DI04006021: Estimation & Costing

Complete Lecture Deck

Slide Creator

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Meaning of Estimating

Definition

Estimating is the scientific process of calculating the quantities and predicting the probable cost of various items required for a construction work.

- Prepared by calculating quantities from drawings (plans, elevations, sections).
- Requires thorough knowledge of current market rates and specifications.
- Actual cost is known only after completion, but estimate gives a very close prediction.

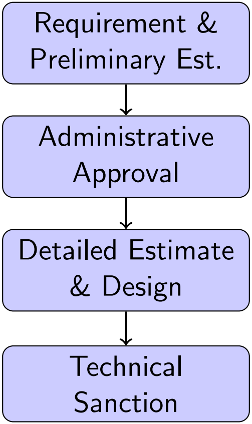
Purpose of Estimating

- **Financial Arrangement:** To know the probable cost and arrange funds.
- **Project Feasibility:** To determine if the project is economically viable.
- **Tendering:** Necessary for inviting tenders and arranging contracts.
- **Material & Labor Planning:** Helps in forecasting material and labor requirements.
- **Expenditure Control:** Acts as a baseline to monitor and control project spending.

Administrative Approval vs Technical Sanction

Administrative Approval	**Technical Sanction**
Formal acceptance by admin dept.	Sanction of detailed estimate by Engg dept.
Focuses on necessity and preliminary cost.	Focuses on structural soundness and detailed cost.
First step in project approval.	Done after administrative approval.
Based on preliminary estimate.	Based on detailed estimate.

Workflow of a Project



Broad Classification of Estimates

Main Categories

Estimates in civil engineering are primarily classified into two main types based on their accuracy and purpose:

1. Approximate (Preliminary) Estimate
2. Detailed Estimate

Other special types (Revised, Supplementary, etc.) are variations or updates of the detailed estimate.

Approximate vs Detailed Estimate

Approximate Estimate	**Detailed Estimate**
Quick and less accurate.	Highly accurate and time-consuming.
Prepared using empirical methods (Plinth area, etc.).	Prepared by calculating exact quantities from working drawings.
Used for Administrative Approval.	Used for Technical Sanction.
Required before detailed design.	Required after detailed design is finalized.

Types of Detailed Estimates

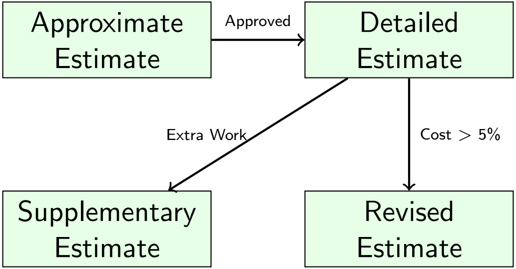
Revised Estimate: Prepared when the sanctioned estimate cost exceeds by $> 5\%$ or admin approval by $> 10\%$, due to rate changes or material deviations.

Supplementary Estimate: Prepared for additional works required during execution, which were not foreseen in the original estimate.

Repair & Maintenance: For routine upkeep (Annual Repair) or major renewals (Special Repair).

Renovation Estimate: For modernizing or upgrading an existing facility.

Estimate Lifecycle Diagram



Approximate Estimate: Definition

What is it?

An **Approximate Estimate** (or Preliminary Estimate) is a rough calculation prepared to determine the probable cost of a project quickly, without detailed drawings.

- Based on practical knowledge and cost of similar existing works.
- Evaluates feasibility without spending heavy resources on detailed engineering.
- Also known as: Budget Estimate, Rough Estimate.

Data Required for Preparation

Information Needed

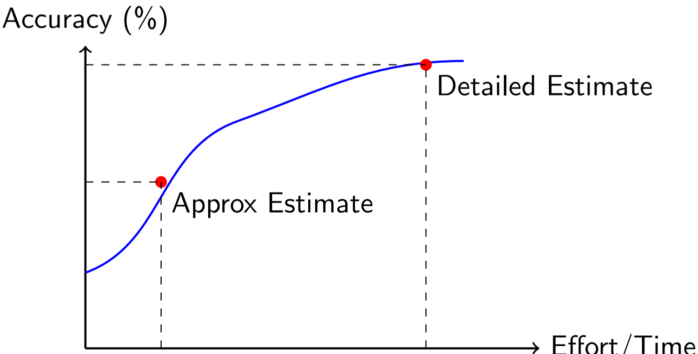
To prepare a preliminary estimate, the estimator typically needs:

1. **Line Plan:** A simple sketch or rough plan of the proposed structure.
2. **Basic Specifications:** Type of foundation, masonry, roofing, etc.
3. **Past Cost Data:** Rates from similar completed projects in the same locality.
4. **Site Conditions:** Basic topography to estimate preliminary earthwork.

Purpose of Approximate Estimate

- **Administrative Approval:** It is the primary document submitted to authorities for project go-ahead.
- **Budget Allocation:** Helps funding agencies or clients allocate the necessary budget for the financial year.
- **Feasibility Study:** Essential for evaluating the Benefit-to-Cost ratio (especially for public works).
- **Alternative Comparison:** Allows quick comparison of different proposals or sites to choose the most economical one.

Accuracy vs Effort



Plinth Area Rate Method

Formula

Approximate Cost $=$ Plinth Area $\times$ Plinth Area Rate

- **Plinth Area:** Covered built-up area measured at the floor level. Open areas (like courtyards) are excluded.
- **Plinth Area Rate:** Cost of a similar structure in the locality divided by its plinth area.
- *Example:* If a 100 m^2 house costs Rs. 20,00,000, Plinth Area Rate $=$ Rs. 20,000/m^2. For a proposed 150 m^2 house, Approx Cost $= 150 \times 20,000 =$ Rs. 30,00,000.

Cubical Content & Service Unit Methods

Cubical Content Method: Cost = Volume × Cubical Rate. Volume = Plinth Area × Height. This is more accurate for buildings with varying heights like godowns or cinema halls.

Service Unit Method: Cost is based on the functional unit of the structure.

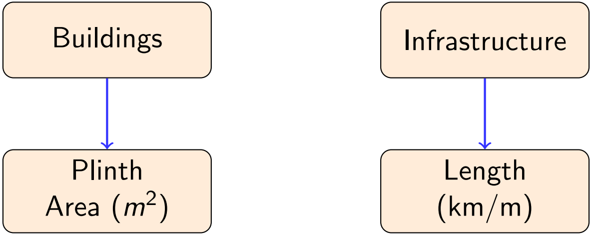
Structure	**Service Unit**
Hospital	Per Bed
School / College	Per Student / Classroom
Cinema Hall	Per Seat
Water Tank	Per Litre / Gallon

Approximate Estimates for Infrastructure

For large scale civil engineering projects, approximate costs are derived based on a characteristic length or area:

- **Roads & Highways:** Cost per Kilometer (differentiating between single lane, double lane, etc.).
- **Railways:** Cost per Kilometer of track length.
- **Bridges & Culverts:** Cost per running meter of span.
- **Irrigation Canals:** Cost per Kilometer length OR per Hectare of culturable command area.
- **Water Supply / Sewerage:** Cost per capita (per person served).

Comparison Diagram



Who is an Estimator?

Definition

An **Estimator** is a specialized civil engineer/professional responsible for calculating the quantities of materials, labor, and equipment, and predicting the total cost of a construction project.

Essential Qualities:

- **Visualization:** Ability to read 2D drawings and imagine the 3D structure.
- **Technical Knowledge:** Deep understanding of construction methodologies and sequences.
- **Market Awareness:** Up-to-date knowledge of local material, labor, and equipment rates.
- **Detail-Oriented:** High precision to avoid omissions.

Key Roles of an Estimator

1. **Quantity Take-off:** Accurately measuring dimensions from architectural and structural drawings to calculate quantities (e.g., m^3 of concrete, kg of steel).
2. **Rate Analysis:** Calculating the logical unit rate of items considering materials, labor, tools, and contractor profit.
3. **BOQ Preparation:** Drafting the Bill of Quantities which forms the basis for tendering and contracts.
4. **Valuation:** Assisting in the valuation of existing properties.

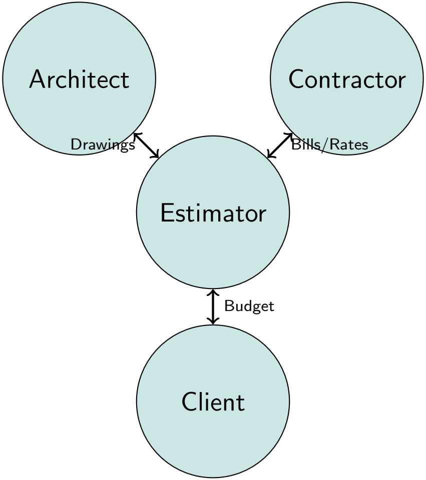
Core Responsibilities

Critical Duties

The estimator holds the financial key to the project. Mistakes can lead to huge losses.

- Ensuring strictly that no item of work is missed (e.g., forgotten excavation for minor footings).
- Strictly applying IS Code rules for measurements and deductions (e.g., deducting for windows in brickwork).
- Reviewing and verifying contractor bills during the execution phase.
- Updating estimates if design changes occur (Revised Estimates).

Estimator's Ecosystem



Checklist for Estimating (Sequence)

Estimating strictly follows the physical sequence of construction to ensure no item is missed:

1. Earthwork in excavation for foundation.
2. Plain Cement Concrete (PCC) in foundation.
3. **Load Bearing:** Brick/Stone masonry in foundation & plinth.
   Framed: RCC Footings, Columns up to plinth, Plinth beams.
4. Damp Proof Course (DPC).
5. **Load Bearing:** Brickwork in superstructure.
   Framed: RCC Columns, Beams, Slabs, followed by partition brickwork.
6. Roofing, Flooring, Doors/Windows.
7. Plastering, Pointing, Painting.

Standard Measurement Sheet

Purpose

Used to record dimensions taken from drawings and calculate the total quantity for each item of work.

Standard Format:

Item No.	Description	No.	L	B	H/D	Qty	Remarks
1	Earthwork in excavation	1	10.0m	1.0m	1.0m	10.0 m^3	Main wall

Standard Abstract Sheet

Purpose

Used to calculate the cost of each item by multiplying the total quantity (from measurement sheet) by its unit rate.

Standard Format:

Item No.	Description	Quantity	Unit	Rate	Per	Amount (Rs.)
1	Earthwork in excavation	10.0	m^3	350	m^3	3500.00

The **Face Sheet** (Top Sheet) summarizes this abstract and adds percentages for contingencies (3-5%) and work-charged establishment (1.5-2%).

Units of Measurement (IS: 1200)

The unit of measurement generally depends on the dominant dimensions and thickness:

Item of Work	**Unit**
Earthwork, Concrete, Thick Masonry	m^3 (Volume)
Plastering, Flooring, DPC, Half-brick wall	m^2 (Area)
Cornice, Skirting, Fencing wire	m (Linear)
Steel Reinforcement, Structural Steel	kg or MT (Weight)
Supply of Bricks, Electrical Points	Nos (Number)

Desired Accuracy

Precision as per IS: 1200

To maintain uniformity and avoid disputes:

- Dimensions (L, B, H) measured to nearest **0.01 m** (1 cm).
- Areas worked out to nearest **0.01** m^2.
- Volumes worked out to nearest **0.01** m^3.
- Weights worked out to nearest **1 kg**.
- Slab thickness often measured to nearest **0.005 m** (0.5 cm).

Deductions in Brick/Stone Masonry

When calculating total masonry volume, deductions must be made for openings (doors, windows, ventilators).

Exceptions (No deductions made for):

- Ends of dissimilar materials (joists, beams, lintels) up to $\mathbf{0.1}$ m^2 in section.
- Opening up to $\mathbf{0.1}$ m^2 in area.
- Wall plates, bed plates, bearing of slabs up to 10 cm depth.

Note: Lintels over openings are calculated separately in concrete, so the volume of the opening AND the volume of the lintel are deducted from the gross masonry volume.

Deductions for Plastering

Plastering rules are tricky because openings have reveals (jambs, soffits, sills) that also require plastering.

IS: 1200 Rules for Plaster Deductions

- **Area** $< 0.5\ m^2$**:** No deduction made. Jambs/soffits are not added.
- **Area** 0.5 **to** 3.0 m^2**:** Deduction made for one face only. Jambs/soffits are not added (they compensate each other).
- **Area** $> 3.0\ m^2$**:** Deduction made for both faces. Area of jambs, soffits, and sills must be calculated and added separately.

Agenda

- Definition of Specification
- Limitations of Drawings
- Purpose of Specifications
- Importance in Contracts
- Summary

Definition of Specification

What is a Specification?

A specification is a detailed description of the nature and class of work, materials to be used, and the standard of workmanship required for a project.

- It provides critical information that cannot be easily depicted on blueprints or drawings.
- It serves as a comprehensive guide for the contractor during the execution of the work.

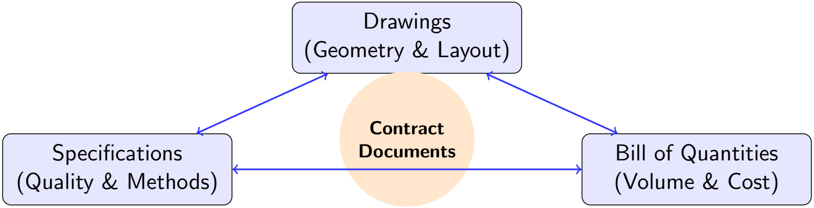
Limitations of Drawings

- **Dimensions vs. Quality:** Drawings show dimensions, layout, and sections, but cannot detail the exact quality of materials (e.g., cement grade, wood type).
- **Workmanship:** Drawings cannot describe the method of preparation, curing time, or specific workmanship standards.

Example

A drawing shows a 230 mm thick brick wall. The specification will define the class of bricks, mortar ratio (e.g., 1:6), and the curing process.

The Contract Triad



Purpose of Specifications

- **Quality Control:** Describes the exact quality and proportion of materials.
- **Workmanship Standard:** Defines the execution method and standards expected.
- **Cost Estimation:** Serves as a reliable basis for calculating the detailed cost of the project.
- **Equipment Definition:** Specifies the tools and plants to be deployed.

Importance in Contracts

Legal Significance

Specifications form an essential part of the contract document and are legally binding.

- **Precedence:** In case of a discrepancy between drawings and specifications, the specifications generally take precedence.
- **Dispute Resolution:** Detailed specifications leave no room for ambiguity, minimizing disputes between the owner and the contractor.
- **Tendering:** They enable contractors to quote accurate and competitive rates during the bidding process.

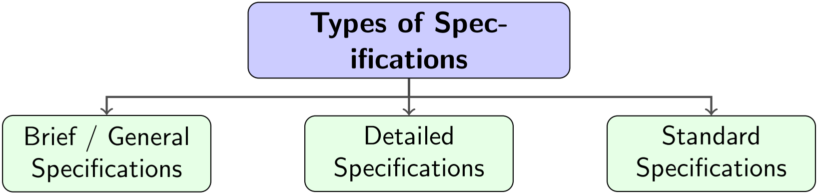
Summary

- Specifications detail the **materials, methods, and workmanship** that drawings cannot convey.
- They form one of the most critical parts of the **contract documents**.
- Clear specifications are essential for accurate **cost estimation** and effective **quality control**.

Agenda

- Classification of Specifications
- Brief (General) Specifications
- Detailed Specifications
- Standard Specifications
- Summary

Classification of Specifications



Specifications are classified based on their level of detail, legal standing, and how they are standardized.

Brief (General) Specifications

Definition

A short description giving the general nature and class of the work and materials in broad terms.

- **Usage:** Primarily used for preparing preliminary estimates and obtaining administrative approval.
- **Legal Status:** Does *not* form part of the legal contract document.
- **Example:** "Foundation shall be of 1:4:8 cement concrete." (Does not specify curing, mixing method, etc.)

Detailed Specifications

Definition

A comprehensive and exhaustive description of every aspect of an item of work.

- **Usage:** Used for executing the work, preparing detailed estimates, and as a guide for the contractor.
- **Legal Status:** Forms an integral part of the contract document. It is legally binding.
- **Precedence:** In case of any contradiction between drawings and specifications, detailed specifications govern.

Standard Specifications

- **Standardization:** Prepared and printed by major government engineering departments like PWD, CPWD, or Railways.
- **Efficiency:** They save time and effort as they do not need to be rewritten for every single project.
- **Uniformity:** Ensure a uniform standard of work across various projects in a state or country.

Special Specifications

When a particular item is not covered by the Standard Specifications, an additional "Special Specification" is drafted and appended to the tender document.

Summary: Brief vs Detailed

Aspect	Brief Specifications	Detailed Specifications
Detail Level	General and superficial	In-depth and exhaustive
Purpose	Preliminary estimate	Detailed estimate & Execution
Legal Validity	Not part of contract	Legally binding

Agenda

- Introduction to Specification Writing
- Key Principles
- Clarity and Precision
- Essential Elements
- Fairness & Practicality
- Summary

Key Principles of Specification Writing

The Goal

To provide clear, unambiguous instructions that ensure the desired quality while remaining fair and practically achievable.

- **Accuracy:** Specifications should exactly describe the requirements without contradictions.
- **Simplicity:** Language should be simple enough for the site supervisor and contractor to understand easily.
- **Completeness:** No necessary information should be omitted.

Clarity and Precision

Vague words lead to disputes and poor quality work. Avoid words like *suitable*, *reasonable*, *good*, or *as directed by the engineer*.

Bad vs. Good Specification

Bad: "Bricks should be of good quality and well burnt."

Good: "Bricks shall be First Class, machine-molded, sound, hard, well-burnt, with a minimum crushing strength of 10.5 N/mm^2 and water absorption not exceeding 15%."

Essential Elements of a Specification

1. General Description
Nature and class of work

2. Materials
Properties, proportions, and tests

3. Workmanship
Preparation, execution, curing

4. Mode of Measurement
Units of payment and deduction rules

Fairness & Practicality

- **Realistic Tolerances:** Do not specify an impossible degree of perfection. Allowable tolerances must be clearly stated.
- **Mutual Fairness:** Specifications should not be entirely one-sided. They should protect the owner's interest without unfairly burdening the contractor.
- **Economic Consideration:** High standards mean high costs. Specifications should match the project's budget and importance.
- **Standardization:** Use references to IS Codes (Indian Standards) wherever possible (e.g., "Cement shall conform to IS: 269").

Summary

- A good specification is the backbone of a successful civil engineering contract.
- It must be **clear, precise, and unambiguous**.
- Every specification must systematically address the **materials, workmanship, and measurement**.
- Avoid vague terminology to minimize legal disputes.

Agenda

- Earthwork in Excavation
- Plain Cement Concrete (PCC)
- First Class Brickwork
- Plastering Work
- Summary

1. Earthwork in Excavation (Foundation)

- **Clearance:** The site shall be cleared of all trees, roots, and rubbish before excavation.
- **Dimensions:** Excavation shall be strictly as per the trench widths and depths specified in the foundation plan.
- **Shoring:** Timbering and shoring shall be provided in loose soil to prevent collapse.
- **Dewatering:** If water is met with, it shall be pumped out at the contractor's expense.
- **Measurement:** Measured in **Cubic Meters (m^3)**.

2. Plain Cement Concrete (PCC) 1:4:8

Component	Specification
Materials	Cement (IS:269), coarse river sand, and 40mm graded broken stone aggregate.
Mixing	Machine mixed. If hand-mixed, done on a watertight platform with 10% extra cement.
Laying	Laid in layers not exceeding 150mm, rammed until mortar creams to the surface.
Curing	Kept continuously wet for at least 7 to 10 days.

3. First Class Brickwork in Cement Mortar (1:6)

Materials & Preparation

Bricks must be First Class, machine-molded, well-burnt, and ringing sound. Bricks must be soaked in clean water for at least 2 hours before laying.

- **Laying:** Laid in **English Bond**. All courses shall be perfectly horizontal and walls strictly plumb.
- **Joints:** Mortar joints shall not exceed 10mm in thickness.
- **Curing:** Masonry shall be kept wet for a minimum of 10 days.
- **Measurement:** Measured in **Cubic Meters (m^3)** (Half brick walls in m^2).

4. Plastering (12mm thick in 1:4)

- **Surface Preparation:** Masonry joints shall be raked out to a depth of 10mm while the mortar is still green. Surface washed and thoroughly wetted.
- **Application:** Mortar (1 cement : 4 sand) applied forcefully and leveled using wooden floats.
- **Finish:** Finished perfectly true and smooth. Thickness shall strictly not be less than 12mm.
- **Curing:** Cured by sprinkling water for at least 7 days.

Measurement

Measured in **Square Meters (m^2)**. Deductions made for openings (doors/windows) as per IS: 1200 rules.

Summary

- Detailed specifications serve as the ultimate instruction manual for construction.
- **Earthwork, PCC, Brickwork, and Plastering** are core items with stringent quality criteria defined by PWD.
- Proper adherence ensures **structural integrity, durability, and fair payment** based on precise measurement modes.

What is a Detailed Estimate?

Definition

A detailed estimate is an accurate estimate prepared by working out the quantities of each item of work separately and then multiplying them by their respective rates.

- It is the most reliable and accurate type of estimate.
- Prepared in two stages:
  1. Taking out quantities (Measurement).
  2. Abstracting (Valuation).

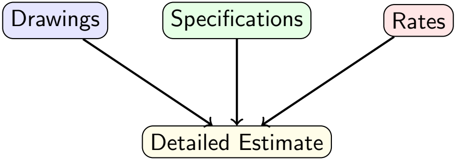
Purpose of Detailed Estimate

- To obtain **Technical Sanction** of the project.
- To arrange for funds or budget provisions.
- To invite tenders and arrange contracts.
- To check the actual execution cost against the estimated cost.
- To control the expenditure during construction.

Data Required for Detailed Estimate

Essential Data

- **Drawings:** Detailed plans, elevations, and sections with complete dimensions.
- **Specifications:** General (brief) and Detailed specifications indicating the nature, quality, and class of work.
- **Rates:** Current Schedule of Rates (SOR) or derived rate analysis.



Components of Total Cost

Civil Cost

The direct cost of all items of work evaluated by taking out quantities and multiplying by rates.

- **GST (Goods and Services Tax):** Typically applied at 18% (or as per current govt norms) on the civil cost of construction.
- Various other percentage charges are added to the civil cost to arrive at the total project cost.

Contingencies & Supervision Charges

- **Contingencies (3% to 5%):**
  - Incidental expenses of miscellaneous character which cannot be classified under any distinct item.
- **Work Charged Establishment (1.5% to 2%):**
  - Temporary establishment (supervisors, watchmen, etc.) employed specifically for the execution of the work.
- **Supervision / Departmental Charges (10% to 15%):**
  - Added when a work is executed by a department (like PWD) for another department to cover the cost of planning, designing, and supervision.

Summary Table of Charges

Type of Charge	Typical Percentage
Contingencies	3% to 5%
Work Charged Establishment	1.5% to 2%
Water Supply & Electrification	8% each
Departmental Charges	10% to 15%
Contractor's Profit	10%

Table: Standard percentage provisions

Step 1: Taking out Quantities

- The dimensions (Length, Breadth, Depth/Height) are taken from the drawings.
- Entered into a standard **Measurement Sheet** or **Details of Measurement Form**.
- Quantities are calculated by multiplying numbers, length, breadth, and depth.

Format of Measurement Sheet

Item No.	Description	No.	L (m)	B (m)	D/H (m)	Quantity	Remarks
1	Earthwork in excav.	1	10.0	1.0	1.0	10.0 m^3	

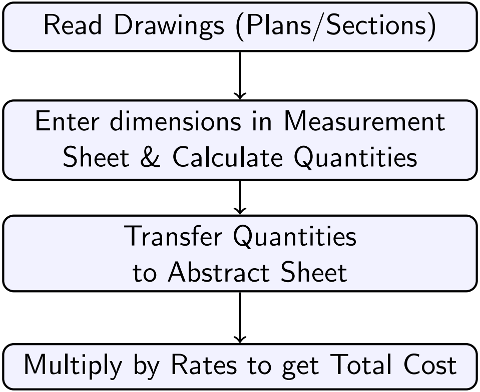
Step 2: Abstracting

- The total quantities of each item are transferred to an **Abstract Sheet**.
- These quantities are multiplied by their respective unit rates to get the cost of each item.
- A percentage for contingencies and work-charged establishment is added at the end.

Format of Abstract Sheet

Item No.	Description	Quantity	Unit	Rate (Rs)	Per	Amount (Rs)
1	Earthwork in excav.	10.0	m^3	350	m^3	3500

Process Flowchart



Introduction to Methods

Depending upon the level of detail and stage of the project, quantities and costs can be calculated using two main methods:

1. **Unit Quantity Method**
2. **Total Quantity Method**

Core Difference

Unit Quantity Method focuses on finding the all-inclusive rate of a composite unit of a structure, whereas Total Quantity Method separates each item of work and prices them individually.

Unit Quantity Method

- The structure is divided into composite units (e.g., one km of road, one running meter of boundary wall, one bay of a factory shed).
- The total cost of one such complete unit is worked out by detailed estimation.
- The total cost of the project = (Cost of 1 unit) $\times$ (Total number of units).

Example

Cost of 1 km of a standard 2-lane highway is calculated as Rs 5 Crores.
For a 20 km stretch, Cost $= 20 \times 5 = 100$ Crores.

Total Quantity Method

- The entire work is broken down into individual items of work (excavation, concrete, brickwork, plaster).
- Total quantity of each item for the whole project is calculated.
- Each total quantity is multiplied by its unit rate to find the total cost.
- **Application:** Used for almost all detailed building estimates.

Item 1 qty	Item 2 qty	Item 3 qty

Sum of Individual Costs = Total Cost

Numerical Problem 1

Problem Statement

Estimate the cost of a compound wall of length 500 m. The detailed cost analysis for 1 running meter of this wall is:

- Excavation: Rs 200
- Foundation Concrete: Rs 500
- Brickwork: Rs 1500
- Plastering & Painting: Rs 300

Solution:

Cost per running meter $= 200 + 500 + 1500 + 300 =$ Rs 2500
Total Length $= 500$ m
Total Cost $= 500 \times 2500 =$ Rs $12, 50, 000$.

Numerical Problem 2

Problem Statement

A canal is to be constructed for 10 km. The cost of earthwork, lining, and finishing for 1 km is estimated at Rs 20 Lakhs. Additional bridges cost Rs 5 Lakhs per km on average. Calculate the total cost.

Solution:

Unit cost per km = Cost of canal works + Cost of bridges
Unit cost per km = 20 Lakhs + 5 Lakhs = 25 Lakhs / km.
Total Length = 10 km.
Total Estimated Cost = 10×25 = 250 Lakhs = Rs 2.5 Crores.

Advantages and Limitations

Advantages	**Limitations**
Very fast once unit cost is known.	Assumes uniformity throughout the project.
Useful for linear projects like roads, railways, pipelines.	Not suitable for complex, asymmetrical buildings.
Easy to explain to laypersons.	Topography variations make it inaccurate.

Numerical Problem 1

Problem Statement

Calculate the total cost of a room $4m \times 3m$ (internal) with wall thickness 0.3m. Height of wall is 3m. Rates: Brickwork = Rs $4000/m^3$, Plastering = Rs $200/m^2$.

Solution:

Total perimeter of wall (centre line) =
$2 \times [(4 + 0.3) + (3 + 0.3)] = 2 \times [4.3 + 3.3] = 15.2$ m.

1. Brickwork Quantity:

$V = L \times B \times H = 15.2 \times 0.3 \times 3 = 13.68m^3$.

Cost of Brickwork $= 13.68 \times 4000 =$ Rs $54,720$.

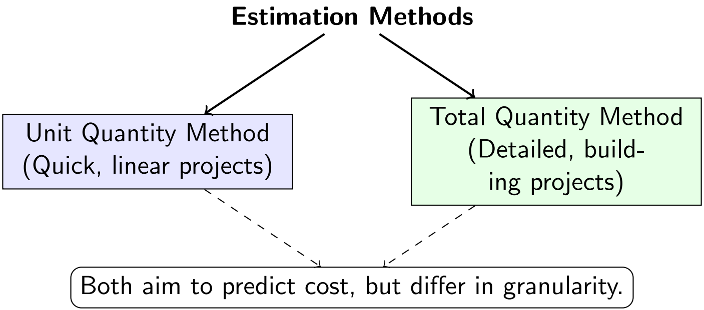
Numerical Problem 1 (Contd.)

2. Plastering Quantity (Inside + Outside):
Inside perimeter $= 2 \times (4 + 3) = 14$ m.
Outside perimeter $= 2 \times (4.6 + 3.6) = 16.4$ m.
Total length for plaster $= 14 + 16.4 = 30.4$ m.
Area of Plaster $= L \times H = 30.4 \times 3 = 91.2 m^2$.
Cost of Plastering $= 91.2 \times 200 =$ Rs $18,240$.

Total Cost

Total Cost = Cost of Brickwork + Cost of Plaster
$= 54,720 + 18,240 =$ Rs $72,960$.

Comparison Diagram



Introduction to the Method

- Also known as the **Out-to-Out and In-to-In method** or the **Separate Wall method**.
- Typically, walls running in the longitudinal direction are termed **Long Walls**.
- Walls running in the transverse direction are termed **Short Walls**.

Basic Principle

Measure the external (out-to-out) length of the long walls and the internal (in-to-in) length of the short walls.

Formulas for Calculation

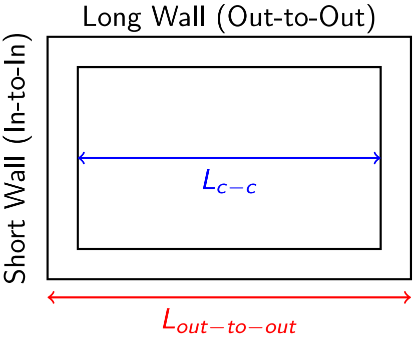
To find lengths at any construction level (like earthwork, concrete, brickwork):

- **Length of Long Wall (Out-to-Out)**
  $L =$ Centre-to-Centre length $+$ Width of item at that level
- **Length of Short Wall (In-to-In)**
  $L =$ Centre-to-Centre length $-$ Width of item at that level

Important Note

The length of a long wall *decreases* as we move from foundation to superstructure, whereas the length of a short wall *increases*.

Schematic Diagram



Introduction to Centre Line Method

- The total length of the centre line of all walls, long and short, is calculated.
- This total length is multiplied by the breadth and depth of the respective item to get the total quantity at once.
- **Advantage:** Very quick method for estimating.

Total Quantity

$Q =$ Total Centre Line Length $\times$ Width $\times$ Depth

Handling Junctions

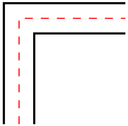
When walls intersect, there is an overlap in the centre line measurement which must be deducted.

- **L-Junction (Corner):** No deduction required.
- **T-Junction (Partition wall):** Deduct $\frac{1}{2} \times$ width of the item for each T-junction.
- **Cross-Junction (+ intersection):** Deduct $1 \times$ width of the item for each cross-junction.

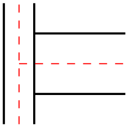
Modified Length

Net Centre Line Length $=$ Total C.L. - (No. of T-junctions $\times \frac{w}{2}$) - (No. of Cross-junctions $\times w$)

Diagram of Junctions



L-Junction (0)



T-Junction ($\frac{w}{2}$)

Comparison of Methods

Long Wall & Short Wall	Centre Line Method
Accurate and highly reliable.	Quick and less tedious.
Calculations change at every footing step.	Length remains constant, only deductions vary.
No junction deductions needed.	Requires careful deduction at T and Cross junctions.
Preferred for unsymmetrical layouts.	Preferred for symmetrical, continuous walls.

Numerical Problem

Problem

A room of internal size $4m \times 3m$ has wall thickness 0.3m. Find earthwork in excavation if trench width is 0.9m.

By Centre Line Method:

Total C.L. $= 2 \times (4.3 + 3.3) = 15.2$ m.

No T-junctions (it's a simple room).

Excavation Qty $= L \times W \times D = 15.2 \times 0.9 \times D$.

Numerical Problem (Contd.)

By Long Wall & Short Wall Method:
Long wall C-C $= 4.3$ m.
Short wall C-C $= 3.3$ m.
L.W. (Out-to-out) $= 4.3 + 0.9 = 5.2$ m.
S.W. (In-to-in) $= 3.3 - 0.9 = 2.4$ m.
Total length for excavation $=$
$2 \times (5.2) + 2 \times (2.4) = 10.4 + 4.8 = 15.2$ m.

Conclusion

Both methods yield the same total equivalent length (15.2 m) and hence the same quantity!

What is Bar Bending Schedule?

- A tabular statement containing all details of reinforcement bars.
- Includes shape, diameter, length, number of bars, and total weight.

Standard Hook and Bend Allowances

- 45° bend: add $1d$
- 90° bend: add $2d$
- 135° bend (hook): add $3d$
- 180° standard hook length: $9d$ (Total hook addition $=$ $9d \times 2 = 18d$ for both ends)

where d = diameter of the bar.

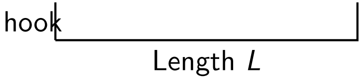
BBS Format

Bar Mark	Shape	Dia (mm)	No.	Length (m)	Total L (m)	Wt/m	Total Wt (kg)
1	[shape]	12	10	1.5	15.0	0.89	13.35

Unit Weight of Steel $= \frac{D^2}{162}$ kg/m (where D is in mm).

BBS for Footing

- Footing reinforcement generally consists of a mesh (grid) of straight bars with U-hooks at ends.
- **Cutting Length** = Total dimension - (2 $\times$ clear cover) + (2 $\times$ hook length).



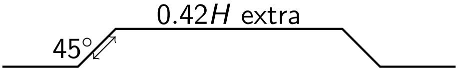
Reinforcement in Beams

Beams usually have:

1. **Main Straight Bars:** At the bottom.
2. **Bent-up (Crank) Bars:** Bent near supports to resist shear.
3. **Anchor / Top Bars:** To hold stirrups.
4. **Stirrups:** Shear reinforcement.

Cutting Length of Bent-up Bar

- A bar bent at 45° increases in length by $0.42H$, where H is the depth between top and bottom reinforcement.
- **Total Length** = Clear Span + 2(Bearing) - 2(Cover) + 2(Hooks) + (No. of cranks $\times 0.42H$).



Cutting Length of Stirrups

- For a rectangular beam of size $B \times D$, let a and b be the inner dimensions of the stirrup.
- $a = B - 2(\text{cover})$
- $b = D - 2(\text{cover})$
- **Cutting Length** $=$ $2(a + b) + \text{Hook length (approx. } 24d \text{ for two } 135^\circ \text{ hooks)} - \text{Bend deductions.}$

Reinforcement in Slabs

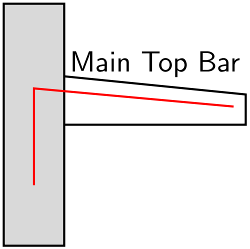
- **One-way Slab:** Main reinforcement is placed along the shorter span. Distribution steel is along the longer span.
- **Two-way Slab:** Main reinforcement is provided in both directions.

Alternate Cranking

Main bars are often cranked alternately near the supports. Number of bars $= \left(\frac{\text{Span}}{\text{Spacing}}\right) + 1$.

BBS for Chajja (Sunshade)

- Chajjas act as cantilever slabs.
- The main reinforcement is provided at the **top** to resist negative bending moment.
- Distribution bars are provided in the transverse direction.



Summary of BBS

- Accurate calculation of H (depth for crank) is vital.
  $H = \text{Slab Thickness} - 2(\text{Cover}) - \text{Bar dia.}$
- Distribution bars are straight bars without cranks.
- After calculating all lengths, they are categorized by diameter.
- Total weight is calculated using $\frac{D^2}{162}$ formula to order steel in kg or tonnes.

Contingencies

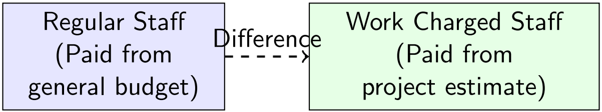
Definition

Incidental expenses of a miscellaneous character which cannot be classified under any distinct item of work but are likely to occur during execution.

- Generally, a provision of **3% to 5%** of the estimated cost is made.
- Used for minor unexpected items (e.g., pumping out rainwater from trenches, minor design adjustments).
- Does not require a supplementary estimate unless the expense exceeds the allotted percentage.

Work Charged Establishment

- Refers to the temporary establishment employed for the specific execution and supervision of a project.
- Includes staff like **supervisors, watchmen, clerks, mates**, etc., whose salaries are charged directly to the specific work.
- Usually, **1.5% to 2%** of the estimated cost is provided.
- Their employment ends when the work is completed.



Centage Charges (Departmental Charges)

- When an engineering department (like PWD) takes up work for other departments (like Health, Education) or local bodies.
- A charge of **10% to 15%** is levied to cover the cost of planning, designing, and supervision by the PWD staff.
- It is added to the total estimate as a percentage.

Tools and Plants (T&P)

For ordinary works, tools and plants are generally brought by the contractor. For specialized departmental work, **1% to 1.5%** may be provided.

Contractor's Profit

- Generally, **10%** is considered as contractor's profit in rate analysis and detailed estimates.
- For small works where the contractor has to invest time for a small return, profit margin might be taken as 15%.
- It is applied on the cost of materials and labour.

Provision	**Percentage**
Centage Charges	10% - 15%
Contractor's Profit	10%
Tools & Plants	1% - 1.5%

Table: Summary of Percentages

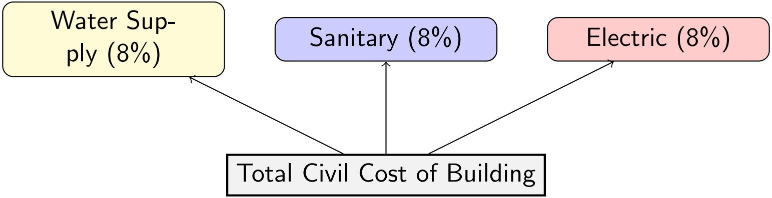
Water Supply & Sanitary Charges

For building projects, detailed estimating of plumbing is complex at the initial stage. Instead, a lump sum percentage is added:

- **Water Supply:** Generally **8%** of the building cost is added.
- **Sanitary & Drainage:** Generally **8%** of the building cost is added.
- Often, these two are combined and taken as **15%** of the civil cost.

Electrification Charges

- Includes internal wiring, switches, distribution boards, and fixtures.
- A provision of **8%** of the building cost is normally made.
- For buildings with specialized needs (like air-conditioning or heavy machinery), this percentage is increased or a separate detailed estimate is prepared.



Prime Cost

Definition

Prime Cost (P.C.) is the actual net cost of materials to be supplied or specialized work to be executed by a nominated sub-contractor.

- It does not include the main contractor's profit or attendance costs.
- Used for items where the client wants to choose the exact specification later (e.g., designer tiles, expensive door fittings).
- The contractor is paid the actual cost plus an agreed percentage for profit and handling.

Provisional Sum & Quantities

- **Provisional Sum:** A sum provided in the BOQ for work that cannot be entirely foreseen or detailed at the time of tendering. It is spent only upon the instruction of the engineer/architect.
- **Provisional Quantities:** Quantities included for items whose exact quantum is uncertain (e.g., extra excavation for weak soil). They are subject to remeasurement.

Prime Cost	Provisional Sum
For specific items/materials.	For unforeseen works.
Client decides the supplier.	Engineer directs the work.
Contractor gets handling fee.	Daywork or negotiated rates apply.

What is a BOQ?

- A document used in tendering containing an itemized list of materials, parts, and labor (with their costs) required to construct a project.
- Prepared by the cost consultant / estimator based on the completed drawings and specifications.

Purpose of BOQ

- Standardizes the tender process (all contractors price the exact same quantities).
- Forms the basis for valuation of work during construction (interim bills).

Format of BOQ

Item No.	Description of Work	Quantity	Unit	Rate (Rs)	Amount (Rs)
1	PCC 1:4:8 in foundation	50.0	m^3	[To be quoted]	[Calculated]
2	First class brickwork	120.0	m^3	[To be quoted]	[Calculated]

- The unpriced BOQ is given to contractors.
- The contractor fills in the 'Rate' and 'Amount' columns.
- The sum of the amount column is the Total Bid Price.

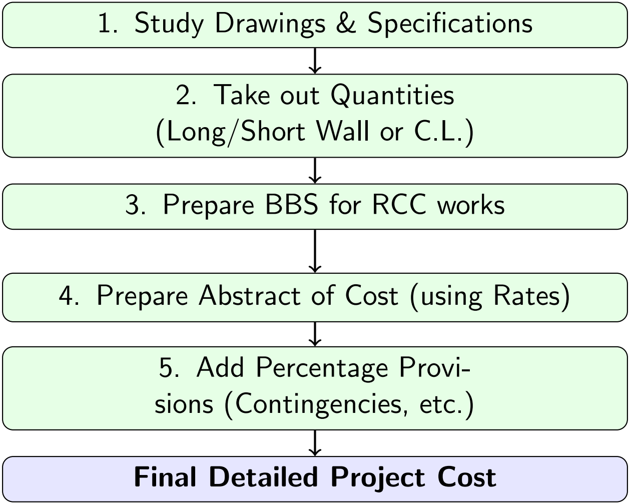
Spot Items or Site Items

- Certain items of work are very difficult to measure accurately or define in standard units (e.g., dismantling a complex structure, clearing dense bushes, tricky repairs).
- These are termed as **Spot Items** or **Site Items**.
- They are generally estimated on a **Lump Sum (L.S.)** basis by visiting the site ("on the spot").

Daywork

For works that cannot be priced by standard measurement, contractors are paid based on the actual time spent by workers and actual materials used, known as **Daywork**.

Summary of Detailed Estimate (Unit 3)



DI04006021: Estimation & Costing

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Agenda

- 1. Introduction to Earthwork
- 2. Cross Section of Embankment
- 3. Mid Sectional Area Method
- 4. Mean Sectional Area Method
- 5. Summary

Introduction to Earthwork

Earthwork calculation is essential for estimating the cost of roads, railways, and canals.

The earthwork is typically classified into two types: **cutting** and **banking (embankment)**.

Key terminology:

- **Formation Width (B):** Top width of embankment or bottom width of cutting.
- **Side Slope (S:1):** Ratio of horizontal to vertical slope.
- **Depth/Height (d):** Vertical distance from ground level to formation level.

Mid Sectional Area Method

In this method, the mean depth (d_m) is calculated first from depths d_1 and d_2 at the ends.

Formulae

Mean Depth, $d_m = \frac{d_1+d_2}{2}$
Area of mid-section, $A_m = B \cdot d_m + S \cdot d_m^2$
Volume, $V = A_m \times L$

Where L is the length of the section.
This method assumes the profile between the two sections is a straight line.

Mean Sectional Area Method

Here, the areas of the two end sections are calculated first, and then their mean is taken.

Calculation Steps

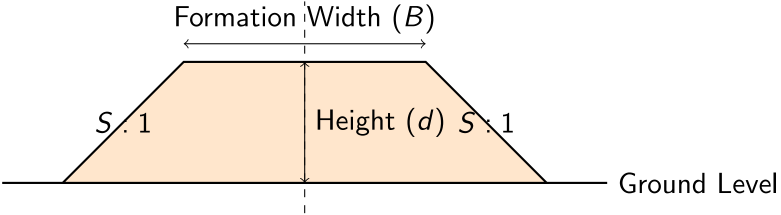
1. Calculate Area at section 1: $A_1 = B \cdot d_1 + S \cdot d_1^2$
2. Calculate Area at section 2: $A_2 = B \cdot d_2 + S \cdot d_2^2$
3. Mean Area, $A_{mean} = \frac{A_1 + A_2}{2}$
4. Volume, $V = A_{mean} \times L$

Generally, Mean Sectional Area method gives a slightly larger volume compared to Mid Sectional Area method.

Summary

Earthwork involves cutting and banking.
Mid Sectional Area uses average depth.
Mean Sectional Area uses average of end areas.
Next class: Prismoidal and Trapezoidal rules.

Cross Section of Embankment



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Agenda

- 1. Introduction to Volume Calculation Rules
- 2. Trapezoidal Formula
- 3. Prismoidal Formula
- 4. Comparison
- 5. Summary

Trapezoidal Rule (Average End Area Method)

The Trapezoidal rule assumes that the volume is made up of a series of trapezoidal prisms.

Formula

$$V = \frac{D}{2}[(A_1 + A_n) + 2(A_2 + A_3 + \cdots + A_{n-1})]$$

Where:

- $D =$ distance between sections
- $A_1, A_2, \ldots, A_n =$ cross-sectional areas

It tends to slightly overestimate the actual volume.

Prismoidal Formula

The Prismoidal formula is more accurate and assumes the shape is a prismoid.

Condition: This rule is strictly applicable only when there is an **odd number** of cross-sections (i.e., n is odd).

Formula

$$V = \frac{D}{3}[(A_1 + A_n) + 4(A_2 + A_4 + \dots) + 2(A_3 + A_5 + \dots)]$$

In words: $V = \frac{D}{3}[(\text{First} + \text{Last}) + 4(\Sigma\text{Even}) + 2(\Sigma\text{Odd})]$

Comparison Table

Feature	Trapezoidal Rule	Prismoidal Rule
Accuracy	Approximate (overestimates)	Highly Accurate
No. of Sections	Any number	Must be Odd
Shape Assumption	Straight lines between sections	Parabolic curve between sections

Summary

Trapezoidal rule is simpler but less accurate.
Prismoidal rule requires an odd number of sections but provides true volume.
Next: Application to Canals and Lead/Lift.

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Agenda

- 1. Canal Cross Sections
- 2. Fully in Cutting / Banking
- 3. Partial Cutting and Banking
- 4. Lead and Lift
- 5. Summary

Canal Cross Sections

Unlike roads, canals carry water and therefore their cross-section design is critical for flow and preventing seepage.
Canals can be constructed in three main ways depending on ground level (GL) and full supply level (FSL):

- **Fully in Cutting:** GL is above the top of the canal banks.
- **Fully in Banking:** GL is below the bed level of the canal.
- **Partially in Cutting and Banking:** GL is between bed level and top bank level.

Lead and Lift Concepts

Earthwork rates depend significantly on how far and how high the excavated earth must be moved.

Definitions

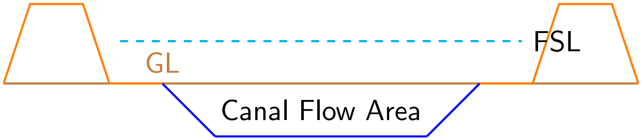
Lead: The horizontal distance from the center of the borrow pit (excavation) to the center of the spoil bank (disposal/embankment). Standard lead is usually 30m.
Lift: The vertical distance from the center of gravity of the excavated earth to the center of gravity of the placed earth. Standard lift is usually 1.5m.

Extra payment is required for lead or lift exceeding standard values.

Summary

Canals have specific cross-section requirements.
Balancing cutting and banking is economical.
Lead and Lift determine the transportation cost of earthwork.

Canal in Partial Cutting and Banking



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Agenda

- 1. Introduction to Septic Tanks
- 2. IS Specifications
- 3. Components of a Septic Tank
- 4. Earthwork and PCC Estimation
- 5. Summary

Introduction to Septic Tanks

A septic tank is an underground chamber made of concrete, fiberglass, or plastic through which domestic wastewater flows for basic treatment.

- Settling and anaerobic processes reduce solids and organics.
- Effluent usually discharges to a soak pit or dispersion trench.
- Dimensions depend on the number of users (capacity).

Indian Standard (IS) Specifications

Important design criteria for estimation (IS 2470):

- **Length to Width Ratio:** Usually 2 to 3 times the width.
- **Liquid Depth:** Minimum 1.0 m to 1.3 m.
- **Freeboard:** Minimum 300 mm above top liquid level.
- **Thickness of walls:** Minimum 20 cm for brick masonry.

Knowing these dimensions is crucial for accurately calculating excavation and material volumes.

Summary

Septic tanks rely on anaerobic digestion.
Standard dimensions dictate the estimation parameters.
Next class: Detailed calculation of brickwork and slabs.

Earthwork and PCC in Septic Tank

Estimation Logic

- **Earthwork in Excavation:**
  $L_{exc} = L_{inner} + 2 \times (\text{Wall Thickness}) + 2 \times (\text{PCC projection})$
  $W_{exc} = W_{inner} + 2 \times (\text{Wall Thickness}) + 2 \times (\text{PCC projection})$
  $\text{Volume} = L_{exc} \times W_{exc} \times \text{Depth from GL}$
- **PCC Base:**
  Normally 1:4:8 or 1:3:6 mix.
  $\text{Volume} = L_{exc} \times W_{exc} \times \text{Thickness of PCC (usually 15-20cm)}$

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Agenda

- 1. Brickwork Calculation
- 2. Baffle Wall
- 3. Plastering & Waterproofing
- 4. RCC Cover Slab
- 5. Summary

We use the Long Wall - Short Wall method or Center Line method.

Long Wall & Short Wall Method

Long Wall Length: $L_{inner} + 2imes(1/2extwallthickness)$
Short Wall Length: $W_{inner} - 2imes(1/2extwallthickness)$
Wait, correction: Length of Long wall out-to-out $=$ $L_{in} + 2imesextthickness$.
Length of Short wall in-to-in $= W_{in}$.

Volume $=$ Length $\times$ Width $\times$ Height.

Plastering and RCC Cover Slab

Plastering:

- Inside plastering (typically 12mm thick, 1:3 cement mortar) with water-proofing compound is mandatory to prevent seepage.
- Bottom floor (PCC or RCC) is also finished with a neat cement punning.

RCC Cover Slab:

- Placed over the walls. Volume = Outer Length $\times$ Outer Width $\times$ Thickness.
- Needs deductions for manhole covers/openings.

Abstract of Quantities Table

Item No	Description	Qty	Unit
1	Earthwork in excavation	15.5	cum
2	PCC 1:4:8 in foundation	1.2	cum
3	Brick Masonry in CM 1:4	4.5	cum
4	12mm plaster with water-proofing	22.0	sqm
5	RCC 1:2:4 in cover slab	0.8	cum

Summary

Calculated quantities for brickwork using long wall/short wall.
Accounted for specialized items like waterproof plastering.
Deductions are necessary for openings in the RCC slab.

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Agenda

- 1. Components of a Well
- 2. Earthwork and Sinking
- 3. Brick Steining
- 4. Platform and Parapet
- 5. Summary

Components of a Community Well

A traditional open community well consists of several key structural parts:

- **Well Curb:** An RCC or timber ring with a cutting edge at the bottom.
- **Steining:** The cylindrical brick or stone masonry wall forming the body of the well.
- **Parapet Wall:** Masonry built above ground level for safety.
- **Platform:** Concrete or paved area around the well for users and drainage.

Earthwork and Sinking

Estimation for well excavation is unique because it involves **sinking**.

Sinking Process

The curb is laid at a shallow excavated depth. Steining is built over it. Earth is excavated from inside the curb, causing the entire structure to sink under its own weight.

Measurement: Excavation (sinking) is paid per cubic meter, but rates increase for different depth slabs (e.g., 0-3m, 3-6m) and for different strata (dry soil, wet soil, rock).

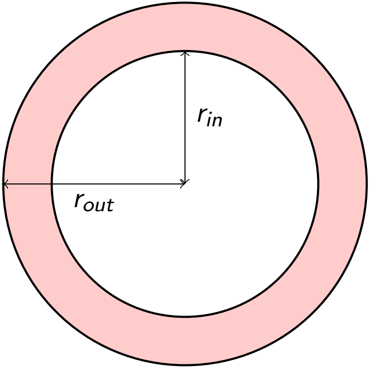
Summary

Community wells involve specific structural elements like the curb and steining.

Excavation is specialized (sinking) and rates vary by depth and soil type.

Next: Use of computers in estimation.

Brick Steining Calculation



Plan View of Steining

Volume of Steining:
$V = \pi(r_{out}^2 - r_{in}^2) \times \text{Height}$

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Agenda

- 1. Need for Computer-Aided Estimation
- 2. Advantages
- 3. Spreadsheet Software (Excel)
- 4. Digital Measurement Book (MB)
- 5. Summary

Need for Computer-Aided Estimation

Manual estimation involves extensive repetitive calculations, which are prone to human error.

Advantages of Software:

- **Speed:** Rapid recalculation if dimensions or rates change.
- **Accuracy:** Eliminates arithmetic errors.
- **Standardization:** Consistent formats for tenders and contracts.
- **Database linkage:** Connect directly to standard Schedule of Rates (SOR).

Spreadsheet Software (Excel)

MS Excel is the most fundamental and widely used tool for estimation.

Excel Functionality

Formulas are used to multiply L, B, and D/H. `=PRODUCT(D2:F2)`
Abstract sheets link dynamically to measurement sheets. If a quantity changes, the total cost updates automatically.

Provides flexibility to design custom templates.

Digital Measurement Book Template

S.No.	Description	No.	L	B	D	Qty	Total Qty
1	Earthwork in Foundation						
	Long walls	2	10.6	0.9	1.0	19.08	
	Short walls	3	4.2	0.9	1.0	11.34	
						Total	**30.42 cum**

Summary

Computers drastically reduce time and errors in estimation.
Excel is the backbone tool for standard measurement entries.
Next: Specialized 3D and 5D estimating software.

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Agenda

- 1. Specialized Estimation Software
- 2. On-Screen Takeoff
- 3. BIM and 5D Estimation
- 4. Workflow of Digital Estimation
- 5. Summary

Specialized Estimation Software

Beyond Excel, specialized software manages complex projects, integrating estimating, planning, and accounting.

- **PlanSwift / Bluebeam:** Excellent for 2D on-screen takeoff. Allows estimators to click and drag over PDF drawings to calculate areas and perimeters instantly.
- **Candy (CCS):** Industry standard for detailed resource-based estimating, rate analysis, and project control.
- **CostX:** Supports both 2D and 3D takeoff.

BIM and 5D Estimation

Building Information Modeling (BIM) goes beyond 3D geometries.

5D BIM

3D: Spatial Geometry (X, Y, Z)
4D: Time (Scheduling, MS Project/Primavera)
5D: Cost (Estimation)

In 5D BIM, every 3D object in the model (e.g., a wall) contains data about its material and cost. If the architect lengthens the wall in the software, the total project cost updates **automatically**.

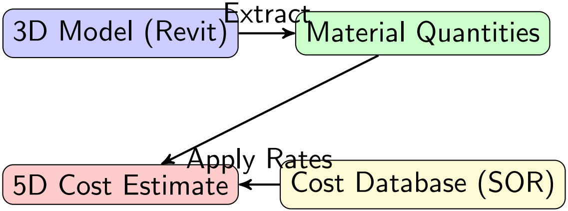
Summary

Specialized software like PlanSwift and Candy streamline complex estimating.

5D BIM links the 3D model directly to time and cost.

This brings high efficiency, accuracy, and agility to civil engineering works.

Workflow of 5D BIM Estimation



Definition of Rate Analysis

What is Rate Analysis?

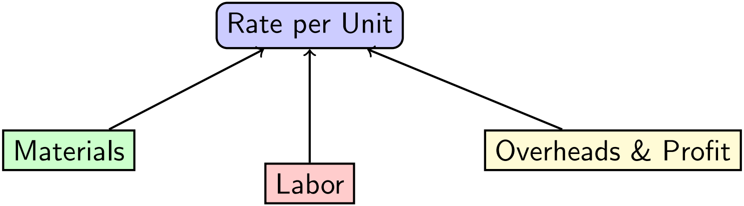
It is the process of determining the rate per unit of a particular item of work, such as cubic meter of concrete or square meter of brickwork.

- Considers cost of **materials**.
- Considers cost of **labor**.
- Includes **machinery/tools** and plant charges.
- Includes **water charges** (usually 1%).
- Includes **contractor's profit** (usually 10%).

Purpose and Importance

- To determine the actual cost per unit of item.
- To examine the viability of rates offered by contractors.
- To calculate the cost of **extra items** which are not provided in the contract bond.
- To revise the schedule of rates due to increase in the cost of material and labor or change in technique.

Components of Rate Analysis



Factors Affecting Rate Analysis

Key Factors

- **Specifications of works:** Strict specifications require higher quality materials and skilled labor, increasing costs.
- **Location of site:** Remote areas increase transportation costs (lead) for materials and labor.
- **Quantity of materials:** Bulk purchases often yield discounts.
- **Availability of water:** If water is scarce, its arrangement adds to the cost.

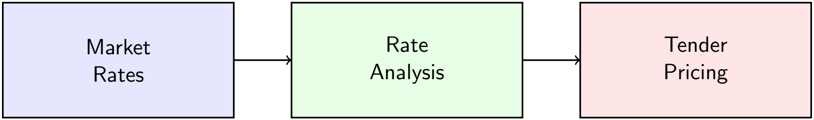
Market Fluctuations

Dynamic Pricing

The rates of materials and labor are not static. They fluctuate based on:

- Inflation and economic conditions.
- Supply and demand in the local market.
- Changes in minimum wage laws.
- Seasonal variations (e.g., monsoon affects brick prices).

Impact on Tendering



Rate analysis provides the baseline for contractors to quote competitive and realistic prices during tendering.

Lead and Lift

Definitions

- **Lead:** The horizontal distance for transport of earth or materials from the source to the site of work. Standard lead is generally 30 m.
- **Lift:** The vertical distance through which excavated soil or materials are lifted. Standard lift is generally 1.5 m.

Extra lead and lift charges are added to the rate if the actual distances exceed the standard values.

Overhead Charges

Overhead charges are indirect costs not directly attributable to a specific item of work.

- **General Overheads:** Establishment, office rent, stationery, telephone, travel (approx. 2.5% to 5%).
- **Job Overheads:** Supervision, amenities for labor, temporary structures, safety measures at a specific site.

Water Charges and Contractor's Profit

Component	Standard Percentage
Water Charges	1% to 1.5% of total cost
Contractor's Profit	10% of total cost

Table: Standard Additions in Rate Analysis

Note: Contractor's profit is calculated on the total cost of materials and labor (including lead and lift).

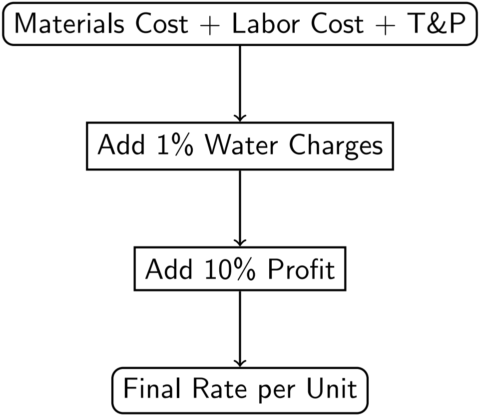
Procedure for Rate Analysis: Steps 1-3

- **Step 1: Determine the Unit and Quantity**
  Decide the unit of measurement (e.g., $10m^3$ for earthwork or $1m^3$ for RCC). Choose a suitable standard quantity for calculation.
- **Step 2: Material Cost**
  Calculate the exact quantities of various materials required. Multiply by current market rates (including transport/lead).
- **Step 3: Labor Cost**
  Determine the number and categories of labor (Masons, Mazdoors, etc.) required based on standard 'Task Work'. Multiply by their daily wages.

Procedure for Rate Analysis: Steps 4-6

- **Step 4: Tools & Plants (T&P)**
  Add a lumpsum or percentage (usually 1% to 2% of labor cost) for minor tools and plants.
- **Step 5: Water Charges**
  Add 1% or 1.5% on the total cost of materials and labor for water required for construction and drinking.
- **Step 6: Contractor's Profit**
  Add 10% on the total cost (Materials + Labor + T&P + Water) as contractor's profit. Divide the grand total by the standard quantity to get the rate per unit.

Flowchart of Rate Analysis



Definition of Task Work

Task Work (Out-turn Work)

The capacity of doing work by an artisan or skilled labor in the form of quantity of work per day (usually an 8-hour shift) is known as task work or out-turn work.

Importance:

- Helps in determining the number of labors required for a specific job.
- Forms the basis for calculating the labor cost in rate analysis.
- Useful in project scheduling and resource allocation.

Factors Affecting Task Work

The out-turn of work varies depending on:

- Nature and size of the work.
- Skill and experience of the labor.
- Working conditions and weather.
- Proximity to tools and materials.
- Degree of supervision.

Standard Task Work of Skilled Labor

Item of Work	Laborer	Out-turn/Day
Excavation in ordinary soil	Mazdoor	$3.00\,m^3$
Brickwork in cement mortar	Mason	$1.25\,m^3$
Plastering (12mm thick)	Mason	$8.00\,m^2$
Painting (one coat)	Painter	$30.00\,m^2$

Table: Typical Out-turn (Task Work) Values

Categories of Labor

Construction work requires various categories of skilled and unskilled labor:

- **Head Mason / Mistry:** Supervises the work of masons.
- **Mason:** Skilled in brickwork, plastering, concrete work.
- **Carpenter:** Skilled in formwork and woodwork.
- **Blacksmith:** Skilled in reinforcement bending and cutting.
- **Mazdoor (Beldar):** Unskilled labor for digging, carrying, mixing.
- **Bhisti:** Labor responsible for curing and supplying water.

Daily Wages

Minimum Wages Act

Daily wages are governed by the Minimum Wages Act and vary by region and state. Wages are periodically revised to adjust for inflation.

- Skilled laborers (Masons, Carpenters) command higher wages.
- Unskilled laborers (Mazdoors) have standard base wages.
- Overtime or hazardous work may require premium wages.

Labor Requirement for Different Items

Example: For $10\mathrm{m}^3$ of Brickwork in Superstructure

Labor Category	**Number Required**
Head Mason (Mistry)	0.5 (Half day)
Mason	10
Mazdoor	10
Bhisti	2

Table: Labor Requirement for $10\mathrm{m}^3$ Brickwork

Transportation Charges of Materials

Transportation constitutes a major part of the cost of heavy materials like aggregates, sand, and bricks.

- **Modes:** Trucks, tractors, or head load for short distances.
- **Calculation Base:** Usually calculated per Ton-km or per cubic meter per km.
- **Loading/Unloading:** Charges for loading and unloading must be included in the transport cost.

Rate = (Base Cost of Material at Source) + (Transportation Cost)

Hire Charges of Machineries

Modern construction relies heavily on machinery.

Types of Charges

- **Per Day / Per Hour:** Hire charges are usually fixed per 8-hour shift.
- **Inclusions:** Hire charges generally include fuel, lubricants, and operator wages (Dry hire vs. Wet hire).
- **Mobilization/Demobilization:** Cost of transporting the machinery to the site and back.

Machinery Examples

Excavator (Earthwork)	Concrete Mixer (Concreting)	Vibrator (Compaction)

Adding machinery reduces labor cost and speeds up work, but increases capital outlay. The balance is found through careful rate analysis.

Item: Earthwork in excavation in foundation ($10\mathbf{m}^3$)

- **Materials:** None required.
- **Labor:** Task work is 3m^3 per Mazdoor per day.
- **Labor needed:** For 10m^3, $10/3 = 3.33 \approx 3.5$ Mazdoors. Add 0.5 Beldar for dressing.
- **Cost:** Calculate
  (4 laborers $\times$ Daily Wage) $+$ T&P $+$ Water $+$ Profit.

Rate Analysis: Concrete Work (PCC 1:4:8)

Item: PCC 1:4:8 in foundation ($10m^3$)

- **Dry Volume:** $10m^3$ wet concrete requires approx. $15.2m^3$ dry volume.
- **Cement:** $(1/13) \times 15.2 = 1.17m^3 \approx 34$ bags.
- **Sand (Fine Aggr.):** $(4/13) \times 15.2 = 4.68m^3$.
- **Coarse Aggr.:** $(8/13) \times 15.2 = 9.35m^3$.
- **Labor:** Mason (1.5), Mazdoor (10), Bhisti (2).

Sustainable alternative: Replace a portion of cement with Fly Ash or use Recycled Aggregates.

Item: Brickwork in CM 1:6 in superstructure ($10m^3$)

Component	**Quantity for $10m^3$**
Bricks (Standard size)	5000 Nos
Dry Mortar Volume	$\approx 3.0m^3$
Cement (1:6)	$(1/7) \times 3.0 = 0.43m^3 \approx 13$ bags
Sand (1:6)	$(6/7) \times 3.0 = 2.57m^3$
Scaffolding	Lumpsum
Labor	Mason (10), Mazdoor (10), Bhisti (2)