Dudley, West Midlands, has opened up former limestone caverns to tourism and is now part of a successful national tourist attraction. The opencast mining of shallow seams of coal has created developable land at no cost— funded by the wealth from coal sales.

Conclusions

The ground conditions which may be encountered in the United Kingdom offer opportunity for surveyors who take the trouble to become better informed, to provide clients and employers alike with an effective land management service. The selection of sites although not conditioned purely by ground conditions is influenced by them. Recognition of all the choices and options open to developers will help surveyors develop their role for the 21st century.

Gordon S Wood FRICS AMIMinE
Partner
Johnson Poole & Bloomer

P.S. St.Luke Chapter 28

"For which of you intending to build a tower sitteth not down first and count out the cost whether he hath sufficient to finish it."

Ground.nts
25.3.1991

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