CHAPTER 04

Construction Management

A. TENDERING AND CONSTRUCTION CONTRACT

4.1 Introduction

- A construction project is an endeavor or a venture taken up by a project team on behalf of an owner or client to build a facility as per the owner or clients requirements.
- From inception to completion, the project goes through various stages.
- Each stage involves definite inputs, processes and deliverable.
- Typically, the life cycle of a project from inception to completion has the following stages:
  - **Project appraisal:** Inception, feasibility and strategic planning.
  - **Project development:** Project planning and design finalization of proposals, procurement method, construction documents along with tender drawings, fabrication drawing, cost estimate, BOQ etc.
  - **Construction planning:** Sequencing of project components, resource planning, time-cost-trade off etc.
  - **Tendering:** Competitive bidding, pre-qualification of agencies, issue of tender documents, bids evaluation, negotiation and award of work.
  - **Construction:** Execution, monitoring, control and acceptance of work.
  - **Commissioning and handing over:** Contract closure, financial closure, defect liability commencement, handing over etc.
- It is always required to get the project done within the specified time limit.
- Project management is essential to provide the necessary directions, coordinating the various activities involved and coordinating the responsibilities of the various stake holders of the project.
- **IS 15883 (Part 2) : 2013** lays down the various construction project guidelines.

4.2 Types of Construction Projects

Construction projects are classified into various categories which are as given below:

1. **On the basis of type of work,** construction projects are classified as:
   (a) Building project
   (b) Infrastructure projects
   (c) Industrial project
   (d) Other projects

2. **On the basis of project completion time,** construction projects are classified as:
   (a) Long duration projects (with duration exceeding 5 years)
   (b) Medium duration projects (with project duration 3 to 5 years)
   (c) Short duration projects (with project duration 1 to 3 years)
   (d) Special short term projects (with project duration less than 1 year)

3. **On the basis of project value,** construction projects are classified as:
   (a) Mega value projects
   (b) Large value projects
   (c) Medium value projects
   (d) Small value projects

4. **On the basis of pace of execution,** construction projects are classified as:
   (a) Fast track projects
   (b) Normal pace projects

4.3 Tenders and Contracts

Tender: Tender is an offer in writing to execute some specified work at certain rates, within a fixed time under some agreement.

Whenever work has to be executed, tenders (i.e., offers) are invited through NIT (Notice Inviting Tender).

Contract: A contract is an agreement between the two parties to undertake a work. This agreement is enforceable by law. Thus any agreement between the two parties that is enforceable by law is called contract.

NOTE: All contracts are agreements but all agreements are not contracts.

Offer: A proposal to perform an act or to pay an amount for that is called as **offer**.

Acceptance: It is the assent to the person to whom offer is made. A proposal when accepted becomes a promise.

The party who makes the offer is called as **promisor** and the party who accepts the offer is called as **promisee**.

Essential conditions of contracts: There are, in general four essential conditions viz.:

(a) **Competent parties:** The parties entering into the contract must be competent i.e., they must not be minor, they must not be of unsound mind and they must not be disqualified by law.

(b) **Free consent:** The parties entering into the agreement must give free consent i.e., consent is not due to coercion, fraud, mistake, misrepresentation or under influence.

(c) **Lawful subject matter:** The agreement is for a lawful consideration i.e., consideration must not be forbidden by law, must not be fraudulent and must not oppose the public policy.

(d) **Not declared void:** The agreement may satisfy all the conditions of a valid contract and must not have been expressly declared void by the law in force.

(e) **Proper and valid consideration:** It is defined as the promise to do something by a party in return of some money or other interest.

4.4 Types of Tender

In general, there are three types of tender viz.:

(a) **Open tender** wherein the tender is open for everyone and any one can take part in the tendering process.

(b) **Limited tender** where the offer of tender is sent to limited parties and is not open for all.

(c) **Single tender** where the tender enquiry is sent only to one party. This type of tender is generally used for certain specialized items of work for which there are very limited firms available.

4.5 Types of Contracts

Contracts in general can be classified as:

(a) **Item rate contract** wherein the contractor is required to quote his/her rate against each item of work as given in the schedule of items.

(b) **Percentage rate contract** wherein the contractor is required to quote his/her percentage above or below the estimated value of work.

(c) **Lump sum contract** where contractor is required is quote his/her lump sum rate to undertake the work. This is generally used for petty works of small values.

B. RATE ANALYSIS AND STANDARD SPECIFICATIONS

4.6 Purposes of Rate Analysis

The main purposes of rate analysis are as follows:

(i) To determine the current rate per unit of an item of work at the locality.

(ii) To examine the viability of rates quoted by contractors

(iii) To ascertain the quantity of materials and labour strength required to complete the project.

(iv) To revise the schedule of rates due to increase in the cost of materials and labour or due to changed situations.

4.7 Requirement for Rate Analysis

Following are the main requirements for rate analysis:

(i) quantity of material and their cost.

(ii) No. of different types of labours to be engaged and their cost.

(iii) Cost of equipment or tools and plants (T&P)

(iv) Cost of water charge (if required)

(v) Contractor's profit

(vI) Overhead cost

Overhead Costs

Overhead charges may be divided under two catagories.

A. General overhead

B. Job overhead

A. General Overhead

All the expenses related to the contractor's office and establishment are termed as general overhead which is a recurring expenditure and does not depend upon the volume of the work under execution. The general overhead consists;

(i) Salaries of office staff (establishment cost).

(ii) Purchase of stationery articles, printings, postage, etc.

(iii) Office rent.

(iv) Telephone and electric bills.

(v) Travelling expenses etc.

B. Job Overhead

The expenses are directly related to construct a job or project such

(i) Supervision cost (Technical and non-technical)

(ii) Temporary sheds for material and godown rents.

(iii) Handling charges of materials

(iv) Repair, carriage and depreciation of T&P.

(v) Amenities of labour.

(vi) Workman's compensation, insurance etc.

(vii) Interest on investment

(viii) Losses/Theft.

Factors Affecting Rate Analysis

The followings factors affect the rate of a particular item of work:

(i) Specifications of works and materials, quality of materials, proportion of mix, method of constructional operation etc.

(ii) Quantities of materials and their rates.

(iii) Number of different types of labour and their rates.

(iv) Location of site of work and its distance from the sources of materials and rates of transport.

(v) Availability of water.

(vi) Miscellaneous and overhead expenses of contractor.

(vii) Site conditions and site organisations.

Procedure of Rate Analysis

The analysis of rate is done for unit quantity of an item of work. Details various materials and labour are worked out and added together to get the total cost of materials and labour. This will also include miscellaneous and T&P cost. To this 1½ % of it is added for water charge (only in those items which require water in any way). 10% contractor's profit is also added. The summation all these costs is known as rate of unit quantity of an item.

Mathematically

Let cost of materials for unit item $= x$

Let cost of labourres, T&P and sundries $= y$

Cost of material and labour $= (x + y)$

Add $1\frac{1}{2}\%$ for water charge $= \frac{15}{100}(x+y)$

Add 10% for contractors profit $= \frac{10}{100}(x+y)$

$$\text{Total cost} = (x+y)\left(1+\frac{15}{100}+\frac{10}{100}\right)$$

Rate for unit of the item $= 1.115\,(x + y)$

Therefore, the following information are imperative to arrive at the rate for unit of the item:

(a) Out-turn or Task

(b) Estimation of labour

(c) Materials for different items of work

(d) Current rate of materials

(e) Current rate of labour of different categories

4.6.2 Specification

- During the preparation of estimate, it may be possible to give the detailed specification for one or more items of work.
- The owner or the department specifies such items and contractor acquires them from the market.
- The payment for these items is made on the basis of prime cost.
- In India, mostly CPWD specifications are followed for construction projects. However there may be department's own specifications also.

C. ESTIMATING AND COSTING

4.8 Estimation

Estimation requires a thorough knowledge of construction procedure, cost of materials, labour, in addition to the skill, experience, foresight etc.

Estimation is not an exact science. Knowledge of construction, detailed plan, working capacity and efficiency is required for good and apt estimate.

It consist of two tasks:

- Determining probable cost
- Determining probable time

4.8.1 Cost Estimate

Cost estimate = Quantity of items required to complete the project × Unit cost of the item.

Need for Estimating and costing:

1. Estimate gives an idea of the cost of the work, idea of time required.
2. Estimate is required to invite the tenders.
3. It is also required to control the expenditure, and decides whether the proposed plan matches the funds available or not.

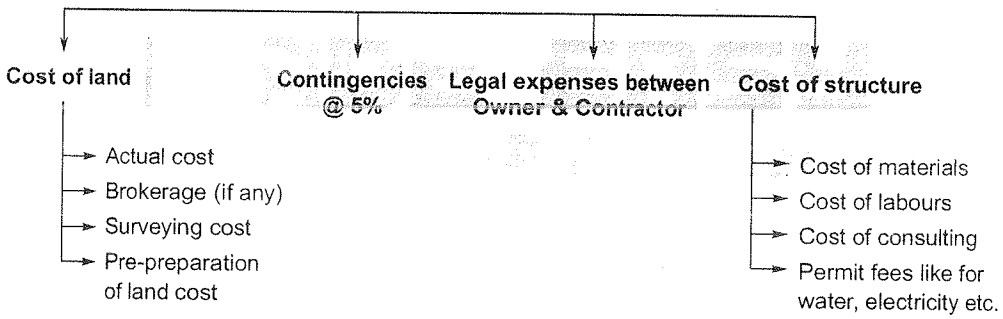
Procedure of Estimating and Costing:

1. Preparing detailed estimate.
2. Calculating the rate of each unit of work.
3. Preparing abstract of estimate.

Data Required:

1. Drawing i.e., plans, elevation, sections.
2. Previously executed similar project(s).
3. Scale of present project, locations, availability of funds and resources.
4. Specifications, rates of each unit of work.

Complete Estimate:



Estimator (Quantity Surveyor)

An estimator is expected to work more closely with all project participants to predict a more accurate estimate. We must be able to for see and details of project, quantity of materials, and prevailing market rates etc.

- Thorough understanding of drawings, specifications, class of work and materials.

Site conditions affecting the overall cost:

- Choice of construction technique viz. machinery, type of formwork etc.
- Quality and productivity of labours.

- Weather condition, ground conditions etc.
- Availability of good quality materials, machinery etc.

Construction Project Cost

Project cost = Direct cost + Indirect cost (overhead cost)

Direct Cost (DC): The cost and expenses that are incurred for a specific activity are termed as direct cost. (material, labour, equipment, cost of subcontractor).

The costs that are spent on a specific activity can also be classified as:

1. Time related cost: Cost spent or incurred along the activity duration.
2. Quantity proportion cost: Cost spent or incurred in proportion to the quantities consumed.
3. Fixed cost: Cost that are often incurred once at a specific point of time.

Indirect Cost (IDC):

Site overhead: It is site related cost like establishment of offices at site, housing for project staff, store and first aid. It also includes the cost of items that are not directly related to a specific work package.

Generally site overhead is estimated as 5-15% of total direct cost.

General overhead: These are the cost that cannot be linked to a specific project but are used to support the overall company activities.

Ex. Salaries of lawyers, directors etc.

Generally, general overhead cost can be estimated as 2-5% of direct cost

4.8.2 Types of Cost Estimates

Table 4.1: Types of cost estimates

Types of Estimates	Level of Details	Expected % Errors	Units of Measurement
1. Conceptual cost estimate	0-30% of construction documents are available.	±10-20%	Cost/unit
2. Semi-detailed estimate	30-80% of construction documents are available.	±5-10%	Assembly cost
3. Detailed cost estimate	80-100% of design drawings and specification are available.	±2-4%	Quantity take off.

(i) Conceptual cost estimate: It is also known as rough estimate, preliminary estimate, feasibility estimate, analogy estimate. It is generally considered as basis for all the cost estimate.

Features of conceptual cost estimate:

- Absence of exact or detailed data as well as shortage of time.
- It is primarily a fusion of art and science of estimation.

Required documents:

- Complete cost analysis of previous similar structure(s).
- Detailed project scope and preliminary specification for proposed project.

Example of cost estimate: Estimation of a school building.

Suppose a school building for 400 students capacity is to be constructed.

Conceptual cost estimate: Unit cost i.e., cost/student will be calculated using previous project data and Total cost = Unit cost × Number of students

Semi-detailed estimate: Estimate for rooms and labs etc. will be calculated.

Detailed estimate: Estimate in accordance with detailed drawings and specifications will be prepared.

Types of method of conceptual estimation:

1. Unit cost method — discussed.
2. Factor method
3. Simulations — Advance methodology.

A. Unit Cost Method

Unit cost is generally prepared using previous projects data, hence it is necessary that estimator should have cost per unit for previously same type of completed project.

$$\text{Unit cost} = \frac{A + 4B + C}{6}$$

Also called as weighted unit cost.

A= Minimum unit cost of previous project

B = Average unit cost of previous project

C = Maximum unit cost of previous project

Example 4.1 Use the weighted unit cost to determine the conceptual cost estimate for a proposed project of parking lot that is expected to contain 135 parked cars. Previous data of similar project is given.

Project No.	Cost (Rs.)	No. of Carb	Unit cost (Rs./Unit)
1.	4,66,580	150	3110.53
2.	2,90,304	80	3628.81
3.	5,25,096	120	4375.8
4.	3,49,920	90	3888.0
5.	2,90,290	60	4321.5
6.	6,57,206	220	2987.3
7.	2,91,718	70	4167.4
8.	7,11,414	180	3952.0

Solution:

$$\text{Forecast weighted unit cost} = \frac{A + 4B + C}{6}$$

$$A = \text{Rs. } 2987.3$$

$$B = \frac{3110.53 + 3628.81 + 4375.8 + 3888 + 4321.5 + 2987.3 + 4167.4 + 3952}{8} = \text{Rs. } 3803.9$$

$$C = \text{Rs. } 4375.8$$

$$UC = \frac{4378.8 + 4 \times 3803.9 + 2987.3}{6}$$

$$UC = \text{Rs. } 3763.1$$

$$\text{Project cost} = UC \times \text{No. of units}$$

$$= 3763.1 \times 135 = \text{Rs. } 508025$$

(a) **Adjustment of time:** The adjustment between two projects represents the relative inflation and deflation of cost, material rate, interest rate.

$$\text{Adjustment cost} = \left(\frac{\text{Cost index for current year}}{\text{Cost index for year of construction}}\right) \times \text{Cost of previous project}$$

(b) **Adjustment of location:** Tender prices vary according to the region of the country where the work is to be carried out. Similarly use of cost information from previous project to forecast the cost of a proposed project will not be reliable unless an adjustment is made proportional to represent the difference in cost between locations of two projects.

Construction cost of project @ city A.

$$= \left(\frac{\text{Cost index for city A}}{\text{Cost index of previous project city}}\right) \times \text{Cost of previous project}$$

(c) **Adjustment of size:** Adjustment should also be made for difference in the size of two projects. The adjustment is simple ratio of the size of the proposed project to size of similar project for which cost data is available.

(d) **Combined adjustment:**

Proposed cost = Previous cost × Time adjustment × Location adjustment × Size adjustment

Example 4.2 Use time and location indices given is the table to prepare the conceptual cost estimate of a building with 62700 m^2 of floor area and location is city B. A similar type of building that cost Rs. 21,97,540 of area 38500 m^2 completed 2 years ago in city E. Estimate the probable cost of proposed buildings.

Year construction	Cost (million)	Cost index
3 years ago	358	For city
2 years ago	359	B = 1.24
1 year ago	362	E = 1.17
Current year	378	

Solution:

We need to extrapolate to find rate of inflation and thus cost at city E three years from now.

$$\frac{\text{Current cost}}{\text{Cost three years ago}} = (1 + i)^3 \qquad i = \text{rate of inflation}$$

$$i = 1.83\%$$

2 years from current

$$\frac{\text{Cost after 2 years}}{\text{Current cost}} = (1 + i)^2$$

Cost after two years = 391.95 million

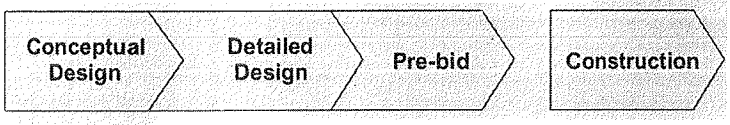
Proposed cost = Previous cost × Time adjustment × Location adjustment × Size adjustment

$$= 2197540 \times \frac{391.95}{378} \times \frac{1.24}{1.17} \times \frac{62700}{38500}$$

= Rs. 3932948.80

4.7.3 Detailed Estimate

It can be owner's estimate, engineer's estimate or contractor's estimate. Detailed estimate is prepared at the end of design phase.



Owner's Estiamte: It is a rough estimate made at conceptual state to make investment decision.

Engineer's Estimate: It is done to determine the expected cost of the project, used to form contract bid document for bidding purpose. It is also used to evaluate the various design alternatives and to look for methodology and construction.

Contractor's Estimate: It can determine more accurate value and can also be used to calculate actual cost of the project.

4.8 Measurement of Materials and Works

4.8.1 Units of Measurements

The units of measurements are mainly categorized for their nature, shape and size and for making payments to the contractor. The principle of units of measurements normally consists the followings:

(a) Single units work like doors, windows, trusses etc., are expressed in numbers.

(b) Works consisting of linear measurements involve lengths like cornice, fencing, hand rail, bands of specified width etc., and are expressed in running metres (RM).

(c) Works consisingof areal surface measurements involve areas like plastering, white washing, partitions of specified thickness etc., are expressed in square meters (m^2)

(d) Works consisting of cubical contents which involve volumes like earth work, cement concrete, masonry etc., are expressed in cubic metres.

Table 4.2: based on IS 1200 (Revised)

Sl.No.	Particulas of Item	Units of measurement	Units of payment
I.	**Earth work:**		
	1. Earth work in excavation	cum	per cum
	2. Earth work in filling in foundation trenches	cum	per cum
	3. Earth work in filling in plinth	cum	per cum
II.	**Concrete:**		
	1. Lime concrete in foundation	cum	per cum
	2. Cement concrete in Lintels	cum	per cum
	3. RCC in slab	cum	per cum
	4. CC or RCC Chujja, Sunshade	cum	per cum
	5. LC in roof terracing (thickness specified)	sqm	per cum
	6. Cement concrete bed	cum	per cum
	7. RC Sunshade (Specified width and Height)	cum	per running meter
III.	**Damp Proof Cource (DPC)** (Thickness should be mentioned)		
IV.	**Brick works:**		
	1. Brick work in foundation	cum	per cum
	2. Brick work in plinth	cum	per cum
	3. Brick work in super structure	cum	per cum
	4. Thin partition walls	cum	per cum
	5. Brick work in arches	cum	per cum
	6. Reinforced brick work (RB work)	cum	per cum
V.	**Sone work:**		
	Stone masonry	cum	per cum
VI.	**Wood work:**		
	1. Door sand windows frames or chowkhats, rafters beam	cum	per cum
	2. Shutters of doors and windows (thickness specified)	sqm	per sqm
	3. Doors and windows fittings (like hinges, tower bolts sliding bolts, handles)	number	per number
VII.	**Steel work:**		
	1. Steel reinforcement bars etc., in RCC and RB work quintal.	Quintal	per quintal
	2. Bending, binding of steel reinforcement.	Quintal	per quintal
	3. Rivets, bolts & nuts, anchor bolts, lewis bolts, holding down bolts.	Quintal	per quintal
	4. Iron hold fasts	Quintal	per quintal
	5. Iron railing (height and types specified)	Quintal	per quinter
	6. Iron grills	sqm	per sqm
VIII.	**Roofing:**		
	1. RCC and RB slab roof (excluding steel)	cum	per cum
	2. LC roof over and inclusive of tiles or brick or stone slab etc. (thickness specified)	sqm	per sqm
	3. Centering and shuttering form work.	sqm	per sqm
	4. AC sheet roofing.	sqm	per sqm
IX.	**Plastering, points & finishing:**		
	1. Plastering Cement or Lime Mortar (thickness and proportion specified)	sqm	per sqm
	2. Pointing	sqm	per sqm
	3. White washing, colour washing, cement was (number of coats specified).	sqm	per sqm
	4. Distempering (number of coats specified).	sqm	per sqm
	5. Painting, vernishing (number of coats specified).	sqm	per sqm

X.	**Flooring:** 1. 25 mm cement concrete over 75 mm lime concrete floor (including LC). 2. 25 mm or 40 mm CC floor. 3. Doors and window sills (CC or cement mortar plain).	 sqm sqm sqm	 per sqm per sqm per sqm
XI.	**Rain water pipe/Plain pipe**	1 RM	per 1 RM
XII.	**Steel wooden trusses**	number	per 1 No.
XIII.	**Glass pannels (supply)**	sqm	per sqm
XIV.	**Fixing of glass panels or clearning**	number	per No.

Abstract of Estimate form

Table 4.3: A typical estimate form

Item No.	Description or particular	Quantity	Unit	Rate	Amount
1.	Earth work		cum		
2.	Concrete		cum		
3.	DPC		sqm		
4.	Brick work/stone work		cum		
5.	Stone work on wall		sqm		
6.	Wood work		number		
	Chowkhat door and windows				
7.	Steel work		quintal		
8.	Roofing		sqm		
9.	Plastering pointing and finishing		sqm		
10.	Flooring		sqm		
11.	Piping		meter		

Methods of Estimation

Method-I: Separate or individual wall method:

In this method the long walls are measured out-to-out and internal or cross walls in-to-in.

To calculate the quantities, length so obtained is multiplied by breadth and the height of wall.

For long wall

Long wall length out-to-out

= centre to centre length + half breadth on one side + half breadth on other side

=centre to centre length + one breadth

For short wall

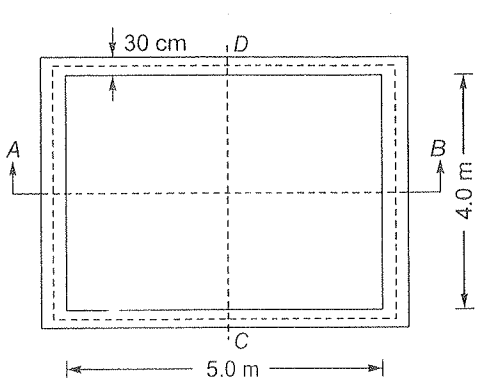
Short wall length in-to-in = centre to centre length – one breadth

It is applicable for symmetrical footing either side all along the walls, also for this centre line remain same for superstructure and for foundation and plinth.

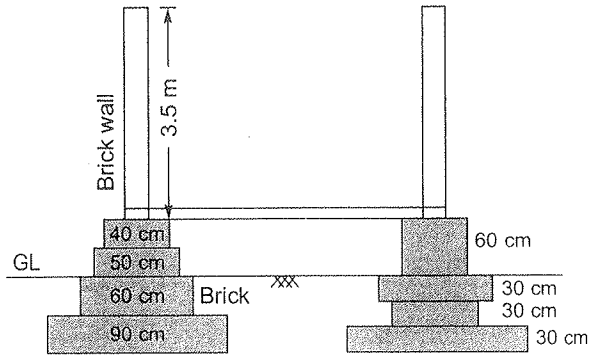
Example 4.3 Figure represents the plan of superstructure wall of a single room building of 5 m × 4 m and section A–B represents the cross-section of a wall with foundations.

Estimate the quantities of:

1. Earth work in excavation in foundation
2. Concrete in foundation
3. Brick work in foundation and plinth
4. Brick work in superstructure



(a) Plan



Section A–B

Solution:

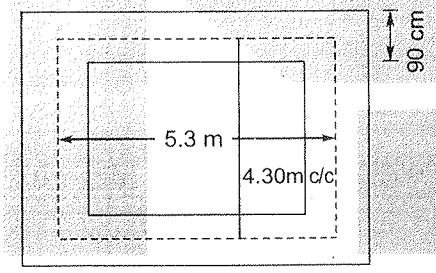
The length of long wall centre to centre = $5+\frac{1}{2}\times 0.3+\frac{1}{2}\times 0.3 = 5.30$ m

Length of short wall centre to centre = $4+\frac{1}{2}\times 0.3+\frac{1}{2}\times 0.3 = 4.30$ m

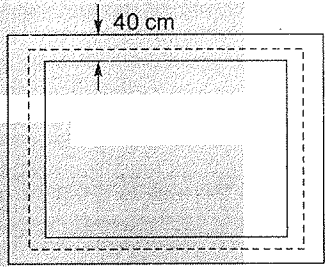
To estimate the quantities, the plan of foundation trench and foundation concrete, the plan of each footing or steps of wall may be imagined as shown below:

Long wall = out-to-out

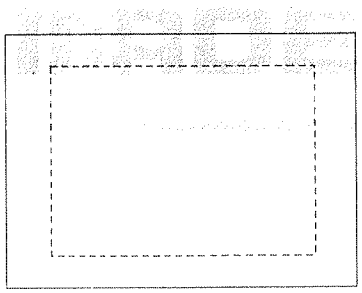
Short wall = in-to-in may be dealt one by one



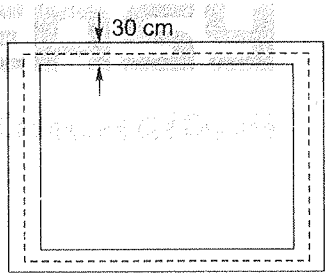
Plan of foundation trench & foundation concrete



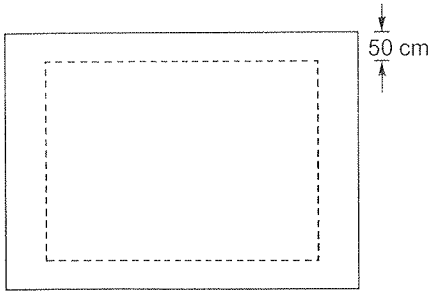
Plan of plinth wall



Plan of 1st footing



Plan of super structure wall



Plan of 2nd footing

Particulars of Item

1. Earth work in excavation of foundation

Long wall	No.	Length	B	H	Quantity
	2	$5.30+\frac{1}{2}\times0.9+\frac{1}{2}\times0.9$	0.9	0.9	$6.2\times0.9\times0.9=10.04$
Short wall	**No.**	**Length**	**B**	**H**	**Quantity**
	2	$4.3-\frac{1}{2}\times0.9-\frac{1}{2}\times0.9$			$3.40\times0.9\times0.9=5.51$
					15.55 cum

2. Concrete in foundation

Long wall	No.	Length	B	H	Quantity
	2	5.30 + 0.9 = 6.20	0.9	0.30	$2\times6.2\times0.9\times0.3$
					3.35 cum
Short wall	**No.**	**Length**	**B**	**H**	**Quantity**
	2	4.30 – 0.9 = 3.40	0.9	0.3	1.84 cum
					5.19 cum

3. Brick wall in foundation and plinth

Long wall	No.	Length	B	H	Quantity
1st footing	2	$5.30+\frac{1}{2}\times0.6+\frac{1}{2}\times0.6=5.90$	0.6	0.3	$2\times5.9\times0.6\times0.3$
					2.13 cum
2nd footing	2	$5.30+\frac{1}{2}(0.5+0.5)=5.80$	0.5	0.3	$2\times5.8\times0.5\times0.3$
					1.174
Plinth wall	2	$5.30+\frac{1}{2}(0.4+0.4)=5.70$	0.4	0.6	$2\times5.7\times0.4\times0.6$
					2.74
Short wall	**No.**	**Length**	**B**	**H**	**Quantity**
1st footing	2	$4.30-\frac{1}{2}(0.6+0.6)=3.70$	0.6	0.3	$2\times3.7\times0.6\times0.3$
					1.33 m^3
2nd footing	2	$4.30-\frac{1}{2}(0.5+0.5)=3.80$	0.5	0.3	$2\times3.8\times0.5\times0.3$
					1.14 cum
Plinth wall	2	$4.30-\frac{1}{2}(0.4+0.4)=3.90$	0.4	0.6	$2\times3.9\times0.4\times0.6$
					1.87 cum
					10.95 cum

4. Brick wall in superstructure

Long wall	No.	Length	B	H	Quantity
	2	$5.30+\frac{1}{2}(0.3+0.3)=5.60$	0.3	3.50	$2\times5.6\times0.3\times3.5$
					11.76
Short wall	No.	Length	B	H	Quantity
	2	$4.30-\frac{1}{2}(0.3+0.3)=4.00$	0.3	3.50	$2\times4\times0.3\times3.5$
					8.40
					20.16 cum

It may be noted that in the case of long wall, the length of the second footing, third footing etc. differ by 10 cm and each is shorter than the previous one by 10 cm. Similarly for the short wall, the length is longer than the previous footing by 10 cm.

Method II: Centre line method

Sum-total length of centre lines of all walls, long and short has to be found out.

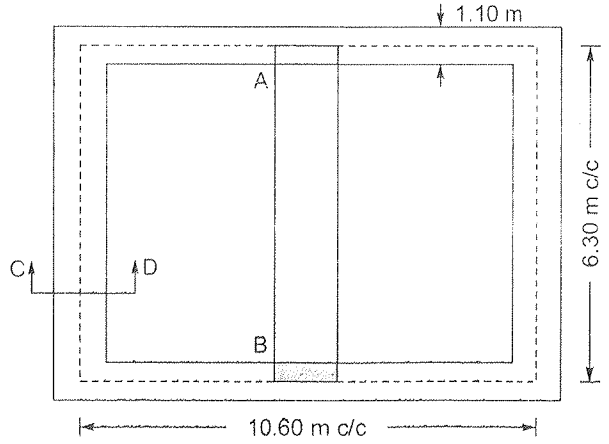
Find the total length of centre line of wall of some type long and short having same type of foundation and footings and then find the quantities is by multiplying the total centre line length by the respective breadth and height.

In this method, the length will remain same for excavation in foundation, for concrete in foundation for all footings and for superstructure (with slight difference when there are cross wall or no. of junction).

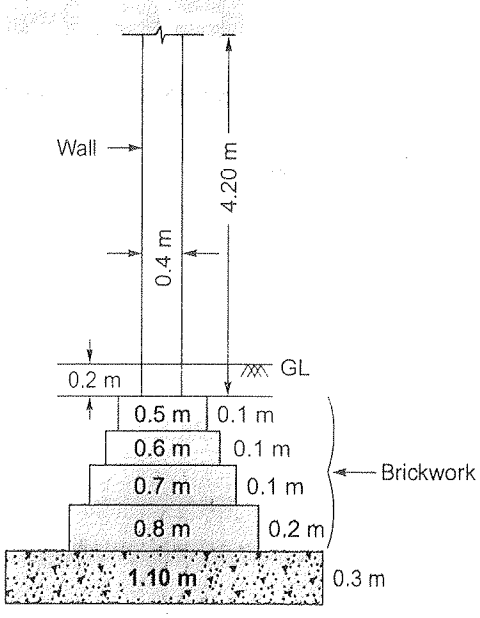
For buildings having cross on partition wall, for each and every junction, half breadth of the respective item on footing in to be deducted from the total centre length. It is also illustrated through example.

Example 4.4 Estimate by centre line method the quantities of the following items of a two room building.

1. Earth work in excavation in foundation.
2. Lime concrete in foundation
3. First class brick work in foundation
4. First class brick work in lime mortar in wall.



Plan



Section C-D

Solution:

In this problem there are two junctions of the inner wall with main wall.

Total central length of walls

$= 2 \times$ c/c of long wall $+ 3 \times$ c/c of short wall

$= 2 \times 10.60 + 3 \times 6.30$

$= 40.10$ m

If total centre length is multiplied by breadth and the depth at the junction, the portion A or B shown above will come twice and we get the quantity in excess in these portions, and these excess shall have to be deducted.

The deduction may be done by reducing the centre length by half breadth for each junction.

$$= \left[\text{Total centre length} - \left(2 \times \frac{1}{2}\right) \text{breadth}\right] \times \text{breadth} \times \text{depth}$$

$$= \left[40.10 - 2 \times \frac{1}{2} \times 1.10\right] \times 1.10 \times 1.00 = 42.90 \text{ cum}$$

The same principle is applied to foundation concrete of footing, plinth wall and superstructure wall.

1. Earth work in excavation in foundation

	Length	B	H	Quantity
	$40.10 - \frac{1}{2} \times 2 \times 1.10 = 39.00$	1.10	1.00 m	42.90

2. Lime concrete in foundation

	Length	B	H	Quantity
	40.10 – 1.10 = 39.00	1.10	0.3	12.87

3. 1st class brick wall

	Length	B	H	Quantity
1st footing	$40.10 - 2 \times \frac{1}{2} \times 0.8 = 39.30$	0.8	0.2	6.29
2nd footing	$40.10 - 2 \times \frac{1}{2} \times 0.7 = 39.40$	0.7	0.1	2.76
3rd footing	$40.10 - 2 \times \frac{1}{2} \times 0.6 = 39.50$	0.6	0.1	2.37
4th footing	$40.10 - 2 \times \frac{1}{2} \times 0.5 = 39.60$	0.5	0.1	1.98
				13.4 cum

4. 1st class brick wall

	Length	B	H	Quantity
	$40.10 - 2 \times \frac{1}{2} \times 0.4 = 39.70$	0.4	4.2	66.7 cum

Deduction of doors, windows, shelves, openings and lintels can also be done accordingly.

4.8.2 Estimation of Labour

Normally a building is made up of many different systems broken down into smaller components and are associated with responsibility of individual workers or crew.

Crew is the team of workers which can be of same trade on a composite composition of different trades.

Example 4.5 Find duration of interior and exterior painting activities for quantities of 440 sq.m, 378 sq.m respectively using crew production rate 11 sq.m/hr and 14 sq.m/hr respectively. Assume that only after interior paint, exterior paint can be done.

Solution:

$$\text{Time required for interior painting} = \frac{440}{11} = 40 \text{ hrs}$$

$$\text{Time required for exterior painting} = \frac{378}{14} = 27 \text{ hrs}$$

$$\therefore \quad \text{Total time required} = 40 + 27 \text{ hrs} = \frac{67}{8} \text{hrs} = 8.38 \text{ days}$$

(Assuming 8 hrs of work per day)

Example 4.6 What is a duration of an excavation activity of 3000 m^3 quantity of excavation using an excavator with the production rate of 200 m^3/day a loader of 250 m^3/day and three trucks of 150 m^3/day? Comment on the crew formation.

Solution:

$$\text{Time required for excavation} = \frac{3000}{200} = 15 \text{ days}$$

$$\text{Time requidred for loader} = \frac{3000}{250} = 12 \text{ days}$$

$$\text{Time required for three trucks} = \frac{3000}{150} = 20 \text{ days}$$

Excavator and loader will remain unused.

$$\text{Try 4 trucks} = \frac{3000}{200} = 15 \text{ days}$$

Crew formation:

Excavator	—	01 nos
Loader	—	01 nos
Trucks	—	04 nos

4.8.3 Analysis of Rates

The basis of arriving at a correct or a reasonable rate per unit work or supply, for a particular item following its specification and detailed survey of materials, labour equipment, etc. are required for each item of work and prevailing rate is called analysis of rate.

Example 4.7 A contractor wants to estimate the equipment related cost for undertaking earth work involving a quantity of 40000 m^3. The contractor has made calculations and arrived at a following requirements for equipment for this excavation work.

Equipment	*Capacity*	*No. Required*	*Duration for which eqip. is reqd.*
1. Poclain CK-90	50 m^3/hr	1	5 months (10 hrs/day @ 2hr OT)
2. Dumpers	6 m^3	3	5 months (10 hrs/day @ 2hr OT)

Calculate equipment cost (cost/m^3) units for earth work

	Changes/months	*Workers*
Poclain CK-90	125000	220 /day
Dumper	50000	200 /day
Helper	—	180 /day

Spare and maintenance = 25% of owning cost

Over time charges = 50% operator cost

Solution:

1. Equipment owning cost + operating charges

Equipment	No.	Charges/month	Duration	Total
Poclain CK-90	1	125000	5	625000
Dumper	3	50000	5	750000
				Rs. 1375000

2. Spars and Maintenance

   25% of owning cost = 0.25 × 1375000 = Rs. 343750

3. Operator cost

	No.	Daily wage	Amount
Operator for poclain	1	Rs. 220/day	1 × 220 × 26 × 5 = Rs. 28600
Helper for bucket cleaning	2	Rs. 180/day	2 × 180 × 26 × 5 = Rs. 46800
Drivers for dumpers	3	Rs. 200/day	3 × 200 × 26 × 5 = Rs. 78000
			Rs. 153400

4. Overtime charges

   50% of operator cost = 0.5 × 153400 = Rs. 76700

   Total cost = Rs. 1948850 for 40000 m^3 of earthwork

   ⇒ Cost per unit of earthwork = Rs. 48.72/m^3 ≃ Rs. 50/m^3

4.9 Detailed and Abstract Estimates of Buildings

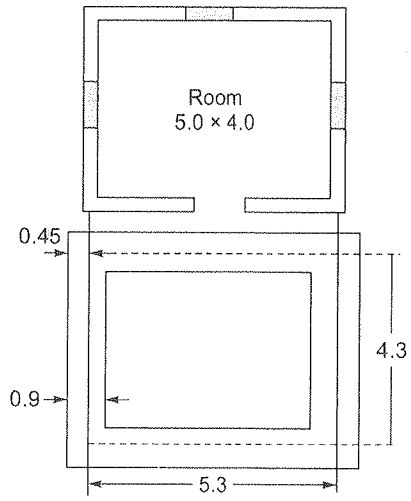
(For detailed understanding)

Example 4.8 From the given figure below, calculate the detailed and abstract estimate for the single room building (Load bearing type structure) by

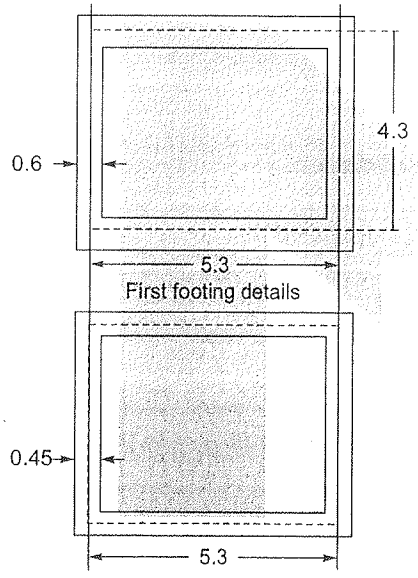
(a) Long wall and short wall method

(b) Centre line method

Solution:

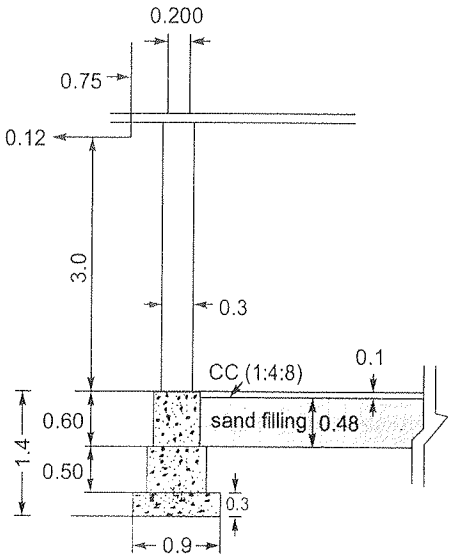


Earth work RCC bed details



First footing details

Second footing details



Cross-section

Note: All dimension are in m
D = 1 × 2.1 m
W = 1.5 × 1.2 m

Single room building (Load bearing type structure)

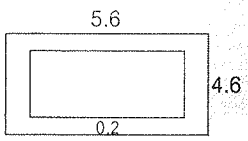
A. Long wall-Short Method

S.No.	Particular of Items	No.	L(m)	B(m)	H(m)	Q(m^2)	Explanation
1.	Earth work excavation for foundation						
	(a) Long walls	2	6.2	0.9	1.4	15.624	L = 5.3 +0.45 + 0.45 = 6.2 D = 0.3 + 0.5 + 0.6 = 1.4
	(b) Short walls	2	3.4	0.9	1.4	8.568	L = 4.3 – 0.45 – 0.45 = 3.4
					Total	24.192 m^3	
2.	CC. (1:4:8) bed for foundation						
	(a) Long walls	2	6.2	0.9	0.3	3.348	
	(b) Short walls	2	3.4	0.9	0.3	1.836	
					Total	5.184 m^3	

3. RC Masonry in CM (1:6) for						
(a) Footings						
(i) Long walls	2	5.9	0.6	0.5	3.54	L = 5.3 + 0.3 + 0.3 = 5.9
(ii) Short walls	2	3.7	0.6	0.5	2.22	L = 4.3 – 0.3 – 0.3 = 3.7
				Total	5.76 m^3	
(b) Basement						
(i) Long walls	2	5.75	0.45	0.6	3.105	L = 5.3 + 0.225 + 0.225 = 5.75
(ii) Short walls	2	3.85	0.45	0.6	2.079	L = 4.3 – 0.225 – 0.225 = 3.85
				Total	5.184 m^3	

Total RC masonry for footings and basement = 5.76 + 5.184 = 10.94 m^3

4. Brick masonry with CM (1 : 6) for superstructure						
(a) Long walls	2	5.6	0.30	3.00	10.08	L = 5.3 + 0.15 + 0.15 = 5.6
(b) Short walls	2	4.0	0.30	3.00	7.20	L = 4.3 – 0.15 – 0.15 = 4.0
(c) For parapet wall						



(a) Long walls	2	5.6	0.2	0.75	1.68
(b) Short walls	2	4.4	0.2	0.75	1.32
				Total	20.28 m^3
Deductions for openings					
(a) Doors	1	1.0	0.3	2.1	0.63
(b) Windows	3	1.5	0.3	1.2	1.62
				Total	–2.25 m^3

Net brick masonry = 20.28 – 2.25 = 18.03 m^3

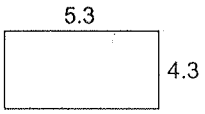
5. RCC (1 : 2 : 4) for						
(a) Roof slab	1	5.6	4.6	0.12	3.09	
(b) Lintels over						
(i) Doors	1	1.2	0.3	0.15	0.054	
(ii) Windows	3	1.5	0.3	0.15	0.203	
(c) Beams						
(i) Long beams	2	5.6	0.3	0.3	1.008	
(ii) Short beams	2	4.0	0.3	0.3	0.720	
				Total	5.075 m^3	
6. Sand filling for basement	1	4.85	3.85	0.48	8.96	L = 5.0 – 0.075 – 0.075 = 4.85
7. CC (1:4:8) for flooring	1	4.85	3.85	0.1	1.87	B = 4.0 – 0.075 – 0.075 = 3.85
8. Flooring with Mosaic tiles	1	5.0	4.0	—	20.0 m^2	
9. Plastering with CM (1 : 6) for super structure						
Inside						
For walls	1	18.0	—	3.0	54.0	L = 2(5.0 + 4.0) = 18.0

Outside						
For walls	1	20.4	—	3.0	61.2	L = 2(5.6 + 4.6) = 20.4
Basement outside	1	21.6	—	0.6	12.96	H = 3.0 + 0.12 + 0.75 = 3.87 (upto parapet wall)
Parapet wall						
(a) Inside	1	18.8	—	0.75	14.1	
(b) Top	1	19.6	0.2	—	3.92	
				Total	146.18 m^2	
Deductions for openings						
Doors	1 × 2	1.0	—	2.1	4.2	
Windows	3 × 2	1.5	—	1.2	10.8	
				Total	15.0 m^2	

Net plastering = 146.18 – 15.0 = 131.18 m^2

10. Plastering for Ceiling with CM (1 : 5)	1	5.0	4.0	—	20.0 m^2
11. White Washing with two coats with Janatha cement					
Same as quantity of plastering for walls and Ceiling					151.18 (= 131.18 + 20 = 151.18)
12. Colour washing with two coats					
Same as quantity of plastering for walls and Ceiling					151.18 (= 131.18 + 20) = 151.18
13. Supply & Fixing of best country wood for					
(a) Doors	1			1 No.	
(b) Windows	3			3 No.	
14. Painting with ready mixed synthetic enamil paints with two coats over primary coat for new wood for					
(a) Doors	$2\frac{1}{4} \times 1$	1.0	—	2.1	4.725
(b) Windows	$2\frac{1}{4} \times 3$	1.5	—	1.2	12.15
				Total	16.875 m^2
15. Petty supervision and contingencies at 4% and rounding off.					

B. Centre Line Method

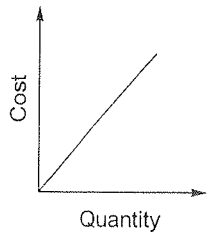
S.No.	Particular of Items	No.	L(m)	B(m)	H(m)	Q(m^3)	Explanation
1.	**Earth work excavation**						
	for foundation	1	19.2	0.9	1.4	24.192 m^3	L = 2(5.3 + 4.3) = 19.2
							
2.	**CC (1 : 4 : 8) bed for**						
	Foundation	1	19.2	0.9	0.3	5.184 m^3	
3.	**RR Masonry in CM (1 : 6) for**						
	(a) Footings	1	19.2	0.6	0.5	5.76	
	(b) Basement	1	19.2	0.45	0.6	5.184	
					Total	10.944 m^3	
4.	**Brick Masonry with**						
	CM (1:6) for superstructure	1	19.2	0.3	3.0	17.28 m^3	
	For parapet wall	1	20.0	0.2	0.75	3.00	
	Deductions for openings						
	(a) Doors	1	1.0	0.3	2.1	0.63	
	(b) Windows	3	1.5	0.3	1.2	1.62	
					Total	–2.25 m^3	
	Net Brick Masonry = 17.28 + 3.0 – 2.25 = 18.03 m^3						
5.	**RCC (1 : 2 : 4) for**						
	(a) Roof slab	1	5.6	4.6	0.12	3.090	
	(b) Lintels over						
	(i) Doors	1	1.2	0.3	0.15	0.054	
	(ii) Windows	3	1.5	0.3	0.15	0.203	
	(c) Beams	1	19.2	0.3	0.3	1.728	
					Total	5.075 m^3	
6.	**Sand filling for basement**	1	4.85	3.85	0.48	8.96	L = 5.0 – 0.075 – 0.075 = 4.85
7.	**CC (1 : 4 : 8) for flooring**	1	4.85	3.85	0.1	1.87	B = 4.0 – 0.075 – 0.075 = 3.85
8.	**Flooring with Mosaic tiles**	1	5.0	4.0	—	20.0	
9.	**Plastering with CM (1 : 6) for super structure**						
	Inside						
	For walls	1	18.0	—	3.0	54.0	
	Outside						
	For walls	1	20.4	—	3.0	61.2	
	Basement outside	1	21.6	—	0.6	12.96	

Parapet wall						
(a) Inside	1	18.8	—	0.75	14.1	
(b) Top	1	19.6	0.2	—	3.92	
				Total	146.18 m^3	
Deduction for openings						
Doors	1 × 2	1.0	—	2.1	4.2	L = 5.0 − 0.075 − 0.075 = 4.85
Windows	3 × 2	1.5	—	1.2	10.8	B = 4.0 − 0.075 − 0.075 = 3.85
				Total	15.0 m^2	
			Net Plastering = 146.18 − 15 = 131.18 m^2			
10. Plastering for Ceiling with CM (1 : 5)	1	5.0	4.0	—	20.0 m^2	
11. White Washing with two coats with Janatha cement						
Same as quantity of plastering for walls and Ceiling					151.18 m^2	(131.18 + 20 = 151.18)
12. Colour washing with two coats						
Same as quantity of plastering for walls and Ceiling					151.18 m^2	
13. Supply & Fixing of best country wood for						
(a) Doors	1				1 No.	
(b) Windows	3				3 No.	
14. Painting with ready mixed synthetic enamil paints with two coats over primary coat for new wood for						
(a) Doors	$2\frac{1}{4} \times 1$	1.0	—	2.1	4.725	
(b) Windows	$2\frac{1}{4} \times 3$	1.5	—	1.2	12.15	
				Total	16.875 m^2	
15. Petty supervision and contingencies at 4% and rounding off.						

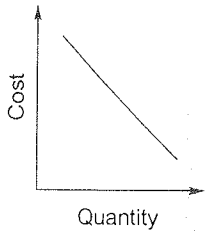
Objective Brain Teasers

Q.1 Correct graph for direct cost in a construction project, at a point of time

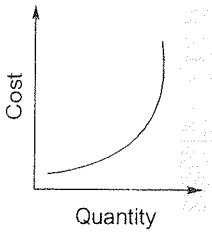
(a)



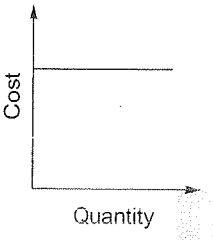
(b)



(c)

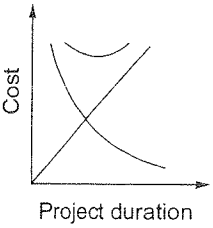


(d)

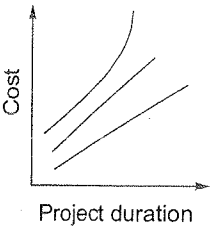


Q.2 In time cost trade off for direct cost, indirect cost and total cost, the variation of cost w.r.t. project duration will be

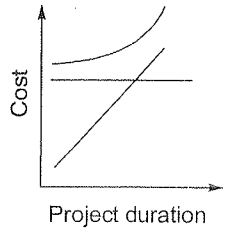
(a)



(b)



(c)



(d) None of these

Q.3 Unit of plastering, points and finishing is

(a) m^3 (b) m
(c) m^2 (d) is numbers

Q.4 Unit of measurement for RC sunshade with specified thickness and width

(a) m^3 (b) m
(c) m^2 (d) is numbers

Q.5 Office expenses of site as well as head office will be included in

(a) Direct cost (b) Indirect cost
(c) Any of the two (d) None of these

Q.6 In cost estimation, site overhead for a project is generally _____ of direct cost

(a) 1-4% (b) 18-20%
(c) 5-15% (d) None of these

Q.7 In conceptual cost estimate of a hospital, the required data will be

(a) Detailed design and specification of project
(b) No initial input is required
(c) Unit cost i.e., cost/unit of patients or bed of previous similar project
(d) Drawing and plan elevations

Q.8 Conceptual estimate is prepared by

(a) Owners or owner's consultant
(b) Engineers
(c) Contractor
(d) Any of the above

Q.9 Pre-bid estimate (detailed) is prepared by

(a) Owner (b) Engineer
(c) Contractor (d) Any of the above

Q.10 Current estimate of a project is Rs. 350 million while the same estimate 4 years back was Rs. 300 million. Calculate inflation

(a) 4.5% (b) 8%

(c) 10% (d) 3.93%

Q.11 Adjustment for location, time, size of A to calculate project estiamte of B will be _____ while x is the cost of project A

(a) $x \times \frac{\text{Time of B}}{\text{Time cost of A}} \times \frac{\text{Location of B}}{\text{Location of A}} \times \frac{\text{Size of B}}{\text{Size of A}}$

(b) $x \times \frac{\text{Time of A}}{\text{Time cost of B}} \times \frac{\text{Location of A}}{\text{Location of B}} \times \frac{\text{Size of A}}{\text{Size of B}}$

(c) $x \times \frac{\text{Only time cost of A}}{\text{Time cost of B}}$

(d) x

Q.12 In unit cost method, unit cost is calculated using

(a) $\frac{A+B+C}{3}$ (b) $\frac{A+4B+C}{6}$

(c) $\frac{A+C}{2}$ (d) B

Where,

A = Min. unit cost of previous project

B = Average unit cost of previous projec.

C = Max. unit cost of previous project

Q.13 For the separate or individual wall estimate calculation of short wall, length measured will be

(a) centre to centre

(b) c/c + one breadth

(c) c/c – one breadth

(d) c/c $- \frac{1}{2} \times$ one breadth

Q.14 Assertion: Separate or individual wall estimate is applicable for symmetrical footing on either side all along

Reason: Centre line will remain same for superstructure and for foundation and plinth.

(a) A and R both are correct and A is correct explanation

(b) A and R both are correct and R is not correct explanation of A

(c) A is wrong R is correct

(d) A is correct R is wrong

Q.15 What will be the duration to install 6000 sq.ft of shuttering for walls if productivity of carpenter is 0.008 man hours/sq.ft.?

(a) 36 hrs (b) 48 hrs

(c) 60 hrs (d) None of these

Q.16 Previous cost of similar project is Rs. 500 lakh.

Time adjustment = 1.20

Location adjustment = 0.95

Size adjustment = 2.1

Final cost of new project will be

(a) 1326.3 lakhs

(b) 1197 lakh

(c) 831.25 lakh

(d) 1050 lakh

Q.17 **Assertion (A):** At every stage in centre line method deduction of half breadth of the main wall at that particular level shall have to be made for junction.

Reason (R): In centre line junction area gets counted twice.

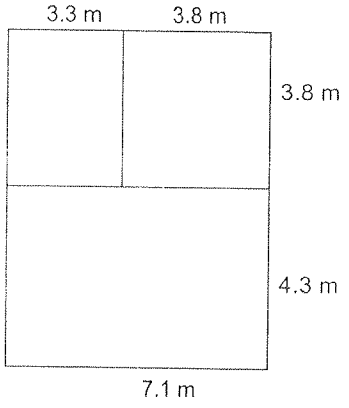
(a) A and R both are correct and A is correct explanation

(b) A and R both are correct and R is not correct explanation of A

(c) A is wrong R is correct

(d) A is correct R is wrong

Q.18 For centre line diagram,



Total centre line length will be

(a) 41.3 m (b) 40 m

(c) 39.5 m (d) None of theset

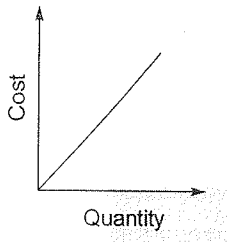
Answers

1. (a)	2. (a)	3. (c)	4. (b)	5. (b)
6. (c)	7. (c)	8. (a)	9. (c)	10. (d)
11. (a)	12. (b)	13. (c)	14. (a)	15. (b)
16. (b)	17. (a)	18. (c)		

Hints & Solution

1. (a) At a particular point of time

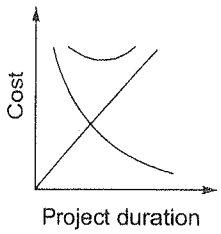
Direct cost $\propto$ quantity



2. (a) With respect to project duration

$$DC \propto \frac{1}{\text{Project duration}}$$

$$IDC \propto \text{Project duration}$$



5. (b) Indirect cost

8. (a) To float tender

9. (c) To apply for a tender

10. (d) Current price = Previous price $(1 + i)^{\text{Time}}$

$$\frac{350}{300} = (1 + i)^4$$

$$i = 3.93\%$$

16. (b) $500 \times 1.2 \times 2.1 \times 0.95$

18. (c) $3(3.3 + 3.8) + 3.8 \times 3 + 4.3 \times 2 = 41.3$ m

$$41.3 - \frac{1}{2} \times \text{breadth} \times \text{No. of junctions}$$

$$= 41.3 - \frac{1}{2} \times 0.9 \times 4$$

$$= 39.5 \text{ m}$$