CHAPTER EIGHT

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CHAPTER EIGHT – ESTIMATING QUANTITIES AND COSTING

8.1 INTRODUCTION

8.1.1 General

The major revision to this Chapter is the inclusion of a brief review on life cycle costing and the Introduction of a new Section on Estimating Quantities and the concept of using a Standard Method of Measurement for this quantification and hence estimating costs at the end of the detailed design stage and for the production of the Engineer's Estimate.

In recent years there has been a trend towards the use of the UK Institution of Civil Engineers Standard Method of Measurement (CESMM) for this. However, this has a number of limitations, not least because it is developed for use in the UK and does not therefore take into account conditions and requirements specific to East Africa in general and Tanzania in particular.

The Ministry is aware of only one modified version of this Standard Method of Measurement developed by an international consultant who has used it in eastern Africa with some success for over fifteen years.

Whilst it is not yet considered perfect, it is felt to be a considerably better alternative than using Standard Methods of Measurement developed for use elsewhere. The latest version is Appendixed here, courtesy of that Consultant for consideration by others. It should at least be considered for use for larger contracts and if used, even in modified form, the source should be acknowledged. As a result the BOQ included in earlier editions of this Mnaual has not been repeated here.

8.1.2 Need for Cost Estimates

Cost estimate to construction project is used as a guide to:

- Project planning arid funding
- Identify the most economical design of project among various alternatives
- Check for viability of a proposed project

8.1.2 Estimating Criteria

The method used for cost estimation varies according to project stages. Thus, during the feasibility studies most items are in lump sum and therefore estimation is a rough figure tending to be very big.

As the project goes on being more detailed at further stages, the cost estimate tends to become more accurate because items are split to very small detailed components for rating.

An example of a pump house is given in the following table:

TABLE 8.1: COST ESTIMATING AT DIFFERENT PROJECT STAGES

PROJECT STAGE	METHODOLOGY
At the feasibility studies stage	Lump sum
At the preliminary design stage	Floor area (m^2) Estimated rate per m^2
At the detailed design stage	Different classes such as: Excavation Concrete work Blockwork, etc. Sub-divided into items

8.1.3 Factor affecting Cost Estimates

Although cost estimate is prepared using basic prices / rates available, it is difficult to be accurate because of the following factors:-

(i) Price fluctuation being a change in price of construction material, labour and transport which occurs often and has been a major factor affecting planned cost estimate of a proposed project.

(ii) Foreign currency exchange rates which like price fluctuation, has caused progressive devaluation of the TSh. This can be particularly problematic when the proportion of materials and goods required from ousdie sources is high;

(iii) Detailing omissions when design and drawings are not detailed enough and thus many items are not then covered during cost estimation. This will create many variations during construction, but can be minimised by reference to a detailed Method of Measurement.

(iv) Time Control meaning that in order to minimise cost variations caused by price fluctuation, exchange fluctuations, etc; the project should be implemented within the period planned. This will minimise unnecessary claims caused by delay of the proposed project.

8.1.4 Life Cycle Costing

The trend towards a Life Cycle Analysis / Whole Life Design approach was discussed in some detail in Chapter 4 on Pipes and Pipelines and again briefly in Chapter Six on Pumping Plants and Systems. As discussed there, the use of life cycle costing which forms the principle component for the basis of a whole life approach is developing rapidly and designers should both keep abreast of these developments and use such an approach wherever it is possible to do so.

To undertake a Life Cycle Cost calculation it is necessary to identify all costs by year and amount and discount them to present value. They are then added to arrive at the total life-cycle costs for each alternative, using a formula such as indicated:

$$LCC = I + Repl - Res + E + T + OM\&R + OC$$

Where,

LCC = Total LCC in present-value (PV) of a given alternative

I = PV investment costs (if incurred at base date, they need not be discounted)

Repl = PV capital replacement costs

Res = PV residual value (resale value, salvage value) less disposal costs

E = PV of energy costs

T = PV of treatment costs

OM&R = PV of non-fuel operating, maintenance and repair costs, and

OC = PV of other costs (e.g., contract costs).

It should be noted that life cycle costing such as described here takes no account of external socio-economic consequences such as damage caused by leaks and bursts or downtime for major repairs, or of long term environmental health implications

8.2 QUANTITY SURVEYING

8.2.1 Taking off Quantities

Quantity Surveying is both a profession in itself and taught as a subject in under-graduate civil engineering courses. Larger consulting firms often employ quantity surveyors both to take-off quantities whilst contractors employ quantity surveyors to control quantity usage and cost and to deal with the basis for contractual claims.

However, for in-house design and project design by smaller firms it is the more common practice to expect the designer to be able to undertake quantity take-off and cost estimating as part of the design process itself. This has certain advantages in that it is the designer who has the best knowledge of what is required and works well providing the quantity take-off is always checked by a third party such as another engineer or an engineering technician. Unfortunately, this checking procedure is all too often omitted either to save cost or due to time constraints and this can then lead to regrettable results and all too often, cost-over-runs during works execution.

Where quantity under-estimation is discerned by a knowledgeable contractor during bidding, this often results in unrealistically high rates being offered for the obviously under-estimated quantity with the result that the contractor, if successful in his bid, then makes a financial windfall when the actual quantity becomes known

8.2.2 Method of Measurement

For larger projects in particular, reference to a detailed Method of Measurement provides a useful cross-check that significant items have not been omitted.

The modified Standard Civil Engineering Method of Measurement annexed here as Annexe 8B, is a good example of this. However it is not applicable to large or complex buildings but does suggest a possible source of a Method of Measurement for such structures.

8.3 STAGES OF COST ESTIMATING

8.3.1 Briefing / Feasibility Stage

Two types of costing are dealt with at this stage namely:

- Cost of conducting feasibility studies
- Cost estimate of the whole planned or proposed project including (i) above.

1. Cost Estimate for conducting Feasibility Studies when the work is to be done by the Ministry, Regional or District Water Department, or Water Authority. Main components are:-

   (a) Manpower:
   Skilled allowance / night
   Unskilled allowance / night
   Labourers daily pay

   (b) Tools / Equipment: to be specified

   (c) Transport: Hire and fare charges or oil, lubricant and minor repair when transport is provides by the office.

   (d) Preparation of Report: This is a lump sum cost of stationeries, lunch allowances, etc.

   (e) Contingencies @ 15%.

2. When feasibility studies and designs are to be done by a consulting firm his cost estimate shall be prepared according to Terms of Reference for the project.

8.3.2 Preliminary Design Stage

At this stage a fully picture of the project is perceived. Cost estimates are often done against major components.

<u>For a Water Supply Project for Example:</u>

Construction Works

Mobilization	– lump sum
Intake structure	– lump sum
Suction pipe (…. m long)	- lump sum
Pumping station (if any)	
Water treatment (if any)	- lump sum
Sump (…..m^3)	- lump sum
Pump house (if any)	- lump sum
Raising main / gravity main (…m long)	- lump sum
Reservoir (…m^3)	- lump sum
Distribution mains (….m long)	- lump sum
Attendants quarters (…. m^2)	- lump sum

Operation and Maintenance costs

1. Administration costs - lump sum
2. Chemicals - lump sum
3. Manpower - lump sum
4. Cost of repairs and servicing of material equipment - lump sum

An alternative is to develop cost curves for each major element of a project in which cost is plotted against size or volume. The appropriate cost can then be quickly read off. However it does require a sufficient number of recent historic examples brought to a present cost value to develop such curves and is therefore more likely to be a costing tool available to a firm of consultants.

8.3.3 Detailed Design and Preparation of Tender Dossier Stage

Preparation of tender documents shall be done if and only if the project is to be executed by a contractor. For this reason, a tender dossier shall be prepared according to the constitutions of contract procedures. Specifications and bill of quantities of the tender dossier shall be prepared in accordance with the detailed designs of the project, the quantity survey and the Method of Measurement opted for. Based on the detailed designs, major components in item 8.3.2 above are split into classes, and divisions or minor items to allow for identification of required materials and more accurate cost estimate of the project.

A cost estimate for borehole drilling and measurement of general construction items are worked as follows:-

(a) Cost estimate for borehole drilling

(b) Measurement of general construction items,

and can follow the following layout:

TABLE 8.2: COST ESTIMATE FOR BOREHOLE DRILLING

	COST ESTIMATE FOR BOREHOLE DRILLING Item Description	Unit
1	Mobilization and Demobilization	Lump sum
2	Drilling	M
3	Drilling mud (bentonite & cement)	Lump sum
4	PVC casings	m
5	PVC screen	m
6	Gravel	m^3
7	Installation of PVC pipes, screen and gravel	hr
8	Development and cleaning	hr
9	Pumptest for 24 hrs	hr
	Sub total	
10	Add 30% for replacement of equipment	

Cont’d

	COST ESTIMATE FOR BOREHOLE DRILLING (CONT'D) Item Description	Unit
11	Add 30% for labour wages, inspection and allowance to driller	
12	Add 10% for contingencies	
	GRAND TOTAL	

Preliminary and General Items

Preliminary and General Items can be included in a Cost Estimate as a % of the total Construction Costs in which case it is recommended that 14% be added onto to the estimated Construction Costs. Again, the Annexed Method of Measurement details out all of these redquirements.

In the Bills of Quantities, two methods are possible, the preferred one being to include a totally separate Bill, Bill One for this purpose. This then enables a clear costing to be established and understood and provides both Client and Contractor with a clear understanding of what is expected and when. The alternative, which is not recommended is to provider a detailed list of requirements and then get Bidders to spread these costs throughout the Works items. Unfortunately this seemingly simple method then often results in disputes, especially where the scope of works changes or there are time over-runs that are beyond the Contractor to control.

Estimating and Including the Cost of Labour

In some cases labour is taken as percentage (% age) of cost of materials (i.e. 20-30%). This method is used but it gives a rough estimate because there are some materials which have very high price but need very little labour to fix in position (e.g. water pumps, etc.) Some items do not have materials to be purchased but need only labour (e.g. excavation). The best method is to identify manpower required at each category (e.g. skilled, unskilled etc.) for each item for a specified period. Labour productivity is essential for estimation of man-days. Total man-days of each category is incorporated as a cost into the bill of quantities cost estimate as deemed most appropriate.-

Estimating and Including the Cost of Transport

Cost of transport shall be worked out in accordance with established hiring rates within the area concerned and again incorporated into the bill of quantities cost estimate as deemed most appropriate.

8.4 OPERATION AND MAINTENANCE STAGE (O AND M)

8.4.1 Operation Costs

These include the following:

a) Manpower

Number of staff required are of different categories (i.e. high skilled level, medium level skills, low level skills and labourers) with different salary scales and allowances. The numbers required in the different categories depends on the size and type of work.

b) Energy

The price of diesel and electricity should be obtained from the District Water Engineer and the Tanzania Electricity Supply Company (TANESCO) respectively. Note that the price of diesel varies from region to region.

c) Chemicals

Cost estimates shall be based on dosage rates and production required. Dosage rates which can be initially assumed for conventional surface water treatment are as follow:-

- Alum - 0.05 kg/m^3 water
- Soda ash - 0.02 kg/m^3 water
- Chloride of lime - 0.002 kg/m^3 water

d) Office Running Costs

These include water, telephone, electricity, rent, transport bills etc. paid for the day to day running of office.

e) Tools, Plants, and Machines Costs

An inclusion must be made for the provision of tools, plant and machinery dependant upon the size and complexity of the operations involved.

8.4.2 Maintenance Costs

For maintenance (replacement) costs see Chapter 4, section 4.3.1, Table 4.1 which suggests the economics life time of various pipe assets and their annual maintenance cost as a percentage (%), and the Table below:

TABLE 8.3: WORKING LIFE AND ANNUAL MAINTENANCE COST FOR OTHER THAN PIPEWORK

COMPONENT OR ASSET		ECONOMIC (DESIGN) LIFE IN YEARS	ANNUAL MAIN-TENANCE COST AS % OF CAPITAL COST
1	Intake Works (concrete)	40	1.5%
2	Boreholes	20	2%
3	Pumps, hand	7-10	5%
4	Pumps, prime mover operated	10-15	5%
5	Hydrams and hydrostats	15	5%
6	Diesel engines / accessories	10	7%
7	Electric Motors / accessories	10-15	5%
8	Treatment Works	30	1.5%
9	Storage Tanks in masonry or reinforced concrete	30-40	1%
10	Elevated Tanks & Structural Steel Towers	15-20	3%
11	Buildings, timber	15	2%

Cont'd

	COMPONENT OR ASSET	ECONOMIC (DESIGN) LIFE IN YEARS	ANNUAL MAIN-TENANCE COST AS % OF CAPITAL COST
12	Buildings, masonry	30	1.5%
13	Domestic Water Points	15	2%
14	Shallow Wells with handpump	10	5%
15	Gantries, other structural steel works etc.	20	2%
16	Tools, plant and equipment	7-10	4%
17	Roads and earthworks	30-40	2%

8.4.3 Revenues

Cost estimates for revenue should be obtained from the Client or responsible authority in the area. The authority should be advised of the estimated capital and operating cost of the project so that they can make any adjustment necessary in this regard.

8.5 MISCELLANEOUS COSTS

8.5.1 Land Acquisition

Cost estimate for land acquisition should be made after consultation with Government or the Regional Valuer.

8.5.2 Electricity Power Transmission Line

Estimates for connection to grid system should be done in consultation with TANESCO.

8.5.3 Property Compensation

Like land acquisition, cost estimates for property compensation shall be made in consultation with the Regional or District Valuer.

It is however extremely important to take careful note of the state of properties and the location and type of buildings that might be effected by a water supply scheme during the initial and final site survey stages as it is not unknown for property owners to quickly erect structures on proposed pipe alignments, etc. with a view to seeking inflated compensation at a subsequent date.

It is also very important to delineate pipeline wayleaves and to make it clear to property owners that any structures constructed subsequently within the wayleave will be demolished at the owners cost and without the right to any compensation whatsoever.

All wayleaves must be formerly registered as such for this to be legally effective, even with road reserves.

ANNEXE A

TABLE 8A.1: COST OF LABOUR

No	ITEM DESCRIPTION	QTY	UNIT	UNIT RATE	AMOUNT TSHS
	Temporary / casual labour	xx	Man days	xx	xx
	Unskilled labourers	xx	Man days	xx	xx
	Skilled labourers	xx	Man days	xx	xx
	Carpenters	xx	Man days	xx	xx
	Block layers	xx	Man days	xx	xx
	Steel fixers	xx	Man days	xx	xx
	Permanent employees Provide night allowance for the following:- Technical auxiliary Technicians Engineers Drivers etc.	 xx xx xx xx	 Nights Nights Nights Nights	 xx xx xx xx	 xx xx xx xx

TABLE 8.A2: TYPICAL BILL OF QUANTITIES PAGE

PROJECT:……………………………… REGION:…………………...

DRAWING NO:……………………….. DATE:………………………

ITEM NO	DESCRIPTION	UNITY	QUANTITY	RATE	AMOUNT TSHS.
			Amount Carried Forward:		

TABLE 8A.3: QUANTITIES OF CEMENT, AND DRY SAND IN 1 M^3 OF WET MORTAR

MIX PROPORTION	CEMENT, KG.	SAND M^3	SAND PER 100KG. OF CEMENT m^3
1:1	1020	0.71	0.07
1:2	680	0.95	0.14
1:3	510	1.05	0.21
1:4	380	1.05	0.28
1:5	310	1.05	0.34
1:6	250	1.05	0.42
1:7	220	1.05	0.48
1:8	200	1.05	0.58

TABLE 8A.4: QUANTITIES OF CEMENT, LIME AND DRY SAND IN 1 M^3 OF WET LIME MORTAR

PROPORTION OF MIX CEMENT, LIME SAND	CEMENT, kg.	LIME m^3	SAND m^3
1:1:3	410	0.264	0.852
1:1:6	250	0.170	0.020
1:1:7	250	0.153	1.071
1:1:8	190	0.132	1.096
1:1:9	170	0.236	1.062

TABLE 8A.4: GUIDE FOR SMALL CONCRETE QUANTITIES PER M^3

	CEMENT IN Kg				DRY SAND, m^3	AGGREGATES, 12 TO 25MM m^3
	MACHINE MIXING		HAND MIXING			
	GRAVEL SHINGLE	BROKEN STONE	GRAVEL SHINGLE	BROKEN SHINGLE		
1:1:2	530	580	570	600	0.40	0.80
1:1.5:3	370	390	380	400	0.42	0.84
1:2:3	360	380	370	390	0.54	0.81
1:2:4	290	310	300	320	0.45	0.90
1:2:5	250	270	260	200	0.46	0.92
1:3:6	190	210	200	220	0.46	0.92
1:4:8	140	160	150	170	0.47	0.94
1:5:10	120	130	120	130	0.48	0.96
1:6:12	100	110	100	110	0.45	0.98
1:6:18	70	80	70	80	0.35	1.00

ANNEXE 8B: EXAMPLE OF A METHOD OF MEASUREMENT