LECTURE 1: INTRODUCTION

Assessment for Part-time programme:
Assessment: Examinations 70%, Continuous assessment 30%.
The 30% for continuous assessment is made up of the following:
- Presentation of tutorial answer: 10%
  OR Essay (self-selection of topic): 10%
- Project work: 20%.

Assessment for Full-time programme:
Assessment: Examinations 70%, Continuous assessment 30% (project work).

OBJECTIVES
1. To give students the concepts of construction project economics
2. To highlight the factors influencing construction cost.
3. To discuss specific costing techniques and their application.
4. To give students an appreciation of the principles of, and procedures relating to, estimating and tendering.

CLASSROOM TUTORIALS
Tutorial questions based on various topics related to the lectures are set. The class representative must identify one student to answer and present each tutorial question. The presenter should spend a maximum of 20 minutes on one question. One student should present only one question. It is the student’s responsibility to ensure that he/she presents once, so as to earn the marks allocated for this activity. The presentation will be evaluated by the lecturer (5%) and fellow classmates (5%) on its clarity, accuracy and presentation skills.

Students who are not presenting may evaluate the presenter. Students must evaluate at least 5 tutorial answers. A maximum of 10% is allocated for the student’s role as an evaluator.

REFERENCES
References are as shown at the start of lecture notes and in the relevant tutorial questions. Students can consult the references in NUS’ digital library, at http://bweb.nus.edu.sg/ecoll/aup_ej.html
(NUS website at http://www.nus.edu.sg, → Resources → Digital Library → ejournals.)
## HOW THE TOPICS ARE LINKED

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<thead>
<tr>
<th>Cost Data Bank</th>
<th>INCEPTION &amp; PLANNING</th>
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<td>Prepare Approximate Estimates. [L3, 4,5]</td>
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<td>Methods:</td>
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<td>1. Functional Unit Method</td>
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<td>2. Gross Floor Area Method</td>
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<td>3. Approximate Quantity Method</td>
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<td>Cost Control During Design Stage [L4]</td>
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<td>Life Cycle Costing [L10, L12]</td>
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<td><strong>TENDER DOCUMENTATION</strong></td>
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<td>Economics of Building Services [L16]</td>
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<td><strong>CALLING TENDERS by consultant QS</strong></td>
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<td><strong>TENDERING by Contractor QS</strong></td>
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<td>pricing works bill, based on built-up rates [Build up rates lectures]</td>
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<td>2. Pricing preliminaries bill and general items</td>
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<td>3. Bidding strategies, tender adjudication [L8]</td>
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<td>1. Evaluate tender</td>
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<td>2. Recommend tender</td>
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<td>3. Award of tender; prepare letter of acceptance of tender</td>
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<td>2. Financial reconciliation by contractor QS.</td>
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<td>2. Valuation of variation</td>
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Build-up rate lectures: Lectures 6, 9, 11, 13, 15, 17, 18, 19, 20, 21.
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<th>Lecture</th>
<th>Tutorials- F/T</th>
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<td>L13B Build-up rate: glazing</td>
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<td>L14 Implications of maintaining buildings to the requisite standards</td>
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<td>L15 Build-up rate: drainage</td>
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<td>L16 Economics of building services</td>
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<td>L17B Build-up rate: plumbing</td>
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<td>L18 Build-up rate: carpentry, joinery, ironmongery and roofing</td>
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<td>11</td>
<td>L19 &amp; 20 Build-up rate: architectural finishes, painting</td>
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<td>12</td>
<td>L21 Prorata rates</td>
<td>IVLE Tutorial 5(no classroom tutorial)</td>
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<td>L22 Value Management</td>
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<td>13</td>
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Lecture 2: Cost Analysis

References


1 What is a cost analysis

1.1 Cost analysis is a systematic grouping of costs of many items in a project. These costs are obtained from the successful tender.

1.2 The purpose of undertaking cost analysis is to obtain useful cost data on a project in which the contract has been awarded. The 'useful cost data' is stored and used to estimate the cost of other projects in future. Cost analysis is undertaken to aid estimating. Cost analysis provides data which allows comparisons to be made between the cost of achieving various building functions in one project with that of achieving equivalent functions in other projects.

1.3 Because the analysis is carried out on a project in which the contract has been awarded, cost analysis is usually prepared after the tender has been awarded.

2 Types of Cost Analysis

2.1 Trade sections of bills of quantities or breakdown cost

Cost of each trade section is expressed as a percentage of the total. This is routinely done by the QS when evaluating tenders. This may help to detect:

a) overspending in a particular section
b) overpricing in a particular section; front loading.

2.2 Labour and material content.

Very difficult to prepare. Used to compare very similar buildings. For example:

a) labour content 25% - 30% of total cost
b) plant 5% - 10% of total cost
c) materials 50% of total cost
d) profits and overheads 15% of total cost

2.3 Single rate cost analysis
The tender cost is converted into a single rate. For example:

a) cost per unit gross floor area = \[
\frac{\text{Building & M&E costs}}{\text{Gross floor area}}
\]
b) cost per unit of accommodation or functional unit rate = \[
\frac{\text{Building & M&E costs}}{\text{Number of units of accommodation}}
\]

2.4 Elemental cost analysis
Most accurate and most useful of the 4 methods.

2.5 Rates for each item
The rates for cost significant items in the BQ are evaluated and analysed. Examples: 150 mm thick concrete floor @ $20/m², formwork to soffit of floor slab @ $30/m², cement and sand paving @ $10/m², ceramic floor tiles @ $50/m².

2.6 Composite rates
From the BQ rates, composite rates or 'all-in' rates can be derived for use in future projects. Example: composite rate for floor slab (excluding reinforcement bar) is $110/m².

3 Sources of Cost Analysis
3.1 Building Cost Information Service [BCIS] from RICS, UK.
3.2 Overseas professional journals such as Chartered Quantity Surveyor, Architects Journal, Building, etc.
3.3 Local professional journals such as PWD Cost Information Quarterly
3.4 Quantity surveying firm's in-house cost analyses of previous projects.

4 Elemental Cost Analysis
4.1 This method of preparing cost analysis is based on the standard form of cost analysis published by the Building Cost Information Service [BCIS] of the Royal Institution of Chartered Surveyors. The aim of using BCIS format is to ensure standardisation of cost analyses and a single format for presentation.

4.2 Elemental cost analysis is the analysis of the cost of a building in terms of its elements.

4.3 An element for cost analysis purposes is defined as a component that fulfils a specific function or functions irrespective of its design, specification, method of construction or type of building.

4.4 Elemental cost analysis can be prepared from priced bills of quantities at the start of the contract or priced final account bills. However, the first type of bills is preferred because:

a) it is more difficult to analyse final account and variation bills.
b) double counting may be involved as rework may be involved.
c) time lag between tender date and availability of data. This is because construction and eventual settlement of project accounts all take time. Delays in the project may also occur. Data may become out of date or inapplicable as technology may have changed.
5 Tools to prepare the Elemental Cost Analysis
To prepare the elemental cost analysis, the following information is required:
5.1 priced bills of quantities of successful tenderer.
5.2 a set of tender drawings showing plans, elevations and other information.
5.3 BCIS list of elements and rules of analyses.

6 Preparing the Elemental Cost Analysis
6.1 Step 1: Fill in project information such as building type, client, location, tender date, brief description of project, site conditions, market conditions, contract particulars, etc.
6.2 Step 2: Fill in Design/Shape information such as areas, heights, gross floor area of the building, etc.
6.3 Step 3: Distribute the cost of each item in the BQ to the appropriate element.
6.4 Step 4: Derive the following information from data obtained in Step 3:
   a) Total cost of element
   b) Cost per square metre of gross floor area
   c) Element unit quantity
   d) Element unit rate.
6.5 Step 5: Calculate the group element cost by adding up the individual cost of elements within the group.
6.6 Step 6: Complete the BCIS form to present the cost analysis.

7 Total cost of element / elemental cost
This is the cost of each element and is also called elemental cost. The elemental cost varies from buildings due to difference in quantities, quality, market price levels, types of tender, contract conditions and other factors. The items that made up this cost must correspond with the list of sub-elements given in the BCIS. Eg:
   element: Roof
   sub-elements within roof element are: roof structure $20,000, roof coverings $50,000, roof drainage $5,000 and roof lights $0.
The total cost of roof element is $75,000.00

8 Cost per square metre of gross floor area
This is the 'total cost of element' divided by the gross floor area of the building. For example:
   Total cost of element roof : $75,000
   gross floor area, GFA : 1000m²
   Cost per square metre of gross floor area, X : $75.00.

\[
X = \frac{\text{Total cost of element or elemental cost}}{\text{GFA}}
\]

9 Element unit quantity, EUQ
This is the quantity of the element. The information is derived from the BQ or measured from drawings. All areas are net quantities. For example for element roof, the element unit quantity is the area measured over all the roof surfaces.
10 **Element unit rate, EUR**
This is calculated as follows:

\[
\text{EUR} = \frac{\text{Total cost of the element or elemental cost}}{\text{EUQ}}
\]

11 **Total cost of group element**
This is the cost of each group element and the items that made up this cost must correspond with the list of elements given in the BCIS. For example:

**group element:** superstructure

**elements within superstructure group element are:** frame, upper floors, roof, stairs, external walls, windows and external doors, internal walls and partitions, internal doors.

12 **Types of elemental cost analysis**
12.1 **Group element cost analysis**
Costs are allocated to 6 mains group elements:

a) substructure  
b) superstructure  
c) internal finishes  
d) fittings and furnishings  
e) services  
f) external works  

For example, roof covering cost would be allocated to superstructure.

12.2 **Elemental cost analysis**
Costs are allocated to individual elements. For example, roof covering cost would be allocated to the element 'roof'.

12.3 **Amplified cost analysis**
Very detailed. Cost of each sub-element shown, where appropriate. Includes 12.1 and 12.2 above, with quantities, cost and specification notes for each item.

13 **Principles of undertaking elemental cost analysis**
13.1 Each building within a project shall be analysed separately.  
13.2 Professional fees shall not form part of the cost analysis.  
13.3 Contingency sums to cover unforeseen expenditure shall not be included in the analysis but shown separately.  
13.4 Preliminaries can be:  
a) shown separately, or  
b) apportioned into the elements.

14 **Principles of using cost analysis**
Before cost analysis is used to prepare cost plan, the cost information should be indexed to current or future prices, as the case may be.
References


**ESTIMATING**

*Process of determining the probable cost of work*

\[
\text{Estimated cost} = \text{Quantity} \times \text{Unit rate} \times \frac{\text{Index present}}{\text{Index past}}
\]

**APPROXIMATE ESTIMATING** carried out by the consultants before tender sum is known (pre-tender estimating).

**TENDER ESTIMATING** carried out by contractor to determine the cost of undertaking the works.

**TENDER PRICE/SUM** = Tender estimate + profit + risks

**Uses of Approximate Estimates**

i Feasibility Studies

ii Obtaining a Budget for Project: cost forecast and financial commitment.

iii Comparative Studies

**Methods of Approximate Estimating**

1 Unit or functional unit method

2 Cube method

3 Superficial method or gross floor area method

4 Elemental cost method

5 Storey-enclosure method

6 Approximate quantities method

7 Superficial-perimeter method

8 Analytical estimating method
Cost modelling method
Financial method

Choice of Method: information available, time available, degree of accuracy.

UNIT METHOD
Use: At early stage of project, Client has only a general idea of the project (eg. number of beds, seats, people or car park lots etc.)

Method
1 Obtain unit rate of completed building of the same type, \( R \)
2 Make adjustments for difference in site conditions, design, construction methods, quality of materials, \( R_1 \)
3 Determine number of units, \( Q \)
3 Multiply the proposed number of units by the unit rate

Total Estimated Cost \[= Q \times R_1 \times \frac{\text{Index present}}{\text{Index past}} \]
+ External works cost + Piling cost + External fire escape cost + Others

Example:
Index in 1990= 140, Today’s index = 150
Cost per hospital bed in 1990 = $180,000
What is the cost of a 200-bed hospital at today’s prices?
Total Estimated cost at today’s prices = \[200 \times 180,000 \times \frac{150}{140} = \$38.57 \text{ million}\]
+ External works cost + Piling cost + External fire escape cost + Others

Advantage
Speed of application
Disadvantage
Difficult to make allowances for: shape, size, construction methods, quality of materials, etc.

CUBE METHOD
Use: Brief design stage; Not used in Singapore.

SUPERFICIAL / FLOOR AREA METHOD
Use: Brief design stage

Method
1 Superficial area of building is measured between the inside faces of external walls with no deduction for partitions, stairwells, lifts, etc.
2 Different construction type or standard of finish measured separately

Total Estimated cost = \[\text{Total area} \times \text{Rate} \times \frac{\text{Index}_{\text{present}}}{\text{Index}_{\text{past}}} \] + External works cost + Piling cost + External fire escape cost + Others

Example:
Index in 1990= 140, Today’s index = 150
Cost per m2 gross floor area for hospital 1990 = $1500/m2
What is the cost of a 24000 m2 gross floor area hospital at today’s prices?
**Total Estimated cost at today’s prices** = 24,000 x $1500 x 150/140 = $38.57 million.
+ External works cost + Piling cost + External fire escape cost + Others

**Advantages**
*Speed of application; easy to calculate
*More accurate than methods above
*Cost relate to floor area
*Easier to understand
*Most frequently used method

**Disadvantage**
- Difficult to make allowances for: shape, size, storey height, number of storeys, construction methods, site conditions, etc.
- Do not know the cost of individual items.

**ELEMENTAL METHOD**
Refer to later lecture.

**STOREY ENCLOSURE METHOD**
*Use: Outline design stage onwards; Not used in Singapore.*

**APPROXIMATE QUANTITIES METHOD**
*Use: Scheme or Detail design stage*

**Method:**
1. Measure approx quantities from drawing
2. Multiply quantity by appropriate rate.
(also can be done by deriving composite rates).

Total Estimated Cost = Cost of every item within the building (eg. upper floors, foundations, columns, beams, finishes ...) + External works cost + Piling cost + External fire escape cost + Others

Cost of each item within the building = Quantity of item x Rate of item

**Example 1 : Individual Rate Method**
Calculate the cost of upper floors within a building.
From drawings, 2000 m2 upper floors, 150 mm thick
Total quantity of concrete for upper floors = 2000 x 0.15 = 300 m3
Find out rate for concrete, say $140/m3.
Total quantity of formwork for upper floors = 2000 m2
Find out rate for formwork, say $32/m2
Total quantity of reinforcement bars, measured from drawings = 24,000 kg
Find out rate for reinforcement bars, say $1.05/kg.
Total cost of upper floors = 300 x $140 + 2000 x $32 + 24,000 x $1.05
= $131,200.00

**Example 2 : Composite Rate Method**
For example, an **Upper floor rate** might include:-
(a) floor construction; concrete, reinforcement bars and formwork.
(b) floor screed and finish; cement and sand screed, ceramic tiles
(c) percentage additions to cover other smaller items such as skirting.

Advantages: Most accurate method. Once composite rates are compiled, it is easy to estimate the cost of a building rapidly with minor adjustments to the rates.

Disadvantage:
Involves more calculations than other methods: quantities and rates.

APPROXIMATE ESTIMATING OF A WHOLE BUILDING

Background: HLP Ltd intends to develop 400 units of middle class condominiums on a piece of 500 x 100 m² land at Clementi. The development includes a 350 m² club house, one half-Olympic size swimming pool, a 50m² substation cum bin centre, 2 tennis courts, 4 BBQ pits, fencing all round the site and one open air carpark lot for each residential unit. Access road and turfing area are estimated to take up 5% and 40% of the land area respectively.

Question: Prepare an Estimating Report as at today’s prices, for the above development.

Information available:
Today’s index: 150. Index in 1995: 145
Middle class condominium: $180,000/unit @ 1995 prices.
Club house: $1800/m² GFA @ 1995 prices.
Olympic size swimming pool: $300,000/no. @ today’s prices.
Substation cum bin centre: $2500/m² GFA @ today’s prices.
Tennis court: $10,000/no. @ today’s prices.
BBQ pit: $2,000/no. @ today’s prices.
Fencing: $120/m@ today’s prices. Carpark: $100/no. @ today’s prices.
Tarmacadam road: $200/m²@ today’s prices. Turfing: $22/m²@ today’s prices.

Calculations:

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<td>Condominium units</td>
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<td>Club house</td>
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<td>External works</td>
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<td>Half olympic size pool</td>
<td>$300,000/2</td>
<td>150,000.00</td>
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<td>2.2</td>
<td>Substation cum bin centre</td>
<td>50 x $2500</td>
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<td>Tennis courts</td>
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<td>BBQ pits</td>
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<td>Fencing</td>
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<td>Road</td>
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<td>Professional fees</td>
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<td>Total construction cost</td>
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### PREPARATION OF THE ESTIMATING REPORT

**Introduction:** *(give a brief description)*

**Details of estimate:**

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<td>1</td>
<td>Building works including m&amp;e</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Condominium units</td>
<td>74,482,758.62</td>
</tr>
<tr>
<td>1.2</td>
<td>Club house</td>
<td>651,724.14</td>
</tr>
<tr>
<td>2</td>
<td>External works</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Half olympic size pool</td>
<td>150,000.00</td>
</tr>
<tr>
<td>2.2</td>
<td>Substation cum bin centre</td>
<td>125,000.00</td>
</tr>
<tr>
<td>2.3</td>
<td>Tennis courts</td>
<td>20,000.00</td>
</tr>
<tr>
<td>2.4</td>
<td>BBQ pits</td>
<td>8,000.00</td>
</tr>
<tr>
<td>2.5</td>
<td>Fencing</td>
<td>144,000.00</td>
</tr>
<tr>
<td>2.6</td>
<td>Road</td>
<td>500,000.00</td>
</tr>
<tr>
<td>2.7</td>
<td>Turfing</td>
<td>440,000.00</td>
</tr>
<tr>
<td>2.8</td>
<td>Car Parks</td>
<td>40,000.00</td>
</tr>
<tr>
<td>3</td>
<td>Piling Cost</td>
<td>3,756,724.00</td>
</tr>
<tr>
<td>4</td>
<td>Sub-Total</td>
<td>80,318,206.76</td>
</tr>
<tr>
<td>5</td>
<td>Preliminaries</td>
<td>8,031,820.67</td>
</tr>
<tr>
<td>6</td>
<td>Contingency</td>
<td>8,031,820.67</td>
</tr>
<tr>
<td>7</td>
<td>Construction Cost</td>
<td>96,381,848.11</td>
</tr>
<tr>
<td>8</td>
<td>Professional fees</td>
<td>5,782,910.89</td>
</tr>
<tr>
<td>9</td>
<td>Total construction cost</td>
<td>$102,164,759.00</td>
</tr>
</tbody>
</table>

### Basis of Estimate:

*(The estimating report should state that the estimate is based on present day cost. This means that no account is taken of future prices. However if a projection of future cost is required, the assumptions used are to be stated in the estimate.)*

The estimate is based on the following:

- drawings provided by the architect
current market prices with no allowance for future fluctuations.

Assumption of Estimate:
All the assumptions and exclusions shall be clearly stated. These assumptions are made usually because information is not available during estimating stage. Some assumption include: method of construction, tendering procedure, contractual arrangement, structural system, quality of finishes.

Piling cost is 5% of building and M&E cost.

Exclusion:
The estimate excludes the following: land cost, statutory and processing fees, loose furniture, diversion of services, GST, finance charges, special equipment, other expenses, works of art and future cost fluctuation.

ACCURACY OF ESTIMATES
Accuracy of estimates depends on: availability of design information, availability of time to prepare the estimate, availability of cost information/data, method of estimating.

Method of estimating is dependent on: time available to prepare estimate, project information, cost data, preference and familiarity, experience of the quantity surveyor.

Most accurate method of estimating: Approximate Quantities Method, followed by:
• Elemental Cost Plan Method
• Superficial Method
• Unit Method
• Ball-park Method, or order of magnitude.

Where the level of information permits, approximate quantities method or the elemental cost plan method should be used.

For the larger and more complex projects, a few revisions of estimates are done. The stages are:
• a preliminary estimate based on the floor area or unit cost method.
• a more detailed estimate based on elemental cost plan method when more details are available.
• a firm estimate based on approximate quantities method when detailed drawings are available.

FACTORS TO BE CONSIDERED IN ESTIMATING
When preparing estimates, rates and prices obtained from: previous project, historic cost data, quotations.
Historical cost data need to be updated using tender price index.
The following factors are taken into account in estimating: site conditions and constraints, project duration, contractual arrangement, market conditions (changes in the cost of resources, labour availability, state of the economy), design (shape, height, size), method of construction, type of client, change in quality, extent of engineering services, external works, allowance for preliminaries (5% - 10%), allowance for contingency (price and design risks; 5% - 20%), professional fees and supervisory cost.
INTRODUCTION
Elemental Cost Planning is one of the methods of approximate estimating.
The method is based on the BCIS Elemental Cost Analysis format.

Use: Scheme or detail design stage
Method
Building is broken down into major elements i.e. elements such as sub-structure,
superstructure, finishings, services, etc. (BCIS)

Total Estimated Cost =
Element(1) Cost + Element(2) Cost + Element(3) Cost + ...

ELEMENT COST(1) =
Element Unit Rate (EUR1) x
Element Unit Quantity (EUQ1)

EUR
1 cost analyses of similar past projects
2 adjustments for variations
EUQ: quantity from drawings

What is a cost plan?
One of the methods of estimating is using elemental cost or Cost Plan method.

Cost planing is a method of determining the estimated cost of the project. It is the architect's
design in financial terms.
It is a more superior method compared with other methods. It is supposed to produce a more accurate estimate.

Cost planning is the technique by which the budget is allocated to the various elements of an intended building project to provide the design team with a balanced cost framework within which to produce a successful design.

**Why undertake a cost plan?**
To find out what the cost of a proposed project would be.

To ensure that the client's maximum amount of money to be spent on the project is not exceeded. Cost plan is equating the **design requirements** with the **cash available**. The tender sum is likely to be closer to the estimate derived from the cost plan.

To have a balanced design. Every element in the building is allocated the appropriate amount of money.

To ensure there is value for money. To ensure that the client receives an economical and efficient project in accordance with the agreed brief and budget.

To make the design process more efficient thus reducing the time needed to produce a successful design.

There is a basis to compare this project with others.

**Disadvantages of cost plan**
* Time consuming to prepare.
* Huge amount of information needed: make design decisions earlier
* Need large data bank

**INGREDIENTS TO PREPARE A COST PLAN**
The following information is needed before a cost plan can be prepared:
- drawings - plans, elevations in sketch form
- design brief, if available
- specification or an indication of the materials to be used and the standard of finishing to be expected.
- cost analysis of a previous similar project
- index at the time tenders were called for the previous project.
- index at the time the tenders would be called for this proposed project.
- factors affecting costs such as method of securing tenders, contract period, probable start date, market conditions at the time of tendering and location factors.
- some cost data such as rates for work items, etc.

**METHODS OF OBTAINING THE COST OF AN ELEMENT WITHIN A COST PLAN**
Total Estimated Cost = Element(1) Cost + Element(2) Cost + ...
How to obtain Element cost?

**Method 1: Approximate quantity method**
Obtain quantity of the element, Q by measuring from drawings.
Obtain rate of the element, R by consulting cost data base, checking with suppliers or contractors, checking from BQs of past projects or build up rate from first principles.

Cost of element = Q x R_{\text{adjusted}}

This method is the first method to be considered as it is also the most accurate. However, it can only be used if approximate quantities can be measured from drawings and the rates of the items measured are known. Besides using actual rates, composite rates, built-up from BQ rates can also be used. The quantities measured would be change to tally with the composite rates.

Method 2: Element Unit Rate method
Obtain element unit quantity, A from drawings.
Obtain the element unit rate, B from a past similar project.
Update the rate to current prices, B_{1}.

Cost of element = A x B_{1}

This method is the second method to be considered. However, it can only be used if the element unit quantity [as defined in the BCIS cost analysis format] is known. The element unit rate of the past project must also be relevant to the new project.

Method 3: By proportion
This method is used when ratios obtained from design data can improve the quality of the estimated cost of the element.

Ratios are usually used in vertical elements eg walls. The wall to floor ratio is then used to make the estimate more accurate.

Alternative 1
Total cost of element of new project =

\[ \text{new wall/floor ratio} \times \text{Cost of element/m2 GFA of past project} \times \frac{\text{past wall/floor ratio}}{\text{GFA of new project}} \times \text{other adjustment factors} \]

Alternative 2
Total cost of element of new project =

\[ \text{new wall/floor ratio} \times \text{EUR of past project} \times \frac{\text{past wall/floor ratio}}{\text{EUQ of new project}} \times \text{other adjustment factors} \]

Method 4: Cost per square metre of gross floor area method
Obtain gross floor area of the project, GFA from drawings or design brief.
Obtain the cost per square metre of gross floor area, W from a past similar project.
Update the rate to current prices, W_{1}.
Cost of element = GFA X W1

NOTE: The actual method to be used depends on the availability of information for the particular element.

ADJUSTING THE COST ANALYSIS
When undertaking the cost plan for a new project, the cost analysis of a past similar project is used as the base.

However, some adjustments need to be made to the past cost analysis. These adjustments are made to cater for:
- changes in quality eg standard of finish is changed.
- changes in construction method and materials
- specific additions of some new items in the new project or some item in the past project is now not used in the new project.
- inflation - movement in index to update the data of the past project.
- location factor eg. it may be more expensive to undertake works in Pulau Ubin as compared with mainland Singapore.
- other adjustments as may be necessary to accommodate the new project.

QUANTITY SURVEYOR’S DUTIES WITH REGARD TO COST CONTROL

<table>
<thead>
<tr>
<th>Design Stage</th>
<th>Quantity Surveyor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility</td>
<td>Prepare feasibility studies and determine budget</td>
</tr>
<tr>
<td>Outline</td>
<td>Consider with client and design team alternative strategies and prepare cost plan</td>
</tr>
<tr>
<td>Proposals</td>
<td></td>
</tr>
<tr>
<td>Scheme Design</td>
<td>Carry out cost checks and update cost plan if necessary</td>
</tr>
<tr>
<td>Detail design</td>
<td>Carry out cost checks</td>
</tr>
<tr>
<td>and production</td>
<td></td>
</tr>
<tr>
<td>information</td>
<td></td>
</tr>
<tr>
<td>Tender action</td>
<td>Prepare reconciliation statement</td>
</tr>
<tr>
<td>Award of contract</td>
<td>Prepare cost analysis for use in future</td>
</tr>
</tbody>
</table>

What is a cost control?
- activity undertaken throughout implementation of project to check that budget, cost limit, or cost target not exceeded. Cost limit refers to the budget set by the client. Cost target refers to the estimate provided by the QS and accepted by the client, in the event that the client did not specify a limit.

- Pre-contract cost control is concerned with planning and monitoring costs during the investigation, planning and design stages, and it finishes at the point where tenders are received, or a contract entered into.

Why undertake cost control?
- ensures that there will be proper accountability for the financial position of the project.
Final cost will not be too far off from estimated cost.

Eliminate waste. Better use of world's scarce resources. Hence, important to forecast and control costs properly.

Greater cost-effectiveness. Cost control should forecast total cost.

Shortage of funds and capital. Therefore need to have greater caution in the use of these funds.

**How is cost control undertaken?**

Cost control of the design process comprises: establishment of the brief, investigation of a satisfactory solution, estimating how much solution will cost and prepare a cost plan, obtain client's approval of the budget, and monitor throughout design to ensure cost is within the estimate.

Also includes:

- Measurement of approximate quantities from the consultants drawings to check quantity
- Check quality same as that set down in the cost plan.
- Check cost of element within limit specified in cost plan.
- Check cost significant elements
- Check elements which have high variability in cost
- Gross floor area should always be checked at any stage.
CONSTRUCTION ECONOMICS/CONSTRUCTION PROJECT ECONOMICS

LECTURE 5: APPROXIMATE ESTIMATING 3
Elemental Cost Planning Case Study

References


CASE STUDY - PREPARING COST PLAN OF A 6 STOREY OFFICE BUILDING

Background to the case
Mr Jasper wants to construct a 6-storey office in Pulau Ubin. He approached an architect about the possible design and costs. He indicated that the gross floor area would be 36,000 m². He intends to call tenders in June 200X. He wants to know how much this building is expected to cost so that he can speak to his bankers about the loan.

These notes explain how the costs of some elements can be estimated using the cost analysis shown in the Appendix. Each element cost is then compiled into a report called the COST PLAN.

1 Step 1 - Choosing the cost analysis

1.1 Find the appropriate cost analysis of a past project that will assist the QS throughout the cost planning of this new project. It would be better to use an analysis that the QS is familiar with. Secondly, use the same analysis throughout rather than use a few analyses.

1.2 For the purpose of this study, we assume that GINZA OFFICE at Clementi (a fictitious project) is a similar project to Mr Jasper’s proposed office. Tenders for GINZA closed in December 1992. The cost analysis is shown in the Appendix.

1.3 GINZA is the past project in which the cost analysis is known. We will now use the cost information to predict the cost of the new project, ie Mr Jasper’s office in Pulau Ubin.

2 Step 2 - Identify project parameters

2.1 Check that the factors that affect costs such as market conditions, contractual arrangement, tendering procedures for the past and new projects are similar.
2.2 We assume that both projects were based on open tenders. The contractual arrangement is based on bills of quantities.

3 **Step 3 - Identify cost adjustment factors**

3.1 Determine the general adjustments to be made to the cost analysis of the past project.

3.2 The first adjustment is inflation

Index in Dec 1992 : 142  
Index today: 150  
Index in June 200X: predicted to be 160.

Therefore, all the costings of GINZA would have to be multiplied by $\frac{160}{142}$ before it can be used in Mr Jasper's costings.

3.3 The second adjustment is the location factor

Let us assume that it is 15% more expensive to carry out construction work in Pulau Ubin because all materials and labour must be transported by barge to the island.

Therefore, all costings of GINZA would have to be multiplied by 1.15 before it can be used in Mr Jasper's costing.

4 **Step 4 - Costing each element in turn**

Determine the cost of each element using one of the methods described earlier. Add up the costs of all the elements. Include a percentage for preliminaries. Prepare cost plan report in BCIS cost analysis format.

5 **Calculating Substructure cost**

Assume that the same specification for GINZA would be used in Mr Jasper's office.

**Method 2: Element Unit Rate method**

Element unit quantity [area for lowest floor] for Mr Jasper's office measured from drawings = 6,000.00 m².  
Element unit rate from GINZA = $1,222.23  
Adjustment to the rate $1,222.23 x 160/142 x 1.15 = $1583.73  
Cost of element 6,000.00 x 1,583.73 = $9.5 M.

**Method 4: Cost per square metre of gross floor area method**

Gross floor area of the project = 36,000 m².  
Cost per square metre of gross floor area from GINZA = $253.69  
Adjustment to the rate $253.69 x 160/142 x 1.15 = $328.73  
Cost of element 36,000 x 328.73 = $11,834,102

6 **Calculating UPPER FLOORS cost**

Assume that the same specification for GINZA would be used in Mr Jasper's office.
The area of one storey is 6,000 m². There would be one ground floor and 5 upper floors. The area of upper floors is 5 x 6,000 = 30,000 m².

**Method 2: Element Unit Rate method**

\[
\text{\$89.86 x 160/142 x 1.15 x 30,000} \\
= \text{\$3,493,149.30}
\]

7  **Calculating ROOF cost**

Mr Jasper said that he would like the roof to be a simple metal roofing sheet supported by steel trusses. The unit cost for metal roofing sheet at today's prices is $50/m². It is estimated that 100,000 kg of steel trusses is needed to support this roof. Unit cost of steel is $4.00/kg at today's prices.

The specifications for the roof is different from GINZA. As such, the EUR and Cost/m2 GFA methods cannot be used.

**Method 1: Approximate quantity method**

- Cost of metal roof = 6,000 m² x $50 = $300,000.00
- Cost of steel = 100,000 kg x $4 = $400,000.00
- Total cost of roof at today's prices = $700,000.00

Today's index is 150.

Prices in June 200X = $700,000 x 160/150 x 1.15 = $858,667

8  **Calculating WALL FINISHES cost**

Mr Jasper specified that the walls of the office should be finished with paint ($3/m² at today's prices) on 20mm thick smooth plaster. The total area to be applied with wall finishes is 40,000 m².

Step 1: Deduct wall paper cost from Element Unit Rate

\[
\text{\$75.90 - \$40.00 = \$35.90/m²}
\]

Step 2: Obtain cost of plaster

\[
\text{\$35.90 x \left[\frac{160}{142}\right] x 1.15 x 40,000 = \$1,860,732.39}
\]

Step 3: Obtain cost of painting

\[
\text{\$3 x \left[\frac{160}{150}\right] x 1.15 x 40,000 = \$147,200.00}
\]

Total cost of wall finishes element $1,860,732.39 + $147,200.00 = $2,007,932.39

**COST PLAN OF A 6-STOREY OFFICE IN PULAU UBIN**

<table>
<thead>
<tr>
<th>No.</th>
<th>Element</th>
<th>Total cost of Element ($)</th>
<th>Workings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>SUBSTRUCTURE</td>
<td>9,500,000.00</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>SUPERSTRUCTURE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Frame</td>
<td>4,910,623.10</td>
<td>36,000m² x $105.27 x 160/142 x 1.15</td>
</tr>
<tr>
<td>2.2</td>
<td>Upper floors</td>
<td>3,493,149.30</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Roof</td>
<td>858,667.00</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Stairs</td>
<td>981,938.03</td>
<td>36,000m² x $21.05 x 160/142 x 1.15</td>
</tr>
<tr>
<td>2.5</td>
<td>External walls</td>
<td>16,008,155.49</td>
<td>36,000m² x $343.17 x 160/142 x 1.15</td>
</tr>
<tr>
<td>No.</td>
<td>Element</td>
<td>Total cost of Element ($)</td>
<td>Workings</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------</td>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.6</td>
<td>Windows and external doors</td>
<td>8,446,066.48</td>
<td>36,000m2 x $181.06 x 160/142 x 1.15</td>
</tr>
<tr>
<td>2.7</td>
<td>Internal walls and partitions</td>
<td>1,473,140.28</td>
<td>36,000m2 x $31.58 x 160/142 x 1.15</td>
</tr>
<tr>
<td>2.8</td>
<td>Internal doors</td>
<td>598,958.87</td>
<td>36,000m2 x $12.84 x 160/142 x 1.15</td>
</tr>
<tr>
<td>3.0</td>
<td>INTERNAL FINISHES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Wall finishes</td>
<td>2,007,932.39</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Floor finishes</td>
<td>18,659,154.93</td>
<td>36,000m2 x $400.00 x 160/142 x 1.15</td>
</tr>
<tr>
<td>3.3</td>
<td>Ceiling finishes</td>
<td>3,437,482.82</td>
<td>36,000m2 x $73.69 x 160/142 x 1.15</td>
</tr>
<tr>
<td>4.0</td>
<td>FITTINGS AND FURNISHINGS</td>
<td>14,731,402.82</td>
<td>36,000m2 x $315.80 x 160/142 x 1.15</td>
</tr>
<tr>
<td>5.0</td>
<td>SERVICES</td>
<td>20,378,129.58</td>
<td>36,000m2 x $436.85 x 160/142 x 1.15</td>
</tr>
<tr>
<td>6.0</td>
<td>EXTERNAL WORKS</td>
<td>9,820,814.61</td>
<td>36,000m2 x $10M/47,499m2 x 160/142 x 1.15</td>
</tr>
<tr>
<td></td>
<td>Sub-Total</td>
<td>115,305,615.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preliminaries 5%</td>
<td>5,765,280.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contingency 5%</td>
<td>5,765,280.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Construction Cost</td>
<td>126,836,177.27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professional fees 6%</td>
<td>7,610,170.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total construction cost</td>
<td>134,446,347.91</td>
<td>say $134.5 million</td>
</tr>
</tbody>
</table>
INTRODUCTION

The Unit Rate
Estimator's task is to predict the cost of construction of items presented in the BQ. Estimator needs to ascertain the unit rate. Unit rates are prepared net Project overheads and other preliminary items priced in the Preliminaries Bill. Profit or mark-up, risk allowances, general overheads are added into the net cost during tender adjudication.

Building up unit rate: prediction of physical resources cost, comprising labour, material, plant.

Factors affecting Unit rates
Reasons same items have different rates: preliminary items, overheads and profits, facilities, site techniques and work procedures, cost information, quotations differ, mistakes, distortion of prices, workmanship, short contract period, eg overtime or pay, liquidated damages, weather conditions.

Reasons same estimator prices differently for same item of work: site conditions, labour availability, supervising officer, competition, financial condition, client.

Distortion of prices and unit rates: front loading, future omissions or additions, individual rate loading, errors, back-end loading, interest rates, currency fluctuations.

"ALL-IN" HOURLY RATE FOR LABOUR

Factors to consider:-
1 Number of working hours per year.
2 Adjustment for inclement weather, holidays and sickness.
3 Non-productive overtime - not used in Singapore.
4 Cost of supervision.
5 13th month allowance and other bonuses.
6 CPF contribution.
7 Payroll tax - suspended
8 Skills development fund
9 Employer's liability and third party insurances.

Determination of Actual hours worked per year - Exercise 1.
Cost of supervision
Assume: 1 foreman supervises 8 operatives, Half of the foreman's time is spent working and half on supervisory duties, Foreman's rate is $1.30 per hour above the operative's rate.

Calculation of cost of supervision per year for labourers - Exercise 2.

13th month allowance and other bonuses
Depending on: employer, performance and profitability of the firm, state of economy. Payable as special bonus, 13th month pay, monthly variable bonus, annual variable bonus.

Central provident fund
Statutory obligation. Below 55 years, 20% by employer for Singaporeans and PR. Foreign workers on Work Permits, Foreign Workers Levy is payable.


Skills development fund
Statutory obligation. Employer pays to SDF. Each employee who earns a gross income of less than $1000 per month, 1% payable.

Employer's liability and third party insurance
Statutory obligation under the Workmen's Compensation Act. 2% of total cost of employment. Paid to injured worker or next-of-kin.

Calculation of all-in hourly labour rate for labourer: exercise 3.

"ALL-IN" RATE FOR MATERIALS
This rate comprises of all costs involved in providing the material to where it is required on site. Factors to consider:-
1 Sum quoted by supplier
2 Discounts allowed by supplier; bulk quantity orders, trade discounts, cash discount for prompt payment.
3 Transport to site (additional transports charges beyond quotation)
4 Site handling and storage (unloading & storage).
5 Quantity of material for a unit rate; actual quantity for the work, material wastage.
Avoidable waste: mistakes (ordering and use), pilfering, carelessness, quality control and work rejection, misuse of materials (facings as common).
Unavoidable waste: cutting to length and size, application, stockpile, residue, transit and breakages.

"ALL-IN" RATE FOR PLANT
Hire or purchase; depends on money availability, volume of current and future work, type of equipment.
Advantage of hiring: no need to worry about idle time.
Disadvantage of hiring: in the long run, more expensive.
Factors to consider:-
*Standing cost: capital sum based on purchase price and operating life, return on capital, maintenance, tax and insurance.
*Operating cost: operators emoluments, fuel, consumable store.

Operating hours per year
Not 365 x 24 = 8760 hours
Not in constant use due to: repairs, inclement weather, periods between contracts.
Typical operating rate = 1500 hours per year

Maintenance Cost
Average annual maintenance cost is estimated as percentage of initial cost.

Expected Life Span

<table>
<thead>
<tr>
<th>Life Span</th>
<th>Maintenance Coff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Concrete mixer</td>
<td>6 - 7 years</td>
</tr>
<tr>
<td>(b) Cranes</td>
<td>8 - 10 years</td>
</tr>
<tr>
<td>(c) Dumper</td>
<td>3 - 4 years</td>
</tr>
<tr>
<td>(d) Excavating plant</td>
<td>5 - 7 years</td>
</tr>
<tr>
<td>(e) Hoists</td>
<td>5 - 7 years</td>
</tr>
<tr>
<td>(f) Lorries</td>
<td>3 - 5 years</td>
</tr>
</tbody>
</table>

Capital Sum
Straight line depreciation method.
Assume a dumper costs $10,000 with a life expectancy of 4 years and is in operation for 1500 hours per year.
Cost of machine $10,000
Less scrap value $500
$9,500

Yearly cost = $9,500 ÷ 4 = $2,375
Cost per hour = $2,375 ÷ 1500 = $1.58

Interest on Capital: Opportunity cost; based on current interest levels.
Tax and Insurance: vehicle licence and tax, insurance (fire, theft, etc.).
Operator's emoluments: machine Operator's pay = craftsman; Labourers as Assistants
Fuel: Cost of electricity, petrol or diesel to run the plant.
Consumable Stores: ropes, cables, lubrication and grease; 20 - 25% of fuel cost.

Production Output Constants

<table>
<thead>
<tr>
<th>PLANT</th>
<th>SIZE</th>
<th>OUTPUT m^3/hour</th>
<th>FUEL litre/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete mixer: rotary drum</td>
<td>3.5t - 0.10m^3</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>100 l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete mixer: batch mixer</td>
<td>5t - 0.14m^3</td>
<td>1.50</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>140 l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete mixer: batch mixer</td>
<td>7t - 0.20m^3</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>200 l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete mixer: batch mixer</td>
<td>10t - 0.28m^3</td>
<td>3.00</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>280 l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLANT</td>
<td>SIZE</td>
<td>OUTPUT m3/hour</td>
<td>FUEL litre/hour</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Excavator tractor: face shovel</td>
<td>¼ m3 bucket</td>
<td>9.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Excavator tractor: backacter</td>
<td>¼ m3 bucket</td>
<td>6.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Influenced by: Quantity of work, Physical site conditions, Weather conditions, Continuous or intermittent work, Experience of operators, Site mgt and organisation.

**Calculation of all-in hourly plant rate based on purchased plant**: exercise 4.

**Calculation of all-in hourly plant rate based on hiring plant**: exercise 5.
References


INTRODUCTION
Tendering process, from the contractor’s point of view, is divided into the following stages.

- Decision to Tender
- Pricing preliminaries
- Pricing construction works bill
- Pricing prime cost and provisional sum bill
- Pricing other general items
- Completing the pricing; tender estimating
- Tender adjudication and bidding strategy
- Submission of tender
- Financial reconciliation
- Tender analysis

DECISION TO TENDER

Tender invitation
Normally, tender invitation is made to ensure client gets value for money. (Compare projects awarded by direct negotiation or waiver of competition.)

Situation 1
No tender documents. A letter of invitation from the client to contractor, describing the work to be done or the contractor invited to inspect the site and submit a tender. Used in minor works.

Situation 2

Situation 3
Most suitable for work of any magnitude. BQ prepared by PQS used as common document for all tenderers to price.

Tender invitation for situation 3 by letter of invitation to tender if selective tender is used. Contractors who have the expertise, resources, ability and desire to tender are invited. If having been invited and the contractor declines to tender, consultants must be advised at the earliest opportunity to allow time for selection of another contractor.

If open tender, tender invitation advertised in the press. For government and statutory board tenders, projects are advertised on Fridays. Advertisement will show:
- project title
- registration category of contractors allowed to participate in tender
- financial category of contractors.
- date of closing of tenders and time
- location to collect tender documents from
- tender document charges or other administrative charges.

**Decision to submit a tender**

A decision to tender is a decision to submit an OFFER. The implication is that if the offer is accepted, the contractor will be able to undertake the works smoothly and proceed diligently to avoid frustrating architect, losing client, getting debarred from future tenders and getting firm into financial problem.

Decision is made after rationally assessing:

- adequacy of information in tender documents
- type and extent of the work involved
- nature of job fits into overall corporate objectives
- present construction workload
- present estimating workload
- availability of manpower, supervisory staff
- availability of plant, machinery, materials
- constructional problems
- previous experience with similar type of work
- availability of financial resources of contractor
- future commitments
- market conditions, general economic and political situation and outlook
- tender period
- competition level
- previous experience with the consultants
- financial resources and commitments of client
- criteria for award of tender
- **seasonal risk**
- risks imposed by the conditions of contract.

**Management of the estimate**

Person in-charge: Chief Quantity Surveyor or Chief Estimator – manager responsible for the production of the tender estimate.

Duties:
plan tendering process, prepare tender programme  
ensure sufficient manpower to undertake taking off (lump sum based on drawings and specifications) and pricing.  
coordinate various staff in preparing the estimate  
chair coordination meetings  
monitor progress during production of cost estimate  
motivate the staff  
overall incharge: tender price, programme, method statement.  

**Check tender documents**  
Ensure all documents are received  
Check drawings are complete and revisions recorded  
Manage corrigendum  
Manage transmission of tender documents to suppliers, subcontractors, etc  

Thorough examination of tender documents:  
- conditions of contract  
- drawings, specifications  
- BQ and departures from the SMM  
- soil reports  
- specialist information  
- non-standard conditions eg. payment, retention sum, guarantees, performance bonds, insurance requirements, nomination procedures, liquidated damages, working hours,  
- other contractors who may also be involved  

Record outstanding information, queries: refer to consultants  
Record discrepancies, divergences: refer to consultants immediately or after award of tender.  

**Time table for production of tender estimate**  
Key dates in the production of tender estimate:  
♥ latest date for despatch of enquiries for materials, plant and subcontracted items  
♥ latest date for receipt of quotations  
♥ visits to the consultants (optional)  
♥ site visits  
♥ finalisation of method statement  
♥ completion of measurement  
♥ completion of pricing  
♥ adjudication meeting  
♥ submission of tender  

**Site visit**  
Site visit is important so that the tender price includes all risks and difficulties which may be encountered during construction. If CQS does not visit site and merely assumes a level of risk and difficulty, the CQS may overprice the risk which will mean losing the job, or underprice the risk and incur loss after obtaining the job.  

Points to note when making site visits:  
- access- roads, rail, MRT, public transport, temporary roads  
- topographical details- trees, site clearance  
- demolition work required
adjacent buildings- nature and use, temporary works needed
ground conditions- surface water, water table
facilities for disposal of soil
existing services- water, sewers, electricity, gas, telephone
security problems- hoarding needed
availability of labour and materials in the locality
availability of subcontractors in the locality
industrial relations in the locality
weather conditions
site constraints- height of tower cranes, spaces for plant and equipment, MRT nearby.

PRICING
In order to ascertain the offer price (tender price), the tenderer has to put a price to the following sections of the tender document:

- preliminaries bill
- construction works bill
- prime cost and provisional sum bills
- other items

PRICING PRELIMINARIES

Pricing principles
Principle governing pricing of preliminaries and general items:
1 time related cost: initial cost, maintenance or operating cost, last/removal cost.
2 fixed cost: initial cost, last cost.

Items in the Preliminaries Bill:

- Site visit, location of site, site conditions such as fire risks, security risks, radiation hazards, underground condition (nuclear, chemical and biological waste),
- infringement of royalties and patent rights,
- Engaging registered surveyor, supervision, engineers to be employed,
- overtime payment and bonus,
- submission of final claim,
- compliance with Acts and Regulations,
- inclement weather,
- temporary access, hoardings, protective barriers, screens, signboards,
- site offices, other site buildings, storage space, labourers' accommodation,
- scaffolding for all trades,
- water, temporary lighting and power,
- provision of bulk bins and dumping of debris and waste,
- protection of exposed excavated surfaces,
- testing and test facilities
- inspection of sewers and checking of levels, open up works for inspection
- protection of existing services, protection of the works
- security and watching,
- housekeeping and fire safety on site, cleaning up and reinstatement of works on completion,
- samples,
- safety requirement under BOWEC,
- traffic control and road safety,
- nuisance caused by littering of roads, liability for nuisance,
- photographs,
- public transport to site for clerk of works, resident architects and engineers
- plant and machinery (purchasing plant for the contract, hiring existing company owned plant, hiring from external sources),
- insurance,
- performance bond,
- time for completion of the works, liquidated and ascertained damages,
- period of maintenance,
- interim payment, final payment, limit of retention.

**PRICING CONSTRUCTION WORKS BILL**
Function of quantity, quality and price.

*Quantity*
- extract from the BQ
- measure from drawings
- refer to amendments and addendums

*Quality*
Refer to specifications, drawings, schedules and BQs.

*Price*
To ensure the tender is competitive, contractor’s rates need to be as accurate as possible. Rates that are too high will prevent contractors from being competitive and will not be awarded the tender because other contractors submitted lower tenders. Rates that are too low enables the contractor to be the lowest tenderer, but if awarded the job, may cause contractors to lose money, which may lead to liquidation.

Accurate costing depends on good production feedback information from parties which have the job knowledge, such as:
- Plant and site managers to feedback on plant output
- Project manager to feedback unrealistic rates used in previous project
- Project manager to feedback to labour productivity rates
- Project manager to feedback on performance of subcontractors and suppliers.

Being lowest in tender depends on:
- accuracy in pricing BQ rates
- quality of quotations received for materials & plant
- sub-contractors' quotations
- markup

Pricing approach depends on how work is going to be carried out.

a) **Subcontract the works**
Call quotations from subcontractors and suppliers for specialist work, special materials, sub-contracted work, labour only sub-contractor.

Provide subcontractors with relevant portions of the BQ for pricing.
Quotations for specialist items and works to be done by subcontractors are obtained to incorporate into the overall pricing. Full and comprehensive enquiries must be made. A full investigation into market trends and selection of suitable sub-contractors will enable CQS to use only the price of sub-contractors who have submitted competitive quotes. Must ensure delivery dates can be met.

b) Contractor carrying out the work in-house
Where works are carried out by contractor directly - contractor prices the BQ using built-up rates. Pricing of BQ is also known as tender estimating. Total cost of a BQ item = BQ quantity x Contractor's rate.
- predicting costs of construction
- stating an honest net price.
- not to secure work for the company

Methods and techniques of building up rates for items in the BQ are covered in other lectures.

**PRICING PRIME COST AND PROVISIONAL SUM BILL**

*Prime cost sums (PC Sums)*

PC Sums included in the BQ for work to be carried out by NSC or materials to be supplied by NS. Contractor may be invited to tender for the items covered under PC Sum.

Estimator to check:
- name of NSC or NS
- who assumes design responsibility of NSC’s design
- co-ordination work required of main contractor
- attendance which main contractor needs to provide
- NSC and NS to comply with main contractor’s programme
- builder’s work clearly defined and measured in the BQ.

Contractor to price for:
- profit
- attendance

General attendance- main contractor to let subcontractor use:
- temporary roads, pavings, paths,
- standing scaffolding,
- hoisting equipment,
- mess rooms, toilets, welfare facilities,
- water and electricity,
- space for office and storage
- clearing away rubbish.

Special attendance- when specially stated in the contract, the main contractor to provide special items for NSC to use:
- special scaffolding,
- unloading, distributing, hoisting, placing in position,
- provision of covered storage,
- power suppliers exceeding normal loading.
Provisional sums
A provisional sum is included in the BQ for an item of work which is needed, but not fully defined at the time of tender.
The sum will eventually become the subject of an architect’s instruction during the construction stage.
The item will usually be undertaken by the contractor (not NSC or NS).
The item will then be incorporated into final accounts, based on rules of measurement and valuation.

Estimator needs to recognise like items of work in the BQ and ensure that items which may increase as a result of the expenditure of a provisional sum, are accurately priced.

Example: diversion of services. BQ rates for excavation must be accurately priced.

PRICING OTHER/GENERAL ITEMS
Daywork
In Singapore, some private sector QS may include a schedule of tradesmen.
These rates are used to value variations which cannot be priced using other valuation methods.
Tenderers are required to:
- price the rates for engaging these tradesmen
- indicate a percentage profit (if not specified in the conditions of contract)

Contingencies
Unforeseen work, especially for sub-structure works, demolition and alteration works.
INTRODUCTION
After deciding to tender and proceeding to price the preliminaries bill, PC and PS bill and the BQ, the next phase is to finalise the pricing and submit the tender. Detailed actions in this phase include:

• Completing the pricing; tender estimating
• Tender adjudication and bidding strategy
• Submission of tender
• Financial reconciliation
• Tender analysis

TENDER ESTIMATING
The chief estimator completes the pricing by:

☑️ compiles all the pricing undertaken by individual estimators.
☑️ pricing for preliminaries bill
☑️ pricing for NSC and NS
☑️ making adjustment to the pricing for fluctuations and necessary allowance for firm price tender.
☑️ conducting necessary checks to ensure consistency, detect mistakes, determine reasonableness of offer price.
☑️ making comparisons between the offer price and cost analyses of past projects.

Chief estimator submits a summary analysis and report to management for adjudication.
Report to highlight to management:
- estimated price
- cash flow projection- overdraft facilities needed.
- method statement, programme
- cost significant items
- departure from normal way of working and pricing
- unusual contract conditions and risks, contract period, liquidated damages, etc.
- unresolved technical or contractual problems- source of claims
- major assumptions made in the pricing
- assessment of profitability of the project
- terms of subcontractors or suppliers’ quotations
- special information regarding clients, consultants, subcontractors or suppliers
- details of other tenderers and their past actions.

TENDER ADJUDICATION AND BIDDING STRATEGY

Converting estimate to tender
Contracting firm’s top management meets to adjudicate the tender. Purpose of adjudication meeting:
- decide on final tender price by converting the net estimate to a tender.
- decide on how to get the job at the best price; securing it in competition by the smallest possible margin and on the best commercial terms.
- head office overheads to be charged to this project - cost of administering a company and providing site services. The apportionment of head office overheads to projects is also decided.
- confirm profit for nominated sub-contract works.
- qualifications to the tender
- decide on percentage of mark up as profit for the project

Bidding strategy
In deciding the appropriate strategy for the tender, to consider:
- market share
- current workload
- future projects with the same client or consultants
- prestige, reputation, use of project as a reference
- consultants and clients’ reputation
- quality of project information,
- risk,
- head office overheads,
- profit,
- discounts,
- financial considerations and cash flow,
- contract period and liquidated and ascertained damages.

SUBMISSION OF TENDER
Procedures set out in the tender document with regard to submission of tender must be followed meticulously to avoid the tender being disqualified. Some requirements include:
- form of tender to be signed by an authorised person
- bond details
- confirmation to keep information confidential
- basic requirements to be met when submitting alternative proposals
Tender must be submitted on or before the time and date stipulated in the invitation to tender. Public sector is does not accept late tenders under any circumstances.

Claims issues to consider:
• avoid under-pricing during tender, and then claim after being awarded the contract (consultant will consider whether the contractor can undertake the works at such low prices)
• flag up potential claims areas (but do not leave these issues until the end of the construction)

FINANCIAL RECONCILIATION
For public sector projects, tender prices are usually announced several hours after tenders closed.

Methods of finding out tender results:
• public notice, government gazettes, Internet.
• owners
• consultants
• subcontractors and suppliers
• competitors.

After tender results are known, consultant QS undertakes financial reconciliation to ensure budget is not exceeded.

If errors discovered:
- confirm error can be absorbed by the contractor
- contractor to withdraw the tender; be prepared for debarment.

Contractor may need to analyse tender results to find out why they were unsuccessful in the tender exercise.

Contractor undertakes financial reconciliation in two stages:
- at the award of contract; to confirm that the pricing are correct and expected profit can be earned
- at the end of construction; compare tender sum with final cost. Identify reasons for the difference in results so as to provide guidance in future estimating.

TENDER ANALYSIS
Tender evaluation is normally carried out by consultant quantity surveyors. Generally, tenders shall be evaluated based on the following factors:

- Price - The tender price is compared to the consultant QS’ estimates, previous tender prices/unit rates and next two lowest tenderers' prices to satisfy that the tender is competitive and prices fair and reasonable.
- Compliance with tender specifications - The tender should comply fully or very substantially with tender specifications.
- Past performance - The tenderer's past performance must be satisfactory.

- Life cycle costing, maintenance cost, present value of money and currency fluctuations, if applicable.

Generally, if everything is equal, price shall be the main consideration.

A recommended tender shall be checked for arithmetical and pricing errors.

For public sector projects, the recommended tenderer's debarment and registration status shall also be checked.

On completion of evaluation, a Tender Evaluation Report is prepared, and signed by the consultant architect and quantity surveyor. It is sent to the client for approval. After the client’s approval is obtained, a letter of acceptance of tender is then issued to the successful tenderer.

In private projects, tender interviews may be carried out, to review prices. Negotiations are carried out among consultants, contractor, suppliers, and subcontractors. During these negotiation sessions, contractors should:
  - Show keen interest and respond quickly
  - Safeguard the company’s interest
  - Be on a lookout for competitors’ actions.

**AWARD OF TENDER**
Documents that form part of the contract to be included in the letter of award, examples:
  - Clarifications during tendering stage and tender evaluation stage
  - Q&A issued during tendering stage.
INTRODUCTION
BULK : increase in volume after excavation. To be considered in transporting and
backfilling.

SMM - Clause 5.02 states that:-
The description of each item of excavation shall be deemed to include excavating around
piles and confined areas, getting out, removing Bakau piles, trimming, levelling and
compacting bottoms of excavations, keeping sides plumb and planking and strutting.

Bulking
Bulking or increase in volume of different soils after excavation:
Sand or gravel- 10%
Clay- 20%
Rock- 50%
Others- 25%

EXCAVATION METHOD
Choice of excavation methods (hand or machine) depends on:
= Quantity of excavation
= Site constraints
= Availability of plant and labour
= Time constraint (Task duration)

Hand excavation
Productivity data for Hand Excavation for normal soil
Usually given in hours/m³

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>hours/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Surface to reduced level</td>
<td>2.00</td>
</tr>
<tr>
<td>(b)</td>
<td>Basements</td>
<td>2.25</td>
</tr>
<tr>
<td>(c)</td>
<td>Foundation trenches, 2 m deep</td>
<td>2.50</td>
</tr>
<tr>
<td>(d)</td>
<td>Pits, 2 m deep</td>
<td>3.00</td>
</tr>
<tr>
<td>(e)</td>
<td>Wheel not exceeding 50m and tipping</td>
<td>1.00</td>
</tr>
<tr>
<td>(f)</td>
<td>Spread and level on site</td>
<td>0.50</td>
</tr>
<tr>
<td>(g)</td>
<td>Throwing in 2.00m stages</td>
<td>1.00</td>
</tr>
</tbody>
</table>
(h) Filling 1.50
(i) Loading lorries 1.50
(j) Filling up barrows 1.00

(k) Levelling & compacting bottom of excavation 5m²/hr
(l) Lifting turf 5m²/hr
(m) Trimming sides of cutting & embankments 5m³/hr

For clay, loose rock and solid rock, output times increased.
- Clay soil 25%
- Loose rock 100%
- Solid rock 500%

**Machine excavation**
Production output depends on:
(a) Size of machine (capacity)
(b) Method of disposal
(c) Degree of finished work
(d) Skills of machine operator

Productivity data for machine excavation

<table>
<thead>
<tr>
<th>Activity</th>
<th>hour/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Surface to reduce level</td>
<td>0.10</td>
</tr>
<tr>
<td>(b) Basements</td>
<td>0.15</td>
</tr>
<tr>
<td>(c) Foundation trenches</td>
<td>0.20</td>
</tr>
<tr>
<td>(d) Pits</td>
<td>0.25</td>
</tr>
</tbody>
</table>

**PLANKING AND STRUTTING**
Factors to consider:
(a) Type of soil
(b) Depth and width of trench
(c) Weather conditions
(d) Vibration from traffic

The cost of planking and strutting:
* amount of labour
* quantity of material (usually timber)
* number of times of reuse

Productivity data for planking and strutting

<table>
<thead>
<tr>
<th>Activity</th>
<th>hours/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Fixing of timbering</td>
<td>10 hrs/m³</td>
</tr>
<tr>
<td>(b) Removal of timbering</td>
<td>5 hrs/m³</td>
</tr>
<tr>
<td>(c) Labour unloading timber</td>
<td>1.25 hrs/ton</td>
</tr>
</tbody>
</table>

**HARDCORE**
Broken bricks
Weight: 1.50 tonnes/m³
Consolidation factor of 25%
Productivity data for hardcore:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Load and fill barrow</td>
<td>0.50</td>
</tr>
<tr>
<td>(b) Wheeling not exceeding 50m &amp; tipping</td>
<td>1.25</td>
</tr>
<tr>
<td>(c) Placing</td>
<td>1.00</td>
</tr>
<tr>
<td>(d) Placing in beds not exceeding 300mm thick</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Productivity data for surface finish to placed hardcore:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Hours/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Consolidating with mechanical punner</td>
<td>0.12</td>
</tr>
<tr>
<td>(b) Rolling</td>
<td>0.10</td>
</tr>
<tr>
<td>(c) Blinding surface</td>
<td>0.50</td>
</tr>
</tbody>
</table>

WAGES FOR OPERATIVES INVOLVED IN EXCAVATION

Operatives involved in planking and strutting (timberman). They are paid more than labourers but less than craftsman. Assume: average of the two rates.

Other operatives such as workers responsible for manual excavation, loading, wheeling, blinding, will be paid based on labourer's rate.

EXERCISES

1. Excavate vegetable soil average 100 mm deep and wheel and deposit in spoil heaps on site a distance not exceeding 50m. Calculate the cost per m²

2. Excavate foundation trench not exceeding 2m deep. Calculate the cost per m³ based on hand excavation and machine excavation.
INTRODUCTION

Facilities in which life cycle costing concepts are relevant include building, engineering system, component, equipment.

TOTAL COST

1. **Initial investment cost**: non-recurring
   * Land cost, acquisition, options, surveys, appraisals, demolition and relocation, legal and filing fees.
   * Fees to authorities and permits
   * Design costs including cost of consultants, in-house staff, special studies and tests.
   * Tendering cost
   * Construction costs including cost of labour, material, equipment, overheads, profit.
   * Commissioning cost
   * Other owner's costs including project administration, construction insurance

2. **Financing costs**
   - Loan fees and one-time finance charges: non-recurring
   - Interest costs for short-term (interim) financing: recurring.

3. **Facility operation and maintenance costs [O&M]**: recurring
   - It includes personnel costs for routine maintenance, cleaning, grounds care, trash removal, space re-configuration, security, building operation, property management.
   - It also comprises costs of fuel, utilities - electricity, water, telecom, supplies, equipment, contract services associated with these activities.

4. **Facility repair and replacement costs**: non-recurring.
   - Examples are: major repairs, planned replacements, other ancillary costs.

5. **Facility alteration and improvement costs**
   - Examples are planned capital improvements, additions, alterations, major re-configurations, other improvements to the facility; non-recurring.

6. **Functional use costs**: recurring
   - Examples are: salaries and benefits, supplies and services required, income tax, property tax, fire insurance.

7. **Salvage costs or values**: non-recurring
   - Examples include: salvage operations including demolition and disposal, site reinstatement, resale value, salvage value - value estimated to remain at the end of the depreciation period.

Conclusion

Construction cost is only a small part of the overall total cost.
LIFE CYCLE COSTING
Life Cycle Costing Definition:
a general method of economic evaluation which considers all relevant costs associated with
an activity, facility or project during its time horizon, comprising the techniques of total life-
cycle cost, net savings, internal rate of return, etc.

Life cycle/Study period/time horizon definition: is the period of time between the starting
points and cutoff date for analysis, over which the costs and benefits of a certain alternative
are incurred.

ESTIMATING COSTs comprises initial investment cost and other costs.
OTHER NAME: Costs in use.

USES OF LIFE CYCLE COSTING
ptune cost implications, evaluating capital costs, incomes, benefits and
other expenditure throughout the life of the facility; real cost of resources assessed;
balanced view of cost over time, rather than shorter term view of capital cost
initial cost: design tool for the comparison of the costs of different designs, materials
and construction techniques
running cost: cost significant items are identified so that reduction in operating costs
can be established.
establish priorities between competing proposals; comparative analysis is possible.
clients can get value for money

THE LIFE OF BUILDINGS, COMPONENTS AND FACILITIES
Structural or physical life
facility loses structural stability
may collapse physically
cannot be maintained economically.
structural life very long
structural life 60 to 65 years ?

Economic life
period from the construction of a facility to its obsolescence
earning power
replacements can increase income or reward
facility continues to generate benefits or savings, earn income or provide a service.

For life cycle costing: consider economic life or useful life.
Reason: long before a building would have reached an age when physical collapse is a
possibility, it has been pulled down and replaced by a new one.

Economic life of components: which alternative component to use

Economic life depends on degree of exposure, amount of wear, amount of atmospheric
pollution.
LCC EVALUATION TECHNIQUES:
To consider all costs over time; present cost, future cost in purchasing, constructing/installing, maintaining, operating, repairing, and replacing facility

Evaluation techniques: economic evaluation techniques, LCC TECHNIQUES - more accurate measure of economic performance.

LCC TECHNIQUES:
1. Net Present Value (Total Life-Cycle Cost) Technique
2. Internal-Rate-of-Return (IRR) Technique.
3. Net Benefits or Net Savings Technique
4. Benefit/Cost or Savings-to-Investment Ratio Technique

1. Net Present Value (Total Life-Cycle Cost) Technique
Find the sum of the costs of initial investment (less salvage value), replacements, operations including energy use, and maintenance and repair, over the life-cycle of an investment, expressed in present value dollars.

2. Internal-Rate-of-Return (IRR) Technique.
Compound rate of interest which, when used to discount the life-cycle costs and benefits of a project, will cause the two to be equal.

3. Net Benefits or Net Savings Technique
Net Benefits - The difference between the benefits and the costs - evaluated in present value dollars
Net Savings - The difference between the savings and the costs - evaluated in present value dollars

4. Benefit/Cost Technique
Benefit-Cost Analysis - comparing the discounted present value or annual value of total expected costs and benefits.
Benefit-Cost Ratio (B/C)
Benefits ÷ Costs = x
x > 1 for an investment to be economically justified

CURRENT AND FUTURE PAYMENTS & TIME VALUE OF MONEY
Problem in LCC: every building project involves streams of payments over a long period of time (usually the life of the building).
Main types of payments:
(a) present payments covering the building site, erection of the building and professional fees;
(b) annual payments relating to minor repairs, cleaning, cooling, lighting, rents, etc.; and
(c) periodic payments such as external painting at five-year intervals and replacement costs

TECHNIQUE OF DISCOUNTING:
Convert all payments to a common method of expression
Incorporate time value of money due to
= changes in the purchasing power of money (i.e., inflation or deflation)
real earning potential of alternative investments over time.

Reason: to permit a meaningful comparison to be made between alternative designs.

Basic premise: money not spent on the project in question it could be invested elsewhere and
would be earning interest.

Time value of money is equivalent to rate of interest.

Rate of interest depends on value of a dollar received at some future time to be equivalent in
value, from the standpoint of the investor, to a dollar received today.

$1_{\text{today}} \text{ NOT EQUAL TO } $1_{\text{tomorrow}}$

LCC technique:

\begin{itemize}
  \item evaluate all available alternatives
  \item present costs and expenditure
  \item present value/worth of future running costs
  \item present value of future revenue
  \item choose option with the highest net present value (NPV) or the highest rate of return (ROR) based on the life cycle costing.
\end{itemize}

Definition of terms related to discounting

Discounting - A technique for converting cash flows that occur over time to equivalent
amounts at a common point in time.

Discount Rate - The rate of interest reflecting the investor's time value of money, used in
discount formulas.

Discount Factor - A multiplicative number, calculated from a discount formula for a given
discount rate and interest period, used to convert costs and benefits occurring at different
times to a common basis.

Opportunity Cost of Capital - The rate of return available on the next best available
investment, indicative of the appropriate value of the discount rate.

Base Period - The time to which all future and past costs are converted when a present value
method is used, usually the beginning of the study period (time zero).

Time Horizon or Study Period or Life Cycle - The length of time over which an investment is
analyzed.
CONSTRUCTION ECONOMICS/CONSTRUCTION PROJECT ECONOMICS

Lecture 11: Build-up rate- concrete works

References

INTRODUCTION

SMM measurement rules
SMM Clause 6.02:
The description of each item of concrete work shall be deemed to include pour, joints, forming or cutting grooves, chases, mortices, holes, openings not exceeding 0.10m² and making good and any other sundry items of a like nature.

Main items in this section are: Concrete, formwork, reinforcement.
Unit rates are different for different locations of concrete items, such as: Substructure and basement works, Ground floor, Suspended floors, Roof slab.

Choice between site mix or ready-mix concrete
Factors to consider: Quantity required, Site constraints, Cost, Instructions by Architect (Contract conditions).

Site mixed concrete: size of mixing plant, position of mixing plant, costs of plant operators and attendants, storage of cement, sand and aggregates, cost of erecting and dismantling plant including transportation, wastage and bulking factor.

Ready mix concrete: quotations obtained comply with specifications, delivery costs (especially beyond normal hours), site access to facilitate placing in final position, reliability of supply and quality.

Distribution of concrete to final position
Direct delivery: at ground and basement level; dumper trucks, lorries, barrows or conveyor belt.
By crane: at higher floors; type and capacity of crane; position of crane (height and operating radius).
By concrete pump: pumpable concrete mixes, height of building.

Cost of plant: preliminaries bill

CONCRETE
Main components: Materials (cement, sand, aggregate, water and admixtures); Mixing; Placing.
Materials
Portland cement: Tonne, in bulk or 50 kg bags; density 1250 and 1400 kg/m³; if cement is delivered in bags, allow 1 hour/tonne for the unloading and placing in storage by a labourer.
Fine aggregate: usually is sand and sold by m³. Density = 1600 kg/m³
Coarse aggregate: usually is crushed granite and sold by tonne. Density = 1400 kg/m³
Water: priced as project overheads in the preliminaries bill.

Mix of concrete specified as:
- parts; eg. 1:3:6
- performance eg. 21.00 N/mm²
- grade

Reduction of volume on mixing; 50%. Wastage: 10% for materials.

Mixing
= Hand mixing (small quantities) at 5 hours per m³.
= Machine mixing depends on size and output of machine.
= Ready mix concrete: to add the price given in the quotation (material and mixing costs) for the placing cost.

Transporting and Placing
= cost of labour to place concrete
= 1.5 hours to transport a m³ of concrete in barrow a distance of 50m.
= Cost of barrow, dumper, crane, pump or chute are priced in Preliminaries Bill under project overheads.
= Labour time to transport and place concrete:

<table>
<thead>
<tr>
<th>Plain Concrete</th>
<th>hours/m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations 300mm thick and over and bases</td>
<td>1.5</td>
</tr>
<tr>
<td>Foundations less than 300mm thick</td>
<td>2.0</td>
</tr>
<tr>
<td>Beds 300mm thick and over</td>
<td>1.5</td>
</tr>
<tr>
<td>Beds less than 300mm thick</td>
<td>2.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reinforced concrete</th>
<th>hours/m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended floor or roof slab</td>
<td>3.5</td>
</tr>
<tr>
<td>Walls 300mm thick and over</td>
<td>2.5</td>
</tr>
<tr>
<td>Walls less than 300mm thick</td>
<td>5.0</td>
</tr>
<tr>
<td>Beams</td>
<td>7.0</td>
</tr>
<tr>
<td>Columns</td>
<td>8.0</td>
</tr>
<tr>
<td>Isolated beam casings, lintels, etc</td>
<td>10.0</td>
</tr>
</tbody>
</table>
FORMWORK

Factors to consider in building up unit rate for formwork:

- Materials (Props and shuttering)
- Labour in fixing and dismantling
- Waste
- Number of re-use

Materials (Props and shuttering)

- Plywood, metal
- Quantity of wood for props varies according to the height to be strutted and the weight of the concrete to be supported

\[
m^3 \text{ of prop for } m^2 \text{ of formwork} \]

<table>
<thead>
<tr>
<th>Soffits to floors and roofs</th>
<th>0.05 m³/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sides and soffits of beams</td>
<td>0.06 m³/m²</td>
</tr>
<tr>
<td>Sides of columns</td>
<td>0.03 m³/m²</td>
</tr>
</tbody>
</table>

- Allow 0.50 kg nails/m² for initial use and 0.125 kg/m² for every subsequent use.
- Wedges; 1 set/m²; $2/set.

Labour in fixing and dismantling

Labour to unload timber is 1.25 hours/ton.
Labour to unload plywood is 0.10 hour/sheet.
Labour to erect, strike and remove.

<table>
<thead>
<tr>
<th></th>
<th>Erection Hrs/m²</th>
<th>Striking &amp; Removal Hrs/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Craftsman</td>
<td>Labourer</td>
</tr>
<tr>
<td>Walls &amp; Soffits of floor slabs</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Beams &amp; Columns</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Waste

Allow 10% waste on forms and props

Number of re-use

Normally 3 to 5 times.

REINFORCEMENT

The build up of unit rates should consider the following: Waste 2½%; Rolling margin 2½%; Tying wire 2½%; Materials (Quantity of steel reinforcement); Labour in cutting, bending and fixing; Labour in unloading and storage (2.5 hrs per tonne).

Labour in cutting, bending and fixing

Hours for craftsman in cutting, bending and fixing per tonne
<table>
<thead>
<tr>
<th>φ mm</th>
<th>6</th>
<th>9</th>
<th>10</th>
<th>12</th>
<th>13</th>
<th>16</th>
<th>20</th>
<th>22</th>
<th>25</th>
<th>28</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>95</td>
<td>78</td>
<td>68</td>
<td>59</td>
<td>50</td>
<td>48</td>
<td>40</td>
<td>37</td>
<td>34</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>84</td>
<td>73</td>
<td>65</td>
<td>57</td>
<td>53</td>
<td>42</td>
<td>39</td>
<td>37</td>
<td>34</td>
<td>31</td>
</tr>
<tr>
<td>C</td>
<td>120</td>
<td>111</td>
<td>90</td>
<td>77</td>
<td>64</td>
<td>61</td>
<td>52</td>
<td>49</td>
<td>47</td>
<td>43</td>
<td>39</td>
</tr>
<tr>
<td>D</td>
<td>175</td>
<td>145</td>
<td>130</td>
<td>115</td>
<td>101</td>
<td>90</td>
<td>75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

A= foundation and beds; B= suspended slabs; C= Wall, columns and beams; D= Links and stirrups.

If rods are purchased already cut, bent and labelled, the labour requirement reduced by 33 1/3%.

**FABRIC REINFORCEMENT (EG. BRC)**

Usually supplied in standard sheets 4.8m long x 2.4m wide or in rolls. 2.4m x 48m long.
Labour unloading and storing (2.5 hrs per tonne).
Allowance should be made for side and end laps.
Example:- Calculation of 300mm side and end laps.
Sheet area = 2.4 x 4.8m = 11.52m²
Width  2.4m - lap 0.3m = 2.1m
Length 4.8m - lap 0.3m = 4.5m
Net area = 2.1 x 4.5 = 9.45m²
Lap area or loss 2.07m²

Therefore, the addition required due to loss in lap is: 2.07 ÷ 9.45 x 100% = 21.90%

Waste: allow 5% for floors and slabs and 7½% for tying wire.
Fixing of fabric reinforcement is carried out by a craftsman assisted by 2 labourers.

<table>
<thead>
<tr>
<th>Hrs/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beds, landings, floors and roof</td>
</tr>
<tr>
<td>Foundations</td>
</tr>
<tr>
<td>Walls</td>
</tr>
<tr>
<td>Staircases</td>
</tr>
</tbody>
</table>

**PRECAST CONCRETE**

Similar to principles of pricing concrete.
Consider the construction of mould and number of re-use.
Quotations from precast concrete specialists, consider the following: Unloading, Placing in position, Bedding materials, Breakage waste, Profits and markup.
EXAMPLES
In these examples, all-in rates for labourer and craftsman are assumed as $6.59 and $10.18 respectively.

1a. 150mm concrete (1:2:4 - 19mm aggregate) suspended floor filled into formwork and packed around rod reinforcement (formwork and reinforcement measured separately). Calculate the cost per m².

<table>
<thead>
<tr>
<th>Material</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement per tonne</td>
<td>83.00</td>
</tr>
<tr>
<td>Unloading 1 hour @ $6.59</td>
<td>6.59</td>
</tr>
<tr>
<td>Per tonne</td>
<td>89.59</td>
</tr>
<tr>
<td>Per m³ @ 1400 kg/m³</td>
<td>125.43</td>
</tr>
<tr>
<td>Sand per tonne</td>
<td>15.00</td>
</tr>
<tr>
<td>Per m³ @ 1600 kg/m³</td>
<td>24.00</td>
</tr>
<tr>
<td>Aggregate per tonne</td>
<td>16.00</td>
</tr>
<tr>
<td>Per m³ @ 1400 kg/m³</td>
<td>22.40</td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
</tr>
<tr>
<td>1m³ cement @ $125.43</td>
<td>125.43</td>
</tr>
<tr>
<td>2m³ sand @ $24.00</td>
<td>48.00</td>
</tr>
<tr>
<td>4m³ aggregate @ $22.40</td>
<td>89.60</td>
</tr>
<tr>
<td>Waste 10%</td>
<td>26.30</td>
</tr>
<tr>
<td>Shrinkage 50%</td>
<td>144.67</td>
</tr>
<tr>
<td>7m³</td>
<td>434.00</td>
</tr>
<tr>
<td>1m³</td>
<td>62.00</td>
</tr>
</tbody>
</table>

Mixing
Assume 200 litre mixer @ $22.98/hr and output of 2m³ per hour.
Cost of mixing per m³ @ $22.98 ÷ 2

$11.49

Placing
Labour placing is suspended slab
3.5 hours @ $6.59

23.07

Material
62.00
Mixing
11.49
Placing
23.07
Profit and oncosts mark up 15%

14.48

111.04

Cost of 150mm = 150

1000

= 16.66

111.04
1b. Reinforced concrete (Grade 40; 1kg cement: 1.2kg sand: 2.4kg aggregate) column, filled into formwork and packed around rod reinforcement (formwork and reinforcement measured separately). Calculate the cost per m$^3$.

Ratio by weight is $\frac{1}{1.2} : \frac{1}{2.4} = 1 : 1.2 : 2.4$

Multiply by 1400 throughout $= \frac{1400}{1680} : \frac{1680}{3360} : \frac{3360}{1400}$

Since volume = mass/density, to convert into ratio by volume, we can simply divide the ratio by the respective density of each component (cement:1400kg/m$^3$, sand:1600kg/m$^3$, aggregate:1400kg/m$^3$)

1400kg of cement = $\frac{1400}{1400} = 1$m$^3$ of cement
1680kg of sand = $\frac{1680}{1600} = 1.05$m$^3$ of sand
3360kg of coarse aggregate = $\frac{3360}{1400} = 2.4$m$^3$ of coarse aggregate

Thus, ratio by volume $= 1 : 1.05 : 2.4$

<table>
<thead>
<tr>
<th>Material</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement per tonne</td>
<td>83.00</td>
</tr>
<tr>
<td>Unloading 1hr @ $6.59</td>
<td>6.59</td>
</tr>
<tr>
<td>Per tonne (1000kg)</td>
<td>89.59</td>
</tr>
<tr>
<td>Per m$^3$ (1400kg/m$^3$)</td>
<td>125.43</td>
</tr>
<tr>
<td>Sand per tonne</td>
<td>15.00</td>
</tr>
<tr>
<td>Per m$^3$ (1600kg/m$^3$)</td>
<td>24.00</td>
</tr>
<tr>
<td>Aggregate per tonne</td>
<td>16.00</td>
</tr>
<tr>
<td>Per m$^3$ (1400kg/m$^3$)</td>
<td>22.40</td>
</tr>
</tbody>
</table>

Concrete

| 1 m$^3$ cement         | 125.43  |
| 1.05 m$^3$ sand        | 25.20   |
| 2.4 m$^3$ aggregate    | 53.76   |
| wastage 10%            | 20.44   |
| shrinkage 50%          | 224.83  |
| 4.45m$^3$              | 337.25  |
| 1 m$^3$                | 75.79   |

mixing

assume 200l mixer @ $22.98 / hr and output of 2m$^3$ / hr

cost of mixing per m$^3$ @ $22.98/2$ $= 11.49$

placing

labour placing in column

8 hr / m$^3$ @ $6.59 / hr $= 52.72$

<table>
<thead>
<tr>
<th>material</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>mixing</td>
<td>11.49</td>
</tr>
<tr>
<td>placing</td>
<td>52.72</td>
</tr>
<tr>
<td>profit and on costs</td>
<td>21.00</td>
</tr>
<tr>
<td>mark up 15%</td>
<td>140.00</td>
</tr>
<tr>
<td>cost / m$^3$</td>
<td>161.00</td>
</tr>
</tbody>
</table>
2. Formwork to soffit of suspended slab. Calculate the cost per m².

**Timber Cost**
- Timber per tonne \((1.416\text{m}^3)\) \(610.00\)
- Unloading 1.25 hours @ $6.59 \(8.24\)

<table>
<thead>
<tr>
<th>Costs per tonne</th>
<th>Cost per m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>618.24</td>
<td>436.61</td>
</tr>
</tbody>
</table>

**Plywood Cost**
- 2.4m x 1.2 x 12mm plywood \((2.88\text{m}^3)\) \(20.00\)
- Unloading 0.10 hour @ $6.59 \(0.66\)

<table>
<thead>
<tr>
<th>Costs per sheet</th>
<th>Cost per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.66</td>
<td>7.17</td>
</tr>
</tbody>
</table>

Assuming an area of 1m² and 5 uses.

**Materials**
- Timber for props 0.05m³ @ $436.61 \(21.83\)
- Plywood form 1m² @ $7.17 \(7.17\)
- 1 set folding wedges \(2.00\)
- Nails - first use \(0.5kg\) \(2.00\)
- 4 Subsequent use x 0.125 \(0.5kg\) \(5.00\)
- 1.0kg @ $1.50 \(1.50\)

\(\sum\) 5 uses \(32.50\)
\(\sum\) 1 use \(30.50\)
\(\sum\) 10% Waste \(0.65\)

**Labour**
- Erecting 1 Craftsman and 1 labourer
  - 1 hour @ ($6.59 + $10.18) \(16.77\)
- Removing 1 hour labourer @ $6.59 \(6.59\)

\(\sum\) Profit and oncosts markup 15% \(4.58\)
**Cost/m²** \(35.09\)

3. 16mm Mild steel reinforcement in columns. Calculate the cost per kg.

\(\text{S}\)
- 1 tonne 16mm diameter steel rods \(637.20\)
- Unloading 2.5 hours @ $6.59 \(16.48\)

\(\sum\) \(653.68\)

Waste, tying wire and rolling margin 7½%
\(\sum\) \(49.03\)

\(\sum\) \(702.71\)

Craftsman, cutting bending and fixing
- 61 hours @ $10.18 \(620.98\)

\(\sum\) \(1323.69\)

Profit and oncosts markup 15% \(198.55\)
**Cost/tonne** \(1522.24\)

\(\sum\) **Cost/kg** \(1.52\)
4. 80mm thick precast concrete planks laid as suspended floors or roofs, hoisting and fixing on prepared columns or beams. per m².

Assume an area of 100m²

Materials

100m² precast concrete planks @ $21.15/m²

Labour unloading, say 1 hour @ $6.59

Waste 5%

Concrete Bedding material, including labour to lay concrete to columns/beams and wastage:
Concrete (1:2:4) @ 0.08m³/100m² planks
0.08 m³ x $96.56/m³

Labour placing planks in position
Craftsman 100m² x 0.75hr = 75 hrs @ $10.18

Sub-total
Profit and oncost markup 15%
Cost of 100m²
Cost/m²

5. Calculate the total cost of construction 1m x 1m x 1m deep pile cap.

<table>
<thead>
<tr>
<th>S/NO</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Excavate pit for pile cap and g.o.</td>
<td>m³</td>
<td>1</td>
<td>42.14</td>
<td>42.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(L7/2a)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>R.E.M.F.S</td>
<td>m³</td>
<td>1</td>
<td>10.00*</td>
<td>10.00</td>
</tr>
<tr>
<td>C</td>
<td>RC G40 to pile cap</td>
<td>m³</td>
<td>1</td>
<td>161.00</td>
<td>161.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(L8/1b)</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Formwork to sides of pile cap</td>
<td>m²</td>
<td>4</td>
<td>35.09</td>
<td>140.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(L8/2)</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>16mm diameter m.s. bar to pile cap</td>
<td>kg</td>
<td>100</td>
<td>1.52</td>
<td>152.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(L8/3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>505.50</strong></td>
<td></td>
</tr>
</tbody>
</table>
INTRODUCTION

Two major methods are used to calculate life cycle costs. These are:
* net present value method
* internal rate of return method

NET PRESENT VALUE (TOTAL LIFE-CYCLE COSTS (TLCC)) TECHNIQUE

This method makes use of a discount rate for evaluation.

Discount rate
Difficult to select rate, varies with time; long periods involved.

Ways of assessing:
(a) The social time preference rate.
(b) The rate of interest at which the Government lends and borrows
(c) The opportunity cost rate of interest - market rate for money borrowed
   (C.f. return on a business investment)

Depends on financial standing of the client, long-term movement of rates.

Present value of $1:

\[ P = \frac{F}{(1 + i)^n} \]

Present value of $1 per annum

\[ P = A \left[ \frac{(1 + i)^n - 1}{i(1 + i)^n} \right] \]

P = present amount or present value
F = future amount at the end of n periods of time
i = discount rate
A = uniform end-of-period amount continuing for n periods

Method of Calculation

The discount factor can be calculated using
(a) scientific calculator, calculated from discount formula
(b) Present value of $1 table and Present Value of $1 per annum (Year's Purchase) tables

Present value of $1: in 30 years at 5% interest is $0.23137 (see Present Value of $1 table)

Present value of $1 p.a.: An expenditure of $1 per annum throughout a sixty-year period is equivalent to a single payment of $18.9292 today, taking an interest of 5%.

Example
Advising which option should be chosen: carpet or parquet.
Period 25 years Discount rate 5.76%

Option 1: Carpet
Capital costs Floor screed $9,858 Carpet $15,701
Total $25,559
Annual maintenance costs Carpet cleaning $2,038
Replacement costs (every 10 yrs)
Carpet (yr 10) $14,484; (yr 20) $14,484

Option 2: Parquet
Capital costs Floor screed $9,858 Parquet $11,527
Total $21,385
Annual maintenance costs Cleaning $3,340 Refinishing $1,222

Replacement costs: NIL

Calculation
Total Net Present Value (life cycle cost) of Option 1:

\[
\text{NPV}_1 = \frac{1.0576^{25} - 1}{0.0576 (1.0576)^{25}} \left( \frac{14484}{1.0576^{10}} \right) - \frac{14484}{1.0567^{20}} = -65231
\]

Total Net Present Value (life cycle cost) of Option 2:

\[
\text{NPV}_2 = \frac{1.0576^{25} - 1}{0.0576 (1.0576)^{25}} \left( \frac{3340 + 1222}{1.0576^{10}} \right) = -81079
\]

Answer: Option 1 is better and should be selected.

INTERNAL RATE OF RETURN TECHNIQUE
Interest rate, i, which makes net present value of the investment equal to zero.
To calculate the internal rate of return, set up the equation and solve for i.
Alternative that has a higher rate of return will be the better choice.

Example: Purchasing a tractor
Option 1: new tractor with a 6-year life
Initial cost - $73,570
Net Annual Income
(revenue - running costs): +$26,000
Salvage value at the end of year 6: +$8,000

Option 2: used tractor with a 3-year life
Initial cost: - $24,680
Net Annual Income: + $12,000
No Salvage value

Equation for option 1:

\[
NPV_{\text{new}} = -73570 + 26000 \left( \frac{(1+i)^6 - 1}{i(1+i)^6} \right) + \frac{8000}{(1+i)^6} = 0
\]

\[i = 28\%\]

Equation for option 2:

\[
NPV_{\text{old}} = -24680 + 12000 \left( \frac{(1+i)^3 - 1}{i(1+i)^3} \right) = 0
\]

\[i = 21.5\%\]

Note that they have unequal lives (6 vs 3 years), i.e. different bases. Hence, the resulting IRRs cannot be compared unless we make additional assumptions in two possible scenarios.

**Truncation method**

**Scenario 1:** Assume the salvage value of the new tractor is $30,000 after 3 years. Calculate its IRR on this basis:

\[
NPV_{\text{new}} = -73570 + 26000 \left( \frac{(1+i)^6 - 1}{i(1+i)^6} \right) + \frac{30000}{(1+i)^3} = 0
\]

\[i_{\text{new}} = 18.9\%\]

With this assumption on the 3-year basis, the old tractor will be a better choice (21.5% > 18.9%).

**Equal replacement method**

**Scenario 2:** Add an equal replacement for option 2 at the end of year 3 so that both options are of 6 years. \[i_{\text{old}} = 21.5\%, i_{\text{new}} = 28\%\] the conclusion reached with this assumption is that the new tractor is a better choice (28% > 21.5%).

\[
NPV_{\text{old}} = -24680 + 12000 \left( \frac{(1+i)^6 - 1}{i(1+i)^6} \right) - \frac{24,680}{(1+i)^3} = 0
\]

\[i_{\text{old}} = 20.5\%\]
To calculate \( i \) when NPV = 0, the following methods can be employed:

(a) Trial and error  
(b) Graph NPV vs Interest Rate  
(c) Computer Spreadsheet Software

**LCC - DEGREE OF USAGE**

Survey carried out in the UK revealed 67 construction related companies; only 6 companies do LCC comprising 5 QS & 1 architect
PROBLEMS WITH USING LIFE CYCLE COSTING TECHNIQUES

1 Lack of data: Initial costs are easily available; longer term costs not available, Data for running costs is often lacking, Proper Life Cycle Cost Analysis not kept nor feedback to persons doing the next Life Cycle Cost Plan.

2 Discount rate: Difficult to decide which discount rate to use, Involves forecasting 25 to 50 years into the future.

3 Lack of awareness and knowledge: Survey in UK: only QS know, Clients, architects and engineers in the design team are not aware, Few people trained in this analysis.

4 Long term predictions; wrought with uncertainties and difficult to foresee long into the future, looks too far ahead into the future using present knowledge - clients' needs change and LCC cannot take this into account.

5 Qualitative decisions; many qualitative decisions have to be undertaken.

6 Importance of capital cost, initial cost is traditionally the only criteria for selecting a design, owners do not view running cost as important as compared to construction cost because:
   ☑ buildings are sold after some time
   ☑ tenants pay for maintenance
   ☑ spend as little as possible in the initial stages of any project - weak economic climate, will not spend more money than is necessary
   ☑ public sector projects - decisions based on lowest cost so long as it meets current public needs.

7 Approved budget not to be exceeded; Initial investments for most projects are on a tight budget - uncertain savings in the future running costs, no incentive to spend valuable time in evaluating other options which may exceed budget.

8 Intangible factors; cannot incorporate qualitative and intangible benefits eg: value of new image, prestige, pride because no monetary value.

9 Practical usefulness; highly theoretical, many assumptions which may not be correct in the long run.

10 Time and money constraints; time and effort involved, higher professional fees - additional expense

11 Accuracy; extensive predictions, not an exact science due to the assumptions made.
INTRODUCTION
1. SMM2 (S’pore) Clause 7.02 states that:-
   The description of each item of brickwork and facings shall be deemed to include all
   holdfasts and bonding ties at abutments to concrete structures, all rough and fair
   cuttings, oversailing and receding courses, rough relieving and discharging arches,
   wedging and pinning, raking out joints for and pointing flashings, bedding plates,
   bedding and pointing of frames, parging and coring flues, labour eaves filling,
   plumbing angles, forming square and rebated reveals, cut squints or birdsmouths,
   notches, forming, leaving or cutting chases, holes and mortices, cutting and pinning
   and making good and any other sundry items of a like nature.

Factors affecting cost of brickwork and blockwork
2. The costs of brick and blockwork are affected by:
   (a) Weather conditions
   (b) Protection of work
   (c) Continuity of work (long straight wall or difficult broken up work)
   (d) Repetition
   (e) Location and height of walls
   (f) Accessibility
   (g) Type of bond
   (h) Thickness of wall
   (i) Type and weight of bricks and blocks

BRICKWORK
3. Factors to consider to building up rate for brickwork:
   (a) Quantity of bricks per unit
   (b) Quantity and cost of mortar per unit
   (c) Cutting and waste
   (d) Labour laying bricks
   (e) Labour for unloading bricks

4. Bricks
   a. Typical brick size : 215 mm x 102.5 mm x 65 mm.
   b. Mortar joint : 10 mm
   c. Number of bricks per m²
      i. ½B wall = 60
      ii. 1B wall = 120
d. For common bricks, the type of bond has little or no influence on the number of bricks in a solid brick wall.

5. **Mortar**
   a. Analysing method of mortar is similar to that of Concrete.
   b. Shrinkage factor 25 - 35%.
   c. Mixing by hand = 6 hrs/m³.
   d. Mixing by machine = 1 hr/m³ (100 litre mixer).
   e. Amount of mortar required varies with the type of brick.
      i. 0.03m³ mortar for each m² of half brick thickness.
      ii. 0.06m³ mortar for each m² of one brick thickness.

6. **Waste**
   a. Depends on handling and stacking, cutting of bricks, unloading and rejection due to poor quality.
   b. Normal allowances for waste:
      - Common bricks = 7.5%
      - Facing bricks = 10%
      - Engineering bricks = 4%

7. **Labour**
   a. Output of bricklayer depends on the complexity of work, wall thickness and skills of bricklayer, etc.
   b. Average productivity is 40 to 80 bricks per hour per bricklayer. For our example, we will assume 60 bricks per hour per bricklayer. For curved work, reduce by 50% and for battered work reduce by 33 1/3%.
   c. It is usual to have one labourer attending to two bricklayers. For complex work, one labourer will attend to one bricklayer.
   d. Labourer to unload bricks:
      - 400 common bricks per hour
      - 300 facing bricks per hour

**BLOCKWORK**

8. Typical sizes:-
   - 390mm x 190mm concrete blocks in 75mm, 100mm and 150mm thickness.

9. Mortar requirement = 0.01m³ per m² for 75mm thickness. Reasonable allowances should be made for other thickness.

10. Waste allowance 10%

11. Unloading of 10m² will take a labourer about 1 hour.

12. Laying = 0.5 hour of bricklayer and labourer for each m² of 75mm thick blockwork.

13. For building to a fairface and pointing, allow an additional 0.25 hour/m² irrespective of wall thickness.
EXAMPLE
In this example, all-in rates for labourer and craftsman are assumed as $6.59 and $10.18 respectively.

One brick wall in common bricks in cement mortar (1:3). Calculate the Cost Per m².

<table>
<thead>
<tr>
<th>Bricks</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 bricks delivered</td>
<td>190.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Labour Unloading</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 ÷ 400 = 2.5 hrs @ $6.59</td>
<td>16.48</td>
</tr>
<tr>
<td>Unloaded cost of brick per 1000</td>
<td>206.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mortar</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1m³ cement @ $219.23/m³</td>
<td>219.23</td>
</tr>
<tr>
<td>3m³ sand @ $23.40</td>
<td>70.20</td>
</tr>
<tr>
<td>Waste 10%</td>
<td>28.94</td>
</tr>
<tr>
<td>Shrinkage 33 1/3%</td>
<td>106.11</td>
</tr>
<tr>
<td>4m³</td>
<td>424.48</td>
</tr>
<tr>
<td>1m³</td>
<td>106.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mixing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Assume 200 litre concrete mixer with output of 2m³ per hour</td>
<td></td>
</tr>
<tr>
<td>1m³ mortar mixed in ½hour @ $26.93</td>
<td>13.47</td>
</tr>
<tr>
<td>Cost of mortar 1m³</td>
<td>119.59</td>
</tr>
</tbody>
</table>

****

Assume an area of 10m² of wall

<table>
<thead>
<tr>
<th>Materials</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bricks</td>
<td></td>
</tr>
<tr>
<td>1200 bricks @ $206.48/1000</td>
<td>247.78</td>
</tr>
<tr>
<td>waste 7½%</td>
<td>18.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mortar</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06m³ x 10 = 0.60m³ Mortar @ $119.59=</td>
<td>71.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Labour</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gang comprising 2 bricklayers and 1 labourer. Gang output is 120 bricks per hour. All-in rate for gang = $10.18 + $10.18 + $6.59 = $26.95</td>
<td></td>
</tr>
<tr>
<td>1200 ÷ 120 = 10 gang hours @ $26.95</td>
<td>269.50</td>
</tr>
<tr>
<td>Profit and oncosts markup 15%</td>
<td>91.14</td>
</tr>
<tr>
<td>10m²</td>
<td>698.75</td>
</tr>
<tr>
<td>Cost per m²</td>
<td>69.88</td>
</tr>
</tbody>
</table>
GLAZING

1. Introduction
1.1 SMM2 Glazing (Clause 20.02)
The description of each item of glazing shall be deemed to include fixing and bedding, replacing scratched, cracked and broken glass, cleaning and polishing and all necessary protection.
1.2 Ordinary sheet glass is supplied in three common quality classification:
   (a) OQ Ordinary glazing quality. (Most often used)
   (b) SQ Selected glazing quality.
   (c) SSQ Special selected quality. (Very best quality, free from ripples, flaws and imperfections).

2. Thickness
2.1 The thicknesses available are: 5mm, 6mm, 8mm, 10mm, 12mm.
2.2 For window panes, 6mm thickness is normally used.

3. Types Of Glass
3.1 The examples are sheet glass (OQ), float glass (SQ) and plate glass (SSQ).
3.2 The various ‘finishes’ to glass include: clear, tinted, obscured, georgian wired, laminated, and tempered.

4. Wastage, Labour, Material Requirements
4.1 Waste: Due to cutting and unusable offcuts. Allow 10% for bulk glass and 5% for cut to size glass.
4.2 Putty: Allow 0.09 kg of putty for every metre girth of glass.
4.3 Labour output
   The output for craftsman to cut and fix per metre square of glass varies from 1.5 hr (small pane) to 0.5 hr (large pane). Average output may be taken as 1.25 hr/m². For glass which is purchased cut to size, allow 1 hr/m².
4.4 Window
   For glazing to metal casements, increase labour output by 25%. Similarly, when glazing wood sashes with beads and putty, allow 25% more for labour.
4.5 Sundry items
   For curved cutting on sheet glass, allow 3m per hour of craftsman's time except plate glass for which allow 2m per hour.
4.6 Unloading
   Labour unloading glass is 0.10 hr/m².
Issues relating to maintenance of a building are:
- technical aspects of maintenance
- management aspects: planning and organising maintenance work
- social aspects: buildings kept in good state of repair, reflects prosperity of the country, quality of life and public pride and prevents anti-social behaviour.
- economic aspects. ****

Why maintain buildings? (from economic point of view)
1. Failure to maintain leads economic obsolescence; loss of key tenants, lower occupancy rate, lower revenue, less funds for maintenance, deterioration and disrepair.
2. Maintain to preserve building value, utility and infrastructure.
3. Maintain to prevent or delay progressive deterioration - age & usage.
4. Badly maintained building: inefficiency in the social and economic activities in building, inconvenience to users, financial loss to owners.
5. Maintain to reduce the fluctuations in overall construction activity.

Maintenance considerations during design and construction
Maintenance issues to be addressed at the design stage.
To consider capital cost, running cost and maintenance cost (life cycle cost considered).

Factors to consider during design stage are:
building form, choice of materials, life cycle cost, satisfactory detailing, proper layout, access to parts requiring maintenance.

Factors to consider during construction stage are:
high quality workmanship, compliance with specifications, eg plaster composition, compliance with minimum time to achieve strength, eg. concrete., proper supervision, raising skill levels of workers, inculcate in them pride in work.

Laws that govern buildings' maintenance
1. Land Titles (Strata) Act (1987 & Amendments)
apartment owners became owners of shared facilities or common property, and are responsible for their upkeep.
management corporation is the ‘owner’ to manage and maintain subdivided building and common property.

Buildings and Common Property (Maintenance and Management) Act (1973) - Commissioner of Buildings [COB]

COB take action if failure to Maintain:
- advisory letters asking owners or MC to spruce up buildings and to outline maintenance plan within 30 days.
- failure to act, notices sent.
- prosecute recalcitrant owners

COB investigates complaints of poor maintenance and management of buildings and take appropriate actions.

Town Councils (Minimum Amount of Charges for Payment Into Sinking Funds) Rules 1989

minimum amount of service and conservancy charges to be set aside for setting up mandatory sinking fund.
25% for residential units and commercial property.
Food and market produce stalls: 20%.

Expenditure in maintenance in Singapore
Total area of building stock: 140 million m² built-up space - residential 50%.
Value of building stock $180B
Maintenance expenditure: $900 million p.a., 15 - 20% of total construction output, public sector 55% expenditure.

Cost of maintenance (1988): hospitals $53.10/m²/year, hotels $14.60/m²/year, commercial building: $12.30/m²/year.

Funding for maintenance = 2% of the annual equivalent capital value of a building.

Funds for maintaining private buildings
Types of funds:
management fund - funding expenditure of a routine nature.
- short term maintenance.
sinking fund - since 1987, mandatory, major repair, cyclical replacement eg. repainting, A/C change, improvement works, medium and long term maintenance.

Sources of funds:

service charge: vary according to building type and location.
Used for maintenance of common areas, utility costs of common services, insurance premium, administrative cost.

returns from investment of unutilised funds accumulated from service charges.

Main problem faced in maintaining buildings to requisite standards is
LACK OF FUNDS:
👀 owners cannot agree on scope of maintenance and upgrading
👀 owners have different perceptions and objectives in relation to their unit

** Funds for maintaining public buildings -**

<table>
<thead>
<tr>
<th>Government agency</th>
<th>Statutory Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>prepare periodic budgets</td>
<td>prepare separate maintenance budgets</td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>consolidate into master budget</td>
<td>consolidate into their respective ministries budget</td>
</tr>
<tr>
<td>↓</td>
<td></td>
</tr>
<tr>
<td>presented, debated and passed in Parliament.</td>
<td></td>
</tr>
</tbody>
</table>

Money from government's Consolidated Revenue Account (government revenue comprising taxes, sale of land, COE)

** Funds for maintaining HDB housing estates**
👀 conservancy and service charges - funding expenditure of a routine nature.
👀 sinking fund - similar to private buildings.

**Source of funds for HDB estate:**
👀 conservancy and service charges paid by residents.
👀 rental collected from letting out office space, community halls and void decks
👀 grant-in-aid from the government
👀 grant from Community Improvements Projects Committee of the MND - 25% - 75% of cost of upgrading and modernisation works eg running tracks, exercise equipment.

**Amount of conservancy and service charges**
❤️ size of the flat.
❤️ Cross subsidy between the 1,2,3-room flats and the 4,5 an executive flats.

**Economic problems in maintaining HDB towns:**
👀 late payment (leading to loss in interest) due to financial difficulties.
  Town councils can -
    + impose punitive interest rates
    + take action in Small Claims Tribunal
    + seize some assets
    + repossess flats
    + levy a penalty fine and administrative fee.

👀的政治考虑。
👀 no effective collection mechanism
👀 expenditure higher than revenue:
    + rapidly rising costs and tight labour market.
    + high standard of maintenance demanded
    + generally in arrears.
Grant-in-aid to balance budget

**Accountability for the funds**

- Legal requirement for accountability
- Need careful budgetary procedures and financial control measures
- Annual estimates of town councils must be prepared and published in government gazette
- Put in prominent locations of each town at the beginning of a financial year.
- At the end of each year, audited financial statements and annual reports presented in parliament.
- Variances between budgeted amount and actual to be explained.

**Future trends in maintenance costs**

Cost of building maintenance expected to increase due to:

- Ageing building stock
  - More maintenance problems.
  - Costly parts of buildings need to be replaced due to wear and tear.
  - Comprehensive repair or upgrading schemes.

- Prevalence of modern high rise buildings
  - Higher component of M&E
  - Needs more money to M to acceptable level.

- BAS, intelligent buildings
  - More sophisticated M, E, electronic and telecom systems
  - Heavy capital investment
  - Continual maintenance is also expensive.

- Users expectation with regard to comfort, cleanliness, efficiency of building operation increase.

- Competition from other buildings
  - Need for high standards of M
  - Users expect complaints to be promptly and adequately dealt with
  - Owners need to maintain high maintenance staff to space ratio.

- Maintenance cost rise due to shortage in labour.

**HDB UPGRADING PROGRAM**

Government’s long term program to improve about 400,000 flats.
Average 20,000 flats upgrades per year.
Total 15 to 20 years to complete.
Money from upgrading comes from budget surplus.

<table>
<thead>
<tr>
<th>Upgrading Program</th>
<th>Cost</th>
<th>Residents pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interim upgrading program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without lift upgrading</td>
<td>4000</td>
<td>0</td>
</tr>
</tbody>
</table>
Upgrading Program | Cost | Residents pay
---|---|---
With life upgrading | 7000 | 0
Main upgrading program
| Without space adding item | 37600 | 2630 (1,2,3 room), 3945 (4 room), 5260 (5 room), 6575 (Exec flat)
| With space adding item | 58300 | 10910 (1,2,3 room), 16365 (4 room), 21820 (5 room), 25205 (Exec flat)


Wef March 2000, new upgrading packages omit
- non essential items; but items add to maintenance costs
- upgrading to surrounding, eg. extensive landscaping
- costly frills, eg. Amphitheatres, façade treatment
- less functional and less cost effective

Main upgrading program
- Refurbishes flats’ interiors and common areas
- Residents pay part of the cost (19% to 43%)
- With or without space adding items (eg extra utility room, larger kitchen, extra balcony)

Interim upgrading program
- Improves common areas
- Fully funded by the government

Basis of choosing estates to upgrade:
- Age of estates; MUP- at least 20 years old, IUP- about 17 years old
- Cleanliness of the housing estate, which indicates community spirit
- Level of support for government policies

Other issues
- Opposition parties accuse government of “pork-barrel politics” (political parties buy votes by dispensing benefits)
- Time table for upgrading is not provided

UPGRADING OF PRIVATE ESTATES
Benchmark of $4000 per dwelling unit.
(Amount is over and above routine maintenance by LTA, ENV, Nparks.)
No co-payment is necessary.

Argument for upgrading private estates: private housing dwellers also pay taxes

Criteria for selection:
- Age of estate
- Cleanliness
- People factor- people in the private estate must want the project.
Lecture 15: Build-up rate- drainage work

References

INTRODUCTION

1. SMM 2 Clause 22.02 states that:
   "The work in each different type of drainage system (eg. agricultural, stormwater, sewer, special trade waste and the like) shall be given separately."

2. SMM2 Clause 22.03 states that:
   "The description of each item of excavation shall be deemed to include getting out, maintaining faces of drain pipe trenches, grading bottoms, ramming, planking and strutting, backfilling, disposal of surplus soil and keeping excavations free from all surface and subterranean water."

EXCAVATION

Trench excavation for drainage work

3. Built-up rate of excavation for drain trenches is similar to trench excavation, but given in linear metre.

4. Factors to consider in building up rate of excavation for drain trenches:
   a. Trimming trench bottom to the correct gradient:
      Productivity Data
      i. Grading bottom of trench: 6m²/hour.
      ii. Levelling and compacting/ramming bottom of excavation: 5m²/hour.

   b. Working space (width of trench). Space should be sufficient for drainlayer to have satisfactory freedom of movement in trench bottom.
   
   c. Planking and strutting.

   d. Earth disposal and backfilling.
CONCRETE WORK

Beds, benching, surrounds and coverings

5. Concrete to beds, benching, surrounds and coverings of the drains is measured separately in liner metre. The price built-up is similar to concrete work. 
Productivity data for placing of concrete in trenches: 3 hours/m³.

6. Formwork is to be included in the built-up rate.

PIPE WORK

7. Pipework is measured the net length along centre line of pipe in linear metre. Waste allowance is usually 5%.

Clay pipes

8. The usual length of pipe in use is **600** mm.

9. Productivity Data for Unloading clay pipes: 0.033 hour for 10 pieces.

10. Productivity Data and Material requirements for **socketed clay pipes**:

<table>
<thead>
<tr>
<th>Diameter of clay pipes</th>
<th>Material required for jointing 10 joints</th>
<th>Time required for 1 craftsman and 1 labourer for laying and joining 10 joints (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
<td>0.20 kg yarn</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>0.05 m³ mortar</td>
<td></td>
</tr>
<tr>
<td>150 mm</td>
<td>0.30 kg yarn</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>0.10 m³ mortar</td>
<td></td>
</tr>
<tr>
<td>225 mm</td>
<td>0.70 kg yarn</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>0.20 m³ mortar</td>
<td></td>
</tr>
</tbody>
</table>

Clay Fittings

11. Clay fittings such as bends are measured as extra over the pipework. It is necessary to deduct the cost of the length of pipe superseded by the fitting. Deductions as follows:

   a. 0.3m for bend
   b. 0.6m for taper
   c. 0.66m for single junction

12. Productivity Data

   Extra time is required to make a joint at a fitting. The extra time for placing and jointing a fitting is 0.25 hour per joint using 1 craftsman and 1 labourer.

Concrete pipes

13. Laying and jointing output of concrete drain pipes and fittings of socketed type may be
considered similar to clay pipes.

14. Laying and jointing output of concrete drain pipes and fittings of Ogee-joint type is similar to clay pipes but the quantity of jointing material is one third of that required for socketed joint.

**PVC pipes and Pitch Fibre pipes**

15. Pipes usually come in 2.4 m or 3.0 m lengths and jointed using tapered couplings. These pipes do not need the support of a concrete bed but the first 300mm of backfilling would need to be in dry material and carefully executed.

16. Output for craftsman and labourer is about 15m/hour.

**Cast iron pipes**

17. Pipes usually come in 3.0 m length. Due to its weight, lorry mounted cranes or truck cranes are used to lower it into trench. Pipes can be laid directly into the trench.

18. **Productivity Data**
a) for labour unloading: 10 pieces of pipes per hour.

b) material and labour requirements for **cast iron pipes**:

<table>
<thead>
<tr>
<th>$\phi$ of pipe (mm)</th>
<th>Weight of 3 m length pipe (kg)</th>
<th>Material required for jointing 3 m length pipe (kg)</th>
<th>Time required for 1 craftsman and 1 labourer for laying and jointing 3m length pipe (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>87 each</td>
<td>0.01 gaskin 2.00 lead</td>
<td>1.00</td>
</tr>
<tr>
<td>150</td>
<td>165 each</td>
<td>0.03 gaskin 3.00 lead</td>
<td>1.75</td>
</tr>
<tr>
<td>225</td>
<td>287 each</td>
<td>0.05 gaskin 6.00 lead</td>
<td>2.00</td>
</tr>
</tbody>
</table>

19. **Productivity data fittings:**

a) labour unloading: 20 pieces per hour.

b) laying and jointing:
   i. 100mm diameter pipe - 1 craftsman and 1 labourer required extra 0.5 hour to make a caulked lead joint on a fitting.
   ii. 150mm diameter pipe - 1 craftsman and 1 labourer required extra 0.75 hour to make a caulked lead joint on a fitting.

**MANHOLES**

19. Work in manholes may be taken as for ordinary work in the respective trades but an overall addition of 25% should be made to all the labour values to cover working with small quantities and in confined situations. Precast concrete circular manholes are usually in rings from 450mm to 600mm deep.
20. **Productivity data:**
   a. 1 m diameter ring 450mm deep requires about 2 hours per section for craftsman to lower and joint.
   b. Clay half round channels and channel bends take a drainlayer 0.25 hours each to set and joint. Nominal quantity of cement mortar must be added.
   c. Benching to average manhole: 2.5 hours for craftsman placing and trowelling to falls.
   d. Step iron - 0.1 hours for building into walls.
   e. Medium weight cast iron manhole cover - 0.5 hours craftsman's time to fix.

**TESTING DRAINS**
21. The cost from the contractor's viewpoint is speculative. Most specifications require drains to be tested with water, first on completion of laying, second prior to handing over.

22. Testing by inserting plugs and filling a length of drain with water and subsequently releasing water requires 2 hours of labourer's time.

**EXERCISE 1:**
Excavate trench for 100mm diameter drain pipe with concrete bed and benching not exceeding 2m deep and average 1m deep. Calculate the cost per m.

**EXERCISE 2:**
Excavate trench for 100mm diameter drain pipe with concrete bed and benching exceeding 2m and not exceeding 4m deep and average 2.5m deep. Calculate the cost per m.

**EXERCISE 3:**
100mm Diameter salt glazed clay drain pipe laid in trench and jointed in cement and sand (1:3). Calculate the cost per m.

**EXERCISE 4:**
Extra over 100mm diameter salt-glazed clay drain pipe for bend. Calculate the cost per No.

**EXERCISE 5:**
100mm Diameter cast iron pipe laid in trench and jointed in caulked lead. Calculate the cost per m.
1. INTRODUCTION - BUILDING SERVICES

Services within the building are classified into:
- Mechanical Services
- Electrical Services
- Plumbing Services

Examples: air-condition, telelift, gondola, lifts, dumbwaiters, escalators, electrical installation, plumbing, drainage system

2. APPROXIMATE ESTIMATING

2.1 QS's role in services:
- cost estimate by Engineers
- complex projects need QS involvement

2.2 Information needed for costing:
- area with services
- schematic drawings & specs
- design parameter
- equipment type
- foundations
- public utility
- services connections

2.3 Methods of approximate estimating:
- approximate quantities method
  - measure approximate quantities, price with build-up rates.

- floor area
  - measure floor area where services are provided
  - multiply with a rate obtained from past projects

- service points
  - count number of service points
  - multiply with a rate obtained from past projects

Example: Service Points
Past Project: Gas installation $50,000. No. of draw-off points/service points: 10. Index 100.
New Project: No. of service points: 12. Index 120.
What is the cost of the gas installation for the new project?

Gas Installation (new project) = $50,000/10 x 12 x 120/100

3. METHODS OF TENDER ESTIMATING
During tender stage, more accurate costing is needed.
Methods used include:
# actual qty
# non special items - price using in-house cost data base.
# specialized items - quotations from suppliers

4. COST ANALYSIS OF SERVICES
- Elemental Cost Analysis format:
  follow BCIS Cost Analysis for Building Works Section 5.0
- BCIS Cost Analysis for Engineering Services
- Other methods of analysis:
  ❖ cost/no.; eg. sanitary appliances, service equipment, lift, escalator
  ❖ cost/m2; eg. soil and waste pipes
  ❖ cost/m3; eg. air conditioning
  ❖ cost/point or cost/outlet; eg. taps for water installation, switches for electrical installation, outlet for gas installation

5. PROCUREMENT
5.1 Procuring Services
- integrated contract; services scope of works included in the main contract
- Nominated subcontract; NSC called and selected by the employer, main contractor then enters into a contract with the subcontractor.
- direct contract; services contractor signs contract directly with the employer.

5.2 Factors to consider in procurement
- contract period of services
- early completion of services for convenience
- early completion for increase productivity
- sequence of installation eg. electrical installation, lifts, communication installation
- lead time of equipment
- services at cutting edge of technology

5.3 Programme & services
*close liaison  *complete cooperation  *follow main contractor's program
*completion schedule  *re-schedule services work  *interfacing

5.4 Problems
Current problems in procurement of building services:
- Lack of integration
- Communication gap between
  - M&E consultants and M&E contractors- designers do not design buildable M&E features; both work independently
  - M&E consultants and main contractors
Interfacing Problems and Issues
Interfacing is important especially during design stages involving architects and engineers. Failure of interfacing may result in wasting time in redesigning.

- Architectural concepts redesigned to cater for running distant, fire escape route, headroom, AHU rooms, big M&E equipment, etc.
- Structural elements redesigned because:
  - change in architectural concepts
  - afterthought to accommodate heavy M&E installation (water tank, chiller plant, cooling tower, etc)
- M&E services redesigned because:
  - failure to obtain fire compartmentalisation layout from architect
  - segmented design of ACMV, sprinkler system
  - insufficient headroom (redesign aircon duct layout)
  - poor grasp of sizes of M&E equipment resulting in insufficient room sizes (AHU rooms, chiller plant rooms, etc)

5.5 How to overcome interfacing problem?
- Single point of communication
- Systematic documentation (list of do’s and don’ts)
- Problems highlighted and discussed regularly at meetings

6 CONTRACTUAL PROVISION FOR SERVICES CONTRACT
Issues to consider include insurance, protection, damage caused by services contractor, temporary facilities, scaffolding, delivery of services equipment, chases, holes, mortices, inserts, bolts and sleeves.

7 MAINTENANCE OF SERVICES
7.1 Maintenance is undertaken during construction, defects liability period, maintenance throughout life of building.

7.2 How is maintenance contract procured?
- standing offer; accepted by Engineer
- call separate maintenance contract
- waive competition.
1. **Introduction**

1.1 SMM2 Structural Steelwork (Clause 13.03)

The description of each item of steelwork shall be deemed to include:

(a) Allowances for rolling margins and the weight of welding materials.

(b) Shop and site fabrication including drilling, cutting, (including holes and openings for other trades), notching, splicing, welding, machining ends and bearings, delivery, unloading, landing, hoisting, erecting, fitting and fixing in position.

(c) Provision of all necessary plant, temporary bracing supports and the like required for erection, providing samples and tests required by the specification, the inspection of welds including the use of any special radiographic techniques.

(d) Nuts and any type of washer which may be required.

(e) Preparation of shop drawings.

1.2 Structural steel is usually sold by weight in tonnes and prices vary according to section or length.

1.3 Unloading per tonne requires 3 hours of labourer's time. For heavy sections, a mobile crane is required.

1.4 The cost of painting a coat of primer on the steel sections is included in the prices by the supplier.

1.5 Allow 5% for waste and rolling margin (i.e. unavoidable inequalities in milling the steel which results in its being plus or minus the theoretical weight per unit length).

2. **Unframed Steelwork**

2.1 Unframed steelwork is still used for load bearing purposes but not in steel framed structures. The productivity data is given below.
2.2 Any cutting, drilling or special fitting required after delivery might be very costly owing to difficulty of execution on site and lack of suitable equipment.

3. **Structural Steel In Steel Framed Structures**

3.1 Gang to erect steel structures consists of 1 skilled craftsman and 4 or 5 semi-skilled labourers.

3.2 Productivity Data (Steel Framed Structure)

<table>
<thead>
<tr>
<th>Description</th>
<th>Craftsman per 50 kg</th>
<th>Labourers Total Hours per 50 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams, stanchions etc.</td>
<td>0.50 hours</td>
<td>2.00 hours</td>
</tr>
<tr>
<td>Steel framed angle iron roof trusses</td>
<td>0.50 hours</td>
<td>2.50 hours</td>
</tr>
</tbody>
</table>

**EXAMPLE**

203 x 102 x 25.33kg joist at first floor level exceeding 3m and not exceeding 6m above ground level in unframed steelwork. Per kg.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per tonne (1000kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel joist delivered per tonne</td>
<td>$1100.00</td>
</tr>
<tr>
<td>Unloading 3 hours @ $4.62</td>
<td>$13.86</td>
</tr>
<tr>
<td>Waste and rolling margin 5%</td>
<td>$55.69</td>
</tr>
<tr>
<td>Labour 1000kg x 1hour/50kg = 20 hours Craftsman and Labour @ ($4.62 + $6.00)</td>
<td>$212.40</td>
</tr>
<tr>
<td>Profit and oncost markup 15%</td>
<td>$207.29</td>
</tr>
<tr>
<td>Cost per tonne (1000kg)</td>
<td>$1589.24</td>
</tr>
<tr>
<td>Cost per kg</td>
<td>$1.59</td>
</tr>
</tbody>
</table>
METALWORK

1. Introduction
1.1 SMM2 Metalwork (Clause 14.03)
The description of each item of metalwork shall be deemed to include:
(i) Allowing for rolling margins and the weight of welding materials.
(ii) Cutting, notching, mitring, welding, fabricating, drilling, delivery, unloading, handling, assembling, hoisting, fitting and fixing in position, bedding, filling in solid and pointing including necessary lugs or other attachments.
(iii) Protection such as wrapping finished work with paper, coating with grease or carrying out such other protective measures as may be required and removing and cleaning on completion.
(iv) Providing samples and testing is required.
(v) Preparation of shop drawings.

1.2 Metalwork is usually sold by weight in tonnes. Metalwork includes metal railings, metal gates, sheet copper, etc. Work is usually sublet to specialists, with the modern heavy presses, cutters and extruding machinery.

1.3 General waste allowance is 5%.

2. Work In Sheet Metal
For ordinary metal coverings of sheet metal, allow craftsman and labourer 2.5hrs/m².

3. Standard Metal Window
3.1 Supplied by specialist manufacturers.

3.2 Usually fixed by bricklayer or carpenter. Labour output: 2m² per hour and 0.3 kg of mastic per m of external frame if required as bedding material. Screws and cramps are usually supplied with the windows.

4. Metal Balustrades
4.1 Tabular balustrades are usually of galvanised mild steel.

4.2 Allow 1 hour craftsman and labourer per 4m of tube including all cutting, treading, drilling and assembling.

5. Ductwork
Allow craftsman and labourer 2m per hour for the assembling and fixing of lightweight galvanised steel ducting.

6. Steel Partition
Allow craftsman and labourer 1m² per hour for assembling and fixing steel office partition.
1. Introduction

The plumber's work usually involves the following:

a) Rainwater goods c/o rainwater down pipes and gutters.

b) Other plumbing works.

1.2 Rainwater goods (SMM2 Clauses 10.29 - 10.32)

a) Rainwater downpipes & eaves gutters shall be given separately in m. The method of jointing and fixing shall be described and measured the mean length over all bends, junctions, angles and the like. Loose standard straps, collars, holder bats or brackets shall be described and included with the fixing of the pipes & gutters.

b) Bends, sawn-necks, offsets, branches, shoes, angles, stopped ends and outlets shall be given in No. as extra over the lengths of pipe or gutter.

c) Heads and gratings shall be given in No.

1.3 Other Plumbing Work (Clauses 17.01, 17.02 & 17.03)

a) Work in each different type of installation shall be measured separately.

(i) Sanitary installation

(ii) Trade waste, acid or other special installation

(iii) Cold water installation

(iv) Fire service installation

(v) Hot water installation

(vi) Gas installation.

b) The description of each item of pipework shall be deemed to include:

(i) All short lengths, joints in the running lengths, joints to all branches, tees, sockets, sleeves, connections, backnuts, nipples, standpipe fixings or supporting clips, saddles, fastening brackets, holderbats, straps and the like.

(ii) Complying with all requirements of the relevant authorities, paying fees and the like in connection with the installation and preparing and submitting drawings for approval if required.

c) Pipes 50mm $\phi$ and below shall be deemed to include all elbows, bends, tees and other fittings.

d) Pipes over 50mm $\phi$ shall have all elbows, bends, tees, junctions and other fittings given separately in No. as extra over.

2. Rainwater Gutters & Downpipes

2.1 Gutters and downpipes are usually made of cast iron, galvanised steel or UPVC. In these notes, cast iron has been selected to demonstrate the principles. The length of pipes used will determine the number of joints required.
2.2 Waste is about 5%.
2.3 Labour and material requirements for cast iron pipe 2m length are shown below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Labour and Material for Laying and Jointing 2m Length - One Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast iron half round gutter up to 125mm wide</td>
<td>1 gutter bolt, 2 gutter brackets with 2 screws to each (preferably brass), 0.20 kg jointing compound, 0.50 hour Craftsman and Labourer</td>
</tr>
<tr>
<td>75mm Diameter Cast Iron rainwater pipe</td>
<td>2 No. pipe nails and distance pieces (if specified), 0.10 kg jointing compound, 0.08 kg tarred hemp, 0.75 hours Craftsman and Labourer</td>
</tr>
</tbody>
</table>

2.4 Labour unloading cast iron 2m length gutters/pipes - 0.25 hrs/10 pieces.

3. **Rainwater Fittings**
3.1 Fittings are measured in No as extra over the gutter or pipes and therefore a deduction should be made of the gutter or pipe superseded by the fittings.

3.2 Labour and material requirements for fittings are shown below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Labour and Material Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop ends</td>
<td>Material for one extra joint and 0.20 hour Craftsman and Labourer</td>
</tr>
<tr>
<td>Angles</td>
<td>Material for extra joint, and 0.25 hour Craftsman and Labourer (deduct 0.33m of gutters) 1 gutter blot, 0.2 kg jointing compound</td>
</tr>
<tr>
<td>Outlets</td>
<td>As for angle (deduct 0.25m of gutters)</td>
</tr>
<tr>
<td>Bends and shoes</td>
<td>Materials for extra joint, 2 pipe nails and distance pieces, 0.50 hour Craftsman and Labourer (deduct 0.30m of pipe)</td>
</tr>
<tr>
<td>Junctions</td>
<td>Materials for two extra joints, 2 pipe nails and distance pieces, 0.75 hour Craftsman and Labourer (deduct 0.66m of pipe)</td>
</tr>
<tr>
<td>Swan neck bends</td>
<td>Materials for one extra joint, 0.50 hour Craftsman and Labourer (deduct 0.50m of pipe)</td>
</tr>
</tbody>
</table>

3.3 Labour unloading fittings - 5¢ per piece.
3.4 Waste - 5%.

4. **Internal Pipes**
4.1 Materials for pipes include galvanised steel, stainless steel, ductile iron, copper, UPVC, etc.

4.2 The number of joints along the running length depends on the length of pipes manufactured. Generally, PVC pipes are laid in longer lengths and have fewer joints.
4.3 Fixings are required for copper and steel pipes at about 1m centres and at 300mm centres for PVC pipes.

4.4 The jointing of steel pipes requires paste and yarn with allowances as follows:
(a) 30m length of 13mm and 20mm diameter pipe - 0.1 kg of paste and 0.02 kg of hemp.
(b) 30m length of 50mm diameter pipe - 0.3 kg paste and 0.04 kg hemp.

4.5 Productivity data for laying steel pipes in horizontal position is given below.

<table>
<thead>
<tr>
<th>Size of Pipe</th>
<th>Length Executed by Craftsman and Labourer in 1 Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>13mm diameter</td>
<td>10m</td>
</tr>
<tr>
<td>20 &amp; 25mm diameter</td>
<td>8m</td>
</tr>
<tr>
<td>32 &amp; 40mm diameter</td>
<td>5m</td>
</tr>
<tr>
<td>50mm diameter</td>
<td>4m</td>
</tr>
</tbody>
</table>

4.6 For fixing to ordinary vertical wall surfaces with pipe hooks or clips would require treble the amount of time or 1/3 of the above quantities per hour.

4.7 Labour unloading = 10m/hr.

5. **Fittings To Internal Pipes**

5.1 The labour and material requirements for cutting, threading and jointing steel pipes to fittings are shown below.

<table>
<thead>
<tr>
<th>Diameter of Pipe</th>
<th>Craftsman and Labourer per Joint</th>
<th>Material Required for TEN Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>13mm &amp; 20mm</td>
<td>10 minutes</td>
<td>0.10 kg paste; 0.02 kg hemp</td>
</tr>
<tr>
<td>25mm &amp; 32mm</td>
<td>15 minutes</td>
<td>0.15 kg paste; 0.03 kg hemp</td>
</tr>
<tr>
<td>40mm</td>
<td>25 minutes</td>
<td>0.25 kg paste; 0.04 kg hemp</td>
</tr>
<tr>
<td>50mm</td>
<td>30 minutes</td>
<td>0.30 kg paste; 0.05 kg hemp</td>
</tr>
</tbody>
</table>

5.2 The following are average times for assembling and fixing plumber's brass (or chromium plated) fittings excluding material which must be added as appropriate.

<table>
<thead>
<tr>
<th>Description</th>
<th>Craftsman and Labourer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taps 13mm &amp; 20mm dia</td>
<td>15 minutes each</td>
</tr>
<tr>
<td>Stop Valve 13mm &amp; 20mm</td>
<td>20 minutes each</td>
</tr>
<tr>
<td>Ball Valve 13mm</td>
<td>15 minutes each</td>
</tr>
<tr>
<td>Unions up to 25mm dia</td>
<td>5 minutes each</td>
</tr>
<tr>
<td>Ditto over 25mm dia</td>
<td>10 minutes each</td>
</tr>
</tbody>
</table>
Lecture 18: Build-up rates: carpentry, joinery, ironmongery and roofing work

References

Carpentry Work
1. Labour unloading all types of timber is generally 1.25 hours/ton.
2. Generally, 1 ton of timber is 1.416 m$^3$.
3. The labour outputs given in this set of notes are for working in **Kapur** timber. The output for other types of timber may be adjusted using the ratios below.

<table>
<thead>
<tr>
<th>Types of Timber</th>
<th>Labour Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balau, Betis, Giam, Keranji, Merbau, Resak, Chengal</td>
<td>110</td>
</tr>
<tr>
<td>Keruing, Kempas, Kulim, Punah, Kapur</td>
<td>100</td>
</tr>
<tr>
<td>Dark Red &amp; White Meranti, Red Meranti, Geronggang, Medang, Melunak, Mengkulang, Merawan, Nyatoh</td>
<td>95</td>
</tr>
<tr>
<td>Teak</td>
<td>115</td>
</tr>
</tbody>
</table>

4. **Waste** allowance for timber in carpentry works:
   - a. 5% generally and for battens
   - b. 10% for roof work.
5. Other information and productivity data relating to carpentry works are given below:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Nails per m$^3$ of timber (kg)</th>
<th>Labour hours per m$^3$ of timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plates, Sleepers and lintels</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Floor Joists</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Upper Floor Joists</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Partitions</td>
<td>0.6</td>
<td>20</td>
</tr>
<tr>
<td>Trussed Partitions</td>
<td>0.6</td>
<td>25</td>
</tr>
<tr>
<td>Roof timber, rafters, and ceiling joists</td>
<td>0.5</td>
<td>20</td>
</tr>
<tr>
<td>Roof trusses</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

6. **Nails**
   For other carpentry work, unless otherwise stated, a reasonable allowance for nails is 0.02 kg per m$^3$. 
JOINERY WORK

7. **Sizes:**
Check whether sizes are 'nominal' or 'finished'. If nominal, a 100mm x 50mm timber wrought all round will measure after planning about 95mm x 45mm. 2.5 mm difference on each surface. SMM provides that all sizes shall be finished sizes (clause 11.18).

8. **Glue, nails and sandpaper**
Joinery work normally requires glue, nails and sandpaper during manufacturing and finishing. Unless information for these items given separately, add 2.5% to the net material cost to cover glue, nails, sandpaper, and waste.

9. **Waste** allowance for timber in joinery works: 5% generally unless otherwise given.

**Flooring**

10. Quantity of tongued & grooved flooring, nails and labour constants for 10m² flooring are given below:

<table>
<thead>
<tr>
<th>Width of board (mm)</th>
<th>Linear meter of board</th>
<th>Nails (kg)</th>
<th>Craftsman laying (hrs)</th>
<th>Craftsman cleaning off (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>156.3</td>
<td>2.6</td>
<td>7.5</td>
<td>1.5</td>
</tr>
<tr>
<td>100</td>
<td>111.1</td>
<td>1.8</td>
<td>7.0</td>
<td>1.5</td>
</tr>
<tr>
<td>125</td>
<td>87.0</td>
<td>1.4</td>
<td>6.5</td>
<td>1.5</td>
</tr>
<tr>
<td>150</td>
<td>71.4</td>
<td>1.2</td>
<td>6.0</td>
<td>1.5</td>
</tr>
<tr>
<td>175</td>
<td>60.2</td>
<td>1.0</td>
<td>5.5</td>
<td>1.5</td>
</tr>
<tr>
<td>200</td>
<td>52.1</td>
<td>0.9</td>
<td>5.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

11. For a given area, it is the number of linear metres of board or strip fixed that controls the labour output. The thickness of boards used does not make any noticeable difference to the labour until a thickness of 32mm is reached when labour constants should be increased by 25%.

12. **Waste on Flooring**
   a. Waste on flooring may be due to: floors are surfaced and edged in planning machine, tongues and grooves are cramped, 'short ends'.
   b. The normal allowance for wastage is as shown:
      i. Surfacing waste on the edges: 150mm board = 3½%;
         100mm board = 5%
      ii. Plain edge flooring: 10% waste
      iii. Tongued and grooved works: 15% waste

**Doors**

13. Fabrication takes about 4-6 hours per m² Joiners' time.
14. Small doors are more difficult thus increasing labour time by 20%. For semi-circular door, the labour constant should be 50% more. For doors with glazed bars, add 25% more labour time.
15. Normal doors: Hanging, fitting and cleaning off takes 1 to 1½ hr per door Joiners' time.
16. Heavy doors: Allow one labourer as assistant.
ROOFING WORK

Tiling

17. **Labour unloading:** A labourer can unload 1000 pieces of tiles in 1 hour.

Number of tiles and Labour output

18. Number of tiles required depends on gauge (fixing centres of tiling battens). Division of roof slope by the gauge will give the number of rows of tiles. Division of eaves length by the effective width of tile will give the number of tiles per row.

19. Output of laying tiles = 90 tiles per hour (1 tiler and 1 labourer). For vertical tiling, increase labour constant by 50%.

20. For half round ridge and hip tiles, calculate the number of tiles by dividing the length of hip or ridge by the length of tile. Mortar required is about 0.10m³ per 10m and waste is about 5%. Tiler and labourer can lay 3m per hour.

Nailing

21. Concrete inter-locking tiles (375 mm x 225 mm) are fixed by nailing through two holes in the head of the tile into battens. Waste is about 5%.

22. Tiles having hanging nibs need only be nailed every third or fourth course.

23. **Number of Nails per kg** is given below:

<table>
<thead>
<tr>
<th>Material</th>
<th>40 mm long nails</th>
<th>50 mm long nails</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>300</td>
<td>220</td>
</tr>
<tr>
<td>Composition</td>
<td>280</td>
<td>200</td>
</tr>
<tr>
<td>Galvanised Iron</td>
<td>280</td>
<td>200</td>
</tr>
</tbody>
</table>

Roof battening

24. If gauge is z, the quantity of roof battening (in linear metre) required per m² is:

\[
\frac{1000}{z} \times 1m
\]

25. A roofer and labourer will fix about 50 m battens per hour. 0.66 kg of 40 mm long nails is required for 50 m long battens. Waste is 5%.

Corrugated sheet roofing

26. Corrugated sheet roofing usually comes in galvanised steel sheet or aluminium. Standard sizes vary according to manufacturer. Usually 600 mm wide and 3 m long.

27. Labour unloading sheets: 100 m²/hour. Roofer and labourer take 0.15 hour/m² to fix sheets. When fixing vertically, an extra labourer should be allowed.

28. Sheets are fixed with side lap and end lap. End lap is usually of 150 mm. Side lap is 50 mm or 1 corrugation.

29. Allowance for loss in laps about 15%. Waste is 5%.

30. Sheets are usually fixed with formed eaves, barge, apron and valley pieces. Output is about 5m per hour Roofer and labourer's time.
PAINTING

Introduction
1. SMM2 Painting (Clause 21.02). The description of each item of painting and decorating shall be deemed to include:
   (i) Preliminary preparatory work to the surface required before the application of any material.
   (ii) All multi-coloured work and cutting to line and rubbing down between coats.

2. Waste: Waste is about 5%.

3. Brushes: Paint brushes are expensive and wear off quickly. Allow 20 cents per hour of use for wear.

4. Ladders: When working in ladders, increase labour hours by 20% due to difficulty of working at heights. Ladder cost is considered in overheads.

5. Labour

5.1 Painter normally do not require assistant unless when working off ladders at heights 6m or in public thoroughfare when an extra man is needed to assist in moving the ladder and anchoring the foot.

5.2 Painting of plasterwork per 100 square metre

<table>
<thead>
<tr>
<th>Description</th>
<th>Materials Required</th>
<th>Painters' Time in Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint (oil) one coat</td>
<td>11.00 litres paint</td>
<td>18.00 hours</td>
</tr>
<tr>
<td>Emulsion - 1st coat</td>
<td>11.00 litres paint</td>
<td>15.00 hours</td>
</tr>
<tr>
<td>Emulsion - 2nd coat</td>
<td>5.50 litres paint</td>
<td>11.00 hours</td>
</tr>
</tbody>
</table>

5.3 Paint woodwork etc. per 100 square metres
### Materials Required

<table>
<thead>
<tr>
<th>Description</th>
<th>Materials Required</th>
<th>Painters' Time in Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knotting &amp; stopping woodwork</td>
<td>0.33 litres knotting &amp; 2 kg putty</td>
<td>5.00 hours</td>
</tr>
<tr>
<td>Priming woodwork</td>
<td>8.00 litres</td>
<td>20.00 hours</td>
</tr>
<tr>
<td>Painting undercoat on wood</td>
<td>9.00 litres undercoat paint</td>
<td>18.00 hours</td>
</tr>
<tr>
<td>Ditto finishing coat</td>
<td>8.00 litres finishing paint</td>
<td>17.00 hours</td>
</tr>
</tbody>
</table>

5.4 Labour unloading paint = 50 litres/hour.

6. **Painting On Ironwork**

6.1 For cast iron, allow 10% more paint for the first coat.
6.2 Metal surfaces are easier to paint than wood, thus labour constant can be reduced by 20%.
6.3 For subsequent coats, there is no difference in productivity and materials.

7. **Staining (Wood)**

7.1 For 100m² of woodwork, it requires about 8 litres of stain and about 15 hours craftsman's time.
7.2 Creosoting rough timber, allow 11 litres per 100m² and 10 hours of craftsman's time.
7.3 Wax polishing on woodwork per 100m² requires 6.25 kg proprietary wax and 30 hours craftsman's time.

8. **Painting To Surface In Narrow Widths**

8.1 The amount of material will depend on the general surfaces.
8.2 It is normally assumed that craftsman's time should be increased in relation to the width as follows:

<table>
<thead>
<tr>
<th>Width</th>
<th>Labour Constant Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not exceeding 100mm wide</td>
<td>Increase labour constant 100%</td>
</tr>
<tr>
<td>Exceeding 100mm and not exceeding 200mm wide</td>
<td></td>
</tr>
<tr>
<td>Exceeding 200mm and not exceeding 300mm wide</td>
<td></td>
</tr>
</tbody>
</table>

**ARCHITECTURAL FINISHES**

**In-Situ Finishes**

1. The pricing of paving and plastering involves 2 main items:
   a. **Preparation and mixing** of the materials which is usually carried out by unskilled or semi-skilled labour.
   b. **Application** of mixed materials to the backing or surface and the final treatment thereof which is carried out by skilled labour.
2. Water
Considerable amount of water are usually used in both the mixing and wetting of the surfaces to be covered. Water is usually priced as project overheads in the preliminaries.

3. Wood screeds
Wood battens are usually required for maintaining the thickness of surfaces, arrises, and joints between pavings. They are usually provided by the main contractor (unless when they are sub-contracted out) and priced in the preliminaries.

4. Scaffolding
Scaffolding is needed when applying finishes beyond arms-reach. They are normally supplied by the main contractor and priced in the preliminaries.

5. Decrease in bulk on mixing
The mixing of materials for finishings (cement, sand, granite chippings, plaster, etc) involves loss in volume due to consolidation, compression or shrinkage.

6. Mixing
Mixing of mortar is usually carried by hand due to small quantities placed. Output of mixing by hand is 6 hrs/m³.

7. Common types of in-situ finishings are: plain paving or bed, granolithic paving, terrazzo paving, plastering or backing.

Cement and sand plain pavings or beds
8. When pricing for screed beds, an allowance of about 10% of the materials should be made for the inequalities of sub-floor or backing surfaces.
9. Normal wastage is 10%.

10. Decrease in bulk on mixing: normal allowance is 33.33%.
11. Labour constants for plain pavings or beds:
   a. Wheeling, laying, spreading and floating time: see Table 1.
   b. Trowelling smooth: allow 0.1 hr/m² of craftsman's time.

Table 1: Labour constants for plain pavings or beds

<table>
<thead>
<tr>
<th>Description</th>
<th>1 Craftsman &amp; 1 Labourer's time</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5 mm thick</td>
<td>0.25 hr/m²</td>
</tr>
<tr>
<td>20 - 25 mm thick</td>
<td>0.29 hr/m²</td>
</tr>
<tr>
<td>40 mm thick</td>
<td>0.35 hr/m²</td>
</tr>
<tr>
<td>50 mm thick</td>
<td>0.41 hr/m²</td>
</tr>
<tr>
<td>63 mm thick</td>
<td>0.47 hr/m²</td>
</tr>
<tr>
<td>75 mm thick</td>
<td>0.52 hr/m²</td>
</tr>
<tr>
<td>Extra for laying to falls per 25mm thickness</td>
<td>0.05 hr/m²</td>
</tr>
<tr>
<td>75 mm high coved skirting with rounded top edge</td>
<td>0.50 hr/m</td>
</tr>
<tr>
<td>Description</td>
<td>Craftsman &amp; 1 Labourer's time</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>150 mm high coved skirting with rounded top edge</td>
<td>0.70 hr/m</td>
</tr>
<tr>
<td>50 x 50 mm triangular fillet</td>
<td>0.20 hr/m</td>
</tr>
</tbody>
</table>

**Granolithic paving**

12. Granite chips are sold in tonnes. A cubic metre weighs 1400 kg (1.4 ton).
13. If granolithic paving is placed directly on sub-floor, an allowance of about **10% of the materials** should be made for the inequalities of sub-floor or backing surfaces.
14. Normal wastage is 10%.
15. Decrease in bulk on mixing: normal allowance 50%.
16. Labour constants for normal granolithic pavings:
   - Hand mixing granolithic mixture: 6 hours/m³.
   - Wheeling, laying, spreading and floating time: same as plain paving and bed.
     See Table 1.
   - Trowelling smooth: allow **0.1 hr/m²** of craftsman's time.
17. Some specifications call for granolithic paving to be treated surface such as surface hardener or non-slip surface. The material and labour constants for these treated surfaces are given below:
   - Surface hardener: Allow **0.05 hour per coat** of craftsman and labourer time.
   - Non-slip surface:
     - Carborundum dust to be sprinkled onto surface of granolithic whilst "green" at a rate of **1 kg/m²**
     - **0.25 hour/m²** of craftsman's time for working into the surface using a steel trowel.

**Terrazzo paving**

18. Terrazzo materials are sold in tonnes. A cubic metre weighs 1400 kg (1.4 ton).
19. If terrazzo paving is placed directly on sub-floor, an allowance of about **10% of the materials** should be made for the inequalities of sub-floor or backing surfaces.
20. Normal wastage is 10%.
21. Decrease in bulk on mixing: normal allowance 50%.
22. Labour constants for terrazzo pavings:
   - Hand mixing terrazzo mixture: 6 hours/m³.
   - Wheeling, laying, spreading and floating time: same as plain paving and bed.
     See Table 1.
   - Trowelling smooth: allow **0.1 hr/m²** of craftsman's time.
   - Grinding and polishing after the surface becomes hard: Allow **0.5 hr/m²** of operator's time for using electrically operated grinding machine.

**Plastering**

23. **Background preparation**: Allow labourer's time of **0.25 hr/m²** for raking out joints in brickwork and **0.50 hr/m²** for hacking for key in concrete surfaces.
24. **Bonding agent**: Where bonding agent is required, the quantity will depend on the manufacturer's instructions. Allow **0.12 hr/m²** for labour.
25. **Coats:** Plaster is usually applied in a number of coats to ensure a high degree finish.

<table>
<thead>
<tr>
<th>Name</th>
<th>Allowance for inequalities of surfaces for materials</th>
<th>Labour constant: 1 craftsman and 1 labourer (hr/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st coat: rendering coat (10mm)</td>
<td>25%</td>
<td>0.25</td>
</tr>
<tr>
<td>2nd coat: floating coat (6 mm)</td>
<td>10%</td>
<td>0.25</td>
</tr>
<tr>
<td>3rd coat: finishing coat (6 mm)</td>
<td>10%</td>
<td>0.30</td>
</tr>
</tbody>
</table>

26. Unless otherwise stated, mix for plaster for whichever coat is usually 1:3 cement and sand.

27. Plastering to ceiling = increase above constants by 25%.

**Sheet, Tile, Slab and Block Finishings**
28. Examples in this category of non in-situ finishings are ceramic tiles, mosaic tiles, brick, stone, marble, granite, pre-cast concrete, pre-cast terrazzo, vinyl, cork, rubber, linoleum, carpet and wood blocks.
29. Labour unloading: 100 m²/hr.

**Tile**
30. Examples of tiling are ceramic tiles, homogenous tiles, brick tiles, glass tiles, marble and slates.
31. Tiles are usually purchased in per metre square, in units of 10, 100 or whatever quantity that fits into easily managed packed depending on individual suppliers.
32. **Size of tiles** and thickness of joint must be known in order to determine the number of tiles per metre square.
33. **Labour output:** For floor tiling, allow 1 hour craftsman and 0.5 hour labourer's time to lay one square metre of tiling. For wall tiling, increase the labour constant by 50% more.
34. **Mortar:** For both floors and walls, allow 0.015 m³/m². For mosaic tiling, allow 0.001 m³/m² cement for flushing up the joint or pointing.
35. Waste: Tiles = 5%; Mortar = 10%.

**Wood block, Linoleum and Vinyl Sheet tiles**
36. Waste = 5%
37. Other labour and material constants are given below.
<table>
<thead>
<tr>
<th>Finishing type</th>
<th>Adhesive (litre/m²)</th>
<th>Craftsman 's time (hr/m²)</th>
<th>Labourer's time (hr/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood block</td>
<td>0.055</td>
<td>1.5</td>
<td>0.75</td>
</tr>
<tr>
<td>Linoleum</td>
<td>0.027</td>
<td>0.25</td>
<td>0.125</td>
</tr>
<tr>
<td>Vinyl sheet tiles</td>
<td>0.027</td>
<td>1.00</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Fibrous Plaster, Plaster Board, Acoustic Tiles And Other Board Finishings**

38. Examples in this category include ceiling boards such as mineral fibre board, calcium silicate boards, gypsum boards, cement boards, fibrous plaster boards, plaster boards, hardboard and acoustic tiles.

39. Waste: Normal = 5%; Patterned finishings = 15%.

40. Labour output for fixing boards without patterns:
   a. For walls, 0.40 hr/m² for craftsman assisted by half of labourer's time.
   b. For ceiling, 0.50 hr/m² for craftsman assisted by half of labourer's time.
   c. For fixing cover strips or batten to face of boarding over joints, allow 0.7 m/hr.

41. When boards are fixed to pattern, the labour constant will be double the normal work.

42. Nails : 0.05kg/m².
LECTURE 21: Pro-Rata Rates

1 At final account stage, it is sometimes found that there are a number of items which vary from the original measurement and description of finished work in the bill of quantities. Those items which differ only in output or quality of materials may be related to contract rates on a pro-rata basis.

2 The price of a unit of finished work will consist of the elements of labour, materials and a markup for profit and oncosts. To obtain pro-rata rate, an illustration is given below: Assuming the rate of 20 mm thick screed is known. Find the rate of 40 mm thick screed. 40mm screed will require double the quantity of material to that of a 20mm screed. This is obtained by simple proportion. However, the labour in laying will not be doubled, as there will be less surface to work to a smooth finish per volume of material laid.

3 There are three main methods of assessing pro-rata rates and some skill is needed to decide which is appropriate to the particular work in hand.

4 By derivation
   By derivation from two or more similar unit rates. This is a simple and straightforward method of obtaining a pro-rate but it may only correctly be used in certain circumstances, and to illustrate this, two examples are quoted below:
   a. Assuming a priced bill has rates for 20mm and 40mm thickness screeds for the same mix laid to a similar specification. To find the rate of 25mm thickness (an additional 5mm over 20 mm thick) all that is needed is to add ¼ of the difference in price between 20mm and 40mm thick screed to the 20mm thickness.
   b. The following items and prices appear in a BQ priced by a contractor:
      50 x 100mm wrot kapoh rebated door frame $2.00
      50 x 125mm wrot kapoh rebated door frame $2.70
      50 x 150mm wrot kapoh rebated door frame $3.40
      From the above calculate the rates for the following:
      50 x 75mm wrot kapoh rebated door frame
      50 x 112.5mm wrot kapoh rebated door frame
      By inspection it can be seen that the rate increases by 70¢ for each increase of 25mm width of frame, also that the increase is not proportionate to the volume of timber contained in each item or to the area of surface. It is therefore reasonable to assume that the price for the other two items given should be derived from the bill figure in the same way as they were priced, viz 70¢ for each increase or decrease in 25mm width. Thus the rates become $1.30 and $2.35 respectively.

5 By analogy
   With a knowledge of pricing and building operations it is sometimes possible to discover items of different description, or even trades, which are equivalent in labour, or labour and material, to the item for which a price is sought.
By way of example, one may require a rate for joinery of a different species of timber to that given, and investigation shows that the cost of the raw material is practically the same and the degree of workability equal. In such case one may well agree with the contractor that item for item there is no variation in price.

6 By reconciliation of analysis
This is by far the most frequent method that has to be employed in preparing proper pro-rata rates. Current market costs of materials are fairly readily available and the quantity of material in a given item may be calculated, as already been shown. Rates of wages generally paid and their on-cost can also be ascertained through enquiry. Therefore the only variables in the Contract Bill rates are the labour outputs and profit and oncosts markup. A difference of a few points in the markup makes very little difference to the ultimate answer and therefore the most important factor left is the labour cost. Working on this theory it is usually practicable to break down a unit rate to arrive fairly closely at the figure included by the contractor as the labour on the item and thus apply it to another item of similar labour output.

The following method has, of course, to be varied slightly in detail to suit the circumstances to discover a material cost included in a bill rate, although generally it is the labour factor which is the uncertain factor in a bill price. It is however, of vital importance to set out the problem in logical steps and to give detailed explanations at each stage.

Components of a build-up rate are shown below.

<table>
<thead>
<tr>
<th>Material: Q x $Rm</th>
<th>$M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour: *Labour productivity (hour) x $Wage/hour</td>
<td>$L</td>
</tr>
<tr>
<td>Sub-total:</td>
<td>NET RATE</td>
</tr>
<tr>
<td>Profit and oncost markup</td>
<td>z%</td>
</tr>
<tr>
<td>Total</td>
<td>BILL RATE</td>
</tr>
</tbody>
</table>

$$\text{Net rate} + z(\text{Net Rate}) = \text{Bill Rate}$$

$$\frac{\text{Net rate}}{1 + z} = \text{Bill Rate}$$

* Unknown.

EXAMPLE: Pro-rate Rates
The Bill rate for "150mm thick concrete (1:3:6 - 38mm aggregate) floor slab" is $16.00 per m².
In dealing with variations you are required to calculate a PRO-RATA rate "150mm thick concrete (1:2:4 - 19mm aggregate) floor slab". per m²

**Step 1**
Assuming 15% profit & oncost markup

$$\text{Net Rate} \times 1.15 = \text{Bill Rate}$$

$$\text{Net Rate} = \frac{16.00}{1.15} = 13.91$$

**Step 2**
Deduct original materials cost

$
<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1m³</td>
<td>$122.67</td>
<td>122.67</td>
</tr>
<tr>
<td>Sand</td>
<td>3m³</td>
<td>$23.40</td>
<td>70.20</td>
</tr>
<tr>
<td>Aggregate</td>
<td>6m³</td>
<td>$22.40</td>
<td>134.40</td>
</tr>
<tr>
<td>Waste 10%</td>
<td></td>
<td></td>
<td>32.73</td>
</tr>
<tr>
<td>Shrinkage 50%</td>
<td></td>
<td></td>
<td>180.00</td>
</tr>
<tr>
<td>Labour cost</td>
<td></td>
<td></td>
<td>5.81</td>
</tr>
<tr>
<td>Material cost</td>
<td>150mm thick</td>
<td></td>
<td>8.10</td>
</tr>
</tbody>
</table>

**Step 3**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1m³</td>
<td>$122.67</td>
<td>122.67</td>
</tr>
<tr>
<td>Sand</td>
<td>2m³</td>
<td>$23.40</td>
<td>46.80</td>
</tr>
<tr>
<td>Aggregate</td>
<td>4m³</td>
<td>$22.40</td>
<td>89.60</td>
</tr>
<tr>
<td>Waste 10%</td>
<td></td>
<td></td>
<td>25.91</td>
</tr>
<tr>
<td>Shrinkage 50%</td>
<td></td>
<td></td>
<td>142.49</td>
</tr>
<tr>
<td>Material Cost</td>
<td></td>
<td></td>
<td>61.07</td>
</tr>
</tbody>
</table>

| Material cost for 150mm thick | 9.16 |
| Labour cost including mixing for 150mm thick | 5.81 |
| Profit and oncost markup 15% | 2.25 |
| New pro-rated rate per m² | $17.22 |