10

Estimating, Costing and Supervision

Technical and Vocational Stream
Learning Resource Material

Estimating, Costing and Supervision

(Grade 10)

Civil Engineering

Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for civil engineering has been developed in line with the Secondary Level civil engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students, parents and concerned stakeholders.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Jagat Kumar Shrestha, Dr. Bhim Kumar Dahal, Er. Anisha Lamsal, Er. Gita Lamichhane, Mr. Durga Bahadur Pun is highly acknowledged. This learning resource material is compiled and prepared by Er. Jagadishchandra Karki, Er. Kedarnath Dahal, Er. Hemantaraj Joshi and Er. Sabin Silwal. The subject matter of this material is edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala. Similarly, the language is edited by Mr. Nabin Kumar Khadka. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes creative and constructive feedback for the further improvement of the material.

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Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions. Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.
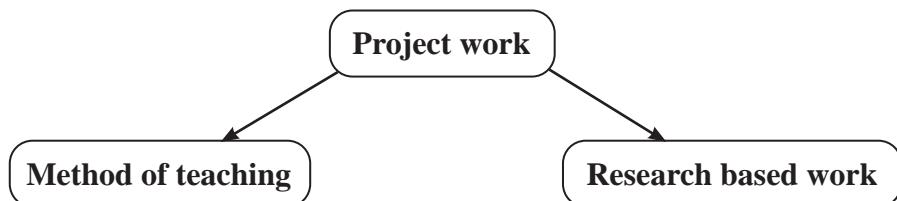
Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional

resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.
- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C.   Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.
Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.
Homework exercises: Assign tasks that provide ongoing feedback on individual progress.
Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.
Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.
Peer feedback forms: Provide structured forms for students to assess their peers.
Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.
Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.
Reflection statements: Ask students to write reflective statements about their work.
Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.
Performance observations: Assess practical skills through direct observation.
Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Unit 1: Definition of Estimating

1.1 Definition of Estimating

Estimate: An estimate is the anticipated or probable cost of a work and is usually prepared based on the available drawings before the construction is taken up.

1.2 Importance of Estimate

- To calculate the quantities of materials required for the project
- To calculate the necessary amount of money required to complete the proposed work
- To calculate the number of different categories of workers to complete the work
- To assess the requirements of tools, plants and equipment required to complete the work
- To draw up a construction schedule and programme
- To justify the investment from benefit cost ratio
- To invite tenders and prepare bills for payment
- To carry out valuation of existing property

1.3 Types of Estimate

Preliminary estimate or approximate estimate or abstract estimate or rough estimate

- It is done to find out the probable cost of a project in short time.
- It is prepared after the preliminary investigation and surveying.
- It does not require detailed survey data and detailed drawings; and is prepared based on the practical knowledge and cost of similar works.
- It is prepared to get the administrative approval of the project from the competent administrative authority.
- It helps to decide whether the investment on the project is justified or not.

Estimating, Costing and Supervision/Grade 10

- Types of preliminary estimate of a building are:
  o Plinth area estimate
  o Cube rate estimate

Detailed Estimate or Item rate Estimate

- It is an accurate estimate and consists of working out the quantities of each item of works and their costs.
- It is prepared after the preliminary or approximate estimate gets the administrative approval.
- The data required for preparing a detailed estimate are:
  o Detailed drawings
  o Specifications
  o Rates of various items of works, materials and wages of different categories of labour
  o Updated methods of measurements
  - The detailed estimate is prepared in two stages:

Details of Measurement and Calculation of Quantities

The details of measurements of each item of work are taken out correctly from the available drawings and quantities under each item are computed or calculated in a tabular form named as details of measurement.

Item no.	Description or Particulars	Unit	No	Length	Breadth	Height or depth	Quantity (n*l*b*h)
1	Earthwork in excavation						
2	Brick soling						
…	…..		..	…	…	…	…

Details of Measurement Form

Abstract of Cost

The cost of each item of work is calculated in tabular form for the quantities already computed and total cost is worked out in *Abstract of Cost*. The rates of different items of work are taken as per schedule of rates of current workable rates or analysed rates for finished items of work.

Item no	Description or particulars	Quantity	Unit	Rate	Amount
1	Earthwork in excavation				
2	Brick soling				
….	…...	…...	…...	….…	….…

2   Revised Estimate

- It is also a detailed estimated but it is required to be prepared only under any one of the following circumstances:
    - o   When the original sanctioned estimate is exceeded or likely to exceed by more than 5%.
    - o   When the expenditure on a work exceeds or is likely to exceed the amount of administrative sanction by more than 10%.
    - o   When there are material deviations from the original proposal of non-structural nature.
- The revised estimate should be accompanied by a comparative statement abstract form showing the variations of each item of works, its quantity, rate and cost under original and revised, side by side, and the reason for variation.

3   Supplementary Estimate

- While a work is in progress, if there are some changes or additional works due to material deviation of a structural nature from the design, an estimate to include all such works must be prepared. Then, such estimate is the supplementary estimate. The method of preparation of the supplementary is same like that of a detailed estimate.
- The abstract of cost shows the amount of the original estimate and the total amount including the supplementary amount for which sanction is required.

4   Annual Repair or Maintenance Estimate (A.R. or A. M. Estimate)

- After completion of a work, it is necessary to maintain the completed work for its proper functioning. The estimation of the items of work which requires renewal, repairs, replacement etc. is annual repair and maintenance estimate. White washing, colour washing, and painting of doors and windows etc. are such works which requires frequent maintenance.

1.4 Different Items of Works and their Units of Measurement

S.NO	Description of items	Unit of Measurement
Earthwork (with 30m normal lead and 1.5 m normal lift)		
	Earthwork in excavation in any type of soil	Cum (m^3)
	Earthwork in hard rock	Cum (m^3)
	Clearing of shrubs, brushwood and small trees	Sqm (m^2)
	Cutting of trees	Number
	Earthwork in filling	Cum (m^3)
	Surface dressing, levelling and cleaning	Sqm (m^2)
	Blasting of rock	Cum ()
Brick Work		
	Brickwork of one or more than one brick wall	Cum (m^3)
	Brickwork in arches	Cum (m^3)
	Reinforced brickwork	Cum (m^3)
	Honeycomb brickwork	Sqm (m^2)
	10cm or half brickwork	Sqm (m^2)
	Flat brick soling	Sqm (m^2)
	Cutting holes through existing brickwork	Per cm
	Cutting openings in existing brickwork	Cum (m^3)
	Cornice (Projection and type specified)	Metre(m)
	Brick edging (by road side)	Metre (m)
	Supply of bricks	Number
Concrete work		
	Lime or cement concrete in foundation	Cum (m^3)
	Reinforced Cement Concrete (RCC)	Cum (m^3)
	Formwork	Sqm (m^2)
	Reinforcement	Quintal
	Damp Proof Course (DPC) (thickness specified)	Sqm (m^2)

	Precast C.C/RCC block/Solid block work/Hollow concrete block wall	Cum (m³)
	Expansion or contraction joints in concrete	Metre or running metre (rm)
	PCC Jaffri work	Sqm ()
	PCC or RCC Chhajja or sun shade	Cum (
	PCC or RCC lintel and sill bands (thickness specified)	Sqm ()
Stone Work		
	Stone masonry wall (Rubble masonry or Ashlar masonry)	Cum (m³)
	Stonework in wall facing (thickness specified)	Sqm (m²)
	Boulder work/stone soling	Cum (m³)
Roofing		
	Lime terracing/tile roofing/ A.C or CGI sheet roofing	Sqm (m²)
	Ridges, valleys, eaves tiles	rm
	Waterproofing on roof	Sqm (m²)
Paving, Flooring		
	Lime or cement concrete floors or paving/Bituminous paving	Sqm (m²)
	Artificial stone to floor/Terrazzo or mosaic flooring/Stone slab flooring	Sqm (m²)
Wood Work		
	Woodwork in door and window frames (Chaukhat)	Cum (m³)
	Door and window shutters (thickness specified)	Sqm (m²)
	Shuttering, centering	Sqm (m²)
	Handrails	rm
	Doors and windows fittings such as hinges, tower bolts, handles	Per number
	Sawing of timber	Sqm(
	Timbering of trenches	Sqm(

	Wood work in partition, ply wood	Sqm(
	Skirting of wooden floor	rm
Steelworks and Ironwork		
	M.S structural works/steel work in trusses	Quintal
	Steel reinforcement bars in RCC, R.B. work	Quintal
	Bending and binding of bars	Quintal
	Bolts, nuts, washers	Kg
	Collapsible gate/rolling shutter/ steel door and window/iron gate	Sqm (m²)
	Barbed wire fencing	rm
Finishing		
	Plastering with lime and cement mortar or pointing with brickwork	Sqm (m²)
	Punning	Sqm (m²)
	Plastering to ceiling	Sqm (m²)
	White washing, colour washing, distempering	Sqm (m²)
	Painting work in doors, windows	Sqm (m²)
	Fixing of glass panes (cleaning and renewing glass panes)	Number
	Supply of glass panes (thickness specified)	Sqm(

1.5   Systems of Measurement

The measurements can be done in following system of units:

1. **Metric or MKS System**

    Length is measured in metre (m), mass in kilograms (kg) and time in second (s). Another basic unit of the system is: Ampere (A) which is the unit of current.

2. **CGS System**

    Length is measured in centimetre (cm), mass in grams (g) and time in second (s).

3. **FPS System**

    Length is measured in feet (ft), mass in pounds (lb) and time in second (s).

4. **International System (SI) of Units**

   It includes all the units from MKS system with units of temperature and luminous intensity also added. So, the basic units are:

   Length: metre (m), mass: kilograms (kg), time: second (s), current: Ampere(A), temperature: Kelvin (K) and luminous intensity: Candela(Cd)

1.6 Conversion of Systems of Units

Length

1m=3.28ft

1ft=12inch=30.48cm

1inch=25.4mm=2.54cm

1 yard=3ft

1mile=1.6km=8 Furlong

1 Furlong = 8 Gunter's chains

1 Gunter's chain = 66 ft = 20.12 m

1hand=1.5ft

1kosh=3.281km

Mass

1 Tola=11.66 gm=100 lal

1kg=1000 gm

1kg=2.2pound

1 kg= 5 Pau in Hllls and 4 Pau in Terai

1 Dharni=2.4 kg

1 quintal=100kg

1MT=10quintal=1000kg

1 cylinder=14.2kg

Area

1bigha=20kattha

1kattha=20dhur=3645

1ropani=16anna=5476

1anna=4paisa=31.8

1paisa=4dam

1 hectare= sqm

1 Acre = 1 Furlong* 1 Chain = 10 Chains* 1 Chain

Units of Area in Descending Order

1 Hectare	1 Hectare = 1.48 Bigha = 2.47 Acre = 19.65 ropani
1 Bigha	1 Bigha = 1.67 Acre = 13.3 ropani
1 Acre	1 Acre=7.95 ropani
1 Ropani	1 Ropani = 1.5 Kattha
1 Kattha	1 Kattha = 10.65 Ana
1 Ana	= 1 Ana = 1.88 Dhur
1 Dhur	1 Dhur = 2.13 Paisa
1 Paisa	1 Paisa = 4 Dam
1 Dam	

Volume

1 =1000 lit

1 litre = 1000

1 lit=1000ml

1 ml=1

1 gallon=3.785lit (US)

1 gallon = 4.546 lit (British)

Temperature

C/5=(F-32)/9

Power

1 Horse power = 736 Watt (Metric)

1 Horse Power = 746 Watt (Imperial or mechanical)

Exercises

Choose the correct answer from the given alternatives.

1. Which of the following is the most accurate method of estimation?

   a. Plinth area estimate   b. Cube rate estimate

   c. Detailed estimate   d. Building cost index estimate.

2. In detailed estimate, the volume are worked out to the nearest.........

   a. $0.001 \ m^3$ b. $0.005 \ m^3$ c. $0.01 \ m^2$ d. $0.005 \ m^2$

3. The unit of measurement for concrete work in R.C.C. is...........

   a. sq m   b. cu m   c. 10 sqm   d. 10 cum

## Write short answer to the following questions.
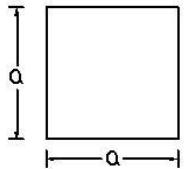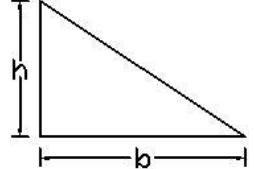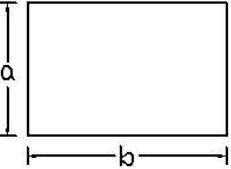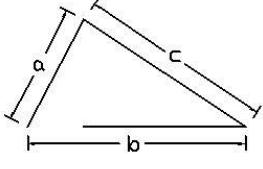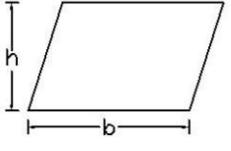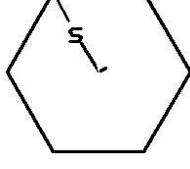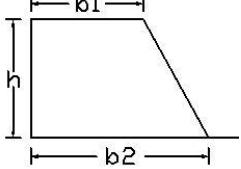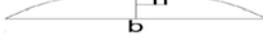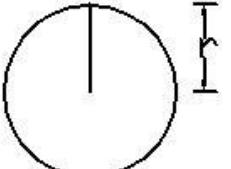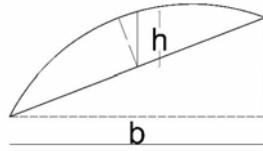
1. What are the importance of estimate?

2. Define estimate? Write any three items of works and their units of measurements.
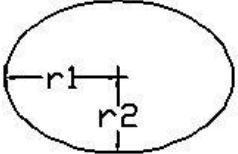
Write long answer to the following questions.

1. What are the types of estimate? Explain.

2. What are the systems of measurements? Convert the following units:

   a. 100 ft. to cm

   b. 50 m2 to ft2

   c. 25 cm3 to m3

Unit 2: Area and Volume Calculation

2.1 Sectional Area of Regular Trenches

Shape/ Formula	Figure	Shape/Formula	Figure
Square a*a		Triangle ½*b*h	
Rectangle a*b		Triangle when	
Parallelogram b*h		Polygon when n = # of sides and S = length from center to a corner	
Trapezoid		Parabolic segment	
Circle Π*r2		Inclined parabolic segment	

Ellipse $\pi*r^1*r^2$			

2.2   Sectional Areas of Irregular Trenches

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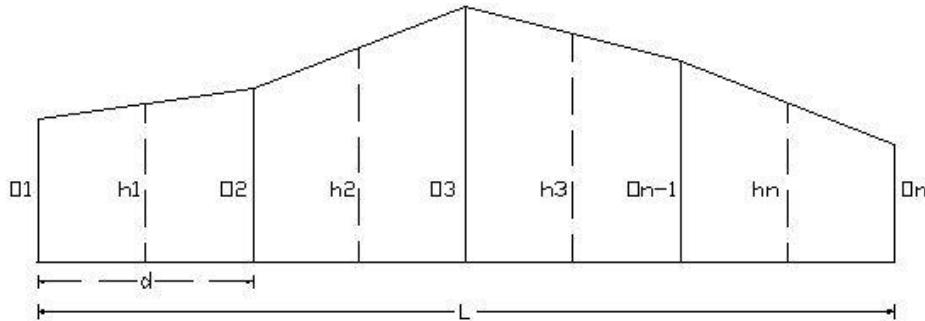
1. **Trapezoidal Rule**

$O_1, O_2, O_3 \ldots\ldots O_{n-1,}$ O_n = Ordinates at equal intervals

d = common distance between ordinates

$$1^{st} \text{ area} = \frac{d}{2}(O_1 + O_2)$$

$$2^{nd} \text{ area} = \frac{d}{2}(O_2 + O_3)$$

$$\text{Last area} = \frac{d}{2}(O_{n-1} + O_n)$$

$$\text{Total area} = \frac{d}{2}\{O_1 + 2*(O_2 + O_3 + \cdots\ldots\ldots O_{n-1}) + O_n\}$$

$$\therefore Area = \frac{common\ distance}{2} * [1^{st} ordinate + last\ ordinate + 2 *$$
$$(sum\ of\ other\ ordinates)]$$

Thus, the trapezoidal rule may be stated as follows:

To the sum of the first and last ordinate, twice the sum of intermediate ordinates is added. This total sum is multiplied by the common distance. Half of this product is the required area.

2. **Mid-ordinate Rule**

$O_1, O_2, O_3 \ldots\ldots O_{n-1,}$ = Ordinates at equal intervals

d = common distance between ordinates

11

$$1^{st} \text{ area} = \frac{d}{2}(O_1 + O_2) = d * \frac{O_1 + O_2}{2} = d * h_1$$

$$2^{nd} \text{ area} = \frac{d}{2}(O_2 + O_3) = d * \frac{O_2 + O_3}{2} = d * h_2$$

$$\text{Last area} = \frac{d}{2}(O_{n-1} + O_n) = d * \frac{O_{n-1} + O_n}{2} = d * h_{n-1}$$

$$\text{Total area} = d * h_1 + d * h_2 + \cdots \ldots \ldots \ldots d * h_{n-1}$$

$$\therefore Area = d * (h_1 + h_2 + \cdots \ldots \ldots \ldots \ldots h_{n-1})$$

3. **Average/mean Ordinate Method**

O_1, O_2, O_3………On = Ordinates at equal intervals

L = Length of the base line

n = numbers of divisions

n+1 = numbers for ordinates

$$Area = \frac{O1 + O2 + O3 \ldots\ldots + On}{n+1} * L$$

4. **Simpson's Rule**

O_1, O_2 and O_3 are three consecutive coordinates and d is the common distance between the ordinates.

Assumption: The irregular surface is assumed as a parabola.

Area of ABCEGD = Area of trapezium ABCEFD + Area of segment DFEG

$$\text{Area of trapezium ABCEFD} = \frac{2d}{2} * (O_1 + O_3)$$
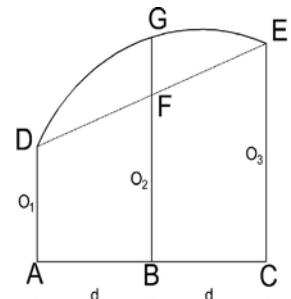
$$\text{Area of segment DFEG} = \frac{2}{3} * 2d * GF$$

$$GF = BG - BF$$

$$BF = BH + HF = O_1 + \frac{O_3 - O_1}{2}$$

$$\therefore GF = O_2 - O_1 - \frac{O_3 - O_1}{2}$$

$$= O_2 - \frac{2O_1 + O_3 - O_1}{2}$$

$$\therefore GF = O_2 - \frac{O_1 + O_3}{2}$$

So, area of segment DFEG $= \frac{2}{3} * 2d * (O_2 - \frac{O_1 + O_3}{2})$

And thus,

Area of ABCEGD $= d * (O_1 + O_3) + \frac{2}{3} * 2d * (O_2 - \frac{O_1 + O_3}{2})$

$$= d\left\{O_1 + O_3 + \frac{4}{3} * \frac{2O_2 - O_1 - O_3}{2}\right\}$$

$$= d * \frac{6O_1 + 6O_3 + 8O_2 - 4O_1 - 4O_3}{6}$$

$$= \frac{d}{6} * (2O_1 + 8O_2 + 2O_3)$$

$$\therefore A_1 = \frac{d}{3} * (O_1 + 4O_2 + O_3)$$

Similarly,

The area of next two consecutive divisions, the ordinates will be O_3, O_4 and O_5 and area is given by, $A_2 = \frac{d}{3} * (O_3 + 4O_4 + O_5)$

For another two consecutive divisions, the area will be, $A_3 = \frac{d}{3} * (O_5 + 4O_6 + O_7)$ and continues so on for all other divisions.

Total area is then the sum of areas of these divisions, so,

$A = \frac{d}{3}(O_1 + 4O_2 + O_3 + O_3 + 4O_4 + O_5 + O_5 + 4O_6 + O_7 + \cdots \ldots\ldots O_{n-2} + 4O_{n-1} + O_n)$

$or, A = \frac{d}{3} * \{O_1 + O_n + 4 * (O_2 + O_4 + O_6 + \cdots\ldots) + 2 * (O_3 + O_5 + O_7 + \cdots.)\}$

$\therefore A = \frac{d}{3} * (1^{st} ordinate + last\ ordinate + 4 * \Sigma \quad even\ ordinates + 2 *$

$\Sigma \quad odd\ ordinates)$

This formula holds true only when the number of ordinates n is an odd number.

5. **Area of a Trapezium With its Side Slopes Given**

    Base of the trapezoid = b

    Side slope (H: V) = s:1

    Height of the trapezoid = h

    Area of trapezoid ABCD = Area of rectangle ABEF+ Area of triangle ADF + Area of triangle BEC

    $or, A = b * h + \frac{1}{2} * sh * h + \frac{1}{2} * sh * h$

    $\therefore A = bh + sh^2$
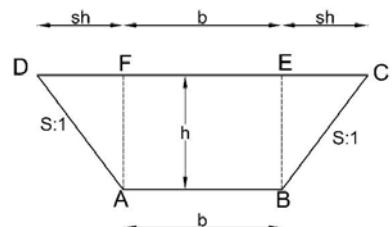
2.3   Calculation of Regular and Irregular Simple Volumes

A 100 m long canal is to be constructed on a sloping ground as shown in the figure.
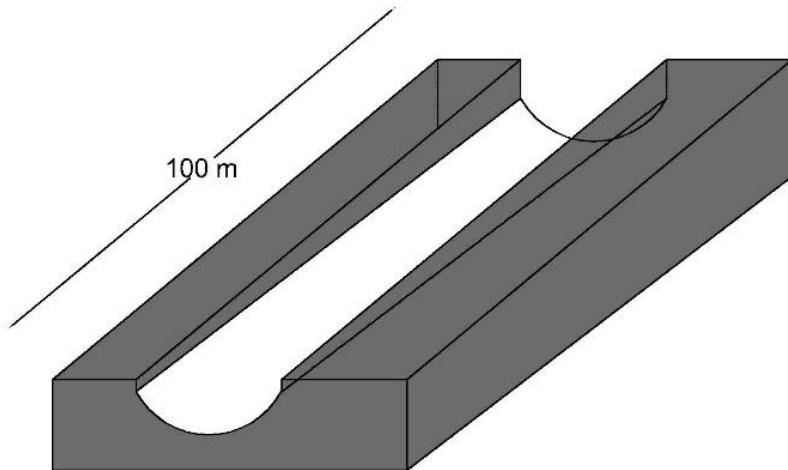
The sectional dimensions of the front and rear section of the canal are given below:
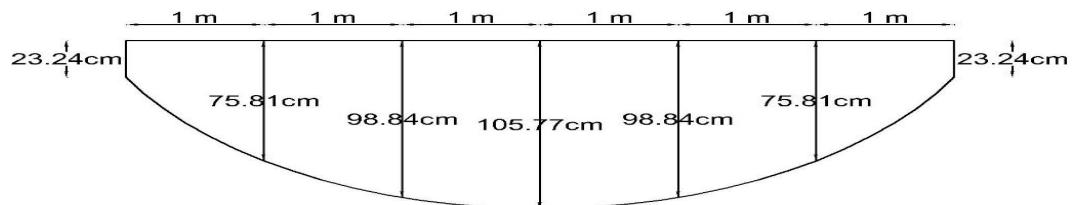
i.   **Front End**

ii.   **Rear End**

Based on the above information:

   i.   Determine the cross sectional area of the front end

   ii.   Determine the cross sectional area of the rear end

   iii. Determine the volume of the soil to be excavated for the canal.

Solution

i.   **Area of Front End**
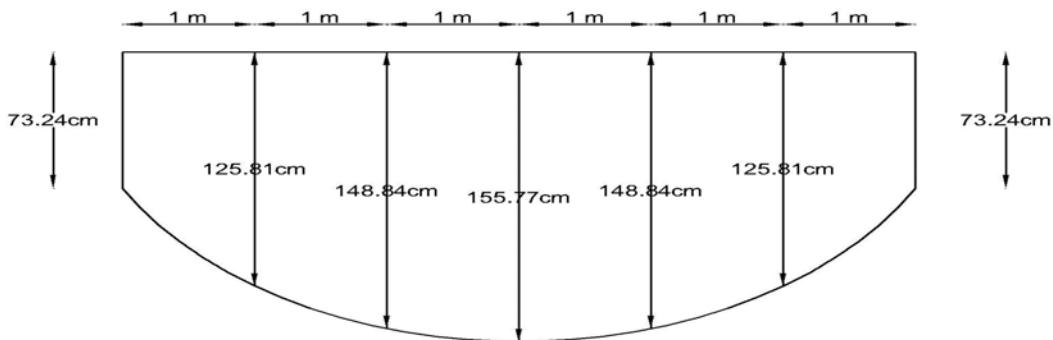
Here, the number of ordinates are odd. So it would be convenient to assume the curve between the ordinates as a parabola and apply Simpson's rule to determine the area as follows:

$$\therefore A = \frac{d}{3} * (1^{st}\, ordinate + last\, ordinate + 4 * \sum even\, ordinates + 2 * \sum odd\, ordinates)$$

$$or, A_f = \frac{100}{3} * \{23.24 + 23.24 + 4 * (75.81 + 105.77 + 75.81) + 2 * (98.84 + 98.84)\}$$

$$\therefore A_f = 49046.67\, cm^2 = 49046.67 \left(\frac{1}{100}\right)^2 = \frac{49046.67}{10,000} = 4.91\, m^2$$

ii.   **Area of Rear End**

Area of rear end can be determined in the similar manner as that of front end.
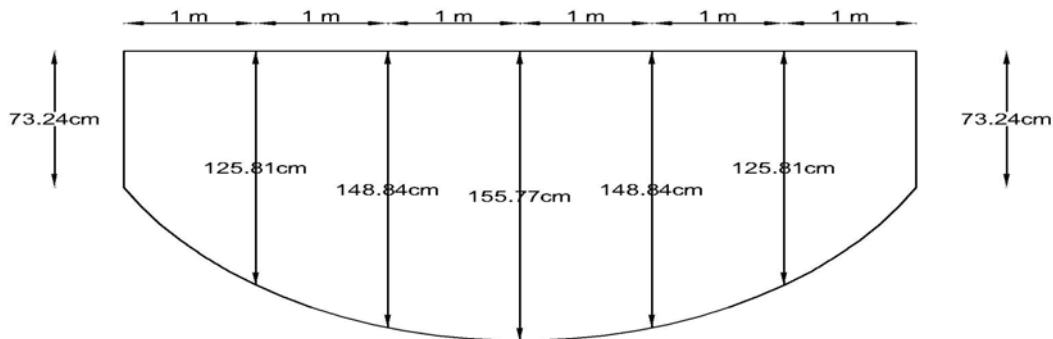
$$\therefore A = \frac{d}{3} * (1^{st}\, ordinate + last\, ordinate + 4 * \sum even\, ordinates + 2 * \sum odd\, ordinates)$$

$$or, A_r = \frac{100}{3} \{73.24 + 73.24 + 4 * (125.81 + 155.77 + 125.81) + 2 * (148.84 + 148.84)\}$$

$$or, A_r = 79046.67\, cm^2 = 7.91\, m^2$$

iii. Volume of Canal

The volume of canal can be calculated by mean sectional area method.
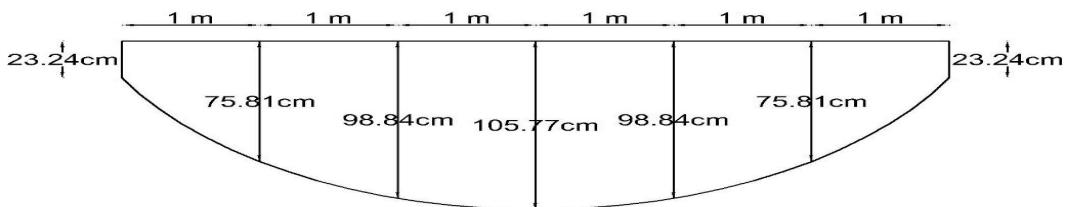
$$V = \frac{A_f + A_r}{2} * L$$

$$or, V = \frac{4.91 + 7.91}{2} * 100 = 641 \ m^3$$

2.4 Estimating Format

S.No.	Descriptions	N				

2.5 Methods of Earthwork Calculation

1. Mid Sectional Area Method

When the height of bank or depth of cutting is different at the two ends of a section, the mean depth may be taken as:

$$d_m = \frac{d_1 + d_2}{2}$$

Area of the mid-section, $= B * d_m + s * d_m^2$

Volume of the whole section of length L is given by,

$$V = Area \ of \ mid \ section * Length$$

$$\therefore \ V = (Bd_m + sd_m^2) * L$$

2. Mean Sectional Area Method

Sectional area at one end, $A_1 = Bd_1 + sd_1^2$

Sectional area at another end, $A_2 = Bd_2 + sd_2^2$

Mean sectional area, $A_m = \frac{A_1 + A_2}{2}$

Volume of entire section, $V = Mean\ sectional\ area * Length$

$$or, V = A_m * L$$
$$\therefore V = \frac{A_1 + A_2}{2} * L$$
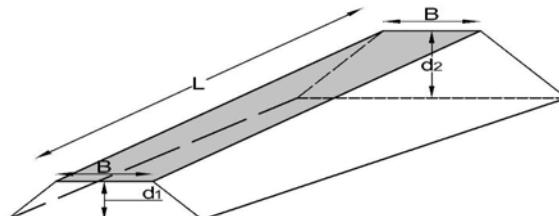
3. **Trapezoidal Formula**

A_1,A_2,A_3,.......A_n are the cross sectional areas separated by a common distance D.

Volume of the entire section can be given by trapezoidal formula as

$A_1, A_2, A_3, ...A_n$ are the cross sectional areas separated by a common distance D.

Volume of the entire section can be given by trapezoidal formula as

$$V = \frac{D}{2}(A_1 + A_n + 2 * (A_2 + A_3 + \cdots. A_{n-1})$$
$$\therefore V = \frac{D}{2}(1^{st}area + last\ area + 2 * sum\ of\ remaining\ areas)$$

4. **Prismoidal Formula**

$A_1, A_2, A_3, ...A_n$ are the cross sectional areas separated by a common distance D.

Volume of the entire section can be given by prismoidal formula as:

$$V = \frac{D}{3} * \{A_1 + A_n + 4 * (A_2 + A_4 + A_6 + \cdots....) + 2 * (A_3 + A_5 + A_7 + \cdots.)\}$$
$$\therefore V = \frac{D}{3}(\{First\ Area + Last\ area + 4 * (sum\ of\ even\ areas) + 2 *$$
$(sum\ of\ odd\ areas)\}$

The sectional dimensions of the front and rear section of the canal are given below:
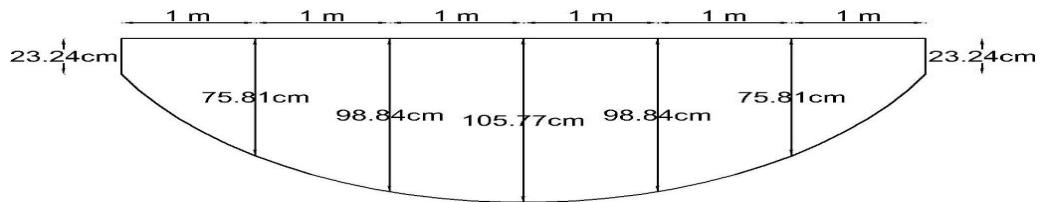
Front End

Rear End

Based on the above information:
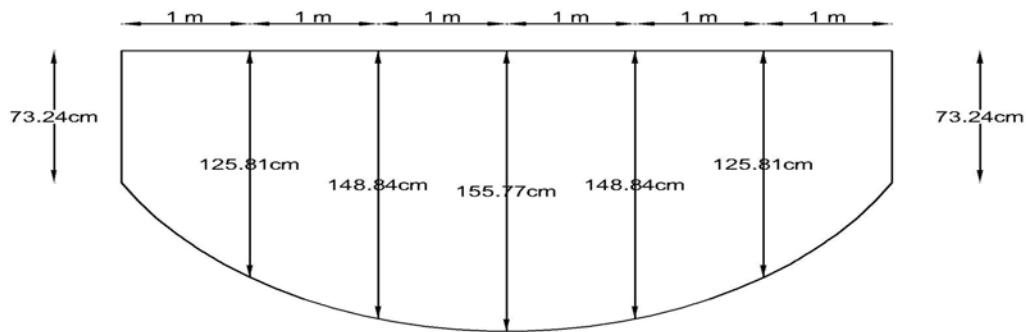
Exercises

Choose the correct answer from the given alternatives.

1. The correct Trapezoidal formula for area is...........

    a. D (first ordinate + last ordinate $+\sum$ even ordinate +odd ordinate)

    b. D/3 (first ordinate + last ordinate $+4 \sum$ even ordinate $+2\sum$odd ordinate)

    c. D/2 (first ordinate + last area+2 (even ordinate +odd ordinate)

    d. D/6 (first ordinate + last ordinate $+2 \sum$ even ordinate $+2\sum$odd ordinate)

2. The correct Prismoidal formula for volume is...............

    a. D (first area + last area $+\sum$ even area +odd area)

    b. D/3 (first area + last area+4 $\sum$ even area $+2\sum$odd area)

    c. D/3 (first area + last area+2 $\sum$ even area $+4\sum$odd area)

    d. D/6 (first area + last area+2 $\sum$ even area $+2\sum$odd area)

Write short answer to the following questions.

1. Prepare typical format of estimate?

2. Write the formula for the area of trangle.

Write long answer to the following questions.

1. What are the methods of earthwork calculations? Explain.

Unit 3: Estimate Quantity of Masonry Footings & Super Structure Wall

3.1   Masonry Footing
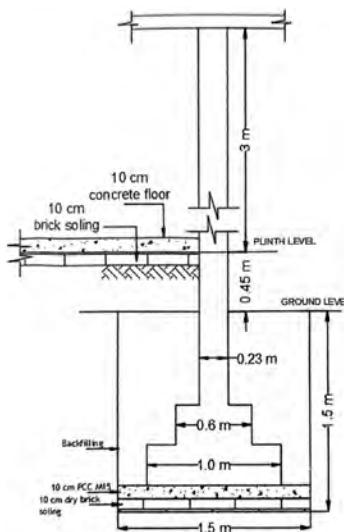
Figure 1: Masonry Footing

3.2   Write Items of Works for Footing Construction

Items of work for footing construction are:

- Earthwork
- Dry soling
- PCC
- Masonry work
- Backfilling

Table 1: Format of estimate

S.N.	Description of items	Unit	No.	Length	Width	Depth	Quantity	Remarks
1	E/W in excavation	Cum	1	2	2	3	12	
2	Flat Brick soling	Sq. m	1	2	2	-	4	
3	PCC	Cum	1	2	2	0.1	0.4	
4	Brickwork	Cum						
a.	First Step		1	1.5	1.5	0.1	0.225	

b.	Second Step		1	1	1	0.1	0.1	
c.	Third Step		1	0.5	0.5	0.1	0.025	
d.	Up to ground level		1	0.23	0.23	2.5	0.132	
Total							0.482	
5	Backfilling	Cum	1	2	2	3	12	
Deduction for Brick work Quantity							-	
Net quantity of Backfilling							11.518	

3.3 Draw Simple Super Structure Wall
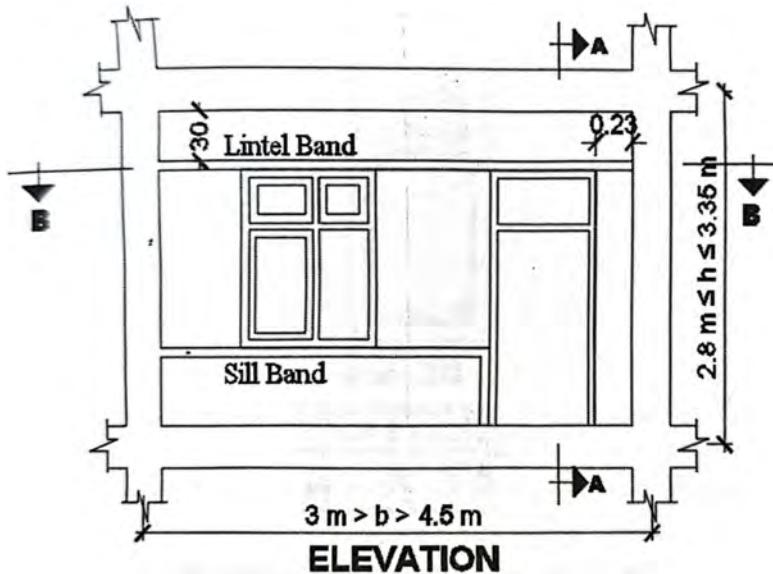
Figure 2: Simple Superstructure wall

3.4 Calculate Quantity of Single Room

Plan and sectional view of a single room without openings are shown in figure below. In order to calculate the brickwork in walls we can use following method:

1 Long wall and Short wall method

2 Center line method

3 Partly center line and partly cross wall method.

Long Wall and Short Wall Method

In this method, the wall along the length of room is considered to be long wall while the wall perpendicular to long wall is said to be short wall. To get the length of long wall or short wall, calculate first the center line lengths of individual walls. Then, the length of long

wall, (out to out) may be calculated after adding half breadth at each end to its center line length. Thus, the length of short wall measured into in and may be found by deducting half breadth from its center line length at each end. The length of long wall usually decreases from earth work to brick work in super structure while the short wall increases. These lengths are multiplied by breadth and depth to get quantities.
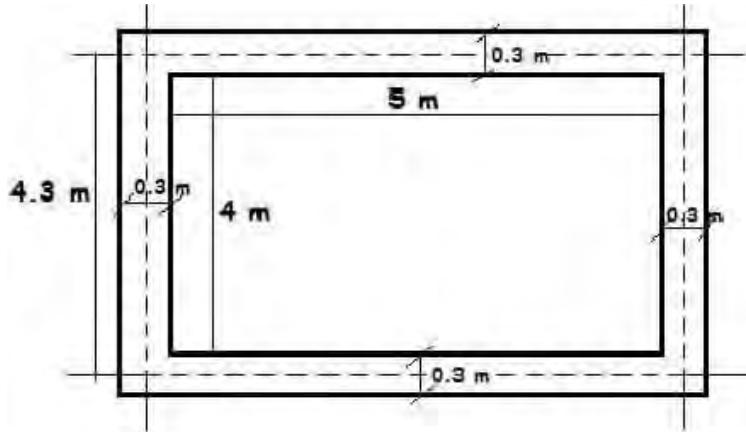
From figure,

Length of long wall = 5.3 + (0.3/2) * 2 = 5.6m

Length of short wall = 4.3 – (0.3/2) * 2 = 4m

Center Line Method

This method is suitable for walls of similar cross sections. Here, the total center line length is multiplied by breadth and depth of respective item to get the total quantity at a time. When cross walls or partitions or verandah walls join with main wall, the center line length gets reduced by half of breadth for each junction. Such junction or joints are studied carefully while calculating total center line length. The estimates prepared by this method are most accurate and quick.

From figure:

Centre to Centre length = 4.3 * 2 + 5.3 * 2 = 19.2 m

Partly Center Line and Partly Cross Wall Method

This method is adopted when external (i.e., around the building) wall is of one thickness and the internal walls having different thicknesses. In such cases, center line method is applied to external walls and long wall- short wall method is used to internal walls. This method suits for different thicknesses walls and different level of foundations. Because of

this reason, all Engineering Departments are practicing this method.

3.5   Deduction Items

Some repeated portions like walls, verandah and other openings such as doors, windows, ventilations etc. are considered as deduction items in the process of estimation

3.6   Draw Simple Concrete Flooring Works
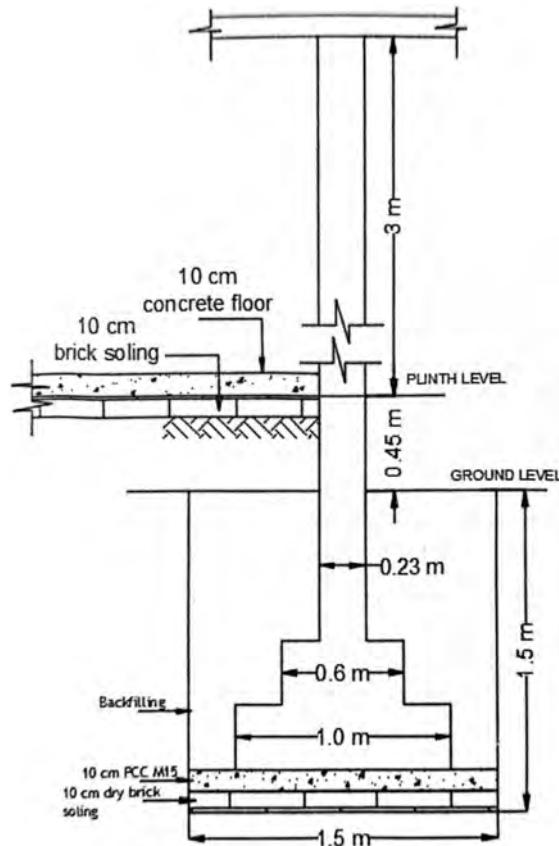
Figure 3: Concrete flooring work

3.7   Determine Density of Steel and Concrete

To determine the density of steel and concrete, you can use the following formulas:

Steel

Density = Mass/Volume. The density of steel is typically between 7,750 and 8,050 kg/m^3. The density of steel can vary slightly depending on its grade and chemical composition.

Concrete

Density = Mass/Volume. The density of concrete depends on the proportions of its

ingredients, such as cement, water, sand, and gravel. A typical concrete mix has a density of around 150 pounds per cubic foot

3.8 Draw Reinforcement Details of Simple Beam, Lintel, Column and Slab
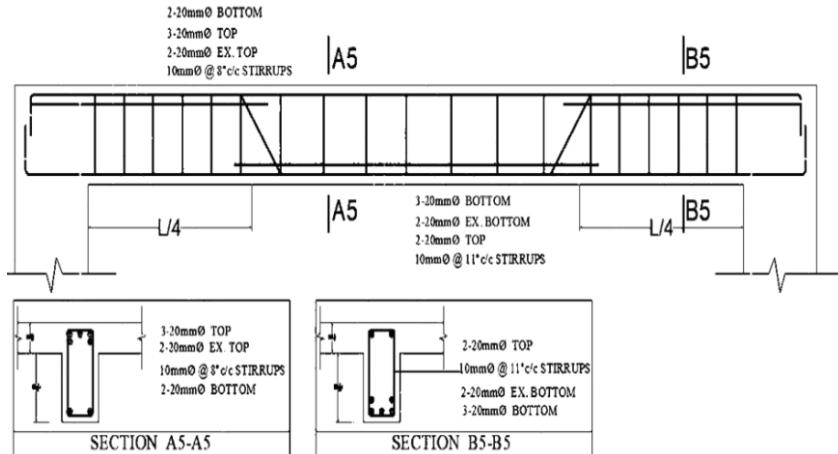
Figure 4: Reinforcement details of a simple beam
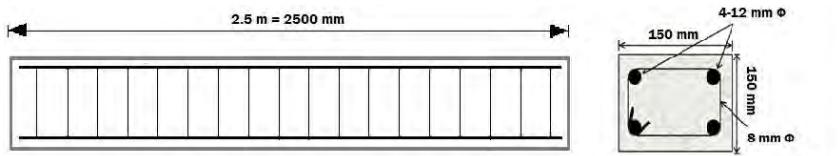
Figure 5: Reinforcement details of lintel
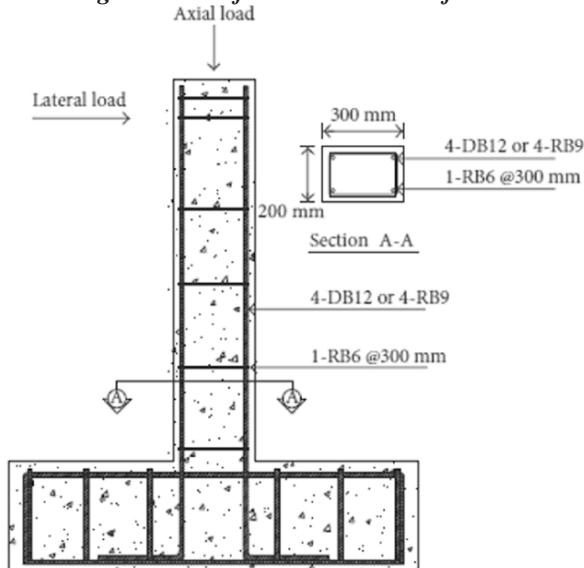
Figure 6: Reinforcement Detail of column
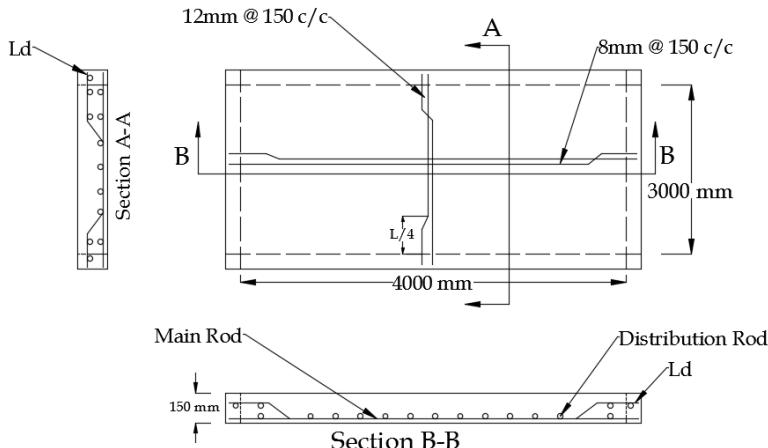
Figure 7: Reinforcement Detail of slab

3.9 Find out Reinforcement Spacing, Bends, Hooks and Development Length

- **Spacing**

  The minimum spacing between two reinforcement bars is the maximum size of the aggregate plus 5 mm. The number of bars can be calculated using the formula:

  $No.\,of\,Bars=(Span/Spacing)+1$

- **Bends**

  The length of a hook for a bar can be taken as 9 times the diameter. The total length of a bar with a hook at both ends is L+18D. The additional length for a bent-up bar depends on the degree of the bend:

- **45 degrees:** The additional length is $0.42d$ or $0.45d$
- **30 degrees:** The additional length is $0.27d$ or $0.3d$

Development Length

The development length is the length of rebar that needs to be embedded in concrete to develop its full tensile capacity. The development length can be calculated using the formula

$Ld=\phi\times0.87fy4\tau bd$

Inadequate development length: Inadequate development length can lead to:

- Rebar pulling out of the concrete
- Cracking in the concrete
- Reduced load-carrying capacity of the structure

Estimating, Costing and Supervision/Grade 10

3.10 Estimate Simple RCC Works

Estimate of RCC is prepared for the following purpose:

I. To purchase the required amount of steel from market

II. To determine the amount of steel required in site

III. To prepare bill of quantities.

A beam and slab structure is shown in figure below. Calculate the quantity of steel reinforcement

3. A beam and slab structure is as shown in figure below. Calculate the quantity of steel reinforcement.
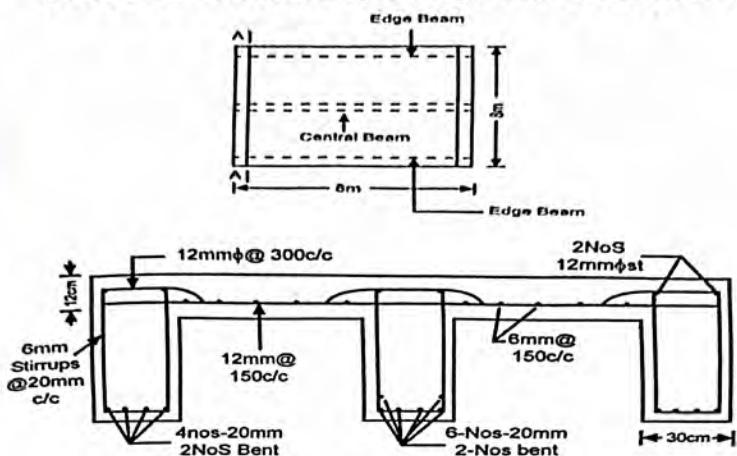
Solution

Let's suppose clear cover is 35 mm.

(1) SIze of bar and position	(2) Overall length	(3) Extra length			(4) less cover (cm)	(5) Acutal length 2+3-4 (cm)	(6) No. of bars	(7) Total length (cm)
		Lap cm	Crank cm 0.42d	Hook cm 9.D				
i. 12 mm straight bab alternate @ 30 cm c/c	800	–	–	2×9×12 mm=22	5	817	810 /30 +1 = 28	22876
ii. 12 mm bend up bars alternate 30 cm/c/c	800	–	4×0.42×7=12	22	5	829	28	23221
iii. 6 mm Distribution bar (a) 15 cm c/c	800	–	–	2×9×6 mm =11	5	806	795 15 +1 = 54	43524

Solution

Let us suppose clear cover is 35 mm.

Size of bar and position	Overall length	Extra length			Less cover (mm)	Actual length (mm)	No. of bars	Total length (mm)
		Lap (mm)	Crank (mm)	Hook (mm)				

12 mm straight bars alternate @ 300 mm c/c	8000	-	-	220	50	8170	28	228760
12 mm bend up bars alternate 300 mm c/c	8000	-	120	220	50	8290	28	232210
6 mm distribution bars alternate @ 150 mm c/c	8000	-	-	110	50	8060	54	435240

Now, Total weight

i.   12 m bars $= 22876 \dfrac{12^2}{162 \times 100} = 203.34\ kg$

ii. 12 mm bent up bars $= \dfrac{23212 \times 12^2}{162100} = 206.4\ kg$

iii. 6 mm dia. bars $= \dfrac{43524 \times 6^2}{162100} = 96.72\ kg$

Total weight $= 203.34 + 206.4 + 96.72\ kg = 506.47\ Kg$

3.11 Define Plastering, Punning and Pointing Works

Plastering: A thin layer of mortar is applied to walls and ceilings to create a smooth, even finish. Plastering can be done on interior or exterior surfaces. It can also protect the underlying material and act as a damp-proof coat.

Pointing: The mortar joints between masonry units, such as bricks or stones, are repaired or renewed. Pointing is usually done on the exterior of a building. It involves raking out old mortar, cleaning the joints, and repointing with fresh mortar.

Punning: A fine job in building construction that forms the beauty of a building. It is the process of applying a thin layer of mortar or plaster onto the surface of interior and exterior walls to create a smooth and even finish.

3.12 Estimate Plastering, Pointing and Punning Works

Estimating plastering and punning (external only) from the following figure
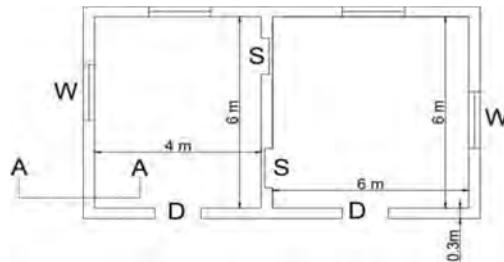
Double room plan

Wall thickness = 0.30 m

Height of room = 3m

Size of D = (1.2 × 2) m

Size of W = (1.2 × 1) m

Shelves S = (1 m x 1.5 m)

S.N.	Items of Work	Unit	No.	L	B	H	Q	Remarks
1	Internal Plaster							
1.1	Room 1	M²	1	19.9	-	3	59.7	
1.2	Room 2	M²	1	19.9	-	3	59.7	
	Deduction							
	Door	M²	2	1.2	-	2	4.8	
	Window	M²	4	1.2	-	1	4.8	
	Shelves	M²	2	1	-	1.5	3	
2.	External Plaster	M²		33.8	-	3	101.4	
	Deduction							
	Door	M²	2	1.2		2	4.8	
	Window	M²	4	1.2		1	4.8	
	Shelves	M²	2	1		1.5	3	

3.13 Draw One, Two, and Multi Room Building
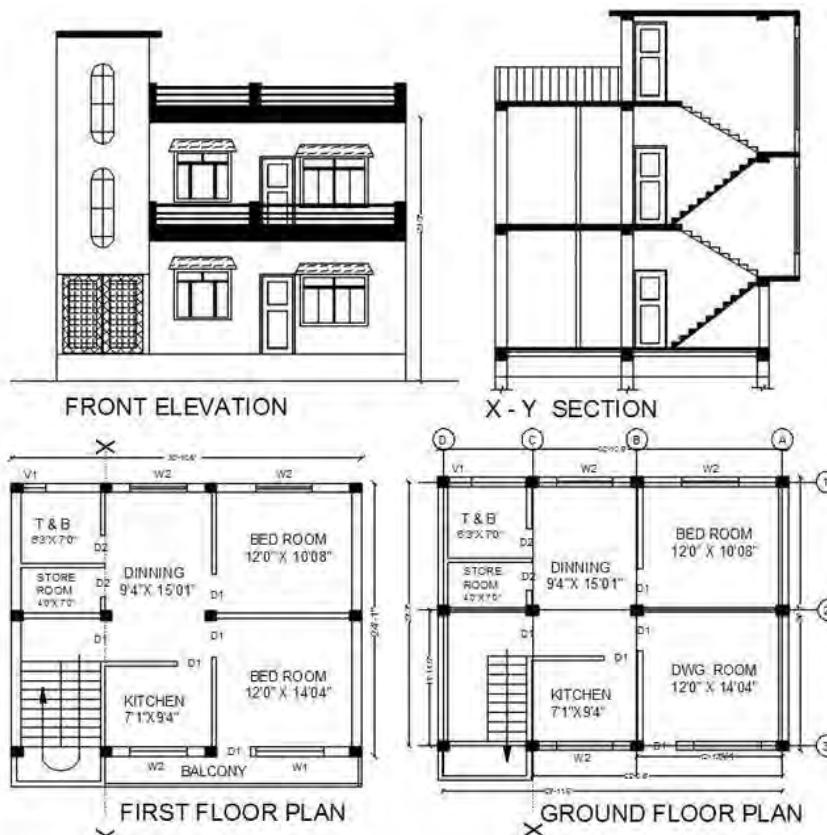
FRONT ELEVATION

X - Y SECTION

FIRST FLOOR PLAN

GROUND FLOOR PLAN

Exercises

Choose the correct answer from the given alternatives.

1.   The quanitity of brick masonry is measured in ......

    a. Square meter   c. Cubic meter

    b. Kilogram   d. Meter

2.   Which of the following is included in the substructure?

    a. Lintle   b. Footing

    c. Roof/slabe   d. Parapet wall

Write short answer to the following questions.

1.   Write the formula for calculating the volume of brick masonry in a wall.

2.   What are the components of a typical footing?

Write long answer to the following questions.

1.   A wall is 10 meter long, 3 meter high, and 0.3 meter thick. Calculate the total quantity of brick masonry.

Unit 4: Rate Analysis

4.1 Introduction

Analysis of rates is the process of calculating per unit item rate by considering cost of materials, cost of labors, hire charge of tools plants and equipment as well as contractor's profit and overheads, taxes etc.

4.2 GON Norms and Current District Rates

GON Norms: Standards set up by Nepal Government in the various items of rate analysis are GON Norms. It includes quantities of materials and number of labours for completing any particular item of works.

Current District Rate: The rates of various types of materials used within any district and also the wages of different types of labors (i.e. skilled and unskilled), technical personnel, etc. are revised and stated at the beginning of every fiscal year and are used for every government project are called current district rate. It is revised every fiscal year by concern office.

4.3 Define Overhead, Water Charge, Tools and Plants, Profit and VAT

Overhead or Overhead Expenses: It refers to an ongoing expense of operating a business. Overheads are the expenditure which cannot be conveniently traced to or identified with any particular cost unit, unlike operating expenses such as raw material and labor. Employee salary office equipment and supplies, travel and entertainment costs, etc. are the examples of the overhead cost. There are two types of overhead cost. They are general overhead and job overhead. It is called combining with contractors' profit.

Water Charge: For drinking of the workers and also for the work, there is an arrangement of water either by sinking tube well or by temporary connection from municipality or corporation i.e. 1% of total cost of the materials and labor is provided as water charge in the analysis of rate.

Tools and Plant: For the purpose of hiring of tools and plants are required for completing some particular item of work, there is provision of adding 3% of the total

Estimating, Costing and Supervision/Grade 10

cost of unskilled labor in the rate analysis of those works requiring such tools and plants.

Profit: Combining overhead and contractor's profit, there is provision of adding 15% of total cost (i.e. cost of materials, labors and hire of tools and plants).

VAT: VAT stands for Value Added Tax which accounts for 13% of vatable amount (total cost of materials that account for VAT).

4.4   Man and Materials Consumption

1.	**Earthwork excavation in soft clay and silt soil including disposal upto (1.5m lift and 10m lead).**						
	Analyzed for: **1 m³**						Norms S.N. **2-1**
	Resources	Level / Type	Quantity	Unit	Rate per unit	Amount	Remarks
	Labours	Unskilled	**0.7**	no.	800.00	560.00	
	Tools & equipments @ 3% of total labour cost					16.80	
	Sub-Total					**576.80**	
	15% Contractor Overhead					86.52	
	Grand-Total					663.32	
2.	**Earthwork Excavation in Gravel and Boulder Mixed Soil Including Disposal upto (1.5m lift and 10m lead)**						
	Analyzed for: **1 m³**						Norms S.N. **2-2**
	Resources	Level / Type	Quantity	Unit	Rate per unit	Amount	Remarks
	Labors	Unskilled	0.8	no.	800.00	640.00	
	Tools and equipment @ 3% of total labor cost					19.20	
	Sub-Total					**659.20**	
	15% Contractor Overhead					98.88	
	Grand-Total					758.08	

4.5 Ratios of PCC in Practise (1:3:6, 1:2:4)

Ratios of PCC in practice:

Grade of concrete	Proportion (C:S:A) by volume-(Nominal Mix)
M25	1:1:2
M20	1:1.5:3
M15	1:2:4
M10	1:3:6
M7.5	1:4:8
M5	1:5:10

Note:

If the thickness of PCC is not given, we use the no. of skilled and unskilled labours as given in the Norms and Standards of Nepal Rate Analysis.

No. of skilled labor = 1

No. of unskilled labor = 4

4.6 Calculations of Dry Volume and Wet Volume of Ingredients

1. **In concrete mix:** To get dry mix (Cement+Sand+Aggregates) increase 50% to 55% of wet mix.

2. **In mortar mix:** To get dry mix (Cement+sand) increase 30% to 35% of wet mix.

3. **In plastering works:** Firstly, increase 25% for filling in between joints and irregular surface. In case of ceiling and concrete surface (plain surface) only 10% - 15% increase of wet mix to get total wet mix. Then, to get dry mix (Cement+sand) increase 30% to 35% of wet mix.

4. **In case stone works:** To get required stone 15% - 20% increase of total works due to wastage and dressing. Volume of dry mortar mix = 30% to 40% of stone masonry.

5. **In RCC work:** To get reinforcement: 1% of volume of RCC. Binding wire: 1Kg per quintal.

Example: 5 cm thick Foundation PCC (1:3:6), 0.95 m wide and 42 m long.

Total quantities of work (PCC) = 42 x 0.95 x 0.15 = 5.99 m3

To get dry vol. of concrete mix increase 50% to 55%,

Vol. of dry mix = 1.5 x 5.99 = 8.99 m3

Total part of mix proportion = 1+3+6 = 10

Required,

Cement = 8.99 x (1/10) = 0.899 m3 = 0.899 x 28.8 = 25.89 bags

Sand =0 .899 x 3 = 2.697 m3

 Aggregate = 0.899 x 6 = 5.394 m3

Water/Cement = 0.5

Water = 0.5 x 25.89 x 50 = 647.25 lit.

4.7 Rate Analysis of E/W, PCC, Form Works, Plastering, Reinforcement Bar

Rate Analysis for Steel Reinforecement Works

- Density of Concrete (PCC)= 2400 kg/m^3
- Density of sand = 1400 kg/m^3
- Density of steel (Reinforcement)= 7850 kg/m^3

No. of labours for PCC of RCC works per m^3

- No. of skilled labour = 0.8
- No. of unskilled labour = 7
- Weight of Binding Wire =1 kg per Quintal

Assuming Weight of Steel Reinforcement = 1% volume of PCC of RCC Works (wet volume)

> **Steel Reinforcement for RCC works per 1MT:**
>
> No. of skilled labour = 12
>
> No. of unskilled labour = 12

4.8 Calculations of a Cubic Meter of Brick Work

Rate Analysis for Brickwork

- Size of a brick = 230*110*55 mm
- Thickness of mortar = (10-12) mm
- Normal size of brick with mortar = 240*120*65 mm
- Density of a brickwork = (1900-2100) kg/m^3

No. of labours required for brickwork per m^3

- No. of skilled labour = 1.5
- No. of unskilled labour = 2.2
- Helper = 0.2 (for ground floor)

  = 0.7 (for 1st floor)

No. of bricks required for 1m3 brickwork = 560 for handmade bricks

= 530 for machine made bricks

4.9 Ratios in mortars (1:4, 1:6)

1:4 Mortar

1 part cement

4 parts sand

This means for every 1 volume unit of cement, you mix 4 volume units of sand.

1:6 Mortar

1 part cement

6 parts sand

For every 1 volume unit of cement, 6 units of sand are added.

Exercises

Choose the correct answer from the given alternatives.

1.   Rate analysis is used to ....

   a. Design the structure   c. Calculate material strength

   b. Estimate the cost of work per unit quantity d. Measure land

2.   Which of the following is not included in rate analysis?

   a. Material cost   b. Labour cost

   c. Earthquake data   d. Tools and equipment charges

Write short answer to the following questions.

1.   Define rate analysis in civil engineering.

2.   List any four component considered in rate analysis.

Write long answer to the following questions.

1.   A plastering work is to be carried out for 10 sq.m. using 1:6 cement mortar. Perform a detailed rate analysis.

Project Work

1.   A Rcc work is to be carried out for 10 sq.m. using 1:2:4 mortar. Perform a detailed rate analysis.

Unit 5: Quotation and Tender Documents

5.1 Define Quotation and Tender

Quotation: It can be defined as a formal document given by the prospective supplier to supply the stated goods or services needed by the buyer at the stated price under specific conditions. It helps the buyer in knowing the cost of goods or services, before making a purchase.

Tender: It is an offer to provide product or services at quoted prices and specified quality, but subject to specific conditions. An invitation to tender is floated by the government, financial institution or a big corporation for different projects when they want to purchase goods on a large scale, hire services or construct something.

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NOTICE INVITING TENDER

(Published on 17 May 2019)

Embassy of Nepal in New Delhi invites Sealed Tender from eligible firms / contractors in Two Bid System for the following work:

NIT NO. 03/NIT/Nepal Embassy/2019

NAME OF WORK: CONSTRUCTION OF PERIPHRAL PEDESTRAIN PATHWAY AROUND BOUNDARY WALL OF THE EMBASSY OF NEPAL AND PROVIDING & INSTALLATION OF OUTDOOR GYM EQUIPMENT

Estimated Cost	INRs. 15,59,555/- (Indian Rupees Fifteen Lakhs Fifty-nine Thousand Five Hundred Fifty-five Only) (inclusive of GST)
Earnest Money	INRs. 50,000/- (Indian Rupees Fifty Thousand Only)
Cost of Tender document (Non-refundable)	INRs. 650/-
Time of Completion	45 Days
Last Date & Time of Submission of Bids	31st May, 2019 UPTO 15:00 Hrs.
Date & Time Of Opening Of Technical and Financial Bid	31st May, 2019 AT 15:30 Hrs.

The Embassy retains the right to amend / modify / annul the notice, if required. For further details, please contact at:

Embassy of Nepal,
Barakhamba Road, New Delhi
Phone: 011-23476247, 23476285;
Email: eonnewdelhi@mofa.gov.np

Figure 8: Format of tender notice

5.2 Quotation and Tender Documents

Tender Document: It is a document prepared by the concerned firm making

invitation to bid/tender from the competent bidders by filling up the suitable rates in the rate column. It is prepared before publishing the tender notice. It is also known as ***bid document.*** It includes the following:

- Instruction to bidders
- Design drawings
- Terms of reference
- Schedule of work
- Bill of quantities
- Evaluation criteria
- Conditions of contract

Quotation Documents

- Overall cost
- Breakdown of the components with price
- Valid document for the quotation period
- Full contact details of business office/enterprises
- Schedule indicating when the work will be done or product delivered.
- Terms of payment and schedule

5.3 Conditions of Contract

Conditions of Contract: Construction involves owner, contractor and consultant (Engineer/Architect). Thus, in the agreement, there must be clauses or conditions which shall define the duties and responsibilities of the owner, contractor and consultants. It depends upon the nature of work, type of contract and situations. Special type of work or special situation usually demands special conditions. Some of the common conditions of the contracts are given below:

- Definition of the term used
- Contract duration
- Engineers duties and authority
- Payment procedure
- Security deposit
- Defective work

- Addition and alterations
- Price escalation, etc.

Special Conditions of Contract

It relates to specific contract which includes terms and conditions applicable for particular contract only and will vary for each contract depending upon nature of work, supplier and other factors. They shall be read in conjunction with GCC. It extends anything not included and modified in supplementary conditions. The SCC provides additional detail and addresses unique circumstances that are not covered by the GCC.

5.4 Types of Contract

Types of contract: Construction work can be executed through following contract:

- **Cost Plus Percentage Contract:** Under this procedure contractor is paid for the actual work performed and an agreed percentage or a fixed sum or a fluctuating fee for the contractor. It has advantages of early completion of work, work of good quality, elimination of disputes arising due to extra work.

- **Equipment Contract**: In this type of contract, contract is given for the supply and management of equipment required for. For other conditions, agreement will prevail.

- **Item Rate Contract**: In this type of contract, contractor agrees to execute the work on the item rate or unit price basis. Work is divided into several activities and rate is fixed for each unit of such activities. Contractor is paid for the total quantity of work done by him. This type of contract is considered suitable for the works that can be broken down into several activities and measurements of quantities are possible.

- **Lump-sum Contract**: In this type of contract, work is carried out as per as drawing and specification given by a client within a specified time in a fixed amount. In this type of contract, detailed estimate is not necessary. Similarly, on the completion of the works whose cost can be guessed with reasonable accuracy. It is considered unsuitable for the work such as difficulty foundation, emergency project, likely to have addition and alterations, etc.

- **Labor Contract**: It is a type of contract in which contract is given for labour only. The owner (or the department) provides all the other required materials, plants, etc. to the contractor. Usually along with the labor, contractor provides

simple tools. Most of the residential buildings are seen constructed on this basis. The contractor is usually paid on item rate or on the lump-sum contract.

- **Material Contract:** In this type, contract is given for the supply of materials required for works. For other condition, agreement will prevail.

- **Target Contract**: In this type, first a target of cost for execution of the work is fixed. Then if the work is completed as per the target, contractor is paid the target amount and an agreed percentage. In addition to this, contractor receives a percentage plus or minus on saving on extra expenditure than the target value.

- **Build Own Operate and Transfer (BOOT) contract**: It is a public private partnership project model in which a private organization conducts a large development project under contract to a public sector partner. The private organization builds the project, owns and operates it for a certain period of time and later hands it over to the public entity.

- **Engineering, Procurement and Construction (EPC) contract**: It is a type of contract in which the contractor designs, procures goods and constructs the project as per his design and hands it over to the public entity after completion of construction.

5.5 Contract Award Procedure

Contract Award Procedure: For the execution of any work, different kinds of contractor are required based on the volume of works. For this prequalification of contractor are required if the number of contractors are much more. First of all, bidding documents are prepared, published through national or international paper to inform the contractors, based on the specified criteria contractors are prequalified.

The eligible contractors purchase the tender documents and submit within the time bond specified by the client. After receiving the tenders from different contractors, a comparative chart is prepared based on the financial value, technical value, equipment value and experience value gained in past specified years. The contractor having lowest value is selected to perform the specified work.

Following are the contract procedures for awarding any types of work to the contractor:

1. Initiation of the proposal of the work.
2. Getting administrative approval of the work.

3. Preparation of design, cost estimate and bidding documents.

4. Publication of tender notice

5. Pre-qualification of bidders

6. Invitation of bids from the eligible bidders.

7. Obtaining of bids and the earnest money deposit.

8. Opening of bids

9. Evaluation of bids

10. Selection of lowest evaluated substantially responsive bid

11. Award of contract to the successful bidder

Exercises

Choose the correct answer from the given alternatives.

1.   ……   a document released by a government establishment or a private company inviting tender proposals from other businesses.

    a. Tender Notice   b. Bidding

    c. Contact   d. All of the above

2.   ……   An agreement enforceable by law concluded between two or more parties.

    a. Tender Notice   b. Bidding

    c. Contact   d. All of the above

Write short answer to the following questions.

1.   Explain about conditions of contract?

2.   Compare between quotation and tender?

Write long answer to the following questions.

1.   What are the types of contract? Explain

2.   Explain contract award procedure

Unit 6: Supervision Works

6.1 Definition of Supervision and Supervisor's Roles

Supervision: It is defined as the process of inspecting and thoroughly monitoring the activities performed by the subordinates or employees and assess the compliance of the performed works with the specified standards. It is a method of quality control and maintaining the effectiveness of the work. It includes planning, organizing, directing and controlling the work and the activities of subordinates or employees.

Supervisor is a person who supervises a person or an activity.

6.2 Duties of Supervisor

The duties of supervisor for running activities in any site are:

- Analyze the work plan submitted by the contractor and give advice if necessary.
- Supervise the works done in the site on the basis of drawings, specifications and bill of quantities from commencement to the completion.
- Testing different materials used in the site.
- Prepare site order book for visiting superior officials.
- Maintain safety measures inside the site and also check them.
- Prepare progress reports of the ongoing or completed works and forward it to the head office.

6.3 Interrelationship among Client, Consultant and Contractors

In the construction work, the client hires the consultant not only to design the project, but to manage the construction process and be the interface between the client and the contractor.

The contractor is hired by the client, with the assistance of the consultant, who will request bids, review them, seek clarifications and recommend to the client who he feels is the contractor of choice. The client may or may not accept the consultant's recommendations, and hires the contractor.

During construction, the contractor interfaces with the consultant, who will be an impartial representative of the client. The client will pay the invoices set forward by the contractor only after they have been reviewed and approved by the consultant. Ideally, the contractor will have little or no contact with the client, as the client is not a construction professional and could be mis-lead. The client gets the assurance of the work progress and the quality from the engineer.

In short:

- **Engineer/Architect:** Designs and manages the construction
- **Client:** Hires architect/engineer and contractor and pays the bills

Exercises

Choose the correct answer from the given alternatives.

1. Who is employer?
    - a. Client
    - b. Consultants
    - c. Contractor
    - d. None of the above

2. The main objective of supervision is:
    - a. To make drawings
    - b. To manage labor salary
    - c. To ensure work is done as per plan and specificaion
    - d. To measure land

3. Which document is essential during site supervision?
    - a. Bank passbook
    - b. Site dairy
    - c. House map
    - d. Lnad deed

Write short answer to the following questions.

1. What are the duties of supervisor?

2. What is the site dairy and why it is important?

3. List the document a supervision must maintain at a construction site.

Write long answer to the following questions.

1. Explain relationship between client, consultant and contractor?

2. Describe the steps a supervision should follow during concereting work?

Unit 7: Construction Site Management

7.1 Major Components of Construction site (site office, store, fabrication yard, worker accommodation, toilets)

Construction Site Management: The process of proper management of waste materials from the site, arrangement of construction materials, tools and equipment, worker's accommodation and making the site clean and attractive is called construction site management. The main objective of construction site management is to carry out the construction works in a safe and efficient manner.

Construction Site Management Works Include

- Proper management of construction equipment, tools used during construction.
- Proper management of solid concrete, reinforcement bars, cement, sand, aggregate, etc.
- Avoiding unnecessary accumulation of waste inside the site.

Major Components of Construction Site

- **Site Office:** For the analysis of day to day works carried out on site, reviewing estimates, bill of quantities, designs, and drawings and carrying out other official works, an office is constructed near the site which is called site office. Reports about ongoing progress of the works is sent to head office through site office.

- **Store:** For storing the construction materials during construction without hampering their quality, tools and equipment, a place is allocated nearby the site known as store. It also keeps records of materials in stock and materials to be ordered from the suppliers and are demanded.

- **Fabrication Yard:** Different types of steel structures are required to be prepared in desired shape as per design which can't be made directly from the suppliers. So, these types of works are carried out nearby the site known as fabrication yard.

- **Worker's Accommodation:** During the ongoing construction works in the site, there should be provision for workers to stay nearby the site which is

accomplished by construction of worker's accommodation. If the workers are near the site then there will be more progress than workers coming from outside.

- **Toilet:** There should also be provision of toilets for workers as well as other technical personnel nearby the site.
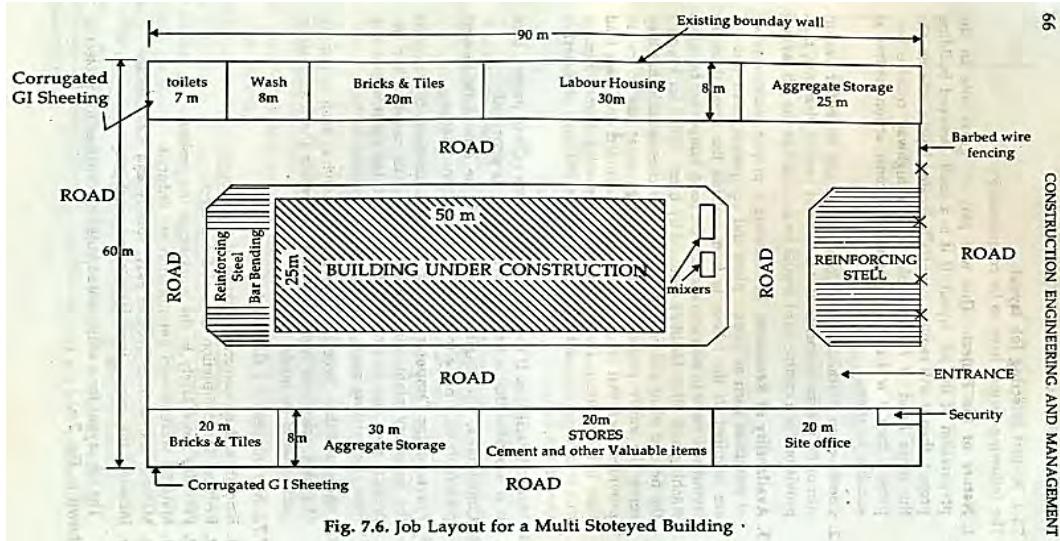
Fig. Site Layout

7.2 Site Logistics

It is the process of planning and executing the efficient transportation and storage of goods from the point of origin to the point of consumption. The goal of logistics is the efficient handling of construction materials in the site. Transportation and warehousing are the two major functions of logistics.

7.3 Site Utilities (telephone, water supply, electricity)

For the effective running of construction activities in the site, there is need of various day to day things, in absence of which the activities will be postponed or there will be delay in the work. Those things are termed as site utilities.

- Telephone is needed for relaying the progress of activities done in the site.
- Water supply is the most important utility which is most essential for the works as well as for the workers too.
- Electricity is another important utility in the absence of which sometimes the work has to be stopped until it is not available in the site.

Estimating, Costing and Supervision/Grade 10

7.4 Surface Drainage and Sanitation

Surface Drainage and Sanitation:

The process of removing the excess water present on the surface of construction site so that there would be no chance of accidents due to slippery surface is called surface drainage.

Sanitation is another factor important to be taken care of in the site. It is directly related with the health of the working people as well as other technical persons involved in running the construction works in the site. Sanitation includes cleaning of site area, collection of all solid as well as liquid waste and its proper disposal.

Arrangement of Equipment: The equipment's to be used in the site is to be arranged in an order so that their operation, maintenance and storing become easy. The mechanical equipment, surveying machines and other vehicles, etc. should be kept in different places nearby the site.

7.5 Site Safety

Site Safety: Safety is the essential factor to be taken care in the site. Accidents happen without giving any early warning. So, one has to be prepared against any possible measure that could lead into accidents.

Proper safety precautions have to be adopted so as to prevent all sorts of accidents ranging from minor to fatal.

Various site safety precautions that should be followed in the site are as:

- Conducting a tool box talk before the starting of the work to instruct the works regarding the safe use of tools and equipment.

- Advising the workers to be concentrated in their work during work time.

- Use of safety tools like reflecting vest, hard helmet, hard boot, goggles, gloves, noise proof devices, etc.

- Providing awareness to the workers regarding the possible causes of accidents and instructing them to adopt safety measures.

- Avoid use of drugs, alcohol, etc. in the site.

- Keeping primary medical treatment utilities near the site and in access of every person involved in the site.

- Securing the critical zones inside the site with warning signs and symbols and also security horn should be available.

- Site should be fenced with appropriate fencing materials to avoid the trespassing of non-concerned people.

Exercises

Choose the correct answer from the given alternatives.

1.   Site office does not include.............

    a. Toilets   b. Meeting room

    c. Fabrication compartments   d. Storages

2.   The purpose of a safety harness is to ....

    a. Carry materials   b. Protect against falling from height

    c. Reduce cement dust   d. Help in lifting heavy equipment

Write short answer to the following questions.

1.   Explain the importance of site safety?

2.   List out four common PPEs used at a construction site.

Write long answer to the following questions.

1.   What are the major components of construction site management? Explain.

Unit 8 : Prepare Log Book & Muster Roll

8.1   Log Book and its Uses

Log Book: It is a systematic daily or hourly record of activities, events and occurrences. It is often used in the workplace, especially by truck drivers and pilots to log hours and distances covered.

Truck drivers use log books to ensure that they are keeping up with various transportation laws. Truck drivers are required to keep a detailed 24-hour log of their location and time spent off and on duty.

Uses of Log Book

- To calculate the distance travelled by vehicle
- To calculate the time taken by the vehicle
- For evaluation of the work done by vehicle
- To give payment to the contractor

8.2   Format of Log Book

Format of Logbook

Vehicle Log Book

lometer reading (at start of period): 3457   Period: [to   ]   Number Plate [   ]

Date	Journey		Odometer reading			Reason for trip	Driver's signature
	From	To	Start	Finish	Dist.(km)		
September 23, 20	Michigan	Lansing	56764	56870	106	Business Trip	

8.3　Definition of Muster Roll

Muster Roll: It is a register used for keeping a complete record of attendance, payment made, unpaid wages and work done by daily labors engaged on the execution of works.

Entry Methods

Generally, labors are paid according to their Roll. In Muster Roll, data are entered as following:

- Name
- Age
- Gender
- Join date of the employee
- Employee type: regular/contract
- Payment rate
- Attendance

8.4　Types of Workers

Types of Workers

According to the requirement of workers, different types of workers are appointed as:

- **Daily workers:** These workers regularly attend the works (i.e. throughout the year)
- **Seasonal workers:** These workers carry out the works in some season and remain unworked during other remaining seasons when there is no work.
- **Permanent workers:** These workers work obeying the rules of some organization as well as paying TAX to the government.

Components of a Muster Roll

Muster roll consists of the following three parts:

a) **Part-1 (Nominal Roll):** In this part of the muster roll full information of the labors employed is recorded and their daily attendance is marked. The labors should be grouped according to their categories such as masons, carpenters, etc.

b) **Part-2 (Register of arrears of wages due to worked people):** This part of

muster roll is used for keeping a record of all unpaid wages.

c) **Part-3 (Details of measurement of work done by labor):** The quantity of the work done by the labor engaged on the Muster Roll is entered in the measurement book, while full particulars of the work done and the reference to pages and numbers of the measurement book are recorded in the part-3 of the muster roll.

Payment Process of Muster Roll

The actual working days of the employees are determined at the end of the month and their absent days are also taken into account. The no. of days exceeding the holidays to be given by the company are also determined and the wages of exceeded holidays is deducted from the actual wage of the employee. This is how the wage of the attended days of the employee is calculated and that amount is transferred to the employee's bank account or directly paid to the employee.

Muster roll format

Contract Labour Act

FORM XVI

¹[See rule 78(2) (a)]

Muster Roll

Name and address of contractor   :-

Name and address of establishment in/ under   :-

which contract is carried on   :-

Name and address of principal employer   :-

Nature and location of work   :-

Wage period Monthly   :-

Sl. No.	Name of workman	Father's/ Husband's name	Sex	Dates																														Remarks
				01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
1	2	3	4	5																															6

Exercises

Choose the correct answer from the given alternatives.

1. Muster roll doesn't consist of

    a. Details of measurement of labor book

    b. Record of wages of worker

    c. Comments made by senior officials

    d. Employee number

2. Muster rolls are used for.

    a. To record the daily construction activity

    b. To pay wages of workers employed on daily basis.

    c. To Evaluate the construction activity.

    d. All the above

Write short answer to the following questions.

1. Explain payment procedure from the muster roll?

2. Write a format for muster roll.

Write long answer to the following questions.

1. Prepare format of log book? What are the importance of log book?

Unit 9: Measurement Book and Billing Process

9.1 Definition of Measurement book (M.B.)

Measurement Book (M.B): The measurements of all the works executed and materials supplied at construction site duly weighed, measured or counted are recorded in a book which is known as measurement book. It serves as the basis for payment to the contractors after completion of some or whole part of the project.

9.2 Importance of Measurement Book

- To check the quantities of actual completed work.
- Various types of bills (running or final) for payment are prepared on the basis of details in measurement book.
- It acts as a valid document avoiding the dispute between client and contractor.

9.3 Size of Measurement Book

Generally, the size of MB is 15 cm(H) X 10 cm(B).

Format of Measurement Book

Name of the Project: Name of the contractor:

Location: ………………   Date of measurements: ………….

SN	Item	Unit	Measurements			Total quantity	Remarks
			L	B	H/D		

Measurement taken by: ………..   Contractor's representative: ……….

Checked by: ……….   Approved by: ………….

Precautions in Entering and Handling of Measurement Book

The following are the precautions during handling or entering data in MB:

- Items stated in agreement should be clearly recorded in MB

Estimating, Costing and Supervision/Grade 10

- All measurements should be recorded in inch/mm.
- No entry is allowed to be erased.
- Errors should be cut with single line and no page should be left blank between two written pages.
- The name of the person preparing, date and index no. of MB should be strictly written.

Endorsement procedure of Measurement Book

- **Progressive Measurement:** It is maintained at the completion of different stages of activity or before each running payment of the activity. The main objective of maintaining the progressive measurement is for monitoring the progress of work and the output of work against the payment made. It is necessary to maintain the progressive measurement book in both the cases whether the work is being implemented on measurement basis or on daily wage basis.
- **Final Measurement:** It is a complete measurement of any physical intervention, which is recorded at the time of completion of any physical intervention. The main objective of maintaining the final measurement is to keep all the measurement at one place. With the help of final measurement actual work done can be compared with the estimate.

9.4 Definition of Bill of Quantities (BOQ)

Bill of Quantities: It is the complete list of all items of work involved in connection with the estimate of a project with the description, quantity and unit rate against each item of work. It is important to release payment to the contractor on the basis of quantity of work.

9.5 Definition of Abstract of Cost

Abstract of Cost: The cost of each and every individual item of work is calculated by multiplying the quantity calculated in the quantity calculation form with the specified rate in tabular form which is known as "Abstract of Cost". It defines the total cost of each items of work done.

9.6 Procedure of Running Bill Payment

Bills are the claims for payment of the works performed.

Types of Bill: Based on the size of the project, there are various types of bill to be

prepared for the purpose of payment to the contractors. They are as:

- **Running Bill**

  This bill is prepared when a construction work is not completed because of large size of project but some portion of particular work is completed and this provides relief to the contractor in different stages of the construction as large project consists of various factors and requires various resources too.

- **Final Bill**

  This bill is prepared after the completion of a project when the contractor applies for final payment. It may also be followed by a running bill. That means although there has been running payment given before, the final bill is to be prepared and this indicates the completion of a project.

Difference Between Running Bill and Final Bill

Running bill	Final bill
The bill prepared by the contractor for seeking payment for the partial works completed while the project is still in progress is known as running bill.	The bill prepared by the contractor for seeking the payment for the complete works done at the end of the project is known as final bill.
It is also called interim payment certificate.	It is also called final payment certificate.
No work completion report is required to be prepared.	Work completion report is prepared along with the final bill.

Procedure of Running Bill Payment

1. The contractor prepares a detailed measurement sheet of the work completed and an abstract of cost of the completed work is prepared as a bill.

2. The total amount of the bill is calculated.

3. Tax, retention money, and advance, if any taken, are deducted from the total amount.

4. A letter along with all these documents is submitted to the consultant for making recommendation for the payment of the bill.

5. The consultant will check the submitted bill within certain time period and forward it to the owner/client for payment to be made.

6. The owner will make payment within the stipulated time period.

Format of the Running Bill:

Name of the project: ………… Name of the contractor: ……..

Date of measurement: ………. Date of Agreement: ……….

Date of running bill: …………

SN	Item	Unit	Measurements			Total quantity	Unit Rate	Amount	Remarks
			L	B	H/D				

Total amount in words:

Bill prepared by: Checked by: Approved by:

Exercises

Choose the correct answer from the given alternatives.

1. Size of measurement book is.

    a.15*10cm   b. 10*10cm

    c. 15*20cm   d. 10*20cm

2. Bill of quantities (BOQ) is prepared based on:

    a. Actual construction quantities

    b. Estimated quantities

    c. Variation in estimated quantities

    d. None of the above

Write short answer to the following questions.

1. Compare between running bill and final bill?

2. What are the importance of measurement book?

Write long answer to the following questions.

1. Explain procedure to prepare running bill?

Unit 10: Layout Work

Layout

Layout of a structure is the process of showing the plan of its foundation on the ground surface according to its drawings, so that excavation can be carried out exactly where required and the position and orientation of the structure is exactly specified. It is set out according to foundation plan drawings and specifications provided by the consultant.

## 10.1 Procedure for the Layout of the Building
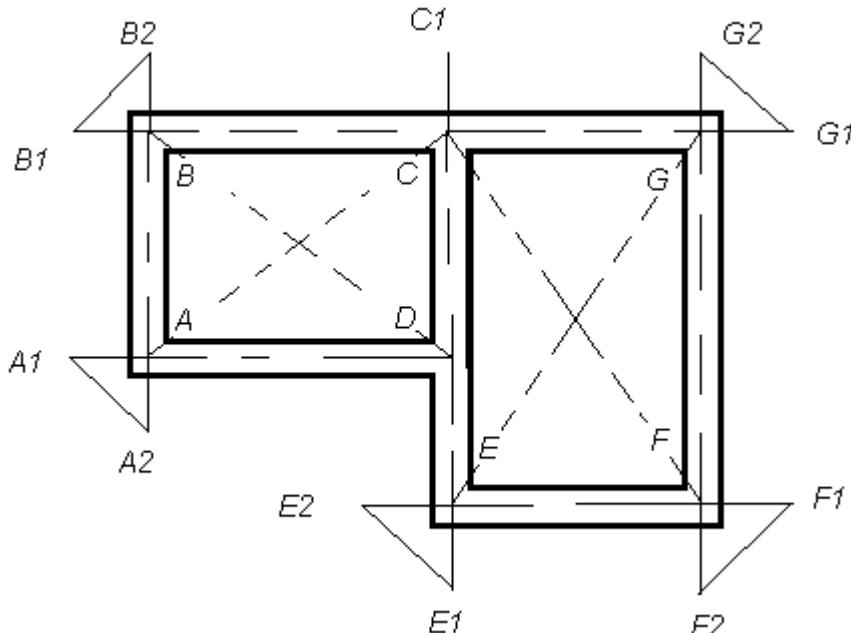
Fig.1: Example plan to be set out on the ground

- First of all, any two adjacent points on the plan are marked on the ground taking measurements with respect to any significant marks on the plot area eg: corner of the plot.
- Then, the grid lines are set out by setting perpendiculars in the ratio 3:4:5. Suppose the corner points are A, B, C, D, E, F and G which are marked by pegs with nails on top.

- The setting of the corner point is checked according to diagonals AC, BD, CF and EG.

- During excavation, the centre points A, B, C, D, E, F, G may be removed. Therefore, the centre lines are extended and the centre points are marked about 2m away from the outer edge of excavation.

- Thus, the points A1, A2, B1, B2 and likewise, are marked outside the trench. Centre lines are shown clearly by stretching thread or rope.

- From the plan details, the width of excavation to be done is also marked by thread with pegs at appropriate positions.

- The excavation width is then marked by lime or by with furrow with spade.

- If the plan is much too complicated and follows a zigzag pattern, then the centre pegs are kept at suitable positions according to site conditions.

10.2 Equipment Required for Building Layout

- Leveling instrument
- Long peg
- Long nails
- Hammer
- Right angle (Guniya)
- Steel tape
- Thin cotton thread
- Bricks
- Cement
- Screen aand
- Lime powder
- Theodolite

10.3 Preparation before Layout

Following are the points to be carried out before layout:

- **Temporary Bench Mark (TBM):** The temporary bench mark is a fixed point on a site to which all levels are related and should be established at an early stage. On the site, it could relate to any permanent fixture, such as a manhole cover or firmly-driven post.

- **Baseline:** The baseline is a straight reference line in respect to which the building's corners are located on the ground. Typically, the first layout task is done by establishing a baseline to which all the setting out can be related. It coincides with the 'building line', which is the boundary of the area, or the outer boundary of a road, often demarcated by the local authority.

- **Horizontal Controls:** These are the points that have known coordinates with respect to a specific point. Other points such as layout corners can then be located. Large no. of control points should be used so that each point of the plan can be precisely located on the ground.

- **Vertical Controls:** These enable design points to be positioned at their correct levels. The vertical control points are established relative to specified vertical datum – often a timber post set in concrete. Horizontal and vertical controls are generally established during the leveling phase using a theodolite or similar instrument.

Exercises

Choose the correct answer from the given alternatives.

1.   Which method is mostly used for layout of simple building.

    a. 3,4,5 method   b. 2,4,6 method

    c. 1,2,3 method   d. 2,3,5 method

2.   Site layout plan is prepared by….

    a. Client   b. Consultant

    c. Contractor   d. Worker

Write short answer to the following questions.

1.   What are the equipment required for the layout works?

2.   Draw the layout work for building construction project.

Write long answer to the following questions.

1.   Explain preparation before layout of simple building?

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