ESTIMATING, COSTING
AND
SPECIFICATION
IN CIVIL ENGINEERING

PRINCIPLE AND APPLICATION
INCLUDING
PROJECT ESTIMATE ●VALUATION ●ACCOUNTS ●CONTRACT ●PLANNING ●C.P.M.

FOR DEGREE, A.M.I.E., DIPLOMA STUDENTS
AND FOR OTHERS IN THE PROFESSION

M. K. S. SYSTEM

ESTIMATES ON BUILDINGS, RENOVATION ESTIMATE, R.C.C. FRAMED BUILDING, R.C.C. WORKS, WATER SUPPLY AND SANITARY WORKS, ROOF TRUSS, EARTHWORK, CULVERT, CAUSEWAY, IRRIGATION, ANALYSIS OF RATES, CARRIAGE OF MATERIALS, HOUSE WIRING, METHODS OF MEASUREMENTS, SPECIFICATION, VALUATION, ACCOUNTS, CONTRACT, COST INDEX, FORMULAE TO CALCULATE QUANTITY OF MATERIALS AND LABOUR, PLANNING, NETWORK TECHNIC, SCHEDULE OF RATES, CONVERSION FACTOR, AND STEEL TABLE, ETC.

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PUBLISHED BY AUTHOR
21B, Bhabananda Road,
Calcutta—26

FIRST EDITION ... 1963

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Printed by : R. K. Gupta, at R. K. Printers, 10B, Creek Lane, Cal-700014

PREFACE TO THE FIRST EDITION

Being in touch with many Civil Engineering Students as a lecturer of Civil Engineering, I realised that the students face great difficulties in studying this subject for want of an up-to-date book on "Estimating, Costing and Specification." This realisation gave me an incentive to write a book of this nature. From my practical experience in Govt. service also, for a long time, I have tried to cover up in my book those problems which the students generally face in the practical field after passing from Engineering institutions. The book will, therefore, be useful to the men in the practical field also.

Many drawings in enlarged forms have been incorporated in this book so that the students may follow drawings perfectly co-ordinating the subject matter. In the R.C.C. chapter numerous informative notes with drawings have been arranged first before starting the detailed estimate. Endeavour has been made to characterize the individuality of different chapters viz. Water-Supply and Sanitary Works, Division and Areas of Land, Analysis of rates, Roads etc. Numerous examples including some question papers of both West Bengal and Bihar engineering degree and diploma courses have been solved. A number of estimates have been prepared in F.P.S. and Metric system, so that the students may feel free to work in any system or to convert any estimate from one to the other system.

I acknowledge the great helps received by me from various eminent engineers of different Engineering departments and outside too. To compile various subjects in this volume it has been necessary for me to consult innumerable books. Of them R. C. Designers Hand book by Reynolds and Civil Engineering Hand Book by Khanna deserve special mention.

Sympathetic suggestions from different corners are cordially invited for further improvements in the subsequent editions.

August, 1963. M. CHAKRABORTI

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CHAPTER—1

INTRODUCTION

1-1. What is an Estimate ?—Before taking up any work for it's execution the owner or builder should have a thorough knowledge about the volume of work that can be completed within the limits of his funds or the probable cost that may be required to complete the contemplated work. It becomes therefore necessary to prepare the probable cost or estimate for the intended work from its plan and specification. Otherwise, it may so happen that the work has to be stopped before its completion due to shortage of funds or of materials. Besides the above an estimate for any public construction work is asked to be prepared and submited beforehand so that sanction of necessary funds may be obtained from the authority concerned.

Thus an estimate for any construction work may be defined as the process of calculating the quantities and costs of the various items required in connection with the work. To prepare an estimate, drawings consisting the plan, the elevation and the sections through important points, alongwith a detailed specification giving specific description of all workmanship, properties and proportion of materials, are required.

1-2 Different kinds of Estimates—An estimate prepared from the plans and specifications and consulting the present market prices of materials is never the actual cost of work. Because the cost of materials and labour may vary during the period of its actual execution or due to variations and modifications of actual dimensions shown in the drawing or due to some unforseen contingencies. The difference between the estimated and the actual cost will depend upon the skill and accuracy of the estimator. There are different kinds of estimates and they are—

(1) A detailed Estimate—This includes the quantities and cost of everything required for satisfactory completion of work and this is the best and most reliable estimate that can be made. A detailed estimate is accompanied with (a) Report, (b) Specifications, (c) Detailed drawings showing plans, different Sections, Key or Index plan etc., (d) Design datas and calculations, (e) Basis of rates adopted in the estimate. Such a detailed estimate is prepared for technical sanction, administrative approval and also to execute a contract with the contractor. The method of preparation a detailed estimate has been described in the next article.

(2) A preliminary or approximate or rough Estimate—This is an approximate estimate made to findout an approximate cost in a short time and thus enable the responsible authority concern to consider the financial aspect of the scheme for according sanction to the same. Such an estimate is framed after knowing the rate of similar works and by the use of any one of the following methods of estimates :—

(a) Unit rate estimate **(b) Plinth area estimate** **(c) Cube rate estimate.**

(a) Unit rate Estimate—In this method all costs of a unit quantity such as per k.m. for a highway, per metre of span for a bridge, per classroom for school building, per bed for hospital, per litre (or gallon) for water tank etc. are considered first and the estimate is prepared by multiplying the cost per corresponding unit by the number of units in the structure.

(b) **Plinth area Estimate**—In this method the plinth area should be calculated by taking the external dimensions of the building at the plinth. Court yard and other open areas should not be included in the plinth area. At the begining, when plan of a building has not yet been prepared or available determine the total floor area of all the rooms corridor, verandah, kitchen, W. C. and bath according to the requirement of the owner, and of the total areas thus found, may be added for walls and waste to get the approximate total plinth area. The plinth area thus found shall be multiplied by the plinth area rate for similar type design and specification of building at the locality.

(c) **Cube rate Estimate** –The method of estimating building cost by the cubic metre (or cubic foot) of volume is more accurate in general, than the method of estimating cost by plinth area. Because cost of building depends not only on their plinth area but also on their respective height. The best of estimating costs by the cubic rate is to find the volume of the building (length × breadth × heigth) and then multiply the volume by the local cubic rate for similar type of building. Length and breadth should be measured external to external excluding plinth offset, corbelling, string course etc. The height should be measured from the top of the flat roof (or half way of the sloped roof) to half the depth of the foundation below the plinth. Parapet is not to be included.

(3) **A quantity Estimate or quantity survey**—This is a complete estimate of the quantities of materials that may be required to complete the work concerned.

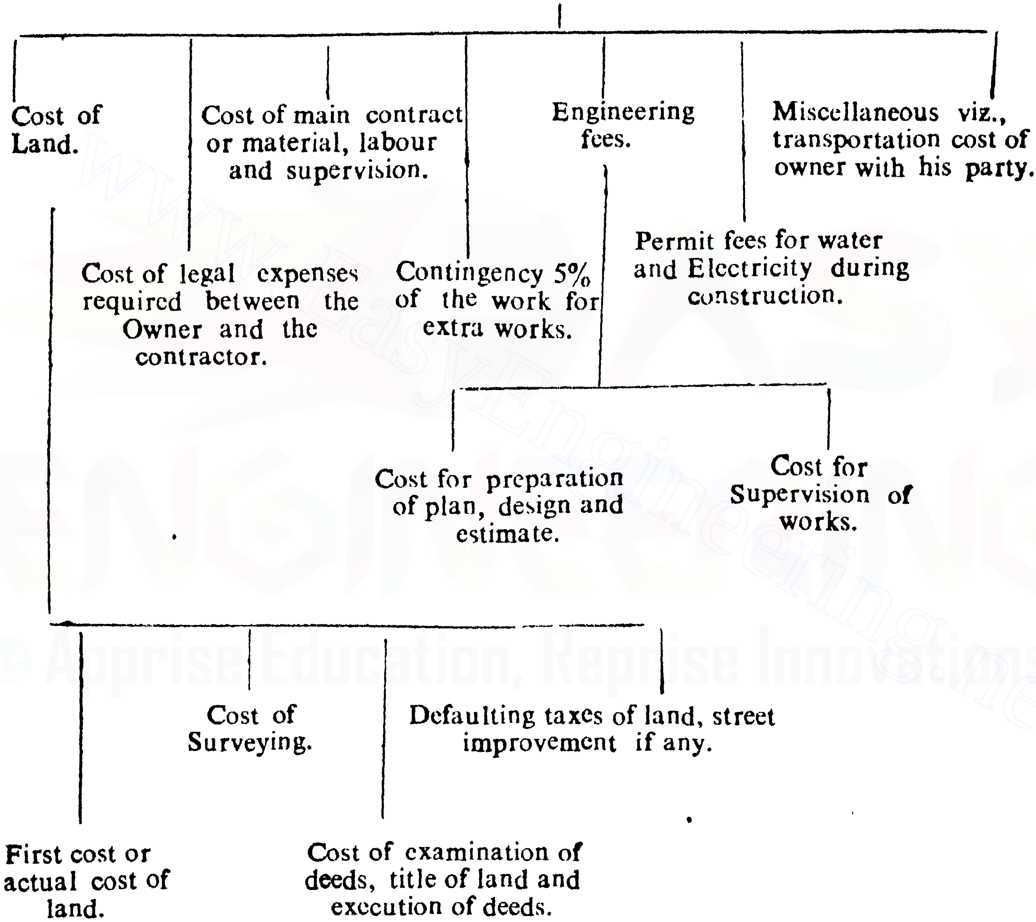
(4) **Revised Estimate** –When a sanctioned estimate is likely to be exceeded by more than 5 percent either from the rates being found insufficient due to change to price level or from any cause whatever, except important structural alterations an estimate is prepared which is called a revised estimate. In case where important structural alterations are contemplated though not necessarily involving an increased outlay revised estimate should also be submitted for technical sanction. The method of preparation a revised estimate is same as that a detailed estimate. A comperative statement showing in an abstract form the probable variations of each item of works, its quantity, rate as compared with the original estimate stating the reasons of variations should be attached with it.

(5) **A Supplimentary Estimate** –While a work is in progress some additional works may be thought necessary for development of a project which was not foreseen when the original estimate was framed and the expenditure for such supplimentary work cannot be meet up from savings elsewhere within the Grant, an estimate is then prepared to cover up all such works which is known as supplimentary estimate. The method of preparation of a supplimentary estimate is same as that a detailed estimate and it should be accompanied by a full report of the circumstances which render it necessary. The abstract must show the amount of the original estimate and the total of the sanction required including the supplimentary amount.

(6) **A complete Estimate**—This is an estimated cost of all items which are related to the work in addition to the main contract or to the detailed estimate.

One may think that an estimate of a structure includes only the cost of land and the cost of the main contracts or labour, materials and supervision. But there are many other cost items to be included. A picture of a complete estimate is diagrammatically shown as below.

COMPLETE ESTIMATE



(7) **Annual Maintenance Estimate**—After completion of a work it becomes necessary to maintain the same for its proper function and for the same estimate is prepared for the items which require renewal, replacement, repairs etc. in the form of a detailed estimate

1-3. How to prepare a detailed Estimate—The unit-quantity method is followed to prepare a detailed estimate. In this method the rates per unit work of one item (viz., one cu m concrete, one cu m brickwork etc.) including profit are considered first and the total cost for the item is found by multiplying the cost per unit of the rate by the number of units. For example on a simple concrete job the rate of one cubic metre of concrete would be first found (including profit) and this unit cost is multiplied by the number of units (each in one cubic metre) required in the job to obtain the total cost on concrete work.

Thus after obtaining the cost of each and every individual item of work and then adding them all together, an abstract of estimated cost is prepared. This estimated cost is increased by 5% (according to the practice of Public Works Departments) for any unforeseen expenditure and is called 'contingencies'. To maintain additional supervising staff at work site called 'workcharged' establishment, a further amount of $2\frac{1}{2}$% (as mostly followed in various public works departments) is directly charged to the estimate prepared from the item works. ***Thus by summation of (a) cost obtained by adding all items priced, (b) contingencies 5% and (c) workcharged establishment $2\frac{1}{2}$%, a detailed estimate is prepared.***

The detailed estimate is accompanied with :—

(1) Report.

(2) Specifications (for departmental works departmental specifications are followed).

(3) Drawings consisting of (a) Plans, sections and elevations, (b) Site plan or layout plan or Index plan.

(4) Design charts and calculations.

(5) Particulars of rates. In case of schedule of departmental rates this is to be mentioned, otherwise analysis of rate is required.

The detailed estimate thus prepared is submitted for technical sanction and for granting the necessary fund.

1-4 Factors to be considered during preparation of a detailed Estimate—

(*a*) ***Quantity of materials***—For a large construction a large quantity of materials is required and this can be purchased at a rate cheaper than the rate of materials required for minor work. Therefore, rate of works should be framed considering the volume of work.

(*b*) ***Availability of materials***—Estimated cost of a particular item becomes higher than the scheduled rate if there is no assurance that the materials will be available as and when required, because it is detrimental to the progress of the work if the workers and maintainance staff remain idle for paucity of materials.

(*c*) ***Transportation of Materials***—If smallar quantity of materials is required to be transported to a considerable distance, the proportionate cost of transportation becomes higher in comparison with the cost of a larger quantity transported at a time.

(*d*) ***Location of site***—If the site of work is located at such a place where loading, unloading, stacking and restacking of materials become necessary several times due to different kinds of journey, the point of damage or loss in transit should be considered carefully.

(*e*) ***Local labour charges***—Skill and daily wages of local labourer should be considered before preparation of a detailed estimate.

1·5. How to fix up rate per Unit of an item—(Unit means unit of rate viz, 1 cu m brickwork, 1 cu m concrete work etc.). The following five sub-heads are estimated and a summation of these is the rate per unit of an item.

(a) Quantity of materials and cost
(b) Labour costs
(c) Costs of equipments or Tools and plants (T. and P.)
(d) Overhead or Establishment charges (including incidental)
(e) Profit.

(*a*) ***Quantity of materials and cost***—The estimator takes off the quantities of various materials required per unit quantity of an item following the detaild specification and calculate costs from local market rates. This cost includes first cost, freight, transportation and insurance charges.

(*b*) ***Labour cost***—To obtain labour costs, the number and wages of the different categories of labourers, skilled, and unskilled, namely mason or carpenter, mazdoor, boy etc. required for each unit of work should be known and this number is to be multiplied by the respective wage per day (or per hour).

(*c*) ***Cost of equipments***—Wherever possible the cost of equipments should be allocated to specific item of rate ; for example, the cost of operating a concrete mixer should be spread over those items of rates for which it is used. For certain tools and plants it is difficult to allocate their use to an individual item of rates and it is, therefore, suggested to include expenditure in such cases to over-head i. e. establishment charges.

Tools and Plants (T. and P.)—For big work or project it becomes necessary to use special type of tools and plants, viz., for Calcutta Metropoliton Transport Project special type of concrete mixture machins named as Batching plants, special type of mixed concrete transport vehicles named as 'Tripping wagon or Dumbe', Cranes etc. are in use. Thus for a road project a number of Road rollers are required. In order to purchase such type of special equipments an amount of 1% to $1\frac{1}{2}$% of the estimated cost is provided in the estimate.

(*d*) ***Overhead or Establishment Charges***—This includes such items as office rent and depreciation of its equipments, salaries of office staff, postage, lighting, travelling, telephone account, plan and specification etc. Small tools, planks, ladders, ropes and such hand-tools as the contractor provides for his workmen should also be included in the overhead charge as suggested in (c). This is usually $2\frac{1}{2}$% of the net cost of a unit of rate and may rise upto 5%

1-14. Departmental charges – When an Engineering department execute the work of other department or Government or local bodies etc. a percentage amount 10% to 15% of the estimated cost is charged for recovery of the cost of establishment for planning, desigining, supervision, pensionary, audit charges etc. Local Administration fix up the percentage in consultation with the Accountant General.

The total expenditure for above works should be shown separately thus—

For works expenditure – Rs.......

For Percentage charges – Rs.......

1-15. Work Value – This is the total amount for all schedule items of works provided in the estimate. That is the estimated value of the work excluding the amount for contingencies, Workcharged Establishment, Tools and plants etc.

Work value is the amount put to invite tender.

1-16. Administrative Approval—This terms denotes the formal acceptance, by the administrative department concerned of the proposal for incurring any expenditure on a work initiated by or connected with the department. It is, in effect, an order to the department to execute certain specified works at a stated sum to meet the administrative needs of the department requiring the work.

1-17. Technical Sanction – This name is giving to the order of competent authority sanctioning a properly detailed estimate of the cost of a work of construction or repair proposed to be carried out in the department.

EXERCISES 1

1. What do you understand by estimating? Why the same is necessary in a project? ***Ans :—Article 1-1***
2. What do you understand by rough estimate of a project? Why the same is necessary and how this is prepared?

   Ans :—Item (2) from the Article 1-2.
3. What is a detailed estimate and how this is prepared?

   Ans :—Item (1) from the article 1-3.
4. Write short notes on (a) contingency, (b) Work-charged establishment (c) Schedule of rates (d) market rate.

   Ans :—Articles from 1-6 to 1-8 and 1-10
5. When a revised or a supplimentary estimate may be called for?

   Ans :—Items (4) and (5) from the article 1-2.
6. How rate per unit of an item is prepared? Describe briefly. ***Ans :—Article 1-5*** :

CHAPTER II

ELEMENTS OF BUILDING ESTIMATE

2-1. Metric System—Metric system is a very simple system, because the units are in multiples of ten or one-tenth of one another. In this system arithmetical calculation is simpler than in any other system and minute measurements can be done more conveniently.

There are altogether five main units in metric system (a) Metre for length (replacing foot), (b) Square metre for area (replacing square foot), (c) Cubic metre for volume (replacing cubic foot), (d) Kilogram for weight (replacing pound), (e) Litre for capacity (replacing gallon). There are sub-units and multiple units for each main unit.

2-2. Dimensions in metric system to be used in place of F. P.S. system

Metric System		F.P.S. System
1. Size of Rooms—		
2·4m × 2·4m	...	8′ × 8′
2·4m × 3·0m	...	8′ × 10′
3·0m × 3·7m	...	10′ × 12′
3·7m × 4·3m	...	12′ × 14′
4·6m × 5·5m	...	15′ × 18′
2. Height of Building—		
3·0m	...	10′-0″
3·2m	...	10′-6″
3·4m	...	11′-0″
3·7m	...	12′-0″
4·3m	...	14′-0″
3. Height of Plinth—		
45 cm	...	1′-6″
60 cm	...	2′-0″
75 cm	...	2′-6″
90 cm	...	3′-0″
4. Steps Rise and Tread		
15 cm × 25 cm	...	6″ × 10″
15 cm × 27 cm	...	6″ × 10½″
15 cm × 28 cm	...	6″ × 11″
18 cm × 28 cm	...	7″ × 11″
5. Damp Proof Course (D.P.C.)—		
1·5 cm thick	...	½″ thick
2cm thick	...	¾″ thick
2·5 cm thick	...	1″ thick
4cm thick	...	1½″ thick
6. Floor Thickness—		
2·5 cm thick	...	1″ thick
4 cm thick	...	1½″ thick
8 cm thick	...	3″ thick
7. Thickness of R.C.C. Roof		
5 cm	...	2″
8 cm	...	3″
9 cm	...	3½″
10 cm	...	4″
13 cm	...	5″
8. Thickness of Lime or Cement Concrete in Foundation		
10 cm	...	4″
15 cm	...	6″
23 cm	...	9″
30 cm	...	12″
45 cm	...	18″
9. Plastering Thickness—		
6 mm	...	¼″
12 mm	...	½″
20 mm	...	¾″
10. Thickness of Door & Window Shutter		
25 mm	...	1″
30 mm	...	1¼″
40 mm	...	1½″
45 mm	..	1¾″

Metric System		F.P.S. System
11. Size of Chowkats or Door and Window Frames		
8 cm × 6 cm	...	3″ × 2½″
8 cm × 8 cm	...	3″ × 3″
9 cm × 8 cm	...	3½″ × 3″
10 cm × 8 cm	...	4″ × 3″
13 cm × 8 cm	...	5″ × 3″
***13. Diameter of M.S. Bar—**		
6 mm	...	¼″
10 mm	...	⅜″
12 mm	...	½″
16 mm	...	⅝″
20 mm	...	¾″
22 mm	...	⅞″
25 mm	...	1″
28 mm	...	1⅛″
32 mm	...	1¼″
36 mm	...	1⅜″
15. Plans, Sections and Elevations—		
1 cm = 0·5 (1 : 50)	...	1 in = 4 ft
1 cm = 1 m (1 : 100)	...	1 in = 8 ft
1 cm = 2 m (1 : 200)	...	1 in = 16 ft
17. Large Scale Surveying & Layout—		
1 cm = 5 m (1 : 500)	...	1 in = 32 ft
1 cm = 10 m (1:1000)	...	1 in = 64 ft
19. Topographical Maps		
1 cm = 2·5 km (1:250,000)	..	1 in = 4 miles
1 cm = 1 km (1:100,000)	..	1 in = 2 miles

Metric System		F.P.S. System
12. Size of Door—		
0·75m × 1·8m	...	2′-6′ × 6′-0″
0·75m × 1·9m	...	2′-6″ × 6′-0″
0·91m × 1·9m	...	3′-0″ × 6′-0″
1·1m × 1·9m	...	3′-6″ × 6′-6″
1·2m × 2·1m	...	4′-0″ × 7′-0″
****14. Size of M.S. Beams—**		
100mm × 50mm	...	4″ × 1⅞″
125mm × 75mm	...	5″ × 3″
175mm × 90mm	...	7″ × 4″
200mm × 100mm	...	8″ × 4″
225mm × 110mm	...	9″ × 4″
250mm × 125mm	...	10″ × 4½″
300mm × 140mm	...	12″ × 5″
350mm × 140mm	...	12″ × 6″
16. For Detailed Drawings—		
1 cm = 1 cm (1 : 1)	...	1 in = 1 ft
1 cm = 1 cm (1 : 2)	...	6 in = 1 ft
1 cm = 2·5 cm (1:2·5)	...	4 in = 1 ft
1 cm = 5 cm (1 : 5)	...	3 in = 1 ft
1 cm = 10 cm (1:10)	...	1 in = 1 ft
1 cm = 20 cm (1:20)	...	½ in = 1 ft
18. Town Surveys		
2 cm = 1 km (1:50,000)		1 in = 1 mile
4 cm = 1 km (1:25,000)		3 in = 1 mile
10 cm = 1 km (1:10,000)		6 in = 1 mile
1 cm = 50 m (1: 5000)		1 in = 500 ft

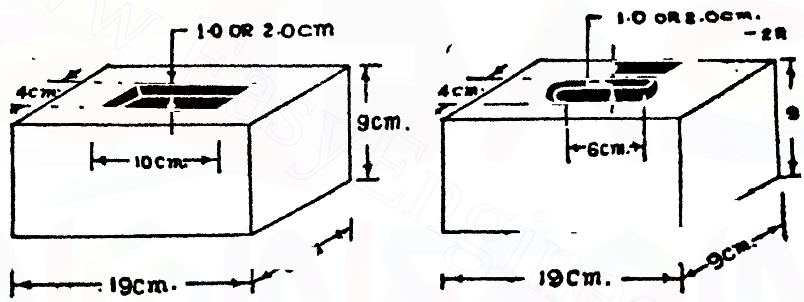
* Weights of M.S. bar per unit length has been given in the R. C. C. Chapter.

** Weights and other details are in the Appendix.

2-2A. Size of Bricks -Size of brick varies according to the practice of different Public Works Departments. To introduce a uniform system throughout the country, Indian Standard Institute has fixed up the size of standard modular bricks as below :—

Type of brick	Actual size as manufactured	Nominal size i.e. with mortar	Converted dimensions for traditional bricks	
			Actual Size	Nominal Size
(a) Standard Modular	19cm × 9cm × 9cm	20cm × 10cm × 10cm	—	—
(b) Traditional brick	$9\frac{5}{8}'' \times 4\frac{5}{8}'' \times 2\frac{5}{8}''$	$10'' \times 5'' \times 3''$	24·8 cm × 12·1cm × 7cm	25 cm × 12·5 cm × 7·5 cm
(c) Traditional brick	$8\frac{5}{8}'' \times 4\frac{1}{8}'' \times 2\frac{5}{8}''$	$9'' \times 4\frac{1}{2}'' \times 3''$	22·4cm × 11·2cm × 7cm	23 cm × 11·5 cm × 7·5cm

Actual size of standard Modular bricks with two types Frogs.



ALL DINENSIONS IN CENTIMETRES

FIG. 2-1

2-3. Thickness of Wall for Different Sizes of Bricks—Brick walls upto and including three bricks in thickness shall be measured in multiples of half-brick which shall be considered to be inclusive of the mortar joints as 10 cm irrespective of the actual thikness as shown in the table below. For walling which is more than three bricks in thickness, the actual thickness of wall shall be measured to the nearest one centimetre. Fractions including 0·5cm and above shall be taken as 1 cm and fractions below 0·5 cm shall be neglected.

Type of brick	Wall Thickness					
	½ brick	1 brick	1½ bricks	2 bricks	2½ bricks	3 bricks
(a) Modular brick— 20 cm × 10 cm × 10 cm	10 cm	20 cm	30 cm	40 cm	50 cm	60 cm
(b) Traditional brick— $10'' \times 5'' \times 3''$ (25cm × 12·5cm × 7·5cm)	5″ (12·5cm)	10″ (25 cm	15 (37·5cm)	20″ (50cm)	25″ 62·5cm)	30″ (75cm)
(c) Traditional brick— $9'' \times 4\frac{1}{2} \times \times 3''$ (23cm × 11cm × 7·5cm)	$4\frac{1}{2}''$ (11cm)	9″ (23 cm)	$13\frac{1}{2}''$ (34cm)	18″ (45cm	$22\frac{1}{2}''$ (56 cm)	27″ (67cm)

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2-4. The Mode of Measurement for wall thickness adopted by the P. W. D. department for traditional bricks 10″ × 5″ × 3″ (nominal).

The Thickness of brick wall made with—

(a) One brick laid on ledge (with the long side parallel to the length of the wall i.e. for 3″ walls) shall be measured as 7·5 cm.

(b) One brick laid flat (with the long side paralled to the length of the wall i.e. for 5″ walls) shall be measured as 12·5 cm.

(c) One brick thick walls (with the length of brick parallel to the thickness of the wall i.e. for 10″ wall) shall be measured as 25cm.

(d) One and half brick walls (one brick along the length and one brick along the width i.e. for 15″ wall) shall be measured as 37·5 cm.

(e) Two-brick walls shall be measured as 50 cm. For further ½ brick thickness add 12·5cm

2-5. General items of work, unit of measurement, unit of rate and mode of measurement—Unless specifically mentioned in the description of the item itself, the rate for any item of work shall apply equally to all floors, in any position and upto any height. The work upto a particular floor level means all works upto the roof of that floor. Arrangement of water for soaking bricks, mixing concrete, mortar, washing of stonechips or sand curing of concrete etc. and construction of platforms, labour shade or site godown are included in the rate of work and no separate payment shall be made. Unless specially mentioned otherwise, the following modes of measurement (as shown in colum 4) shall be adopted. To introduce a uniform system throughout the country, modes of meaurement have been written following I.S.I. recommendations.

The unit of different items of work are based on the following principle—

(a) Mass voluminous and thick works shall be taken in cubic unit or volume. (viz. cubic metre cum)

(b) Thin, shallow and surface work shall be taken in square unit or in area. The thickness shall be specified in the description of the item and the measurement of length and breadth or projection shall be taken to calculate the area. (viz. square metre sq m).

(c) Long and thin work shall be taken in linear or running unit, and linear measurement shall be taken (viz. running metre, r m)

(d) Piece work, jobwork etc. shall be taken in number.

Works shall be measured net as fixed in its place. The description of item shall include where necessary, all charges for storing, delivery, handing unloading, fabrication, hoisting and labour for fitting, fixing in position, finishing to required shape and size.

In booking dimensions the order shall be in the sequence of length, breadth or width and height or depth.

Description of item.	Unit of measurement	Unit of rate	Mode of measurement
Earthwork :—			
1. Earthwork in excavation in any type of soil.	cu m	% cu m	Measurement shall be taken as per drawing. According to I.S.I., excavation over areas not exceeding 30 cm in depth shall be considered as surface excavation and given in sq m stating the average depth. Trenches for pipes, cables etc. shall be measured in r m for different diameters. Earthwork in differen kinds of soil and rock formation shall be kept separate. Separate rate shall be provided for successive stages of 1·5m lift stating the commencing level. For each additional lead of every 50m over the initial lead of 50m the rate shall be different. The lead shall be measured from the centre of the block of excavation to the spoil heap. Trimming the side of trenches, levelling, dressing and ramming the bottom including bailing out normal seepage of water, rain water etc. as required are included in the item.
2. Earthwork in filling (by sand or loose earth)	cu m	%cu m	The filling shall be measured and the following deductions shall be made for settlement to arrive at the net quantities ; (a) 10% in consolidated fills, except where the consolidation is done by heavy machinery in which case the deduction shall be 5% (b) where measured in loose stacks or in carts, or lorries a 25% deduction, (c) no deduction shall be made in the case of consolidated fills in confined situations like floors. Side filling of trenches shall be taken accurately as volume of earthwork in excavation less volume of structure upto G.L. But considering the rate of earth work, side filling are also taken as $\frac{1}{6}$th of excavation approximately.
3. Hire and labour charge for shoring walls (for protection side of trench)	sq m	sq m	Measurement shall be taken for the area in contact with and supporting the earth. The item shall include all necessary timber work including plank walling, struts, poling boards, etc. For successive depths of 1·5m measurement shall be kept separately.

Description of item.	Unit of measurement	Unit of rate	Mode of measurement.
Brickwork :—			
4. Brickwork (with lime or cement mortar) of one or more than one brick wall (one brick thick walls when length of brick is parallel to the thickness of the wall).	cu m	cu m	Thickness of brickwork shall be measured in multiples of half brick. For 19cm × 9cm × 9cm modular bricks the nominal size shall be 20cm × 10cm × 10cm and the corresponding half size brick shall be 10cm. Thus for nominal size 10" × 5" × 3" and 9" × 4½" × 3" the corresponding half brick size shall be 5" and 4" respectively. Net measurement shall be taken after deduction of all openings with lintels. For small curves or chamfers measurement on the square (i.e. without deduction for the quantity removed for forming the small curves or chamfers) is allowed. Round pillars or pillars of polygonal form shall be calculated as if they were square, the dia. being taken as the side of the square. Brickworks circular on plan to a mean radius not exceeding 6m shall be measured separately. But brickworks curved on plan to a mean radius exceeding 6m shall be included with the general brickwork. Brickwork at different levels as in foundation and plinth, superstructure ground floor, 1st floor etc. shall be measured separately. No extra payment shall be made for forming the small curves or chamfer. No deduction shall be made for openings like ventilators, flues etc. having openings up to 0·1 sq m in section. Thus for ends of dissimilar materials like beams, josits, rafters etc. up to 500 sq cm in section in walls no deduction shall be made. Extra rate shall be allowed for cutting and waste shall be considered for brickwork circular on plan to a mean radius not exceeding 6m.
4A. Brickwork in Arches.	cu m	cu m	Measurement is required separately to provide xtra over rates of corresponding items for brickwork n arches. For spans exceeding 6m centering shall be measured separately. Hire and labour charges for centering and shuttering shall be included in the item for spans upto 6m
5. Reinforced brickwork.	cu m	cu m	Reinforced brickwork shall be kept separate from general brickwork. Reinforcement shall be measured separately. Methods of deductions are same as in general brickwork.
6. Honey comb brickwork.	sq m	sq m	The thickness of wall and the pattern of honey combing shall be stated. Honey comb openings shall not be deducted.

Description of item.	Unit of measurement	Unit of rate	Mode of measurement
7. 10cm or half brick walls of 5″ or 4½″) with lime or cement mortar.	sq m	sq m	Net measurement shall be taken after deduction of all openings. Brick on edge wall shall also be be paid in sq m Wire netting etc. if provided shall be included in the item.
8. Brick flat soling (one or two layers).	sq m	sq m	Measurement shall be taken as per drawing. The item shall include filling the gaps between, bricks by sand etc.
9. Cornices, String courses, Drip courses etc.	r m	r m	Different types shall be measured separately. Depth and width of the projection shall be fully described. Plastering, moulding etc. shall be included in the item.
10. Cutting holes through existing brickwork	per cm	per cm	Rates for cutting holes shall be given per cm depth separately for (a) holes upto and including 250 sq cm in area, (b) holes more than 250 sq cm and upto 0·1 sq m in area. The area of holes shall be measured as the net area required after making good and not the area actually cut.
11. Cutting openings in existing brickwork.	cu m	cu m	Cutting openings exceeding 0·1 sq m in area including the provision for fixing and removal of temporary supports and shoring shall be included in the item. The area of opening shall be measured as the net area required after making good and not the area actually cut.
Concrete work :—			
12. Lime or Cement concrete in foundation	cu m	cu m	Measurement shall be taken on the finished works to the nearest centimetre. The kind, size, grading and proportions of materials to be used and the method of mixing shall be described in the item. Particulars of any test required of materials, mixes and of the finished work shall be stated. Different kinds of concerete shall be kept separate. Reinforced concrete as in raft foundation shall be kept separate from unreinforced concrete.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
13. Reinforced cement concrete (R.C.C. excluding reinforcement and shuttering).	cu m	cu m	All measurements shall be taken to,the nearest 1 cm except that the thickness of slabs, partitions etc. and sectional dimensions of different R.C.C. members shall be taken to the nearest 0·5 cm. No deductions shall be made for (a) the volume occupied by reinforcement, (b) the volume occupied by water pipes, conduits not exceeding 25 sq cm (c) openings upto 0·1 sq m. No extra labour for forming voids or opening shall be allowed for cases as described under groups (a), (b) and (c).
14. Damp proof course (D.P.C.)	sq m	sq m	Measurement shall be taken as per drawing stating the thickness. The description shall include framework, finishing, levelling, curing etc. Verandah and door openings do not came into account when D.P.C. is laid on plinth level.
15. R. C. Chajja	r m	r m	The item shall include all frame work. The projection and its average thickness shall be stated. The projection shall be measured from the face of the wall to the outside edge of chajja horizonally. The running length shall be the average of the lengths measured along the wall and along the free end of chajja. The bearing on the wall shall be deemed to be included in the item. Concrete portion of chajja may also be given in cum inclusive of the bearing. The reinforcement in this case is measured separately. Where chajja is combined with lintel etc. the common portion shall be paid with lintel etc.
16. Precast C.C. or R.C.C. blocks.	cu m	cu m	Concrete block construction exceeding 10 cm on bed shall be given in cu m and that not exceeding 10 cm on bed, in sq m. Reinforcement if any shall be measured separately or fully described and included with the item. The work shall be described as including all moulds, finished faces, hoisting and setting in position.
17. Hollow concrete Block wall.	cu m	cu m	No deduction shall be made for the hollows in the blocks. Others are same as described above (i.e. in 16). Work in which hollows of blocks are filled during construction shall be measured separately.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
18. Expansion joints in concrete.	r m	r m	Expansion joints in roofs, floors, walls, roads etc. shall be given in rm stating the width and depth of the joint and the material used in filling the joint. All framework and labours necessary to form the joint are included with the item, so no separate payment shall be allowed.
19. Concrete Jaffries or allies etc.	sq m	sq m	The thickness and other particulars of the Jaffries shall be described. The reinforcement shall be described and included with the item. No separate payment for shuttering etc. shall be provided.
20. Concrete fencing posts, terminal posts etc.	cu m	cu m	Posts shall be classified as (a) sectional area not exceeding 100 sq cm (b) sectional area exceeding 100 sq cm but not exceeding 250 sq cm (c) area exceeding 250 sq cm. Reinforcement shall be described and included with the item. The item shall include all frame work, chamfers or rounded angles, holes for wire or rails.
Stone Work –			
21. Random Rubble masonry, Coursed Rubble masonry, Ashlar masonry walling and arches.	cu m	cu m	The thickness of wall shall be measured to the nearest 1 cm, fractions including 0·5 cm and above shall be measured as 1 cm and fractions below 0·5 cm shall be ignored. Other particular shall be same as brickwork. Rules for deduction for openings are similar as in brickwork. Different kinds of stone masonry shall be kept separate.
22. Stone work in wall facing etc.	sq m	sq m	The character of facin the average width of bed and thickness of the joints shall be stated. Circular facings exceeding 6 m in radius shall be included with the general facing. If the facing stone is the same as that used in the body of the walls an extra over rate shall be allowed for dressing the face and the entire work shall be given in cu m as walling. External angles in facing shall be given in r m.
23. Cut or Dressed stone work as in sills, steps, cornices, lintels, copings etc.	cu m	cu m	The work shall be grouped according to the following sizes : Each stone (a) upto 1 m or vol. 0·06 cu m, (b) between 1 m to 2 m or vol. 0·06 cu m to 0·18 cu m, (c) between 2 m to 4 m or vol. 0·18 cu m 0·36 cu m, (d) beyond the limit as in (c). Labours other than for dressing on rectangular faces, beds and joints shall be measured separately.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
24. Boulderwork	cu m	cu m	Boulderwork shall be classified as (a) dry filling and packing, (b) dry filling and hand packing, (c) dry walling, (d) walling in mortar. The size of boulder shall be stated.
Roofing—			
25. Terraced roofing portion of tiles, bricks or stone slabs	sq m	sq m	The thickness, size and quality of tiles, bricks or stone slabs shall be stated. The number of layers, method of laying, pointing and the kind of mortar with proportion shall be stated and included in the item. The supporting rafter and beams shall be measured separately under the relevant clauses. Tiles laid in chajja and sunshades shall be measured separately.
26. Lime terracing on roof	sq m	sq m	The proportion of mixing and average consolidated thickness shall be described. If special top surface finish is desired this shall be paid separately in sq m. Insertion in parapet (i.e. ghoondies) shall be accounted. Madras terrace roofing shall include top & underside plaster finish.
27. Reinforced brick (R.B.) roof or slab	cu m	cu m	Measurement shall be taken as per drawing. The steel reinforcement shall be measured separately in quintal. Shuttering shall be measured separately. For all other R. B. works the same unit may be followed.
28. Tiled roofing (excluding supporting frame work)	sq m	sq m	Measurements shall be taken as per finished work describing the kind, pattern, quality and size of the tiles. Single and double tiling shall each be measured separately. Semi-circular ridges, hips and valleys shall be measured in r m stating the girth.
29. Asbestos Corrugated (A.C.) or Galvanised Corrugated Iron (G.C.I.) sheet roofing (excluding supporting frame work)	sq m	sq m	Measurements shall be taken as per drawing stating the gauge of the material and the method of fixing. Sheeting bent to a curvature shall be measured separately. Corrugated sheeting shall be measured flat and not girthed. No addition shall be made for laps. Ridges, hips and valleys shall be measured in r m stating the laps. For A.C. sheating the type of sheeting and thickness shall be described.
30. Jack arch roofing (including centering.)	sq m	sq m	Jack arch roofing shall be measured flat overall describing the clear span, rise and thickness of arch and the method of laying. Lime concrete terracing shall be measured separately and given in sq m.

Description of item	Unit of mersu-rement	Unit of rate	Mode of measurement
31. Water proofing on roof with a layer of tar or bitumen.	sq m	sq m	The quality and type of water-proofing and quantities of tar or bitumen per sq m shall be described. Surface painting if applied shall be measured separately.
32. Felt work (dressing top with bitumen or tar).	sq m	sq m	The felt shall be fully described stating the weight per sq m and the materials to which it is fixed, laps etc. shall be stated. All dressing at top of felt shall be described. Narrow felt strips sandwiched between laps of corrugated sheeting shall be measured on flat and given in sq m.
33. Ceiling (with Paste board, plain A.C. sheet etc) excluding supporting members.	sq m	sq m	The material, its thickness and method of fixing shall be described. No deduction shall be made for openings below 0·4 sq m each. Different kinds of ceiling shall be kept separate. Work formed to circular surface shall be measured separately.
Flooring—			
34. Brick on Edge or brick Flat flooring.	sq m	sq m	Each type shall be measured separately as per drawing. Grouting of side joints or raking out mortar and pointing shall be included in the item. The pattern of laying shall be described. Brick tile flooring shall be measured similarly in sq m.
35. Lime or Cement concrete floors or pavings.	sq m	sq m	The the thickness shall be stated. Where thickness exceeds 20cm it shall be measured as work in foundation. The surface finish, except rough finish shall be measured separately.
36. Artificial stone to floor, dado, stair case etc.	sq m	sq m	Measurament shall be taken as per drawing. The thickness shall be measured net exclusive of any bedding mortar. Each type of work as floor, dado etc. shall be measured separately for separate rate. Internal and external rounding angles shall be given in r m. Narrow bands not exceeding 7·5 cm in width shall be given in r m.
37. Terrazzo or Mosaic flooring.	sq m	sq m	The thickness shall be measured after polishing the floor. Others are same as Artificial stone floor. Materials of dividing strips shall be stated and given in r m mentioning its thickness.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
38. Stone slab flooring.	sq m	sq m	The thickness shall be measured minimum at any point excluding any bedding mortar. Quality, size and type of stone shall be included in the item.
Wood work—			
39. Door and Window Shutters of different types.	sq m	sq m	Net measurement shall be taken stating the thickness as per opening in the framework including ribets but excluding extra width for rebated or splayed meeting styles of doors and windows. The surface shall be measured to the nearest 1 cm and thickness to the nearest 2 mm. The thickness of Battened leaves shall be the thickness of the battens only and not the combined thickness of the battens and the ledges. But in the description the thickness of the ledges and braces shall be stated. Diffecent types of shutters shall be measured separately. No allowance shall be given for joining, nails, screws, bamboo- pins etc. Fittings viz. tower bolt, hinge etc. or screws for fittings are not included in the item.
40. Wood work in door and window frames.	cu m	cu m	Length shall be measured to the nearest 2 cm. Width and thickness to the nearest 2 mm. Measurement shall be taken as per opening and including the length for joining, horns etc. No deduction shall be made for rebating, chamfers etc. Segmental or circular portion of frame if any shall be measured separately.
41. Shuttering, centering.	sq m	sq m	Measurement shall be taken on area in actual contact with concrete. The description of framework shall include all supports, struts, braces, battens, nails etc. and also striking and removal of the framework. Framework to mouldings shall be measured sparately in sq m. Dressing the framework with oil may also be included. For different classes of shuttering viz. (a) staircases, (b) pillars or columns, (c) sides and soffits of beams, lintels, (d) suspended floor etc. shall be measured separately.
42. Scantlings, battens, trusses etc.	cu m	cu m	Length and cross-sectional dimensions shall be measured upto nearest 2 cm and 2 mm respectively. Framed and fixed timber shall include lapping, notching, boring for bolts, hoisting, erecting and fixing in position, chamfering and such similar item of labours. Roof battens may be given in sq m stating the size and spacing.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
43. Hand rails.	r m	r m	Measurement shall be taken along top centre line stating the extreme section of the straight portion and wheather rounded or moulded. Housing joint, hand rail screws etc. shall be stated.
44. Roof boarding, ceiling, floors, shelves etc.	sq m	sq m	Measurement shall be taken stating the finished thickness and shall be fully described. In the case of rebates, tongues and grooves etc. the extra width of rebates, tongues etc. shall be ignored and measurement shall be net as fixed.
45. Ballies.	r m	r m	Mean diameter shall be stated. Fixing of ballies shall be described as including all labours, nails, spikes etc. The mean diameter shall be the average of the two diameters at the ends.
46. Wood Piles.	r m	r m	Length over 6 m shall be measured in stages of 1m. The piles shall be described and the size stated. Shoeing and pointing shall be enumerated separately stating their weights.
Iron work :—			
47. M. S. reinforcement (for R.C.C., works) including distribution bars, stirrups, binders, etc.	quin	quin	The measurement shall be on the basis of calculated weight of reinforcement only (i.e. without considering the weight of binding wire) actually consumed in the finished work as per drawing. Hooks, cranks and laps as per standard practice shall be measured. Binding wire required for supporting the reinforcement shall be included in the item and not measured separately. Fabric reinforcement shall be given in sq m
48. M.S. structural works, R S.J., Channels, Angles, Tee, round or sq. bar etc.	quin	quin	Measurement on finished work shall be taken. If the weight of rivet is calculated from tables, no deduction shall be made for rivet or bolt holes. The weight of cleats, gusset plates, packing pieces, rivet heads etc. shall be added to the respective items. Holding down bolts shall be measured separately. Unloading, getting in, hoisting and fixing steel works shall be included with the items. The height of the structure above or below ground level shall be stated.
49. Cast iron Bracket, Gratings, Frames, Pulley, Grills etc.	quin	quin	Articles not exceeding 6·5 kg each and those exceeding 6 5 kg each shall be measured separately. Pulley is also measured at some places as each stating the diameter.

Description of item	Unit of measurement	Unit of rate	Mode of measurement.
50. Holding down bolts, nuts, washers, bolts etc.	quin	quin	Articles shall be grouped according to diameter. Wedging-up under grillages or stanchion bases shall be stated. Site drilling shall be stated describing the diameter of holes and thickness of metal.
51. Collapsible Gate with rails, runners and channels	sq m	sq m	Measurement shall be taken on the area of opening covered by the gate, stating the channel pickets, pivoted flat bars and the meshes formed by them when fully extended. The top and bottom runners, pulleys, locking lugs and handles shall be described and included in the item. This is also measured in quintal. The item of work shall also include erection in position and securing runners with brackets etc.
52. Rolling Shutters.	sq m	sq m	Measurement shall be taken of the opening covered or actual area of shutters. The guage and type of the slats, the bridge depth and the distance between centres of interlock shall be described and included in the item. The item shall include top cover, bottom rail, locking arrangement, spring winding mechanism etc.
53. Steel Doors and Windows.	sq m	sq m	The sizes of various members, methods of fixing and hanging and fastenings shall be described and included in the item. Any protective treatment required to be applied shall be described.
54. Wire Fencing.	r m	r m	Plain or barbed wire in fencing shall be described stating the gauge. Each line of wire shall be measured. Patent, plain wire fencing shall be measured in sq m
55. Expanded metal, wire netting etc.	sq m	sq m	The gauge and mesh and the method of fixing shall be described. Opening exceeding 0·2 sq m shall be deducted.
56. Lightening conductors.	r m	r m	Conductors and bands of tape shall be measured after fixing, describing gauge or thickness of metal etc. Socket attachments and rods shall be enumerated and shall be described separately.

Description of item	Unit of measurement	Unit of rate	Mode of measurement.
Finishing :—			
57. Plastering (to wall, floor etc.) with lime or cement mortar or pointing to brickwork.	sq m	sq m	Measurement (exterior or interior) shall be taken as per surfaces of walls before plastering and deductions for openings shall be made as follows :—(a) No deduction or addition shall be made for ends of joists, posts steps etc. and opening not exceeding 0·5 sq m. (b) For opening exceeding 0·5 sq m but not exceeding 3 sq m and when both faces are plastered with the same plaster, deduction shall be made for one face only and no additions shall be made for jambs, soffits, sills etc. (c) For openings of area exceeding 3 sq m deduction shall be made for the openings, but jambs, soffits and sills shall be measured. When two faces of wall are plastered with different plasters or if one face is plastered and the other pointed, deduction shall be made on the side of frames on which the width of reveals, jambs etc. etc. is less than that on the other side. Plastering bands upto 30 cm or below shall be measured separately in r m.
58. Plastering to ceiling.	sq m	sq m	Dimensions of ceiling betweeen walls shall be taken before plastering. Ceiling with projected beams shall be measured over beams and the sides of beams shall be measured and added to plastering on ceiling. Soffits of stairs shall be measured as plastering on ceiling.
59. White or colour washing and distempering.	sq m	sq m	The number of coats shall be stated in the item. Deductions for openings shall be made as per plastering. Corrugated surface shall be measured flat. That area shall be increased by (a) 14% for corrugated steel sheets, (b) 20% for asbestos cement sheets with large corrugations, (c) 10% for semi-corrugated A. C. sheets. The various decorative treatment shall be measured separately. Preparation of surfaces shall be stated and included in the item.
60. Painting on Eaves, Gutters Rain-water and Ventilation pipes etc.	r m	r m	The size or girth of the articles shall be stated. Fittings, such as bends, branches, heads etc. shall be included in the length.
61. Painting letters and figures.	No,	Each	The height and form or style shall be stated. Commas, hyphens, stops etc. shall be included in the item.

Description of item	Unit of measurement	Unit of rate	Mode of measurement.
62. Painting work in doors, windows, grills, gratings, gates, corrugated roofing etc.	sq m	sq m	In all cases the 'Area' shall be measured flat (and not girthed). For doors and windows no separate measurement shall be made for the frames (chowkats) the area in such cases represents the area of the wall openings covered by the frames. The area measured as above shall be multiplied by the factors as given hereafter. Work on different surface viz, smooth, semi-absorbent, absorbent etc. shall be measured separately. Painting upto 15 cm in width shall be paid in r m but components of truses, girders and similar work shall be given in sq m.

The Multiplying factors for different surfaces to get equivalent plain area shall be followed according to I.S.I. recommendation as given below :—

Name of surface painted.	Multiplying factors for both sides	Remarks
1. Panelled, framed and braced, ledged and battened or ledged battened and braced.	$2\frac{1}{4}$ times	
2. Fully glazed or gauzed	1 time	
3. Part panelled and part glazed or gauzed	2 times	
4. Fully venetioned or louvred ...	3 times	
5. Flush	2 times	
Other Works :—		
6. Guard bars, gratings, railings, gates, grills, expanded metal etc	1 time (for all over sides)	For item no. 6 :—Guard bars gates, grills, gratings, expanded metal partitions etc. shall be measured on one side only, when coated on all exposed surfaces without any deduction for open spaces.
7. Corrugated iron sheets (measured flat)	2·28 times	
8. Nainital pattern roof using plain sheets ...	2·20 times	
9. Trellis or Jaffri work one-way or two way ...	2 times (all over sides)	For item no. 9 :—Supporting members of battens shall not be measured separately.
10. Roof battens for slate and tile roofing (measured flat without deduction for open spaces) ...	$\frac{3}{4}$ times (for all over sides)	For item no. 10 :—No deduction shall be made for open spaces.

Description of item	Unit of measurement	Unit of rate	Mode of measurement
Miscellaneous :—			
63. Rain-water, Vent, Waste pipes etc.	r m	r m	The length shall be measured along the centre line of the pipes and fittings. Length as laid or fixed shall be measured over all fittings such as bends, angles etc. which shall not be measured separately. The material and the gauge or the weight of a standard length shall be described. All pipes shall be classified according to their diameters. The diameters shall be the nominal dia. of the internal bore. Ventilating-cowls over tops of vent pipes shall be measured separately. Pipe nails, distance pieces etc. for fixing the pipes shall be included in the description.
64. Surface drains	r m	r m	The item shall be described in detail and a reference shall be given to a detailed drawing. The length shall be the centre length.
65. Sanitary Fittings	No.	Each	Sanitary fittings such as closet pans, urinals, shower roses, flushing pipes etc. shall be fully described. The pattern or makers name shall be specified.
66. Glass-panes	sq m	sq m	Each pane of glass shall be measured to the nearest 0·5 cm. Irregular or circular panes shall be measured as the smallest rectangular area from which the panes can be cut.
67. Broken glass coping	sq m	sq m	The thickness of bedding mortar and weight of broken glass per sq m of coping shall be described.
68. Door handles	No.	Each	Grip length for cast type and overall length for pressed steel type shall be measured. The description shall include the screws, all fittings, cutting, sinking, boring etc.
69. Butt, Purliament and Strap Hinges	No.	Each	Measurement shall be taken as follows :—(a) for butt hinges the length of the joint, (b) for parliament hinges open space between flanges, and the height of flanges, (c) for strap hinges the length of the leaf from the joint to the point. The description shall include the screws, all fittings, cutting, sinking, boring etc.
70. Bolts	No.	Each	Measurement shall be taken as follows :—(a) for flush bolts the length of plates (b) for barrel bolts the length of barrel and (c) the length of shoots in other bolts. The description shall include the screws, all fittings, cuttings, sinking, boring etc.

71. Schedule showing minimum height of stacks and the allowance to be deducted for sinkage and/or shrinkage when measured in fresh stacks as per W. Bengal P. W. D.

Materials.	Minimum height of stacks	Allowance to be deducted for sinkage and/or shrinkage
Stone metal, ballast, chips, shingles or gravel	32·5 cm	$\frac{1}{13}$
Stone boulders 15 cm or above size ...	53 cm	1
Stone boulders below 15 cm size ...	45 cm	$\frac{1}{9}$
Jhama bats or brick bats	53 cm	$\frac{1}{7}$
Jhama metal, khoa or chips	34 cm	$\frac{1}{9}$
Sand	61 cm	$\frac{1}{4}$
Surki	61 cm	$\frac{1}{4}$
Lime	61 cm	$\frac{1}{4}$
Mooram	32·5 cm	$\frac{1}{13}$
Carried earth	34 cm	$\frac{1}{9}$
Rubbish (Building or kiln)	34 cm	$\frac{1}{9}$
Steam coal or slack coal	61 cm	$\frac{1}{8}$

2·6. **Degree of accuracy in Esimating.**—During preparation of an estimate of a main head smaller dimensions in its various sub-heads should not be neglected as those affect the total quantity of main head. No approximation should be made after omitting fractional dimensions either directly from the drawings or from those determined from the plan.

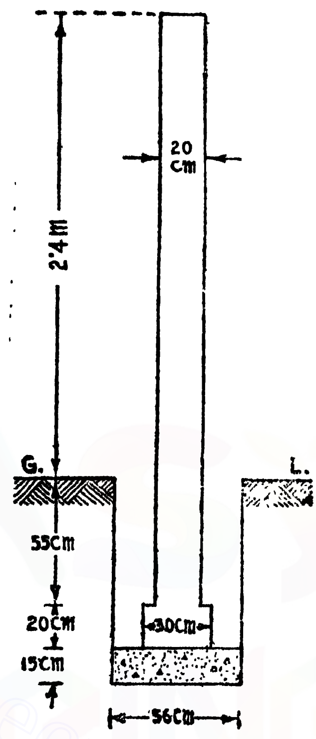
Method of measurement according to I. S. I.—

(*a*) ***Dimensions shall be measured to the nearest 0 01 metre (or 1 cm).***
(*b*) ***Areas shall be worked out to the nearest 0·01 sq. metre.***
(*c*) ***Cubic contents shall be worked out to the nearest 0·01 cu. metre.***

The degree of accuracy in calculations depends upon the rate of the item of work. Thus where the rates are per % or per ‰ units, greater accuracy is not required. But where the rates are per m, sq m, cu m, arithmetic calculation should be carried out up to two places of decimal for greater accuracy at higher rate.

Any work done by the contractor extra over the specified dimensions shall be ignored.

2-7. Some Simple Estimates :—(a) Quantity Estimate of a Symmetrical wall *(using Standard Modular Bricks)*—Estimate the quantities of earthwork in excavation, lime concrete in foundation, brickwork below ground level and above G. L. for a wall 10 metres in length whose cross section has been shown in the fig. 2-2.



CROSS SECTION

FIG. 2-2

Estimate :—

1. Earthwork in excavation
   $=10\text{m(length)} \times 56\text{cm (breadth)} \times 90\text{cm (depth)}$
   $=5{\cdot}04$ cu m
2. Lime concrete in foundation
   $=10\text{m} \times 56\text{cm} \times 15\text{cm}$
   $=0{\cdot}84$ cu m
3. Brickwork below ground level—
   For 30 cm brickwork
   $=10\text{m} \times 30\text{cm} \times 20\text{cm}$
   $=0{\cdot}60$ cu m
   For 20cm brickwork below G. L.
   $=10\text{m} \times 20\text{cm} \times 55\text{cm}$
   $=1{\cdot}10$ cu m
   ∴Total brickwork below G. L.
   $=0{\cdot}60+1{\cdot}10=1{\cdot}70$ cu m
4. Brickwork above G. L.
   $=10\text{m} \times 20\text{cm} \times 2{\cdot}4\text{m}$
   $=4{\cdot}80$ cu m.

For more clear expression estimate should be prepared in a Tabular form as shown below.

Description	No.	Length	Breadth	Height	Quantity	Total
1. Earthwork in excavation ...	1	10m	56cm	90cm	5·04	5·04 cu m
2. Lime concrete in foundation ...	1	10m	56cm	15cm	0·84	0·84 cu m
3. Brickwork below G.L.						
For 30 cm layer ...	1	10m	30cm	20cm	0·60	
For 20 cm layer ...	1	10m	20cm	55cm	1·10	1·70 cu m
4. Brickwork above G. L. ...	1	10m	20cm	2·4 m	4·80	4·80 cu m

(b) Quantity Estimate of a Railway Platform (*using standard modular brick*) :— Estimate the quantities of earthwork in excavation, lime concrete in foundation, masonry work, precast cement concrete coping stone and precast cement concrete blocks per metre length for a railway platform as shown in the fig. 2-3.

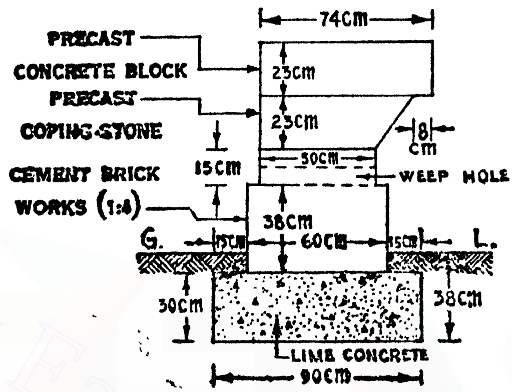


FIG. 2-3

Description	No.	Length	Breadth	Height	Quantity	Total	Explanatory notes
1. Earthwork in excavation	1	1 m	90 cm	38 cm	0·342	0·342 cu m	
2. Lime concrete in foundation	1	1 m	90 cm	30 cm	0·270	0·270 cu m	
3. Masonry work for 60 cm layer	1	1 m	60 cm	38 cm	0·228		
50 cm layer	1	1 m	50 cm	15 cm	0·075		
						0·303 cu m	
4. Precast cement concrete coping stone	1	1 m	(50 cm + 66 cm) / 2	23 cm	0·133	0·133 cu m	Average taken as this forms a trapizium.
5. Precast cement concrete blocks	1	1 m	74 cm	23 cm	0·170	0·170 cu m	

NOTE that quantities in the above estimate even for earthwork have been calculated upto three places of decimal due to the fact that if any approximation be made for unit length of a wall then a gross variation will occur for the total length (say 100m. 200m etc.)

(c) **Quantity Estimate of a Retaining Wall running two-way** (*Using standard modular bricks*) :—Estimate the quantities of lime concrete and brickwork in the retaining wall from the figure 2-4.

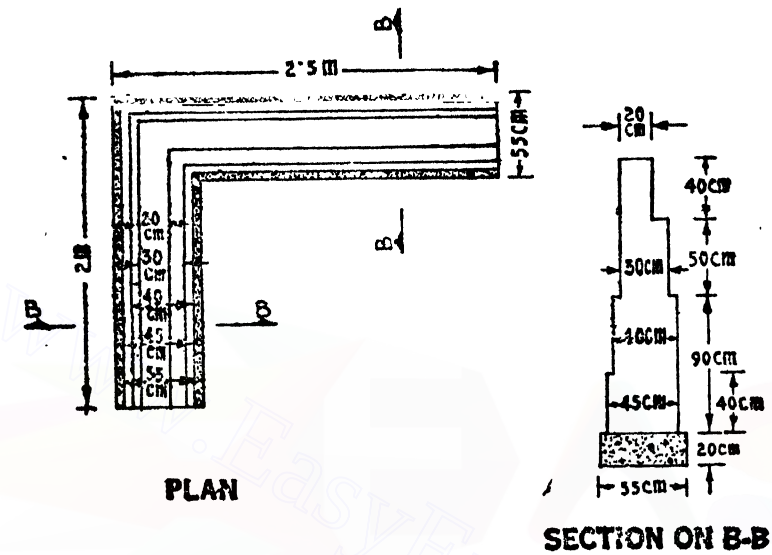


FIG. 2-4

Note that :—*The length of a layer for the long side (overall length 2·5m) has been considered out to out and for the short side (overall length 2m) it has been calculated from out upto the meeting point of the respective layer with the long side. Adding these lengths total length has been taken in the estimate and further clarified in the explanatory notes.*

Estimate :

Description	No	Length	Breadth	Height	Quantity	Total	Explanatory notes
1. Lime concrete in foundation		3·95 m	·55m	·20m	0·44	0·44 cu m	3·95 = 2·5 + (2—·55)
2. Brickwork for							
(a) 45 cm layer		3·95 m	·45m	·40m	0·71		3·95 = (2·5—0·5) + (2—0·5—·45)
(b) 40 cm layer		3·90 m	·40m	·50m	0·78		3·90 = (2·5—·10) + (2—·10—·40)
(c) 30 cm layer		3·90 m	·30m	·50m	0·59		3·90 = (2·5—·15) + (2—·15—·30)
(d) 20 cm layer		4·00 m	·20m	·40m	0·32	2·40 cu m	4·00 = (2·5—·15) + (2—·15—·20)

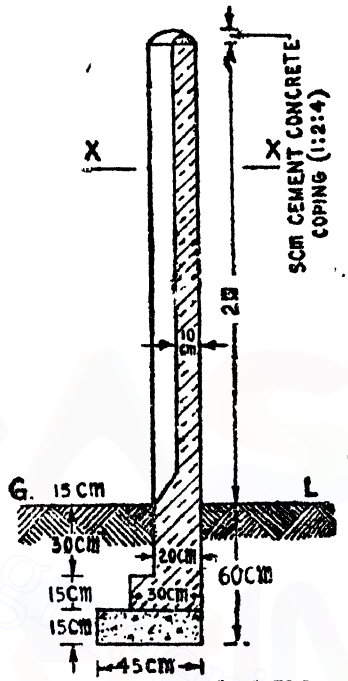
(d) Detailed Estimate of an Unsymmetrical Boundary wall (*Using Standard Modular Bricks*). Prepare a detailed estimate for a boundary wall of length 37m whose plan and sectional elevation has been shown in the fig. 2-5. No work beyond the length as specified is permitted.

General specification and rates of work are as below—

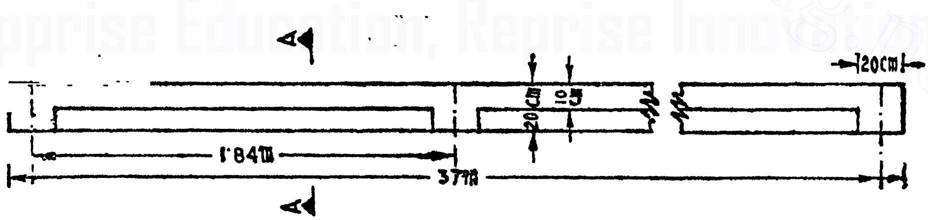
(1) Earthwork shall be as per drawing and trench shall be filled up with loose earth.
Rate Rs. 300 per %cu m

(2) Concrete work in foundation shall be of lime (1:2:5)
Rate Rs. 195·00 per cu m.

(3) Brickwork in foundation and above shall be 1st. class in cement mortar (1:4)
Rate Rs. 245·00 per cu m.



SECTIONAL ELEVATION ON A-A



PLAN AT X-X FIG 2-5

(4) 10cm thick brickwork shall be in cement mortar (1:3), Rate Rs. 30·00 per sq m.

(5) Cement concrete coping (1:2:4) with stone chips shall be on the top of pillars and panals) Rate Rs. 400·00 per cu m.

(6) All faoes except top of the wall shall be 20 mm thick cement plastered (1:4), Rate Rs. 7·00 per sq m

(7) All faces except top of the wall shall be two coats colour washed over a coat of white washing. Rate Rs. 0·80 per sq m.

Description	No.	L	B.	H.	Quantity	Total	Explanatory notes
1. Earthwork in							
excavation	1	37 m	·45 m	·60 m	9·99		Appx. $\frac{1}{8}$th, but accurately to be vol. of excavation less vol. of work below G.L.
filling ...	$\frac{1}{8}$	th. of	excav	ation=	2·00	11·99 cu m	
2. Lime concrete in							
foundation ...	1	37 m	·45 m	·15 m	2·50	2·50 cu m	
3. Brickwork for							
30 cm layer ...	1	37 m	·30 m	·15 m	1·67		
20 cm layer ...	1	37 m	·20 m	·45 m	3·33		Chamfer has been considered square
20 cm × 20 cm pillars only ...	21	·20 m	·20 m	1·85 m	1·55	6·55 cu m	1·85m=2m—15 cm, No. of pillars= $\frac{37m-20cm}{1 \cdot 84m}+1$
4. 10 cm brick work							
for panels ...	20	1·64 m	—	1·85 m	60·08	60·08 sq m	
5. Cement concrete coping							
(a) top of pillars ...	21	·20 m	·20 m	$\frac{0+5cm}{2}$	0·02		
(b) top of panels ...	20	1·64 m	·10 m	$\frac{0+5cm}{2}$	0·08	0·10 cu m	
6. Cement plastering							
(a) outside ...	1	37 m	—	2m	74·00		
(b) inside ...	1	41 m	—	2m	82·00		41m=37m+
(c) two ends ...	2	·20 m	—	2m	0·80	156·80 sq m	20×2×10cm
7. Colour washing		Same as	sand	Plaster	=	156·80 sq m	

ABSTRACT OF ESTIMATED COST

Description	Quantity	Unit	Rate	Unit	Amount Rs. P.
1. Earthwork in foundation ...	11·99	cu m	300·00	cu m	35·97
2. Lime concrete (1:2:5) in foundation ...	2·50	cu m	195 00	cu m	487·50
3. Brickwork in cement mortar (1:4) ...	6·55	cu m	245·00	cu m	1604·75
4. 10cm thick brickwork in cement mortar (1:3)	60·08	sq m	30·00	sq m	1802·40
5. Cement concrete (1:2:4) coping ...	0·10	cu m	400·00	cu m	40·00
6. 20mm thick cement plastering (1:4) ...	156·80	sq m	7·00	sq m	1092·00
7. Colour wash over two coats of white washing ...	156 80	sq m	0·80	sq m	125·44

Total= 5188·05
Add 5% Contingency= 259·40
Add $2\frac{1}{2}$% W C establishment= 129·70
Grand Total=Rs. 5 577·15

2-8. Different Methods for Estimating Building Works:—

The quantities of various items such as earthwork in excavation, foundation concrete, brickwork in foundation and plinth, brickwork in superstructure, etc. can be estimated by any of the following three methods :—

(1) **Centre line method**

(2) **Long and short wall or out to out and in to in method**

(3) **Crossing method**

(1) **Centre line method** :—In this method calculate the total centre line length of walls in a building and multiply the same by the breadth and depth of the respective item to get the total quantity at a time. For different sections of walls in a building, the centre line length for each type shall be worked out separately. In case of partition or verandah walls joining with main wall the centre line length shall be reduced by half of the breadth of the layer of main wall that joins with the partition or verandah wall at the same level. Number of such joints are studied first to calculate the centre line length.

By this method estimates may be prepared more quickly and this method is as accurate as the other methods. Only in the case of an unsymmetrical wall which is generally rare, no advantage may be claimed by this method over others as the centre line length varies at every layer. But to estimate circular, hexagonal, octagonal etc. shaped buildings this method shall specially be adopted.

(2) **'Long and short wall' or 'out to out' and 'in to in' method** :—In this method the longer walls in a building (generally in one direction) are considered as long walls and measured from out to out ; and the shorter or partition walls, in a perpendicular direction of the long walls, are considered as short walls and are measured from in-to-in for a particular layer of work. These lengths of long and short walls are multiplied separately by the breath and height of the corresponding layer and are added to get the quantity. Such lengths of long and short walls vary in every layer of footing.

To calculate the lengths of long and short walls determine first their centre to centre lengths individually from the plan. Then the length of long wall, out-to-out may be calculated after adding half breadth of wall at each end with its centre to centre length. Thus the length of short wall measured in-to-in may be find out after subtraction half breadth at each end from its centre to centre length. Length of long wall generally decreases from earthwork to brickwork in superstructure and in the case of short wall, its length increases.

In some of the working examples it may be noticed that a wall is considered as a short wall at one end and as a long wall at the other end. Such case arises in a wall which joins as a long wall with another long wall previously considered. The joining end of the wall later considered as long wall is actually treated as short end, ***and such a wall is named as Long-Short wall in this book.***

(3) **Crossing Method** :—In this method calculate the overall perimeter of the building and subtract from this four times the thickness of wall to obtain the centre line length. This method is now rarely use.

Example 1. Earthwork for Trenches :—Fig. 2-6 represents plan and section of a thench which is 80 cm wide and 60 cm deep. It is required to calculate the volume of earthwork for the trench.

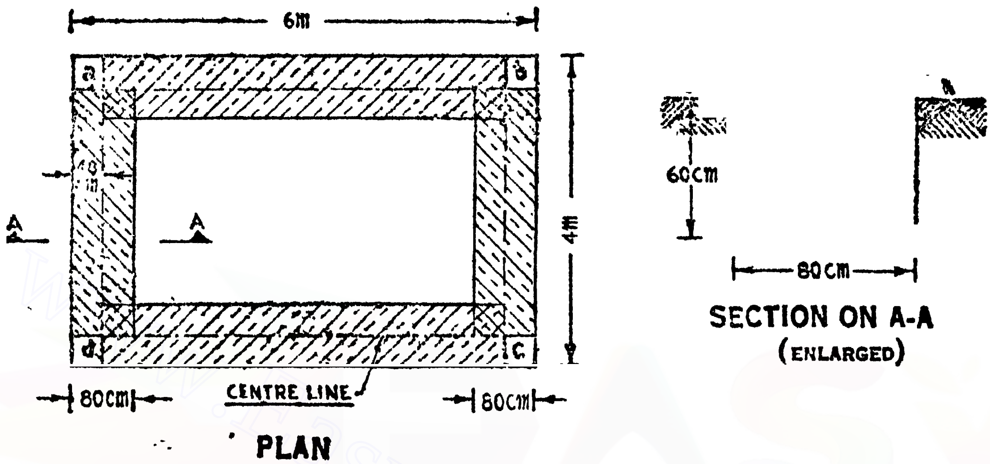


FIG. 2-6

(A) Centre line Method :—

Centre line for long wall = 6m—half trench width from each side

= 6m—40cm—40cm = 5·20m

Centre line for short wall = 4m—40cm—40cm = 3·20m

∴ Total length of centre line of all walls = 2(5·20 + 3·20) = 16·8m

∴ Earthwork in excavation = Sum of centre line × width × depth

= 16·8m × 80cm × 60cm = 8·064 cu m

(B) By long and short wall method :—

Centre line length of long wall = 5·20m (as calculated above)

∴ Length of long wall out to out = 5·20m + half breadth from each side

= 5·20m + 2 × $\frac{80}{2}$cm = 6m

Quantity for long walls = 2 × 6m × 80cm × 60cm = 5·760 cu m

Thus length of short wall in-to-in = 3·20m—2 × $\frac{80}{2}$cm = 2·40m

Quantity for short walls = 2 × 2·40m × 80cm × 60cm = 2·304 cu m

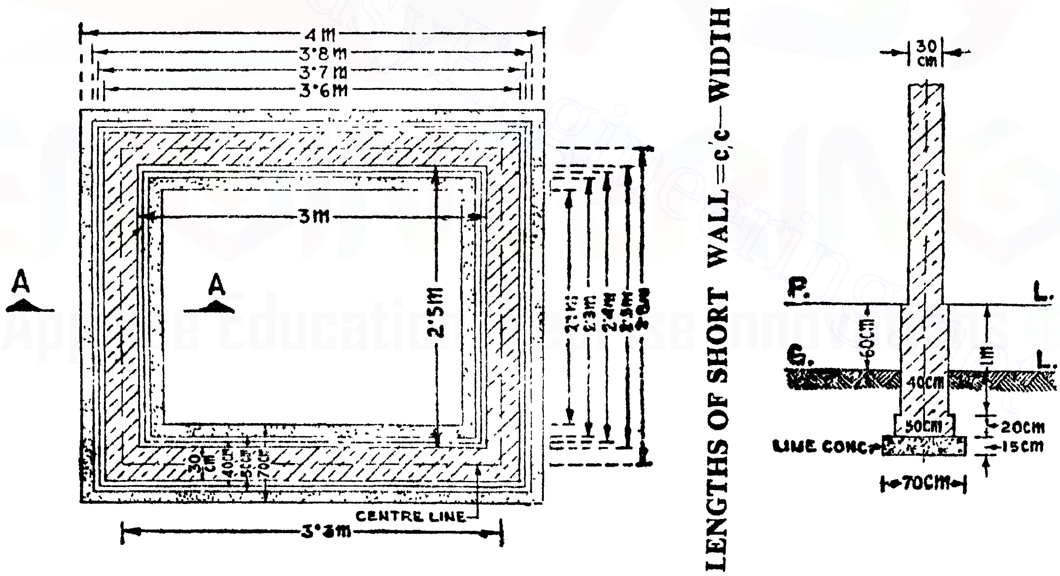
∴ Total quantity of Earthwork in excavation = 5·760 cu m + 2·304 cu m = 8·064 cu m

Mathematically the same result of 8·064 cu m is obtained. But for a clear conception let us investigate how the whole earthwork is considered by the centre line method if work proceeds along the centre lines by means of a diagram as shown by shaded lines in the above figure.

Following the fig. 2-6. line ab+bc+cd+da=total length of centre line. Let us first excavate the line 'a' to 'b' with 40 cm width on each side, but not beyond 'a' or 'b'. Similarly excavate lines bc, cd and da. Investigating the excavation following the shaded lines it is observed that blocks in which the letters a, b, c and d are marked have not been considered at all i. e. it appears that these blocks are remaining unexcavated, whereas blocks opposite to them have been considered twice (as showm by double hatched lines.) Now, the adjacent block of 'a' which has been considered twice may represent once its equal and opposite block 'a'. Similarly the Blocks 'b' 'c' and 'd' are to be represented by their respective adjacent and equal blocks. ***Therefore, by centre line method the entire work has been considered and no portion has been left out without excavation or considered twice. It is important to note that at corners of trench or walls no addition or subtraction of the centre line is required.***

Example-2. Single Room building :—**Fig. 2-7** represents the plan and section of the foundation wall (after removal of earth) of a building internally measuring 3m × 2·5m. Estimate the quantities of (1) Earthwork in excavation in foundation, (2) Lime concrete in foundation, (3) Brickwork in foundation and plinth.

LENGTHS OF LONG WALL=c/c+WIDTH



PLAN AFTER REMOVING EARTH FIG.2-7 SECTION ON A-A

(A) **By centre line method** :—To estimate the quantities, calculate first the total length of centre line which remains constant for varying widths of works, and multiply this constant length of the centre line with the respective breadth and height. Thus quantities of all items may be calculated easily.

$$\text{Total length of centre line} = 2\left[\frac{(3\text{m}+2\times 30\text{cm})}{2}+\frac{(2{\cdot}5\text{m}+2\times 30\text{cm})}{2}\right]=12{\cdot}2\text{m}$$

iption	No.	Length	Breadth	Height	Quantity	Total
. Earthwork in excavation ...	1	12·2m	·70m	·75m	6·41	6 41 cu m
2. Lime concrete in foundation ...	1	12·2m	·70m	·15m	1·28	1·28 cu m
3. Brickwork in foundation and plinth						
(a) 50 cm layer ...	1	12·2m	·50m	·20m	1·22	
(b) 40 cm layer ...	1	12·2m	·40m	1·00m	4·88	6·10 cu m

(B) By long and Short wall method :—

Centre to centre length of long walls $= 3 + 2 \times \frac{.80}{2} = 3.30$m

Centre to centre length of short walls $= 2.5 + 2 \times \frac{.80}{2} = 2.80$m

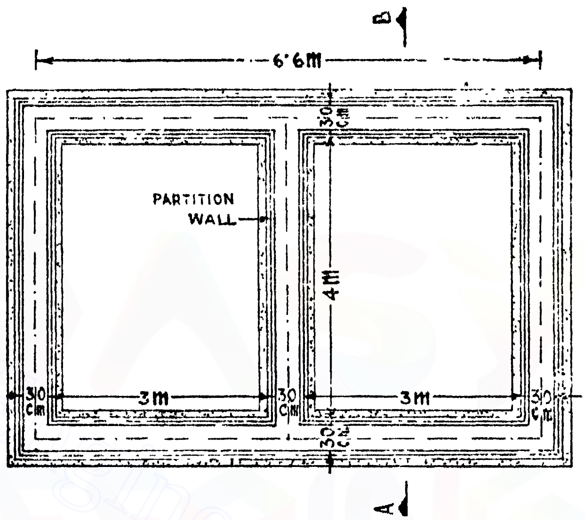
The length of long walls out-to-out and short walls in-to-in vary in every layer of footing. To calculate the length of long walls add half breadth of that layer at each end with the centre to centre length and for short walls subtract half breadth of the layer from each end. Lengths thus obtained may also be verified from the plan as shown in the figure 2-7.

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1. Earthwork in excavation							
Long walls ...	2	4·00	·70	·75	4·20		$4.00 = 3.30 + 2 \times \frac{.70}{2}$
Short walls ...	2	2·10	·70	·75	2·21		$2.10 = 2.80 - 2 \times \frac{.70}{2}$
						6 41 cu m	
2. Lime concrete in foundation							Width of concrete is same as earthwork so lengths are same as excavation.
Long walls ...	2	4·00	·70	·15	·84		
Short walls ...	2	2·10	·70	·15	44		
						1·28 cu m	
3. Brickwork in foundation and plinth							
Long walls							
1st footing 50 cm ...	2	3·80	·50	·20	·76		$3.80 = 3\ 30 + 2 \times \frac{.50}{2}$
2nd footing 40 cm ...	2	3·70	·40	1·00	2·96		$3.70 = 3.30 + 2 \times \frac{.40}{2}$
Short walls							
1st footing 50cm ...	2	2·30	·50	·20	·40		$2.30 = 2.80 - 2 \times \frac{.50}{2}$
2nd footing 40 cm ...	2	2·40	·40	1·00	1·92		$2.40 = 2.80 - 2 \times \frac{.40}{2}$
						6 10 cu m	

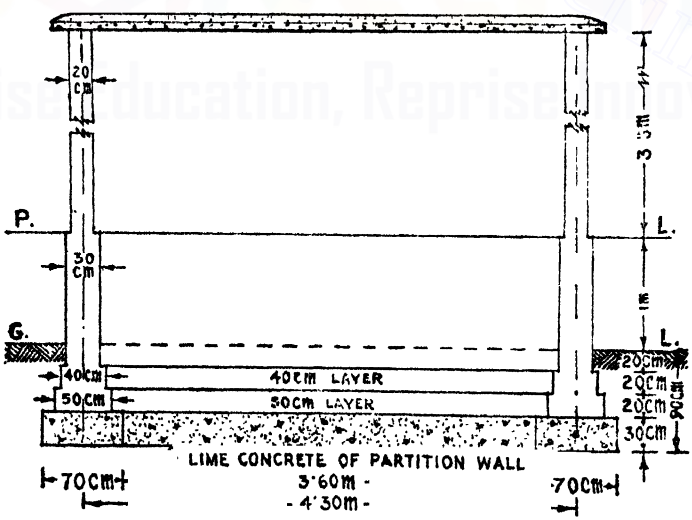
Comparing the quantities as calculated by the centre line and long-short wall methods it is observed that the same results have been obtained by any one of the methods. But to estimate the quantities of works by long-short wall method as illustrated above, when lengths of long and short walls vary for different widths of works it becomes more laborious a job than to estimate the quantities of different works through centre line method. It is, therefore, a common practice now-a-days to calculate the quantities of works for symmetrical sections through centre lines and this is as accurate as that of long-short wall method.

2-9. Partition Wall :—(a) Partition Wall having the same section to that of main wall.

Example 1.—Two roomed building. Fig. 2-8 shows the plan and cross. section of foundation wall of a building after removal of earth Let us calculate the quantity of earthwork in excavation and quantities of concrete and brickworks in foundation and plinth.



PLAN AT PLINTH AFTER REMOVING EARTH



SECTION ON A-B (ENLARGED) AFTER REMOVING EARTH

FIG. 2-8

(A) **Centre Line Method**—In the previous article (example-2) it has been observed that centre line length for main outer walls remains constant for different layers of work. But the centre line length for the partition wall will vary due to influence of main walls.

Length of centre line for main outer walls

$=2[(6{\cdot}90—30\text{cm})+(4{\cdot}60\text{m}—30\text{cm})]=$ **21·80m**

This length of 21·80m remains constant for all works from earthwork to brickwork in superstructure.

Length of center line for partition wall $=4\text{m}+$half of wall thickness at each end $=4+2\times\frac{\cdot 30}{2}=4{\cdot}30\text{m}$

For earthwork $=4{\cdot}30\text{m}$—half of trench width at each end

$=4{\cdot}30\text{m}—2\times\frac{\cdot 70}{2}\text{cm}=3{\cdot}60\text{m}$

∴ For earthwork total length of center line $=21{\cdot}80\text{m}+3{\cdot}60\text{m}=$ **25·40m**

Now, the question may raise as to why the actual length of centre line for the partition wall has been reduced to half of trench width from both ends where this wall joins along with the main wall. Following the fig. 2-8 (see section) for explanation of the above question it is observed that, when 70cm wide trench has been excavated for the main wall, a portion measuring half of the trench width has already been excavated from the original length of centre line of the partition wall 4·30m at each end and therefore, this portion shall not be taken into account during earthwork in excavation of this partition wall.

In working out examples number of such joint shall be studied first and deduction by half width of work for the number of joints be made without any explanation. Thus **calculate the total centre to centre lengths of all walls having same section and then deduct by half width of the work for the number of junctions with which the partition wall joins. Note that there will be a junction when three walls meet at a place.**

Thus total length of centre line $=21{\cdot}80+4{\cdot}30=26{\cdot}10\text{m}$

For earthwork $26{\cdot}10\text{m}—2\times\frac{\cdot 70}{2}=25{\cdot}40\text{m}$

Centre line for concrete work—This remains same as that of earthwork (25·40m) because concrete work for partition wall joins at a same level with concrete work for the main wall and width of earth and concrete works are the same.

Centre line for brickwork 50cm wide $=26{\cdot}10—2\times\frac{\cdot 50}{2}=25{\cdot}60\text{m}$

The question of reducing half of 50cm width of brick layer from both ends of partition wall where this joins along with the main wall is same as that of earthwork explained above.

Thus, centre line for brickwork 40cm wide $=26{\cdot}10—2\times\frac{\cdot 40}{2}=$ **25·70m**

Centre line for brickwork 30cm wide $=26{\cdot}10—2\times\frac{\cdot 30}{2}=$ **25·80m**

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1. **Earthwork** in excavation	1	25·40	·70	·90	16·00	16·00 cu m	
3. **Lime concrete** in foundation	1	25·40	·70	·30	5·33	5·33 cu m	
3. **Brickwork** in foundation and plinth							
(a) 50cm layer	1	25·60	·50	·20	2·56		
(b) 40cm layer	1	25·70	·40	·20	2·06		
(c) 30cm layer	1	25·80	·30	1·00	7·74		
						12·36 cu m	

(B) Long and short wall method :—Referring the plan of Fig. 2·8.

Centre to centre length of long walls $=(3·0+·30+3·0)+2\times\frac{·30}{2}=6·60$m

-do- -do- of short walls $=4·0+2\times\frac{·30}{2}=4·30$m

Note that the partition wall is to be considered here as short wall as the same is parallel to it.

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1. **Earthwork** in excavation							
(a) Long walls	2	7·30	·70	·90	9·20		$7·30=6·60+2\times\frac{·70}{2}$
(b) Short walls	3	3·60	·70	·90	6·80		$3·60=4·30-2\times\frac{·70}{2}$
						16·00 cu m	
2. **Lime Concrete** in foundation							
(a) Long walls	2	7·30	·70	·30	3·07		Lengths same as earthwork for same width at a same level
(b) Short walls	3	3·60	·70	·30	2·26		
						5·33 cu m	
3. **Ist Class brickwork** in foundation and plinth							
(a) Long walls—							
1st footing 50cm	2	7·10	·50	·30	1·42		$7·10=6·60+2\times\frac{·50}{2}$
2nd footing 40 cm	2	7·00	·40	·30	1·12		$7·00=6·60+2\times\frac{·40}{2}$
3rd footing 30cm	2	6·90	·30	1·30	4·14		$6·90=6·60+2\times\frac{·30}{2}$
(b) Short walls—							
1st footing 50cm	3	3·80	·50	·20	1·14		$3·80=4·30-2\times\frac{·50}{2}$
2nd footing 40cm	3	3·90	·40	·20	0·94		$3·90=4·30-2\times\frac{·40}{2}$
3rd footing 30cm	3	4·00	·30	1·00	3·60		$4·00=4·30-2\times\frac{·30}{2}$
						12·36 cu m	

Note that by both the methods (A) and (B) same quantities of work have been estimated.

(b) Partition and Verandah Walls having Different Cross section to that of Main Wall. Fig. 2-9 shows plan at plinth and cross section of different walls of a building. We are now to calculate the quantities of (1) earthwork in excavation, (2) concrete work in foundation and brickwork in foundation and plinth.

(A) By Centre line Method :

The method of calculation of centre lines is described below.

Main Outer Walls :—

Back and front$=2(7{\cdot}9-{\cdot}40)$
$=15$m

Note : Back AB$=$front CD$+$EF

Sides$=2(5{\cdot}2-{\cdot}40)=9{\cdot}6$m

Note : Side BC$=$sides DE$+$FA.

Total$=2{\cdot}46$m

This centre line length of 24·6m remains constant for all works because at corners no addition or subtraction is required as illustrated previously in the example-I of article 2-8. Length of this centre line must not be amalgamated along with that of the centre line for the partition and verandah walls having a different section.

For Partition & Verandah Walls :—

Before starting calculations for centre line, attention should be paid to note at how many places these walls join with the main walls, since centre line varies due to such joints. A joint occures when three walls meet at a place. In this problem there are altogether four such joints as marked by 'stars' on the plan.

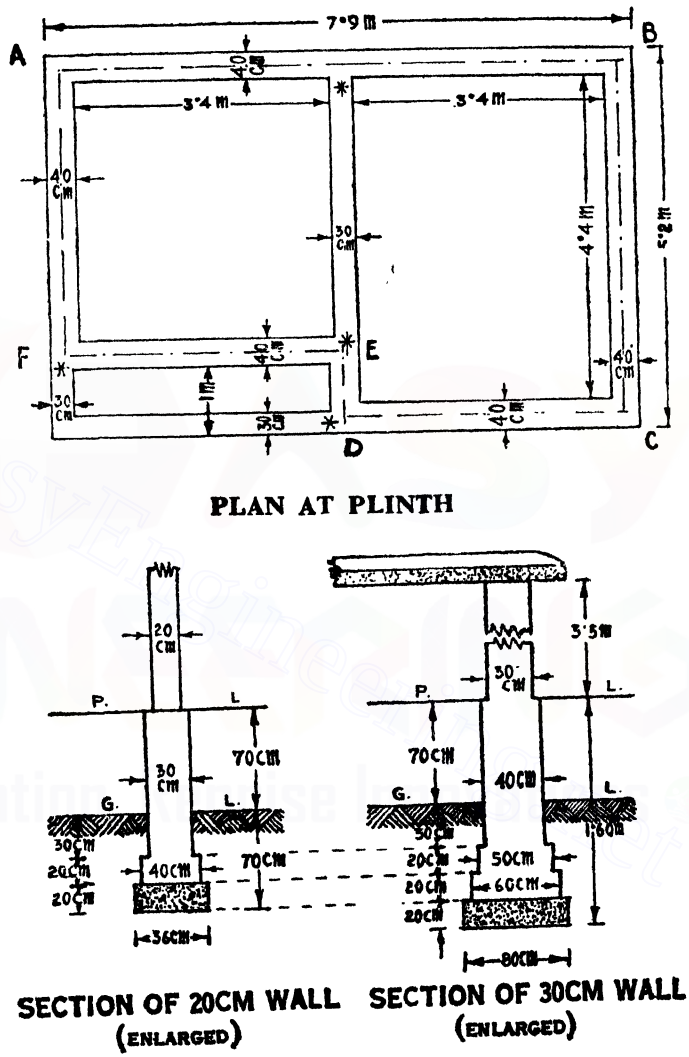


FIG. 2-9

To calculate the length of centre line—

Partition Wall inner to inner length$=5{\cdot}2-1{\cdot}0-2\times{\cdot}40=3{\cdot}4$m

Length of centre line for partition wall$=(3{\cdot}4+{\cdot}40)=3{\cdot}80$m

Thus, centre line for ***Verandah Wall***—

Front$=(3{\cdot}4+{\cdot}30+{\cdot}40)-\frac{{\cdot}80}{2}-\frac{{\cdot}40}{2}=3{\cdot}75$m

Side$=(1{\cdot}4+\frac{{\cdot}40}{2}-\frac{{\cdot}80}{2})=1{\cdot}05$m

Total length of centre line for partition and Verandah walls $=3{\cdot}8+3{\cdot}75+1{\cdot}05=8{\cdot}60$m

$\therefore$ Total length of centre line for earthwork $=8{\cdot}60-4\times\frac{\cdot80}{2}=7{\cdot}00$m

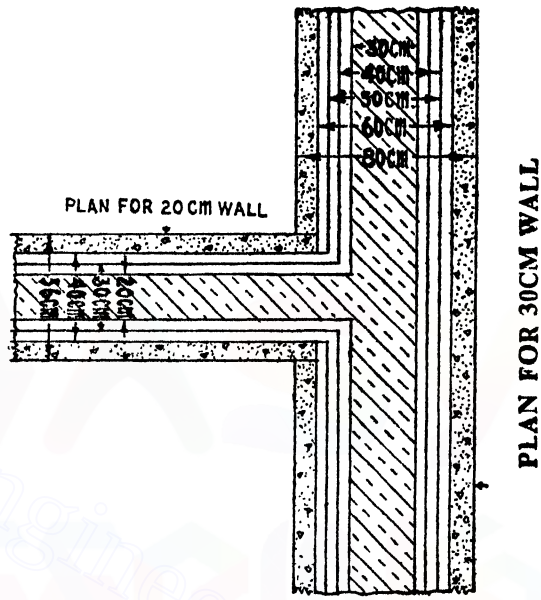
and the total length of centre line ***for concrete work*** which joins with 60cm brick layer of main wall $=8{\cdot}60-4\times\frac{\cdot60}{2}=7{\cdot}40$m

In the previous article it has been found that centre line of concrete work for the partition wall remains same as that of earthwork. In this case a question, therefore, may arise why the centre line is increased over that of earthwork. The reason of addition is that in the previous article section of main and partition walls are the same, but here they differ. Because of such difference, concrete of the partition wall joins with the 60cm brickworks of the main wall as shown in the fig. 2-10.

While calculating centre line for earthwork of the partition wall, length upto the border of excavation for main wall was considered. Now, to meet 60cm brick layer of main wall an additional concrete work (equal to the shift of 60cm thick layer towards centre from that of 80cm concrete work) is necessary.

Thus, ***centre line for 40cm brick layer*** of partition and Verandah walls $=8{\cdot}60-4\times\frac{\cdot50}{2}$ $=7{\cdot}60$m and ***centre line for 30cm brick layer*** $=8{\cdot}60-4\times\frac{\cdot40}{2}=7{\cdot}80$m

Estimate for quantities of works may be prepared without any illustration as described above.



PLAN SHOWING THE JUNCTIONS

FIG. 2-10

Description	No.	L. m	B m	H. m.	Qu.	Total
1 Earthwork in excavation						
(a) Main outer walls ...	1	24·60	·80	·90	17·71	
(b) Partition & Verandah Walls ...	1	7 00	·56	·70	2·74	
						20·45 cu m
2. Concrete work in foundation						
(a) Main outer walls ...	1	24·60	·80	·20	3·94	
(b) Partition and Verandah Walls ...	1	7·40	·56	·20	·83	
						4·77 cu m
3. Brickwork in foundation and plinth						
(a) Main outer walls—60cm brick layer ...	1	24 60	·60	·20	2·95	
50cm brick layer ...	1	24·60	·50	·20	2·46	
40cm brick layer ...	1	24·60	·40	1·00	9·84	
(b) Partition & Verandah Walls						
40cm brick layer ...	1	7·60	·40	·60	·61	
30cm brick layer ...	1	7·80	·30	1·00	2·34	
						18·20 cu m

(B) Long and Short wall method :—*Referring the plan of fig. 2-8 Centre to centre distances* :—

Entire back as long wall	$= 7{\cdot}9 - {\cdot}40 = 7{\cdot}5$m
Front big room —do—	$= 3{\cdot}4 + {\cdot}40 = 3{\cdot}80$m
Front small room —do—	$= (3{\cdot}4 + {\cdot}30 + {\cdot}40) - 2 \times \frac{\cdot 40}{2} = 3{\cdot}70$m
Verandah front as long & short wall	$= (3{\cdot}4 + {\cdot}30 + {\cdot}40) - \frac{\cdot 40}{2} - \frac{\cdot 30}{2} = 3{\cdot}75$m
Verandah left as short wall	$= 1{\cdot}0 - \frac{\cdot 30}{2} + \frac{\cdot 40}{2} = 1{\cdot}05$m.
Verandah right —do—	$= 1{\cdot}0 - \frac{\cdot 40}{2} + \frac{\cdot 40}{2} = 1{\cdot}00$m
Right of big room —do—	$= 4{\cdot}4 + {\cdot}40 = 4{\cdot}80$m
Left of small room —do—	$= 5{\cdot}2 - 1{\cdot}0 - 2 \times \frac{\cdot 40}{2} = 3{\cdot}8$m
Partition wall —do—	$= 3{\cdot}8$m (same as left of small room)

Note that :—(1) For back the two rooms have not been considered separately because (a) the entire back being a continuous wall should not ordinarily be split into two parts, (b) the partition wall is different in section to that of the main wall.

(2) Fronts of both the rooms not being a continuous wall, the entire front can not be considered simultaneously as in the case of the back wall.

(3) The Verandah front wall joints with another long wall at its right hand end previously considered. So this end of Verandah wall shall actually be treated as short wall while its other end as long wall and accordingly this wall is named as long-short wall (as described in the article 2-8).

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes.
1. Earthwork in excavation							
Entire back *as long*	1	8·30	·80	·90	5·97		$8{\cdot}30 = 7{\cdot}5 + 2 \times \frac{\cdot 80}{2}$
Front big room -do- ...	1	4.60	·80	·90	3·31		$4{\cdot}60 = 3{\cdot}8 + 2 \times \frac{\cdot 80}{2}$
Front small room -do- ...	1	4·50	·80	·90	3·24		
Ver. front *as long & short*	1	3·63	·56	·70	1·42		$3{\cdot}63 = 3{\cdot}75 + \frac{\cdot 56}{2} - \frac{\cdot 80}{2}$
Verandah left *as short* ...	1	0·37	·56	·70	·14		$0{\cdot}37 = 1{\cdot}05 - \frac{\cdot 56}{2} - \frac{\cdot 80}{2}$
Verandah right -do ...	1	0·20	·80	·90	·14		$0{\cdot}20 = 1{\cdot}0 - 2 \times \frac{\cdot 80}{2}$
Right of big room -do- ...	1	4·00	·80	·90	2·88		$4{\cdot}00 = 4{\cdot}8 - 2 \times \frac{\cdot 80}{2}$
Left of small room -do- ...	1	3·00	·80	·90	2·16		$3{\cdot}00 = 3{\cdot}8 - 2 \times \frac{\cdot 80}{2}$
Partition wall -do- ...	1	3·00	·56	·70	1·18	20·44	cu m
2. Lime concrete in foundation							
Entire back *as long* ...	1	8·30	·80	·20	1·33		
Front big room -do- ...	1	4·60	·80	·20	0·73		
Front small room -do- ...	1	4·50	·80	·20	·72		
Ver. front *as long & short*	1	3·73	·56	·20	·42		$3{\cdot}73 = 3{\cdot}75 - \frac{\cdot 60}{2} + \frac{\cdot 56}{2}$
Verandah left *as short*	1	0·47	·56	·20	·05		$\cdot 47 = 1{\cdot}05 - \frac{\cdot 60}{2} + \frac{\cdot 56}{2}$
Verandah right -do- ...	1	0·20	·80	·20	·03		
Right of big room -do- ...	1	4·00	·80	·20	·64		
Left of small room -do- ...	1	3·00	·80	·20	·48		
Partition wall -do- ...	1	3·20	·56	·20	·36	4·76	$3{\cdot}20 = 3{\cdot}8 - 2 \times \frac{\cdot 60}{2}$ cu m

Description	No	L m	B m	H. m.	Qu.	Total	Explanatory notes.
3. Brickwork in foundation and plinth							
Entire back *as long*							
1st footing 60 cm ...	1	8·10	·60	·20	·96		$8{\cdot}10 = 7{\cdot}5 + 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	8·00	·50	20	·80		$8{\cdot}00 = 7{\cdot}5 + 2 \times \frac{{\cdot}50}{2}$
3rd footing 40 cm ...	1	7·90	·40	1·00	3·16		
Front big room *as long*							
1st footing 60 cm ...	1	4·40	·60	·20	·53		$4{\cdot}4 = 3{\cdot}8 + 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	4·30	·50	·20	·43		$4{\cdot}3 = 3{\cdot}8 + 2 \times \frac{{\cdot}50}{2}$
3rd footing 40 cm ...	1	4·20	·40	1·00	1·68		
Front small room *as long*							
1st footing 60 cm ...	1	4·30	·60	·20	·52		$4{\cdot}30 = 3{\cdot}70 + 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	4·20	·50	·20	·42		$4{\cdot}20 = 3{\cdot}70 + 2 \times \frac{{\cdot}50}{2}$
3rd footing 30 cm ...	1	4·10	·40	1·00	1·64		
Verandah front *as long & short*							
1st footing 40 cm ...	1	3·70	·40	·20	·30		$3{\cdot}7 = 3{\cdot}75 - \frac{{\cdot}50}{2} + \frac{{\cdot}40}{2}$
2nd footing 30 cm ...	1	3·70	·30	1·00	1·11		$3{\cdot}7 = 3{\cdot}75 - \frac{{\cdot}40}{2} + \frac{{\cdot}30}{2}$
Verandah left *as short*							
1st footing 40 cm ...	1	0·60	·40	·20	·05		${\cdot}60 = 1{\cdot}05 - \frac{{\cdot}50}{2} - \frac{{\cdot}40}{2}$
2nd footing 30 cm ...	1	0·70	·30	1·10	·21		${\cdot}70 = 1{\cdot}05 - \frac{{\cdot}40}{2} - \frac{{\cdot}30}{2}$
Verandah right *as short*							
1st footing 60 cm ...	1	0·40	·60	·20	·05		${\cdot}40 = 1{\cdot}00 - 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	0·50	·50	·20	·05		
3rd footing 40 cm ...	1	0·60	·40	1·00	·24		
Right big room *as short*							
1st footing 60 cm ...	1	4·20	·60	·20	·50		$4{\cdot}20 = 4{\cdot}8 - 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	4·30	·50	·20	·43		
3rd footing 40 cm ...	1	4·40	·40	1·00	1·76		
Left small room *as short*							
1st footing 60 cm ...	1	3·20	·60	·20	·38		$3{\cdot}20 = 3{\cdot}8 - 2 \times \frac{{\cdot}60}{2}$
2nd footing 50 cm ...	1	3·30	·50	·20	·33		
3rd footing 40 cm ...	1	3·40	·40	1·00	1·36		
Partition wall *as short*							
1st footing 40 cm ...	1	3·30	·40	·20	·26		$3{\cdot}30 = 3{\cdot}8 - 2 \times \frac{{\cdot}50}{2}$
2nd footing 30 cm ...	1	3·40	·30	1·00	1·02		$3{\cdot}40 = 3{\cdot}8 - 2 \times \frac{{\cdot}40}{2}$
						18·19 cu m	

N. B. Compare the quantities calculated by method (A)

(c) Partition or Verandah Wall having Different Cross Section to that of Main Wall and when a same footing joins along with Several Footings of the Main Wall.

Fig. 2-11 shows the plan and sections of walls for a single roomed building with Verandah. Estimate the quantities of the following items ;—(1) Earthwork in excavation in foundation. (2) Lime concrete in foundation, (3) First class brickwork in cement mortar (1:4) in foundation and plinth. (4) First class brickwork in cement mortar (1:6) in superstructure. Neglect step.

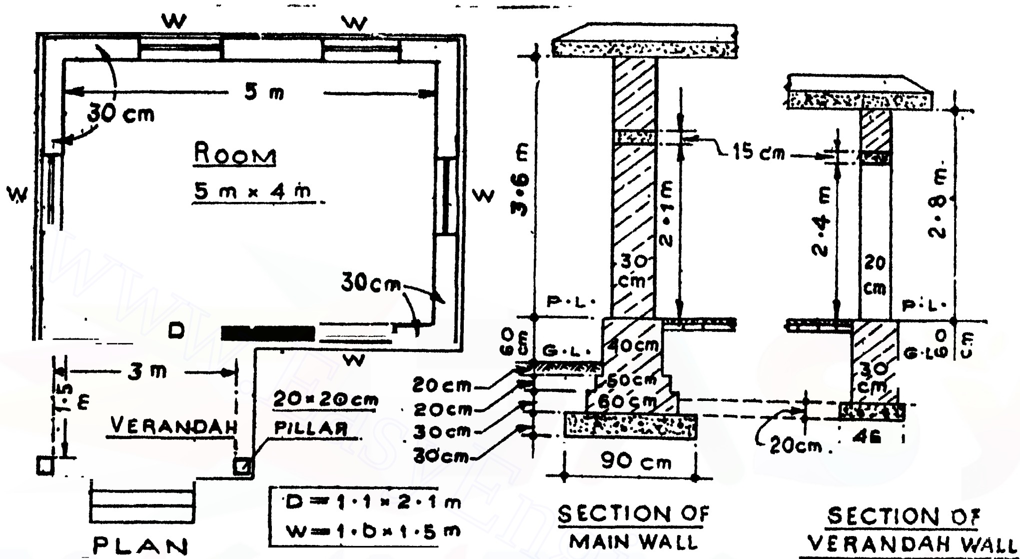


FIG. 2-11 (ENLARGED)

(A) By centre line method :—

(a) Length of centre line for mainwalls $=2\{(5{\cdot}0+2\times\frac{\cdot30}{2})+(4{\cdot}0+2\times\frac{\cdot30}{2})\}=19{\cdot}20$m

(b) Length of centre line for verandah walls, sides $=2(1{\cdot}5+\frac{\cdot30}{2}+\frac{\cdot20}{2})=3{\cdot}50$m

Number of joints = 2nos. Front $=3+2\times\frac{\cdot20}{2}=3{\cdot}20$m

Total $=6{\cdot}70$m

Note that a joint occurs at a place where three walls join.

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes.
1. Earthwork in excavation							Length of verandah is reduced by half of trench width
(a) Main walls	1	19·20	·90	1·00	17·28		
(b) Verandah walll	1	5·80	·46	·70	1·87		
						19·15 cu m	$5{\cdot}80=6{\cdot}70-2\times\frac{\cdot90}{2}$
2. Lime concrete in foundation							
(a) Main walls	1	19·20	·90	·30	5·18		Lime concrete joins with 60cm brick layer of main wall
(b) Verandah walls	1	6·10	·46	·20	·56		
						5·74 cu m	$6{\cdot}10=6{\cdot}70-2\times\frac{\cdot60}{2}$
3. First class brickwork in foundation and plinth (1:4)							
(a) Main walls							
60cm layer	1	19·20	·60	·30	3·46		
50cm layer	1	19·20	·50	·20	1·92		
40cm layer	1	19·20	·40	·80	6·14		
					11·52		

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes
B. F.	...	...	...	...	11·52		
(b) Verandah wall, portion joins with							
(i) 60cm layer of main wall	1	6·10	·30	·10	·18		6·10=6·70—2×$\frac{\cdot 60}{2}$
(ii) 50cm „ „ „	1	6·20	·30	·20	·37		6·20=6·70—2×$\frac{\cdot 50}{2}$
(iii) 40cm „ „ „	1	6·30	·30	·80	1·51		6·30=6·70—2×$\frac{\cdot 40}{2}$
						13·58 cu m	
4 First class brickwork in superstructure walls							
(a) Main walls ...	1	19·20	·30	3·60	20·74		
(b) Verandah walls ...	1	6·40	·20	2·80	3·58		6·40=6·70—2×$\frac{\cdot 30}{2}$
					24·32		
5 Deductions for—							
Door openings, D ...	1	1·10	·30	2·10	·69	(—ve)	
Window openings, W ...	5	1 00	·30	1·50	2·25	„	
Verandah openings, sides	2	1·50	·20	2·40	1·44	„	Verandah lintel with 15cm bearing at the ends in main wall
„ „ front ...	1	3·00	·20	2·40	1·44	„	
Lintel at main wall ...	1	19·20	·30	·15	·86	„	6·70=6·4+2×·15
—do— verandah ...	1	6·70	·20	·15	·18	„	6·4 as that for 20 cm wall in 4(b)
					6·86	17·46 cu m	

(**B**) **Long and short wall method** :—Referring to the Fig. 2-11

Centre to centre lengths for—

Room :—Long walls$=5+2\times\frac{\cdot 30}{2}=5{\cdot}30$m

Short walls$=4+2\times\frac{\cdot 30}{2}=4{\cdot}30$m

Verandah :—Front long wall$=3+2\times\frac{\cdot 20}{2}=3{\cdot}20$

Sides, short walls$=1{\cdot}5+\frac{\cdot 20}{2}+\frac{\cdot 30}{2}=1{\cdot}75$ m

Description	No.	L. m.	B. m	H. m.	Qu.	Total	Explanatory notes
1. Earthwork in excavation							
Room—Long walls ...	2	6·20	·90	1·00	11·16		6 20=5·30+·90
short walls ...	2	3·40	·90	1 00	6·12		3·40=4·30—·90
Verandah—Front long wall	1	3 66	·46	·70	1·18		3·66=3·20+·46
Sides short walls	2	1·07	·46	·70	·69		1·07=1·75—$\frac{\cdot 90}{2}$—$\frac{\cdot 46}{2}$
						19·15 cu m	
2. Lime concrete in foundation							
Room—Long walls ...	2	6·20	90	·30	3·35		
Short walls ...	2	3·40	·90	·30	1 83		
Verandah—Front long wall	1	3 66	·46	·20	·34		
Sides short walls	2	1·22	·46	·20	·22		1·22=1·75—$\frac{\cdot 60}{2}$—$\frac{\cdot 46}{2}$
						5·74 cu m	

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
3. First class brickwork 1:4, in foundation and plinth Room—Long walls							Lime concrete joins with 60cm brick layer of room
60cm layer	2	5·90	·60	·30	2·12		5·90=5·30+·60
50cm layer	2	5·80	·50	·20	1·16		5·80=5·30+·50
40cm layer	2	5·70	·40	·80	3·65		
Short walls 60cm layer	2	3·70	·60	·30	1·33		3·70=4·30—·60
50cm layer	2	3 80	·50	·20	·76		
40cm layer	2	3·90	·40	·80	2·50		
Verandah—front as long 30cm layer	1	3·50	·30	1·10	1·16		3·50=3·20+·30
Sides Short walls 30cm layer							
(i) that with 60cm ,,	2	1·30	·30	·10	·08		1·30=1·75—$\frac{·60}{2}$—$\frac{·30}{2}$
(ii) ,, ,, 50cm ,,	2	1·35	·30	·20	·16		1·35=1·75—$\frac{·60}{2}$—$\frac{·30}{2}$
(iii) ,, ,, 40cm ,,	2	1·40	·30	·80	·67	13·59 cu m	
4. First class brickwork (1:6) in superstructure							
Room—Long walls ...	2	5·60	·30	3·60	12·10		5·60=5·30+·30
Short walls ...	2	4·00	·30	3·60	8·64		4·00=4·30—·30
Verandah—front as long (consider solid first) wall	1	3·40	·20	2·80	1·90		3·40=3·20+·20
sides as Short walls	2	1·50	·20	2·80	1·68		1·50=1·75—$\frac{·20}{2}$—$\frac{·20}{2}$
Deduction for openings, lintel and verandah openings	same	as in	method	(A)	=6·86	(—ve) 17·46 cu m	

(d) A Building having Verandah Dwarf wall, Verandah Pillars with isolated footing and different depths of foundations to that of Main wall.

Estimate the following quantities from the Figure 2-12. (1) Earthwork in excavation, (2) Lime concrete in foundation, (3) First class brickwork in foundation and plinth, (4) First class brickwork in superstructure walls. Neglect step.

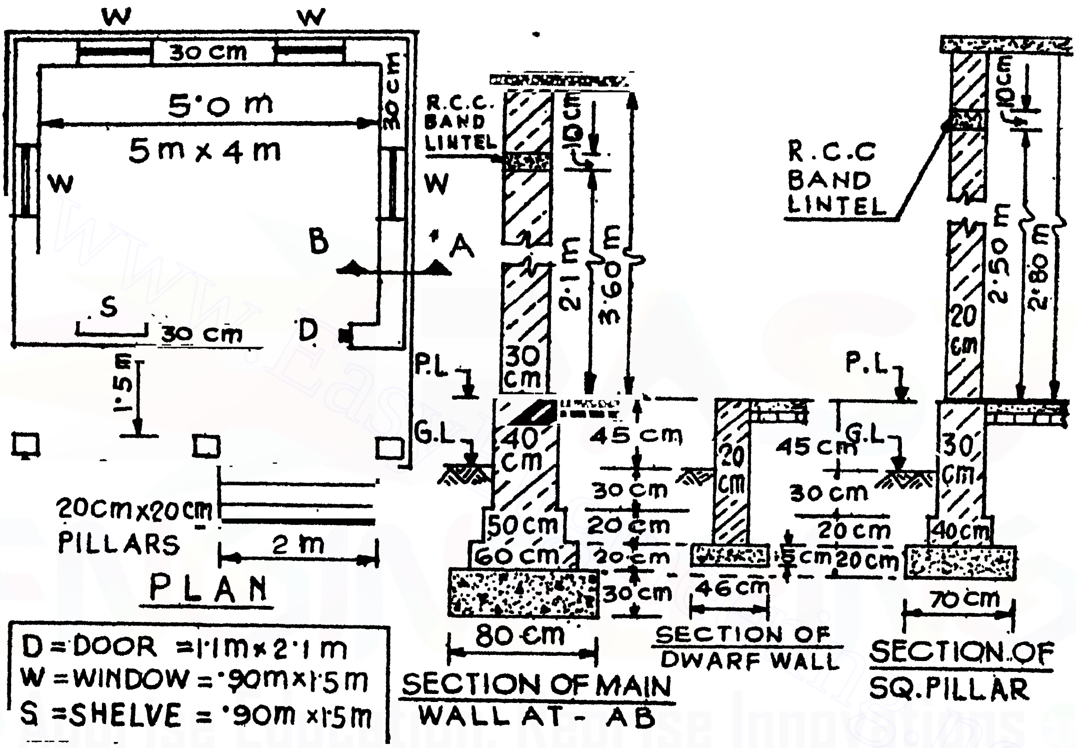


FIG. 2-12. ENLARGED

(A) Centre line method :—

Length of centre line for main walls $= 2[(5{\cdot}0+2\times\frac{\cdot30}{2})+(4+2\times\frac{\cdot30}{2})] = 19{\cdot}20$m

Length of centre line for verandah dwarf walls (considering first as if there is no middle pillar)

Front $= (5{\cdot}0+2\times{\cdot}30-2\times\frac{\cdot20}{2})$ $= 5{\cdot}40$m

Sides $= 2(1{\cdot}5+\frac{\cdot30}{2}+\frac{\cdot20}{2})$ $= 3{\cdot}50$m

Total $= 8{\cdot}90$m

Number of joint = 2nos. with the main wall and deduction for the length covered due to presence of 3nos' pillars shall be made. Pillars shall be considered separately.

Note that the length covered by pillars are 1 time for front and 2 times for sides.

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes
1. **Earthwork in excavation** in foundation trenches							
(a) Main walls ...	1	19·20	·80	1·00	15·36		$6{\cdot}00 = 8{\cdot}90 - 2\times\frac{\cdot 80}{2}$ $-3\times{\cdot}70$
(b) Pillars ...	3	·70	·70	·70	1·03		
(c) Verandah walls ...	1	6·00	·46	·65	1·80		
						18·19 cu m	
2. **Lime concrete in foundation**							
(a) Main walls ...	1	19·20	·80	·30	4·61		$6{\cdot}20 = 8{\cdot}90 - 2\times\frac{\cdot 60}{2}$ $-3\times{\cdot}70$
(b) Pillars ...	3	·70	·70	·20	·29		
(c) Verandah walls ...	1	6·20	·46	·15	·42		
						5·32 cu m	
3. **First class brickwork in** foundation and plinth							
(a) Main walls—							
1st footing 60cm ...	1	19·20	·60	·20	2·30		
2nd footing 50cm ...	1	19·20	·50	·20	1·92		
plinth wall 40cm ...	1	19·20	·40	·75	5·76		
(b) Pillars, 1st footing	3	·40	·40	·20	·10		
plinth wall	3	·30	·30	·75	·20		
(c) Verandah dwarf walls—							
(i) coinside with 50cm of main	1	7·20	·20	·20	·29		$7{\cdot}20 = 8{\cdot}90 - 2\times\frac{\cdot 50}{2}$ $-3\times{\cdot}40$
(ii) coinside with 40cm of main	1	7·60	·20	·75	1·14		$7{\cdot}60 = 8{\cdot}90 - 2\times\frac{\cdot 40}{2}$ $-3\times{\cdot}30$
						11·71 cu m	
4. **First class brickwork in** superstructure walls							
(a) Main walls ...	1	19·20	·30	3·60	20·73		
(b) Verandah (as solid)...	1	8·60	·20	2·80	4·81		$8{\cdot}60 = 8{\cdot}90 - 2\times\frac{\cdot 30}{2}$
					25·54		
Deductions for—							
Door opening, D	1	1·10	·30	2·10	·69	(—ve)	
Window openings, W	4	·90	·30	1·50	1·62	,,	
Shelve, S	1	·90	·20	1·50	·27	,,	consider the depth of shelve is 20 c m
Lintel in main wall ...	1	19·20	·30	·10	·58	,,	
Verandah openings front	2	2·40	·20	2·50	2·40	,,	$2{\cdot}40 = \frac{1}{2}(5{\cdot}0 - {\cdot}20)$
,, ,, sides	2	1·50	·20	2·50	1·50	,,	$9{\cdot}20 = 8{\cdot}60 + 2\times{\cdot}30$
Lintel (continuous) ...	1	9·20	·20	·10	·18	,,	consider 30 cm bearing in main wall at each end
					7·24	18·30 cu m	

(b) By long and short wall method—Centre to centre Length of—

Room—Long walls=5·0+·30=5·30m

Short walls=4·0+·30=4·30m

Verandah—As if there is no pillar except at ends and due to end pillars front and side walls each acts as a short wall. Deduction for intermediate pillar shall be made.

∴ Verandah front=(5·0+2×·30)—2×$\frac{\cdot20}{2}$=5·40m

Sides=1·5+$\frac{\cdot20}{2}$+$\frac{\cdot30}{2}$=1·75m

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes
1. Earthwork in excavation in foundation trenches							
Room—Long walls ...	2	6·10	·80	1·0			6·10=5·30+·80
Short walls ...	2	3·50	·80	1·0			3·50=4·30—·80
	T.L.	19·20	·80	1·0	15·36		Note, total length is same as that by method (A)
Pillars ...	3	·70	·70	·70	1·03		
Verandah front as short ...	1	4·00	·46	·65	1·20		4·00=5·4—2×$\frac{\cdot70}{2}$—·70
„ Sides as short ...	2	1·00	·46	·65	·60		1·00=1·75—$\frac{\cdot80}{2}$—$\frac{\cdot70}{2}$
						18·19 cu m	
2. Lime concrete in foundation							
Room—Long walls ...	2	6·10	·80	·30	2·92		
Short walls ...	2	3·50	·80	·30	1·68		
Pillars ...	3	·70	·70	·20	·29		
Verandah front as short ...	1	4·00	·46	·15	·28		4·00=5·40—2×$\frac{\cdot70}{2}$—·70
„ Sides as short...	2	1·10	·46	·15	·15		1·10=1·75—$\frac{\cdot70}{2}$—$\frac{\cdot60}{2}$
						5·32 cu m	
3. First class brickwork in foundation and plinth							
Room—Long walls							
1st footing 60 cm ...	2	5·90	·60	·20	1·41		5·90=5·30+·60
2nd footing 50 cm ...	2	5·80	·50	·20	1·16		5·80=5·30+·50
plinth walls 40 cm ...	2	5·70	·40	·75	3·42		
Short walls							
1st footing 60 cm ...	2	3·70	·60	·20	·89		3·70=4·30—·60
2nd footing 50 cm ...	2	3·80	·50	·20	·76		3·80=4·30—·50
Plinth wall 40 cm ...	2	3·90	40	·75	2·34		
Pillars, 1st footing 40cm ...	3	·40	·40	·20	·10		
2nd footing 30 cm ...	3	·30	·30	·75	·20		
Verandah front as short ...							
Lower part upto 20cm...	1	4·60	·20	·20	·18		4·60=5·40—2×$\frac{\cdot40}{2}$—·40
Upper part ...	1	4·80	·20	·75	·72		4·80=5·40—$\frac{\cdot80}{2}$—·30
Verandah sides as short ...							
Lower part upto 20cm ...	2	1·30	·20	·20	·10		1·30=1·75—$\frac{\cdot50}{2}$—$\frac{40}{2}$
Upper part ...	2	1·40	·20	·75	·42		1·40=1·75—$\frac{\cdot40}{2}$—$\frac{\cdot80}{2}$
						11·71 cu m	

Description	No.	L. m.	B. m.	H. m	Qu.	Total	Explanatory notes
1. **First class brickwork in superstructure walls**							
Room, Long walls —	2	5·60	·30	3·60	12·10		5·60 = 5·30 + ·30
Short walls —	2	4·00	·30	3·60	8·64		4·00 = 4·30 — ·30
Verandah front as long	1	5·60	·20	2·80	3·14		5·60 = 5·40 + ·20
,, sides as short	2	1·50	·20	2·80	1·68		1·50 = 1·75 — $\frac{\cdot 30}{2}$ — $\frac{\cdot 20}{2}$
Deduction— —		same as method A—			7·37	—(ve)	
						18·17	cu m

(e) A Building with front wall Abutting Road.

In some cases the corporation or municipal authorities do not permit to excavate the road or footpath in order to extend the foundation footings beyond the property line even against payment of necessary fees. Considering high cost of land, the foundation footings for such cases are designed with footing offsets at one side as shown in fig. 2-13. An estimate of quantities for the items for the above type of foundation has been prepared below.

Prepare estimate for the following quantities from the figure 2-13 (1) Earthwork in excavation, (2) Lime concrete in foundation, (3) 1st class brickwork in foundation and plinth in cement mortar (1:4), (4) 1st class brickwork in superstructure walls.

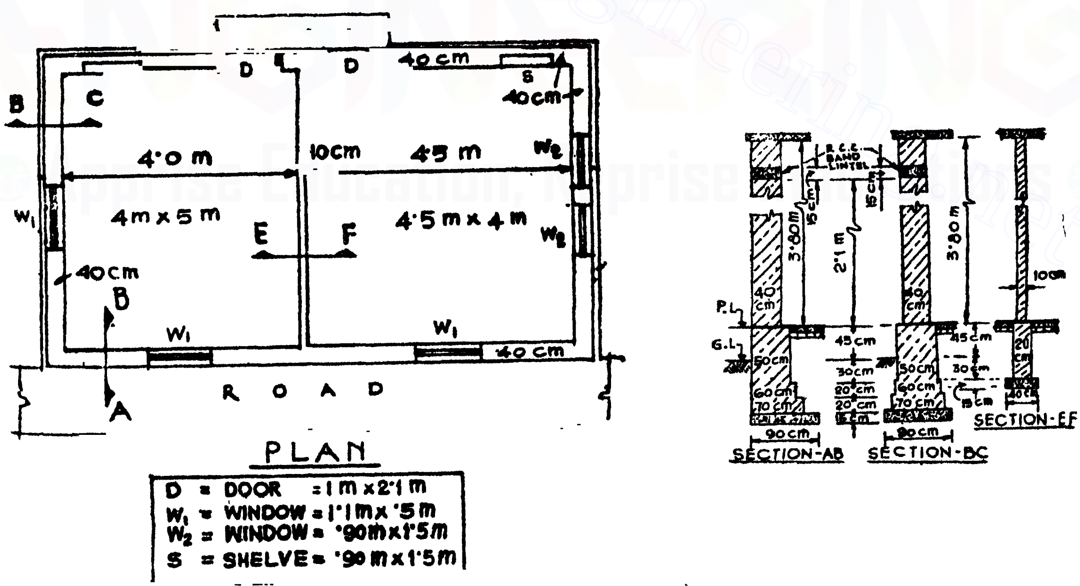


FIG. 2-13

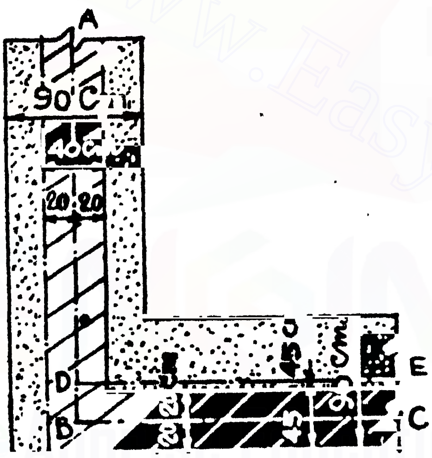
(A) **Centre line method** —The method of estimating in this case is similar as that of the general principle followed and accordingly no addition or subtraction of the length of centre line is required at the corners of rooms formed by two walls. But in this case when a wall having one-sided footing offsets joins along with another wall having symmetrical footing offsets and form a corner the length of centre line varies for different footings.

For such cases calculate first the length of centre line for the superstructure walls and decrease this length of centre line by half of the one sided footing offsets at each corner to find the centre line length for the corresponding layers.

For partition wall joining with such one sided footing offset wall, reduce the length of centre line by the width of offset from the centre as worked out in this example.

In order to verify the procedure diagramatically, consider the plan of such a corner wall having 40cm wide brick layer over 90 cm wide concrete as shown in the fig. 2-14

Let, ABC=Length of centre line for 40 cm wide brickwork and can be calculated from the dimensions of building.



PLAN OF A CORNER

FIG. 2-14

ADE=Length of centre line for 90cm wide concrete and this is required to be calculated from ABC.

Length of centre line for concrete work has been reduced by BD$=\frac{90}{2}-\frac{40}{2}=\frac{1}{2}(90-40)$ cm which is half of the offset of concrete. To prepare the estimate—

For main wall, length of centre line=
$2[(4+\cdot10+4\cdot5+\cdot40)+5\cdot40]=28\cdot8$m

For partition wall— do— do—
$=5\cdot0+\cdot40=5\cdot40$m

Number of corners=2 where length of centre line shall be decreased by half of one sided footing offset.

Description	No.	L. m.	B. m.	H. m	Qu.	Total	Explanatory notes
1. Earthwork in excavation							
Main wall ...	1	28·30	·90	·85	21·65		$28\cdot30=28\cdot80-2\times\frac{1}{2}(\cdot90-\cdot40)$
Partition wall ...	1	4·25	·40	·40	·68	22·33 cu m	$4\cdot25=5\cdot40-\frac{\cdot90}{2}-(\cdot90-\frac{\cdot40}{2})$
2. Cement concrete (1 : 3 :6)							
in Main wall ...	1	28·30	·90	·15	3·82		$4\cdot70=5\cdot40-\frac{\cdot60}{2}-(\cdot60-\frac{\cdot40}{2})$
Partition wall ...	1	4·70	·40	·10	·19	4·01 cu m	

Description	No.	L. m.	B. m.	H. m.	Qu.	Total	Explanatory notes
3. First class brickwork in foundation and plinth							
(a) Main walls							
1st footing 70 cm	1	28·50	·70	·20	3·99		$28{\cdot}50 = 28{\cdot}80 - 2 \times \frac{1}{2}({\cdot}70 - {\cdot}40)$
2nd footing 60 cm	1	28·60	·60	·20	3·43		$28{\cdot}60 = 28{\cdot}80 - 2 \times \frac{1}{2}({\cdot}60 - {\cdot}40)$
plinth wall 50 cm	1	28·70	·50	·75	10·76		
(b) Partition wall ...	1	4·85	·20	·75	·73	18·91 cu m	$4{\cdot}85 = 5{\cdot}40 - \frac{{\cdot}60}{2} - ({\cdot}50 - \frac{{\cdot}40}{2})$
4. First class brickwork in superstructure walls							
(a) Main wall	1	28·80	·40	3·80	43·78		Partition wall may be kept separate and measured in sq m
(b) Partition wall	1	5·00	·10	3·80	1·90		
					45·68		
Deductions for—							
Door openings D	2	1·00	·40	2·10	1·68	(—ve)	
Window „ W_1	3	1·10	·40	1·50	1·98	„	
„ „ W_2	2	·90	·40	1·60	1·08	„	
Shelve „ S	1	·90	·30	1·50	·40	„	
Lintel (continuous)	1	28·80	·40	·15	1·73	„	
					6·87	38·81	cu m

(B) Long and short wall method—

Procedure :—The procedure of estimate in this case is similar as that of general principle followed. The only differenoe is that instead half of width add or subtract the distance covered by the footing offset as worked out hereafter. The wall having with one sided footing offset shall be kept separate from the symmetrical walls.

Centre to centre distance, back and front as long $=(4+{\cdot}10+4{\cdot}5)+{\cdot}40=9$ m

sides as short $=5{\cdot}40$ m

partition as short $=5{\cdot}40$ m

Description	No.	L. m.	B. m.	H. m	Qu.	Total	Explanatory notes
1. **Earthwork** in excavation							
Back and front							
long walls ...	2	9·90	·90	·85			9·90=9+2×·90/2
Sides as short ...	2	4·25	·90	·85			4·25=5·40—90/2
	T.L	28·30	·90	·85	21·65		—(·90-·40/2)
Partition as short ...	1	4·25	·40	·40	·68		Note that total length
						22·33 cu m	is same as that of method (A)
2. **Cement concrete** in foundation							
Back & front long walls ...	2	9·90	·90	·15	2·67		
Sides as short ...	2	4·25	·90	·15	1·15		
Partition as short ...	1	4·70	·40	·10	19		4·70=5·40—·60/2
						4·01 cu m	—(·60—·40/2)
3. **1st class brickwork** in foundation and plinth							
Back and front long walls							
1st footing 70 cm ...	2	9·70	7·0	·20	2·72		9 70=9+·70
2nd footing 60 cm ...	2	9·60	6·0	·20	2·30		
Plinth wall 50 cm ...	2	9·50	5·0	·75	7·12		
Sides as short—							
1st footing 70 cm ...	2	4·55	·70	·20	1·27		4·55=5·40–·70/2 —(·70—·40/2)
2st footing 60 cm ...	2	4·70	·60	·20	1·13		4·70=5·40—·60/2 —(·60—·40/2)
Plinth wall 50 cm ...	2	4·85	·50	·75	3·64		4·85=5·40—·50/2 —(·50—·40/2)
Partiton as short							
plinth wall 20 cm ...	1	4·85	·20	·75	·73		
						18·91	
4. **Ist class brickwork in** superstructure walls							
Back and front as long ...	2	9·40	·40	3·80	28·58		5·00=5·40—·40/2
Sides as short ...	2	5·00	·40	3·80	15·20		—(·40—·40/2)
Partition as short ...	1	5·00	·10	3·80	1·90		Partition wall may be kept separate and measured in sq m
Deducton same as in method	(A)			=	6·87	(—ve)	
						38·81 cu m	

(f) Building having several Rooms along with Front and Back Verandahs.

Estimate the quantity of works of the following items from the attached plan and details of wall sections shown in the Figure 2-15.

(1) Earthwork in excavation in foundation trenches, (2) Lime concrete in foundation, (3) First class brickwork in cement mortar (1 : 4) in foundation and plinth, (4) First class brickwork in cement mortar (1 : 6) in superstructure.

(A) **Centre line method** :—Length of centre line.

(a) For main wall of 30cm.

kitchen and bed combined $= 2[(5{\cdot}5 + {\cdot}20 + 3 + 2 \times \frac{{\cdot}30}{2}) + (4 + 2 \times \frac{{\cdot}30}{2})]$ $= 26{\cdot}60$m

Right hand side beds combined $= 2[(4{\cdot}5 + {\cdot}20 + 4 + 2 \times \frac{{\cdot}30}{2}) + (4 + 2 \times \frac{{\cdot}30}{2})] = 26{\cdot}60$m

Dining cum Drawing, back and front only $= 2(4{\cdot}5 + 2 \times \frac{{\cdot}30}{2})$ ... $= 9{\cdot}60$m

For 30cm total ... $= 62{\cdot}80$m

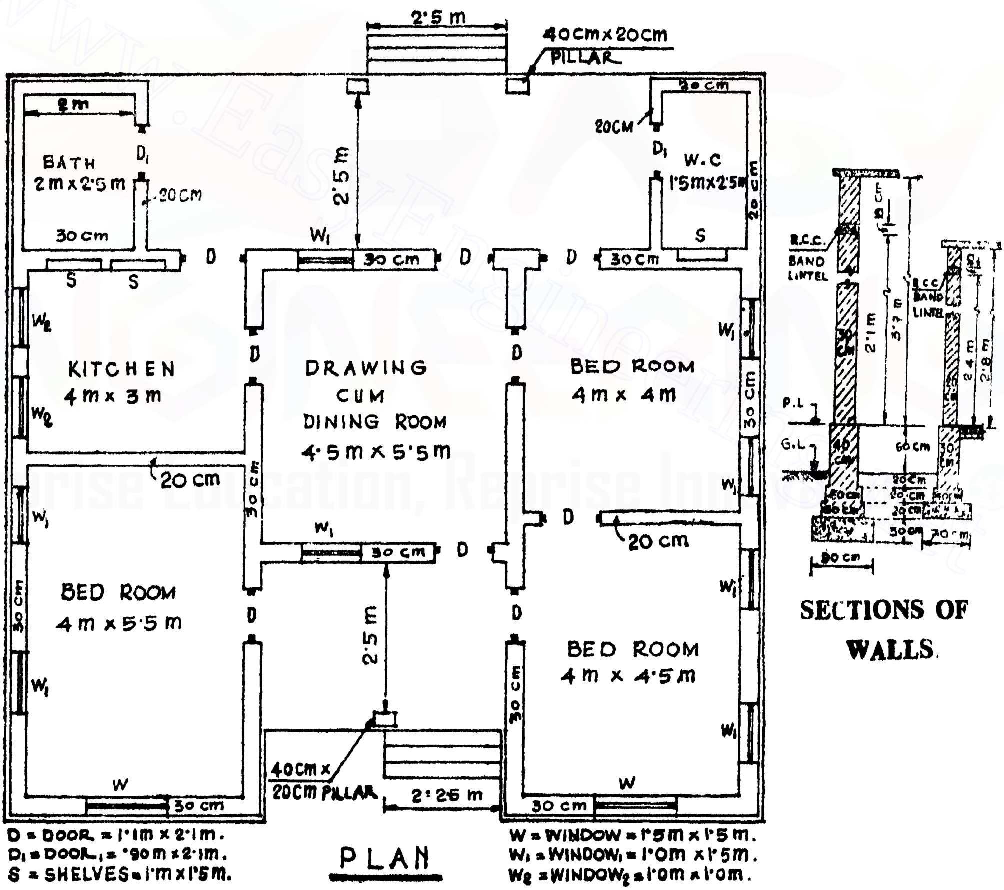


FIG. 2-15

Number of joints $= 2 \times 2 = 4$ **nos. with main wall** (where dining cum drawing room's back and front walls join)

(d) **For 20cm wall** of partition and verandahs—

Partition walls$=2(4+2\times\cdot30)$ ... $=8\cdot6$m (joints=4nos. with main wall)

Front verandah front$=(4\cdot5+\cdot30)$ ... $=4\cdot8$m (joints=2nos. „ „)

Back verandah entire $=(4+4\cdot5+4+4\times\cdot30)-2\times\frac{\cdot20}{2}=13\cdot5$m

Sides of back verandah and front of bath and W. C.$=4(2\cdot5+\frac{\cdot20}{2}+\frac{\cdot30}{2})$ ... $=11\cdot00$m (joints=4nos. with main and 2nos. with 20cm)

For 20cm total=37·90m. Number of joint=10nos. with 30cm. 2nos. with 20cm.

Description	No.	L. m.	B. m	H. m.	Qu.	Total	Explanatory notes
1. Earthwork in excavation in foundation for... ...							
Main walls	1	61·00	90	·90	49·41		$61\cdot00=62\cdot80-4\times\frac{\cdot90}{2}$
Verandah and partition	1	32·70	·70	·60	13·73	63·14 cu m	$32\cdot70=37\cdot90-10\times\frac{\cdot90}{2}-2\times\frac{\cdot70}{2}$
1. Lime concrete in foundation							
Main walls	1	61·00	·90	·30	16·47		
Verandah and partition	1	34·20	·70	·20	4·79	21·26 cu m	$34\cdot20=37\cdot90-10\times\frac{\cdot90}{2}-2\times\frac{\cdot70}{2}$
3. 1st. class brickwork in foundation and plinth for							
Main walls							
1st. footing 60 cm	1	61·60	·60	·20	7·39		$61\cdot60=62\cdot80-4\times\frac{\cdot60}{2}$
2nd footing 50 cm	1	61·80	·50	·20	6·18		
plinth wall 40 cm	1	62·00	·40	·80	19·84		
Verandah and partition							
Footing of 40 cm	1	35·00	·40	·20	2·80		$35\cdot00=37\cdot90-10\times\frac{\cdot50}{2}-2\times\frac{\cdot40}{2}$
Plinth wall 30 cm	1	35·60	·30	·80	8·54	44·75 cu m	
4. 1st. class brickwork in superstructure walls for—							
Main walls 30 cm	1	62·20	·30	3·70	69·04		$62\cdot20=62\cdot80-4\times\frac{\cdot30}{2}$
Verandah (as solid) and partition ...	1	36·20	·20	2·80	20·27 89·31		$36\cdot20=37\cdot90-10\times\frac{\cdot30}{2}-2\times\frac{\cdot30}{2}$
Deductions for—						(-ve)	
Door openings, D	9	1·10	·30	2·10	6·24		
„ „ D_1	3	·90	·20	2·10	1·13	„	
Window openings W	2	1·50	·30	1·50	1·35	„	
„ „ W_1	8	1·00	·30	1·50	3·60	„	
„ „ W_2	2	1·00	·20	1 00	·40	„	
Linted (band) for main wall	1	62·20	30	·15	2·80	„	(40 60=37·20+10×·30 +2×·20
„ for verandah & partition	1	40·60	·20	·15	1·22		(full bearing in 30 cm and 20cm walls)
Verandah openings—							
Front ...	1	4·10	·20	2·40	1·97	„	3·10=(4+4·5+4+4×·20)—2·0—1·5—4×·20 —2×·40
Back ...	1	5·10	·20	2 40	2·45	„	
Shelves S ...	3	1·00	·20	1·50	·90	„	cu m
					22·06	67·25	

(B) **Long and Short wall method** :—Centre to centre distance for—

Kitchen and bed room (combined) ; Long walls $=(3+5\cdot5+\cdot20)+2\times\frac{\cdot30}{2}=9\cdot00$m

Short walls $=4\cdot0+\cdot30$ ... $=4\cdot30$m

Partition ... ... Short walls $=4\cdot0+\cdot30$ ... $=4\cdot30$m

Right hand side bed rooms (combined), Long walls $=(4+4\cdot5+\cdot20)+\cdot30$ $=9\cdot00$m

Partition ... ... Short wall $=4+\cdot30$ $=4\cdot30$m

Drawing cum Dining room, back front short walls $=4\cdot5+\cdot30$ ... $=4\cdot80$m

Front verandah front, short wall $=4\cdot5+\cdot30$ ... ... $=4\cdot80$m

Back Verandah, back, long wall $(4+4\cdot5+4+3\times\cdot30)-2\times\frac{\cdot20}{2}$ ... ... $=13\cdot50$m

Back Verandah sides, and fronts of bath & W.C. short walls $=2\cdot5+\frac{\cdot30}{2}+\frac{\cdot20}{2}=2\cdot75$m

Description	No.	L. m	B. m.	H. m	Qu.	Total	Explanatory notes
1. Earthwork in excavation in foundation.							
Kitchen and Bed (combd.)							
Long walls	2	9·90	·90	·90	16·04		$9\cdot90=9+2\times\frac{\cdot90}{2}$
Short walls	2	3·40	·90	·90	5·51		
Partition, Short wall	1	3·40	·70	·60	1·43		$3\cdot40=4\cdot3-2\times\frac{\cdot90}{2}$
Right hand Beds (combd.)							
Long walls	2	9·90	·90	·90	16·04		
Short walls	2	3·40	·90	·90	5·51		
Partition, Short wall	1	3·40	·70	·60	1·43		
Drawing cum Dining—back and front, Short wall	2	3·90	·90	·90	6·32		$3\cdot90=4\cdot80-2\times\frac{\cdot90}{2}$
Front Verandah, front Short wall	1	3·90	·70	·60	1·64		
Back Verandah back Long wall	1	14·20	·70	·60	5·96		$14\cdot20=13\cdot5+2\times\frac{\cdot70}{2}$
Sides and front of bath & W. C. Short walls	4	1·95	·70	·60	3·28		$1\cdot95=2\cdot75-\frac{\cdot70}{2}-\frac{\cdot90}{2}$
						63·14	
2. Lime concrete in foundation.							
Kitchen and Bed (combd.)							
Long walls	2	9 90	·90	·30	5·35		
Short walls	2	3·40	·90	·30	1·84		
Partition, Short wall	1	3·70	·70	·20	·51		$3\cdot70=4\cdot30-2\times\frac{\cdot60}{2}$
Right hand Beds (combd.)							
Long walls	2	9·90	·90	·30	5·35		
Short walls	2	3·40	·90	·30	1·84		
Partition, Short wall	1	3·70	·70	·20	·51		
Drawing cum Dining—back and front, Short	2	3·90	·90	30	2·11		$4\cdot20=4\cdot80-2\times\frac{\cdot60}{2}$
Front Verandah, front—Short wall	1	4·20	·70	·20	·59		
Back Verandah, back Long wall	1	14·20	·70	·20	1·99		$2\cdot65=2\cdot75-\frac{\cdot70}{2}-\frac{\cdot60}{2}$
Sides and front of bath and W. C. Short walls	4	2·10	·70	·20	1·18		
					21·27	cu m	

Description	No.	L m.	B. m	H. m	Qu.	Total	Explanatory notes
3. 1st class brickwork in foundation and plinth							
Kitchen and bed (combd.)							
Long walls—							
1st footing 60cm.	2	9·60	·60	·20	2·30		9 60=9+·60
2nd footing 50cm	2	9·50	·50	·20	1·90		
Plinth wall 40cm	2	9·40	·40	·80	6·02		
Short walls—							
1st footing 60cm	2	3·70	·60	·20	·89		3·70=4 30—·60
2nd footing 50cm	2	3 80	·50	·20	·76		
Plinth wall 40cm	2	3·90	·40	·80	2·18		
Partition as short—							
1st footing 40cm	1	3·80	·40	·20	·30		3 80=4·30—·50
Plinth wall 30cm	1	3·90	·30	·80	·94		
Right hand side bed rooms (combined) Long walls—							
1st footing 60cm	2	9·60	·60	·20	2·30		
2nd footing 50cm	2	9·50	·50	·20	1·90		
Plinth wall 40cm	2	9·40	·40	·80	6·02		
Short walls—							
1st footing 60cm	2	3·70	·60	·20	·89		
2nd footing 50cm	2	3·80	·50	·20	·76		
Plinth wall 40cm	2	3·90	·40	·80	2·50		
Partition as short—							
1st footing 40cm	1	3·80	·40	·20	·30		
Plinth wall 30cm	1	3·90	·30	·80	·94		
Drawing cum Dining— back and front short walls							
1st footing 60cm	2	4·20	·60	·20	1·01		4·20=4·80—·60
2nd footing 50cm	2	4·30	·50	·20	·86		
Plinth wall 40cm	2	4·40	·40	·80	2·82		
Front verandah front Short wall—							
1st footing 40cm	1	4 30	·40	·20	·34		4·30=4·80—·50
Plinth wall 30cm	1	4·40	·30	·80	1 06		
Back verandah back Long wall—							
1st footing 40cm	1	13·90	40	·20	1·11		13 90=13·50+·40
Plinth wall 30cm	1	13·80	·30	·80	3·31		
Sides and fronts of bath & W. C. Short walls							
1st footing 40cm	4	2·30	·40	·20	·74		
Plinth wall 30cm	4	2·40	·30	·80	2·30		$2·30=2·75-\frac{·50}{2}-\frac{·40}{2}$
						44·45 cu m	

2-10 CALCULATION OF ARCHES :—

There are various types of arches used under different constructional works. But calculations for quantities of masonry works of (a) Segmental arches with a given span and rise, (b) Segmental arches with a given span and central angle, (c) Semi-circular arches and (d) Flat arches are illustrated below. For practical purposes Semi-Elliptical arches may be considered as segmental arches.

In every case quantities are to be calculated by finding the mean length of each arch and then multiplying this mean length by its thickness and breadth.

General notations :—

Referring to the fig. 2-16

lm = length of mean arch

rm = mean radius

r = inner radius

$2a$ = span of arch

h = rise of arch

b = chord of half the arc

t = thickness of arch ring

θ = central angle

w = width of arch (not shown in the fig)

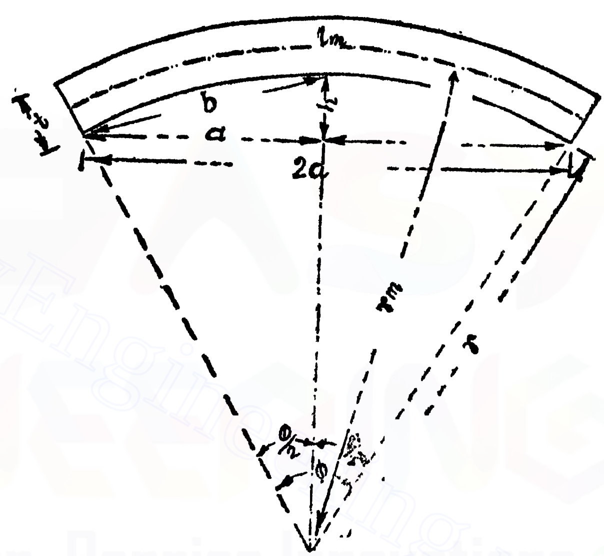


FIG. 2-16

(a) Segmental Arch with a given Span and Rise :—

Referring to the fig. 2-16 we have from geometry $b = \sqrt{r^2+h^2}$ and $b^2 = 2rh$

From the above two equations two unknown values of b and r are to be calculated.

Length of inner arc $= \dfrac{8b-2a}{3}$ (From Mensuration)

Length of mean radius $= r + \dfrac{t}{2}$ (Value of t shall be given).

Now, proportion of $\dfrac{\text{Mean arc}}{\text{Mean radius}} = \dfrac{\text{Inner arc}}{\text{Inner radius}}$

In the above equation everything has been calculated excepting the unknown value of mean arc, lm and the same is to be determined from this equation.

$\therefore$ Quantity of work, $Q = lm \times w \times t$. (Value of w shall be given).

Example : *A Segmental arch has a span of 3m and rise of 60cm. If thickness of the arch is 30cm calculate the quantity of arch masonry for a length of 2m.*

Ans :—By question we have, span, $2a = 3m$ rise $h = 60cm$

If b be the chord of half the arc then, $b = \sqrt{h^2 + a^2} = \sqrt{(\cdot 6)^2 + (1\cdot 5)^2} = 1\cdot 62m.$

Also, $b^2 = 2rh$ $\therefore$ $r = \frac{b^2}{2h} = \frac{(1\cdot 62)^2}{2 \times \cdot 60} = 2\cdot 18m.$

Length of inner arc $= \frac{8b - 2a}{3} = \frac{8 \times 1\cdot 62 - \cdot 30}{3} = 3\cdot 32m$

Mean radius, $r_m = r + \frac{t}{2} = 2\cdot 18 + \frac{\cdot 30}{2} = 2\cdot 33m$

Now, $\frac{\text{Mean arc}}{\text{Mean radius}} = \frac{\text{Inner arc}}{\text{Inner radius}}$ or $\frac{\text{Mean arc}}{2\cdot 33} = \frac{3\cdot 32}{2\cdot 18}$

$\therefore$ Mean arc $= \frac{3\cdot 32 \times 2\cdot 33}{2\cdot 18} = 3\cdot 55m$ $\therefore$ Quantity, $Q = lm \times w \times t = 3\cdot 55 \times 2\cdot 0 \times \cdot 30 = 2\cdot 130$ cu m

(b) Segmental arch. Case—I with a given Span & Angle :—

Referring to the fig. 2-16. Inner radius, $r = \frac{a}{\sin \theta/_2}$

$\therefore$ Mean radius, $r_m = \frac{a}{\sin \theta/_2} + \frac{t}{2}$ (Value of t shall be given)

Now, $\frac{lm}{2\pi r_m} = \frac{\theta°}{360°}$ $\therefore$ $lm = 2\pi r_m \times \frac{\theta°}{360°}$

$\therefore$ Quantity, $Q = lm \times w \times t$ (Value of w shall be given)

Example : *Estimate the quantity of first class arch work in 10 nos. segmental arch openings having a span of 2m with 75° angle at centre and 20cm thick in a 30cm Verandah wall of a public building.*

Ans:—Inner radius, $r = \frac{a}{\sin \theta/_2} = \frac{lm}{\sin \frac{75°}{2}} = 1\cdot 64m$

$\therefore$ Mean radius, $r_m = r + \frac{t}{2} = 1\cdot 64 + \frac{\cdot 20}{2} = 1\cdot 74m$

Now, length of mean arc, $lm = 2\pi r_m \times \frac{\theta°}{360°} = 2\pi \times 1\cdot 74 \times \frac{75°}{360°} = 2\cdot 28m$

$\therefore$ Quantity of 1st class arch work in one number $= lm \times t \times w = 2\cdot 28 \times \cdot 20 \times \cdot 30$

$\therefore$ Quantity for 10 nos. $= 10 \times 2\cdot 28 \times \cdot 20 \times \cdot 30 = 1\cdot 368$ cu m.

Segmental arch. Case—2 with a given Span and Angle forming equilateral triangle over an opening i.e. forming an angle of 60° at the centre.

Referring to the fig. 2-16, since equilateral triangle is formed by span and radii.

$\therefore$ span $2a = r$; $r_m = r + \frac{t}{2}$

$\therefore$ $\frac{lm}{2\pi r_m} = \frac{60°}{360°}$ $\therefore$ $lm = \frac{1}{6} \times 2\pi r_m$

Quantity $Q = lm \times t \times w.$

Example : ***The segmental arch of span 90cm over a window opening is equilateral on the span and radii. If the arch ring is 20cm thick and the thickness of wall is 30cm estimate the quantity of brickwork in 10 such arches.***

Ans. :—Referring to the fig. 2-16, since equilateral triangle is formed by the span and radii ; radius, $r = 2a = 90$cm

$$\text{Mean radius, } r_m = r + \frac{t}{2} = 90\text{cm} + \frac{20\text{cm}}{2} = 1{\cdot}00\text{m}$$

The angle of an equilateral triangle is 60° $\therefore$ central angle $\theta = 60°$

We have $\frac{lm}{2\pi r_m} = \frac{60°}{360°}$ or, $\frac{lm}{2\pi \times 1{\cdot}00} = \frac{60}{360}$ $\therefore$ $lm = \frac{1}{6} \times 2\pi = 1{\cdot}047$m

Quantity for one opening, $Q = lm \times t \times w = 1{\cdot}074 \times {\cdot}20 \times {\cdot}30$

$\therefore$ Quantity for 10 openings $= 10 \times 1{\cdot}074 \times {\cdot}20 \times {\cdot}30 = 0{\cdot}644$ cu m

(c) Semi-circular arch with a given Span :—

Since the arch is semi-circular, the quantity of masonry work may be calculated knowing the span, thickness and width of arch.

For semicircular arch $r = a$; Mean radius, $r_m = r + \frac{t}{2} = a + \frac{t}{2}$

$\therefore$ Length of mean arch $lm = \frac{2\pi r_m}{2} = \pi r_m$ $\therefore$ Quantity, $Q = lm \times w \times t$

Example : ***A semi-circular arch has a span of 2m. If thickness of the arch is 30cm and width 60cm, calculate the quantity of arch masonry.***

Ans :—Inner radius, $r = \frac{\text{span}}{2} = \frac{2\text{m}}{2} = 1$m $\therefore$ Mean radius, $r_m = + \frac{t}{2} = 1 + \frac{{\cdot}30}{2} = 1{\cdot}15$m

Length of mean arc, $lm = \frac{2\pi r_m}{2} = \pi r_m = \pi \times 1{\cdot}15$

$\therefore$ Quantity, $Q = lm \times w \times t = \pi \times 1{\cdot}15 \times {\cdot}60 \times {\cdot}30 = 0{\cdot}650$ cu m

(d) Flat arch :—Flat arch should have an angle of 60° at the skewback as shown in the fig. 2-17. In practice a small camber of 3mm for 90 cm of span is provided.

Referring to the fig. 2-17 if t be the thickness of the arch, then projection at one

side $= \frac{}{\tan 60°}$ $\frac{}{1{\cdot}732} = 0{\cdot}57t$

$\therefore$ Mean length of arch, $lm = \text{span} + 0{\cdot}57t$;
Quantity $Q = lm \times t \times w$

N.B. For practical purpose $lm = \text{span} \times {\cdot}5t$

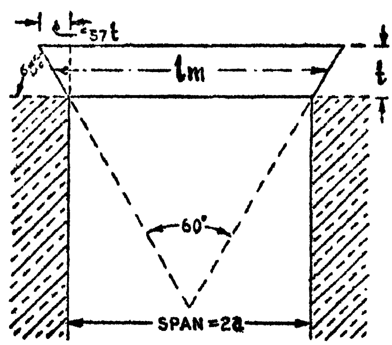


FIG. 2-17

Example : *Estimate the quantity in 5nos flat arch masonry over 90cm wide window openings if the thickness of arch is 20cm and the thickness of the wall is 30cm.*

Ans. : If t be the thickness of the arch then projection at one side $= \frac{t}{\tan 60°} = \cdot 57t$

∴ Mean length of the arch $lm = \text{span} + \cdot 57t = 90\text{cm} + \cdot 57 \times 20\text{cm} = 1\cdot 01\text{m}$

Quantity in 5 nos. arches $= 5 \times lm \times t \times w = 5 \times 1\cdot 01 \times \cdot 20 \times \cdot 30 = 0\cdot 603$ cu m.

2-11 CALCULATION OF DIFFERENT TYPES OF STEPS.

(a) **Ordinary Steps** :—(i) Fig. 2-18 shows the details of steps having a regular rise of 15cm and tread of 30cm. All exposed surfaces of the steps shall be 20mm thick cement plastered with neat cement finish. Prepare a complete quantity survey to construct such steps.

(ii) If the rise of 1st i.e. bottom step be 25cm with 10cm below G.L. and all other particulars being same as in (i); then calculate the quantites of works.

(iii) If the number of steps be 4 Nos. instead of 3 Nos. as in (i) with a regular rise of 15cm and tread of 30cm then calculate the quantity of brickwork only.

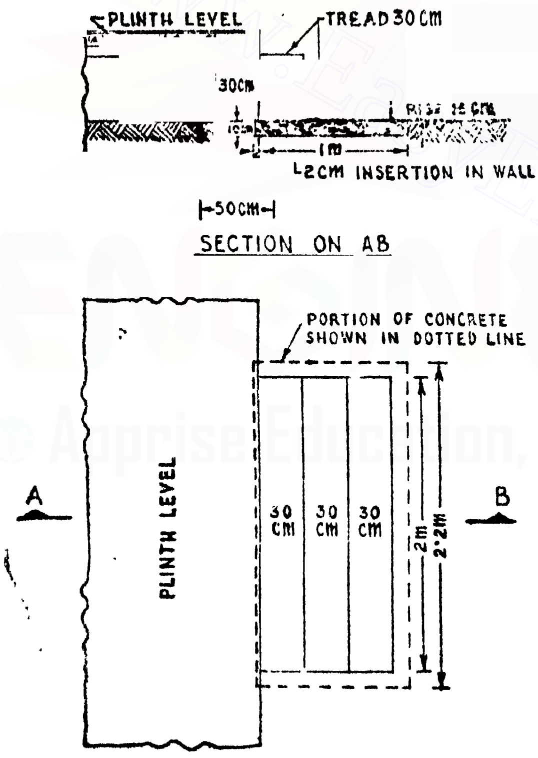


FIG. 2-18

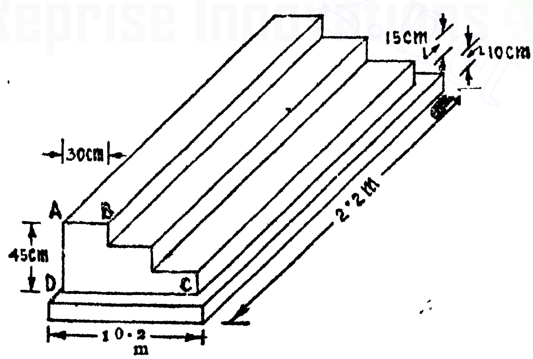


FIG. 2-18A

Ans :—(i) To calculate the quantity of brickwork (referring to the fig. 2-18A a trapezium ABCD may be formed by joining BC. The portion excluded from the actual figure will be equal to the additional portion included.

$$\text{Area of the trapezium ABCD}=\frac{\text{Sum of parallel sides}}{2}\times\text{height}$$

$$=\frac{\cdot 30+\cdot 90}{2}\times\cdot 45=0\cdot 27 \text{ sq m}$$

Quantity of brickwork $=0\cdot 27\times$ length $=0\cdot 27\times 2=0\cdot 54$ cu m

Let us now calculate the different quantities in a tabular form.

Item No.	Description	No.	L m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Earthwork in excavation	1	2·2	·90	·10	·198	·198 cu m	·90=1·00—·10 Deduction of ·10 for trench excavation has been made although it might be filled up after foundation work of verandah wall.
2.	Concrete work in foundation ...	1	2·2	1·02	·10	·224	·224 cu m	
3.	Brickwork ...	1	2·0	$\frac{(\cdot 30\times\cdot 90)}{2}$	·45	·450	·540 cu m	
4.	20mm thick plastering							
	Rises (including plinth rise)	4	2·0	—	·15	1·20		
	Treads ...	3	2·0	—	·30	1·80		
	Sides ...	2	2·0	$\frac{(\cdot 30+\cdot 90)}{2}$	—	2·40		
							5·40 sqm	

(ii) Dimensions and quantities for all items are same as in (i) except that the depth of earthwork will be 10cm more and the portion of brickwork below G.L. (i.e. the irrespective portion of brickwork for regular rise) is to be calculated separately.

(1) Total quantity of earthwork $=2\cdot 2\times\cdot 90\times\cdot 20$ $=\cdot 396$ cu m
(2) Brickwork below G.L. $\cdot 2\cdot 0\times\cdot 90\times\cdot 10$ $=\cdot 180$
Brickwork above G.L, =same as in item (3) $=\cdot 540$
Total $=0\cdot 720$ cu m

(iii) Quantity of brickwork $=2\times\left(\frac{\cdot 30+1\cdot 20}{2}\right)\times\cdot 60=\cdot 90$ cu m

Note :—In general the quantity of brickwork can also be calculated in different ways viz, by finding the quantity of work for individual step and then adding them all together or by finding the quantity required for the middle steps and multiplying the same by the number of steps. The latter procedure holds good only when the steps are of odd number. But for even number of steps, mean volume for the middle two steps is to be calculated first and then multiplied by the length of step (each of the steps having the same length). Avoiding such complications as well as for short calculation, the trapezoidal method should be followed which holds good for any number of steps having an uniform rise.

(b) Steps running in two directions :—(i) Fig 2-19 shows the plan and section for steps running two ways. All exposed sides of the steps is to be 20mm thick cement plastered. Prepare a complete estimate for the quantity of works.

(ii) If the rise of 1st i.e. bottom step be 25cm with 10cm below ground level, all other particulars being same as in (i), then calculate the quantity of brickwork only.

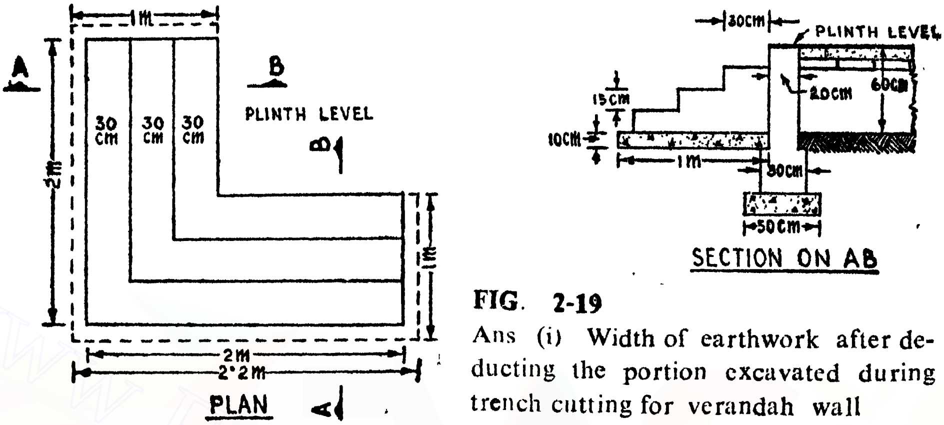


FIG. 2-19

Ans (i) Width of earthwork after deducting the portion excavated during trench cutting for verandah wall $=1{\cdot}00-\frac{1}{2}({\cdot}50-{\cdot}20)={\cdot}85$m

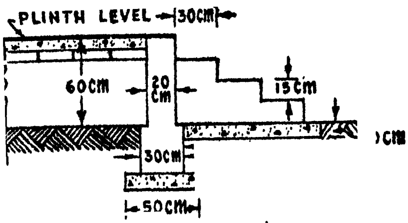
Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Earthwork in excavation for two sides ...	2	$\frac{(2{\cdot}2+1{\cdot}35)}{2}$	·85	·10	·302	·302 cu m	1·35=Inner to inner length=2·2—·85
2.	Concrete work for two sides. ...	2	$\frac{(2{\cdot}2+1{\cdot}2)}{2}$	1 00	·10	·340	·340 cu m	1·2=in to in =2·2—1·00
3.	Brickwork for two sides. ...	2	$\frac{(2+1{\cdot}1)}{2}$	$\frac{({\cdot}30+{\cdot}90)}{2}$	·45	·837	·837 cu m	1·1=in to in =2·00—3×·30
4.	20mm thick cement plaster for two sides Rises (including plinth	2×4	$\frac{(2+1{\cdot}1)}{2}$	—	·15	1·86		
	Treads ...	2×4	$\frac{(2+1{\cdot}1)}{2}$	·30	—	2·79		
	Side ends ...	2	$\frac{({\cdot}30+{\cdot}90)}{2}$	—	·45	·54	5·19	sq m

(iii) The portion of brickwork below G.L. (or the irrespective portion of brickwork for regular rise of 1st. step is to be calculated separately. The portion above G.L. is same as in (i)

Brickwork below G.L. for both sides$=2\left(\frac{2+1{\cdot}1}{2}\right)\times{\cdot}90\times{\cdot}10={\cdot}279$

Brickwork above G.L. for both sides=Same as in (i) $={\cdot}837$

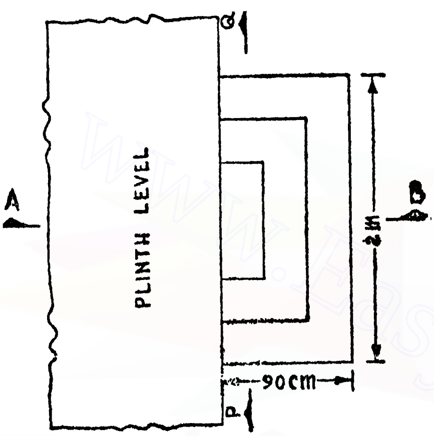
Total$=1{\cdot}116$ cu m

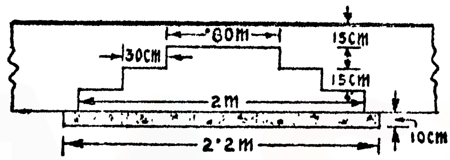


SECTION ON AB

(c) Steps having three ways :— Fig. 2-20 shows the plan and sections for steps having three ways. All exposed sides of the steps shall be 20 mm thick cement plastered. Prepare a complete estimate for the quantity of works.

N. B. Projection of concrete below steps in sec. on AB=15cm.



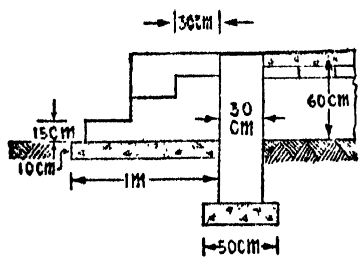


SECTION ON PQ

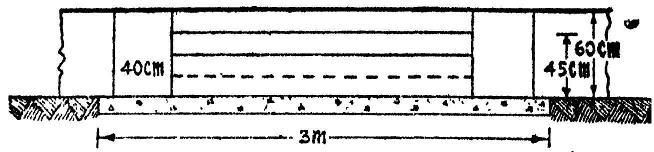
FIG 2-20

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Earthwork in excavation...	1	2·2	·90	·10	·198	·198 cu m	
2.	Concrete work ...	1	2·2	1·00	·10	·220	·220 cu m	
3.	Brickwork 1st step ...	1	2·0	·90	·15	·270		
	2nd step ...	1	1·40	·60	·15	·126		1·40=2·0—2×·30
	3rd step ...	1	2 80	·30	·15	·036		·60=·90—·30
							·432 cu m	
4.	20mm thick cement plaster							
	Rises three sides							
	1st step ...	1	3·8	—	·15	·57		3·8=2·0+2×·90
	2nd step ...	1	2 6	—	·15	·39		2·6=1·4+2×·60
	3rd step ...	1	1·40	—	·15	·21		1·40=·80+2×·30
	plinth rise ...	1	·80	—	·15	·12		
	Treads three sides							3·20=2 0+2×·60
	1st step ...	1	3·20	·30	—	·96		
	2nd step ...	1	2·00	·30	—	·60		
	3rd step ...	1	·80	·30	—	·24		
							3·09 sq m	

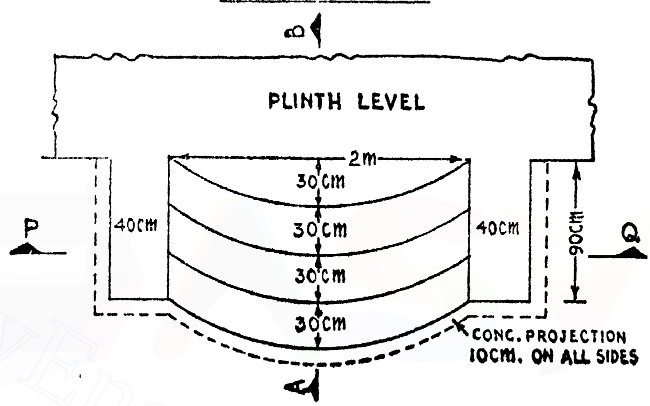
(d) **Segmental Steps** :—Fig. 2-21 shows the plan and sections for segmental steps having an uniform rise of 15cm and treads of 30cm bounded by 2 nos. wing walls built up from the same bed level. All exposed surfaces are to be 20mm thick cement plastered. Prepare a complete quantity survey.



SECTION ON AB



SECTION ON PQ



PLAN

To calculate curved length of step –
Let, b=chord of half the arc
2a=span, h=rise

$\therefore\ b=\sqrt{a^2+h^2}=\sqrt{1^2+(\cdot30)^2}$
$=1\cdot04$ m

∴ Length of arc i.e. the curved length of step

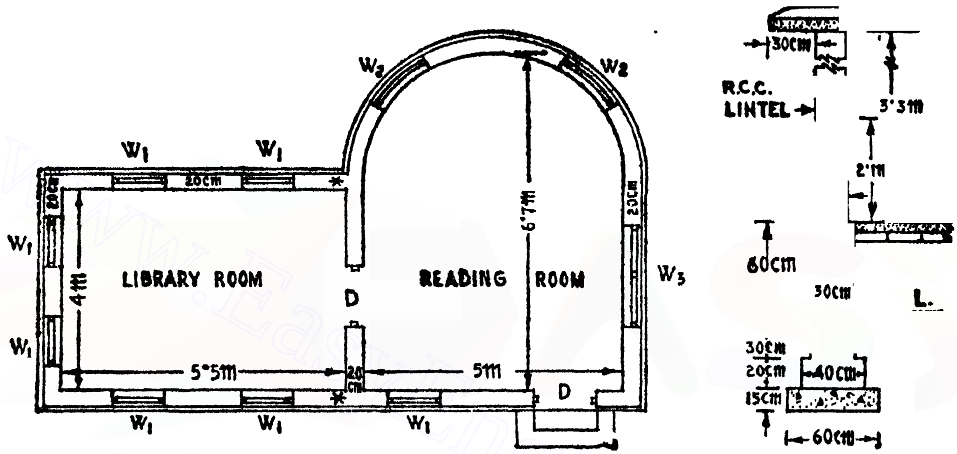
$=\dfrac{8b-2a}{3}=\dfrac{8\times1\cdot04-2\cdot0}{3}=2\cdot11$ m

FIG. 2-21

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Earthwork in excavation...	1	3·00	1·00	·10	·30		Portion excluded=portion included to form a rectangle.
	Deduction for trench portion ...	1	3·00	·10	·10	·03	(ve) ·27cu m	
2.	Concrete work in foundation ...	1	3·00	1·00	·10	·30	·30cu m	$3\cdot0=2\cdot0+2\times\cdot40+2\times\cdot10$
3.	Brickwork in foundation For steps ...	1	2·11	$\dfrac{(\cdot30+\cdot90)}{2}$	·45	·570		
	For wing walls...	2	·90	·40	·60	·432	1·002 cu m	
4.	20mm thick plastering Steps and plinth rises ...	4	2·11	—	·15	1·27		
	Treads ...	3	2·11	·30	—	1·90		
	Wing walls—Tops ...	2	·90	·40	—	·72		
	Fronts ...	2	·40	—	·60	·48		
	Both sides ...	2×2	·90	—	·60	·216		
	Less portion covered by Step section ...	2	$\dfrac{(\cdot30+\cdot90)}{2}$	—	·45	·54	(ve) 5·99 sq m	

2-12. Calculation of Brickwork for typical figures and finding Floor Areas :—

(1) Building with a Semi-circular portion :—Fig. 2-22 shows the plan and section of wall for a proposed library building. Estimate the following items (1) First class brick work in lime mortar (1:4) for walls in foundation and plinth, (2) First class brickwork in cement mortar (1:6) in superstructure and (3) 15cm thick lime concrete flooring.



D = 1·2m × 2·1m
W_1 = 1·0m × 1·5m
W_2 = 1·2m × 1·5m
W_3 = 2·0m × 1·5m

PLAN

SECTION OF WALL (ENLARGED)

FIG. 2-22

(A) **By centre line method** :—To calculate the centre line length :—

Reading room :—An investigation into the figure reveals that the outer edge of 20cm wall of library room joins at the springing point of the curve.

Rise = 6·7m—(4m + 20cm) = 2·5m and this is half of span 5m.

∴ The curved portion is semi-circular with an inner radius of 2·5m

∴ Mean radius, r_m = 2·5m + 10cm = 2·6m

∴ Centre line for curved portion = $\pi r_m = \pi \times 2{\cdot}6$ = 8·17m.

Centre line for the remaining continuative walls = 2(6·7m—2·5m + 10cm) = 8·6m

Back = 5m + 20cm = 5·2m

Library room :—

Centre line for short side = 4m + 20cm = 4·2m.

Long sides = 2(5·5m + 20cm) = 11·4m

∴ Total length of centre line = 8·17m + 8·6m + 5·2m + 4·2m + 11·4m = 37·57m

Note that the number of joints is two as marked by star marks where deduction of centre line by half width of brick layer shall be necessary for brickworks.

Item No	Description	No	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Brickwork in lime mortar** (1:4) in foundation & plinth							
	(a) 1st layer 40cm	1	37·17	·40	·20	2·97		
	(b) 2nd layer 30cm	1	37·27	·30	·90	10·06	13·03 cu m	37·17=37·57—·40/2 37·37=37·57—2×·30/2
2.	**Brickwork in cement mortar** (1:6) in superstructure	1	37·37	·20	3·3	24·66		37·37=37·57—2×·20/2
	Deduction for doors, D	2	1·2	·20	2·1	1·01	(-ve)	
	Windows, W_1	7	1·0	·20	1·5	2·10	,,	
	,, W_2	2	1·2	·20	1·5	0·72	,,	
	,, W_3	1	2·0	·20	1·5	0·60	,,	
	lintel	1	37·37	·20	·15	1·12	,,	
							19·11 cu m	
3.	**15cm thick lime concrete flooring**							
	(a) For library room	1	3·9	3·9	—	15·21		3·9=4·0—2×·05 (i.e. offset in floor)
	(b) For reading room							
	(i) Circular portion	$\frac{1}{2}$	$\times\pi\times$	$\left(\frac{4\cdot9}{2}\right)^2$	—	9·43		
	(ii) Rectangular portion	1	4·15	4·9	—	34·20		4·15=6·7—2·5—·05
							44·98 sq m	

(B) By long and short wall method —

Centre to centre lengths of walls :—

Reading room:—Curved portion semi-circular (as explained before)=$\pi r=\pi\times2\cdot6$m=8·17m

Continuative to semicircular as Long walls=6·7m—2·5m+0·10m=4·3m

Back as short wall=5m+·20m=5·20m

Library room :—

Long sides as long-short wall=5·5m+·20m=5·70m

Short wall =4·0m+·20m=4·20m

Note that the long walls of library room join with the long wall of the reading room as previously considered (marked by stars). So these walls of library room are actually considered as long-short walls.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
(1)	**Brickwork in lime mortar (1:4)** for walls in foundation and plinth							
	(a) Reading room—							
	Semicircular portion—							
	1st layer 40cm ...	1	8·17	·40	·20	0·65		
	2nd layer 30cm ...	1	8·17	·30	·90	2·21		
	Long walls—							
	1st layer 40cm ...	2	4 50	·40	·20	0·72		4·50=4·30+1×·4/2
	2nd layer 30cm ...	2	4·45	·30	·90	2·40		4·45=4·30+1×·30/2
	Short wall—							
	1st layer 40cm ...	1	4·80	·40	·20	0·38		4·80=5·20—2×40/2
	2nd layer 30cm ...	1	4·90	·30	·90	1·32		4·90=5·20—2×·30/2
	(b) Library room—							
	Long as long-short walls							
	1st layer 40cm ...	2	5·70	·40	·20	0·91		5·70=5·70+·40/2—·40/2
	2nd layer 30cm ...	2	5·70	·30	·90	3·08		
	Short wall—							
	1st layer 40cm ...	1	3·80	·40	·20	0·30		3·80=4·20—2×·40/2
	2nd layer 30cm ...	1	3·90	·30	·90	1·06		3·90=4·20—2×·30/2
							13·03 cu m	
(2)	**Brickwork in cement mortar (1:6)** in superstructure							
	(a) Reading room—							
	Semicircular portion ...	1	8·17	·20	3·3	5·39		4·40=4·30+·20/2
	Long walls ...	2	4·40	·20	3·3	5·81		5·00=5·20—2×·20/2
	Short walls ...	1	5·00	·20	3·3	3·30		
	(b) Library room—							
	Long as long-short walls	2	5·70	·20	3·3	7·52		4·00=4·20—2×·20/2
	Short wall ...	1	4·00	·20	3·3	2·64		
	Deduction for doors, D	2	1·2	·20	2·1	1·01	(—ve)	
	-do- windows W_1	7	1·0	·20	1·5	2·10	(,,)	37·37 is the total
	-do- -do- W_2	2	1·2	·20	1·5	0·72	(,,)	length of wall from
	-do- -do- W_3	1	2·0	·20	1·5	0·62	(,,)	item (2)
	-do- Lintel ...	1	37·37	·20	1·5	1·12	(,,)	
							19·11 cu m	
(3)	**15cm thick cement concrete flooring** ...	same as in method (A)=					44·98 sq m	

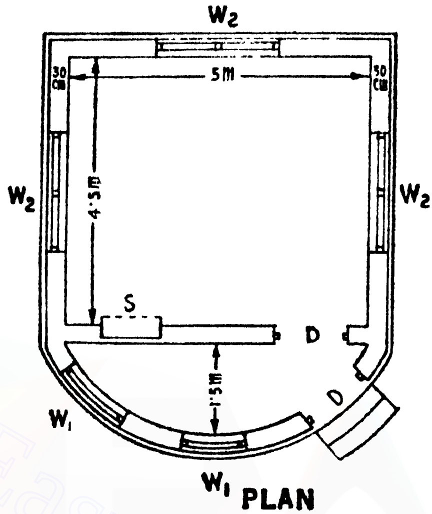
(2) Portion of a Building with Segment of a Circle :—Estimate the following quantities of work from the fig. 2-23 (1) First class brickwork in lime mortar for walls in foundation and plinth, (2) First class brickwork in cement mortar (1:4) in superstructure, (3) 10cm thick lime concrete flooring as sub-base.

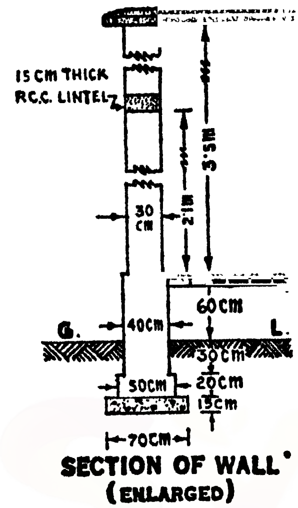
(A) By centre line method :—

To calculate the length of mean arc :—

Rise upto the centre of the wall,
$h = 1{\cdot}5 + {\cdot}15 = 1{\cdot}65\text{m}$
$\therefore\ b = \sqrt{a^2 + h^2}$
$= \sqrt{(2{\cdot}5)^2 + (1{\cdot}65)^2}$
$= 3{\cdot}00\text{m}$

Length of mean arc
$= \dfrac{8b - 2a}{3} = \dfrac{8 \times 3 - 5}{3}$
$= 6{\cdot}33\text{m}$





$\therefore$ *length of centre line for*

Curved front $= (6{\cdot}33 + 2 \times {\cdot}15) \qquad = 6{\cdot}63\text{m}$

Rectangular room $= 2[({\cdot}5 + {\cdot}30) + (4{\cdot}50 + {\cdot}30)] = 20{\cdot}20\text{m}$

Total $= 26{\cdot}83\text{m}$

FIG 2-23

$D = 1{\cdot}2\text{m} \times 2{\cdot}1\text{m}$
$W_1 = 1{\cdot}0\text{m} \times 2{\cdot}1\text{m}$
$W_2 = 2{\cdot}0\text{m} \times 1{\cdot}5\text{m}$
$S \quad = 1{\cdot}0\text{m} \times 1{\cdot}5\text{m}$

The number of junctions = 2 i.e. at the places where the curved front joins with the rectangular room.

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
1.	**Brickwork in lime mortar** for walls in foundation & plinth							26·33=26·83—2×·50/2
	1st layer 50cm ...	1	26·33	·50	·20	2·63		26·43=26·83—2×·40/2
	2nd layer 40cm ...	1	26·43	·40	·90	9·51		
						12·14 cu m		
2.	**Brickwork in cement mortar** (1:6) in superstructure ...	1	26·53	·30	3·50	27·86		
	Deductions for—							
	Door D ...	1	1·20	·30	2·10	0·76	-ve)	
	Windows W_1 ...	2	1·00	·33	2·10	1·26	,,	
	Windows W_2 ...	3	2·00	·30	1·50	2·70	,,	
	Shelve S ...	1	1·00	·30	1·50	0·45	,,	
	Lintel ...	1	26 53	·30	0·15	1·19	,,	
							21·50 cu m	
3.	10cm thick lime concrete flooring as sub-base							Area of a segment of a circle=2/3rd span × rise (approx.)
	Segmental portion...	⅔ ×	4·90 ×	1·40	(apx.)	4·57		
	Rectangular room...	1	4·90	4·40	—	21·56		
							26·13 sq m	

(B) By long and short wall method :—

Centre to centre lengths of walls :—

Curved front as short wall = 6·33m (same as worked out by method A) + 2 × ·15 = 6·63

Rectangular room, back and front as long wall = 5·0 + ·30 ... = 5·30m

Sides as short wall = 4·50 + ·30 ... = 4·80m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Brickwork in lime mortar** for walls in foundation							
	Curved front as short							
	1st layer 50 cm ...	1	6·13	·50	·20	0·61		6·13 = 6·63 — 2 × ·50/2
	2nd layer 40 cm ...	1	6·23	·40	·90	2·24		6·23 = 6·63 — 2 × ·40/2
	Rectangular room—							
	(a) Back and front as long							
	1st layer 50 cm ...	2	5·80	5·0	·20	1·16		5·80 = 5·30 + 2 × ·50/2
	2nd layer 40 cm ...	2	5·70	4·0	·90	4·10		
	(b) Sides as short							
	1st layer 50 cm ...	2	4·30	5·0	·20	0·86		
	2nd layer 40 cm ...	2	4·40	4·0	·90	3·17		
							12·14 cu m	
2.	**Brickwork in cement mortar** in superstructure							
	Curved front as short	1	6·33	·30	3·50	6·65		6·33 = 6·63 — 2 × ·30/2
	Rectangular room—							
	Back and front as long	2	5·60	·30	3·50	11·76		5·60 = 5·30 + 2 × ·30/2
	Sides as short ...	2	4·50	·30	3·50	9·45		
	Deductions for							
	Door D ...	1	1·20	·30	2·10	0·76	(-ve)	
	Windows W_1 ...	2	1·00	·30	2·10	1·26	(„)	
	-do- W_2 ...	3	2·00	·30	1·60	2·70	(„)	26·53 is the summation of walls from item(2)
	Shelves S ...	1	1·00	·30	1·50	0·45	(„)	
	Lintel ...	1	26·53	·30	0·15	1·19	(„)	
							21·50 cu m	
3.	**10cm thick lime concrete flooring** as sub-base							
	Segmental portion ...	$\frac{2}{3}$	× 4·90	× 1·40	(apx)	4·57		See method (A)
	Rectangular portion ...	1	4·90	4·40	—	21·56		
							26·13 sq m	

(3) **Portion of a room with sides of Polygon** :—Estimate the following quantities from the Fig. 2-24 (1) First class brickwork in lime mortar (1:4) for walls in foundation and plinth, (2) First class brickwork in cement mortar (1:6) in superstructure, (3) 10 cm thick cement concrete flooring as sub-base, (4) 2 cm thick patent stone flooring.

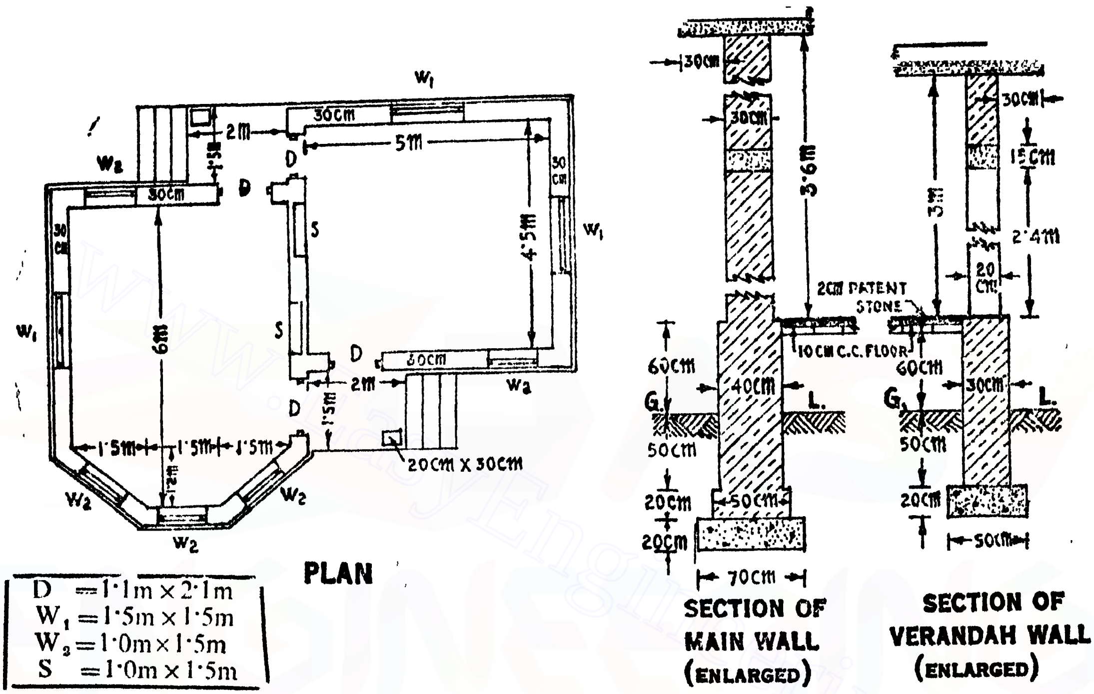


FIG. 2-24

(A) **By center line method** : *To calculate the centre line for main wall* :—

Polygonal room :—Polygonal front (appx.) $= 2\sqrt{(1{\cdot}05)^2+(1{\cdot}35)^2}+1{\cdot}5 = 5{\cdot}76$m

$(1{\cdot}65 = 1{\cdot}5+\frac{{\cdot}30}{2}\ ;\ 1{\cdot}35 = 1{\cdot}2+\frac{{\cdot}30}{2})$.

	Continuative portions	$=2(6{\cdot}0-1{\cdot}2+{\cdot}15)$	$=9{\cdot}90$m
	Back ...	$=4{\cdot}5+{\cdot}30$	$=4{\cdot}80$
Rectangular room :—	Front and back	$=2(5{\cdot}0+{\cdot}30)$	$=10{\cdot}60$m
	Right hand side	$=4{\cdot}5+{\cdot}30$	$=4{\cdot}80$m
	Left hand (rest)	$=(1{\cdot}5+\frac{{\cdot}30}{2}-\frac{{\cdot}30}{2})$	$=1{\cdot}45$m
			Total $=37{\cdot}31$m

Number of junctions = 2(places where the rectangular room joins with the polygonal room)

Back and Front Verandahs (same dimensions) :—Long sides $= 2[2+{\cdot}15-{\cdot}15) = 4{\cdot}0$m

Short sides $= 2[(1{\cdot}5+{\cdot}15-{\cdot}15) = 3{\cdot}0$m

Total $= 7{\cdot}0$m

Note : ***The number of junctions*** = 4(2 for each verandah where this joins with the main walls.)

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Brickwork in lime mortar** (1:4) for walls in foundation and plinth							36·81 = 37·31 — 2 × ·50/2
	(a) Main walls—							36·91 = 37·31 — 2 × ·40/2
	1st footing 50cm	1	36·81	·50	·20	3 68		
	2nd footing 40cm	1	36·91	·40	1·10	16·24		
	(b) Verandah walls— 30cm wide	1	6·20	·30	1·10	2·05		
							21·97 cu m	
2.	**Brickwork in superstructure** in cement mortar (1:6)							37 01 = 37·31 — 2 × ·30/2
	(a) Main walls	1	37·01	·30	3·60	40·02		
	(b) Verandah walls (not considering the openings at first) ...	1	6·40	·20	3 00	3·84		6·40 = 7·0 — 4 × ·30/2
	Deduction for—							
	Door openings D	4	1·10	·30	2·10	2·77	(-ve)	
	Window openings W_1	3	1·50	·30	1·50	2·03	(„)	
	-do- -do- W_2	5	1·00	·30	1·50	2·25	(„)	
	Shelves ...	2	1·00	·20	1·50	0·60	(„)	
	Lintel ...	1	37·06	·30	·15	1·67	(„)	
	Verandah openings with lintel, back & front							
	Long openings	2	1·70	·20	2·55	1·73	(„)	1·70 = 2·00 — ·30
	Short openings	2	1·30	·20	2·55	1·33	(„)	2·55 = 2·40 + ·15
							31·48 cu m	
3.	**10cm thick cement concrete** flooring							
	(a) Polygonal room—							4·40 = 4·5 — 2 × ·05
	Front portion	½ ×	(4·40 ×	1·50) ×	1·15	3·39		1·15 = 1·20 — ·05
	Back portion	1	4·75	4·40	—	20·90		
	(a) Rectangular room	1	4·90	4·40	—	21·56		4·90 = 5·0 — 2 × ·05
	(b) Back & Front Verandahs	2	1·70	1·20	—	4·08		1·70 = 2 — ·30
							49·93 sq m	
4.	**2cm thick patent stone** flooring							
	(a) Polygonal room—							
	Front portion	½ ×	(4·50 +	1·50)	× 1·20	3·60		
		1	4·80	4·50	—	21·60		
	Back portion	1	5·00	4·50	—	22·50		
	(b) Rectangular room							
	(c) Back & Front Verandahs	2	2·00	1·50	—	6·00		Area of pillars neglected as insignificant.
	(d) Door sills ...	2	1·00	·30	—	0·60		
							54·30 sq m	

(B) Long and short wall method :—Centre to centre distance.

Polygonal room : Front portion (appx) $=2\sqrt{(1{\cdot}65)^2+(1{\cdot}5)^2}+1{\cdot}5=5{\cdot}76$m
Continuative left side as long wall=(6·0—1·2+·15)=4·95m
Right side including portion of rectangular room as long wall
=(6·0—1·2+·30+1·5)—·20=6·40m
Back as short wall=4·5+·30=4·80m

Rectangular room : Right side as long wall=4·5+·30=4·80m
Back & front as short wall=5·0+·30=5·30m

Verandah : (Both verandahs having the same dimensions)
Front as long short wall=2·0+·15—·15=2·00m
Side as short wall=1·5+·15—·15=1·5m

Note that the end of the verandah front wall which joins with the main wall is to be considered as short end and so named as long-short wall.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
1.	**Brickwork in lime mortar** for walls in foundation and plinth							
	Polygonal room :—							
	Front portion							
	1st footing 50cm	1	5·76	·50	·20	0·58		
	2nd footing 40cm	1	5·76	·40	1·10	2·53		
	Left side as long wall							
	1st footing 50cm	1	5·20	·50	·20	0·52		$5{\cdot}20=4{\cdot}95+\frac{\cdot50}{2}$
	2nd footing 40cm	1	5·15	·40	1·10	2·27		$5{\cdot}15=4{\cdot}95+\frac{\cdot40}{2}$
	Right side long wall							
	1st footing 50cm	1	6·65	·50	·20	0·67		$6{\cdot}65=6{\cdot}40+\frac{\cdot50}{2}$
	2nd footing 40cm	1	6·60	·40	1·10	2·90		
	Back as short wall							
	1st footing 50cm	1	4·30	·50	·20	0·43		$4{\cdot}30=4{\cdot}80-2\times\frac{\cdot50}{2}$
	2nd footing 30cm	1	4·40	·40	1·10	1·94		
	Rectangular room :—							
	Right side as long wall							
	1st footing 50cm	1	5·30	·50	·20	0·53		$5{\cdot}30=4{\cdot}80+2\times\frac{\cdot50}{2}$
	2nd footing 40cm	1	5·20	·40	1·10	2·29		
	Back and front as short							
	1st footing 50cm	2	4·80	·50	·20	0·96		$4{\cdot}80=5{\cdot}30-2\times\frac{\cdot50}{2}$
	2nd footing 40cm	2	4·90	·40	1·10	4·31		
	Verandahs (both)							
	Front as long-short wall	2	1·95	·30	1·10	1·29		$1{\cdot}95=2{\cdot}00+\frac{\cdot30}{2}-\frac{\cdot40}{2}$
	Side as short wall	2	1·15	·30	1·10	0·76		$1{\cdot}15=1{\cdot}50-\frac{\cdot30}{2}-\frac{\cdot40}{2}$
							21·97 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
2.	**Brickwork in cement mortar (1:6)** for super-structure							
	Polygonal Room—							
	Front Portion ...	1	5·76	·30	3·60	6·22		
	Left side as long wall	1	5·10	·30	3·60	5·51		5·10=4·95+·30/2
	Right side as long wall	1	6·60	·30	3·60	7·13		
	Back as short wall ...	1	4·50	·30	3·60	4·86		
	Rectangular room—							
	Right side as long wall	1	5·10	·30	3·60	5·50		
	Back and front as short	2	5·00	·30	3·60	10·80		
	Verandahs (both)—							
	Considering solid at first							
	Fronts as long walls	2	1·95	·20	3·00	2·34		1·95=2·00+·10–·15
	Sides as short walls	2	1·25	·20	3·60	1·50		10·25=1·50–·10–·15
	Deduction							
	For openings and lintel...	Same as in method (A)=				12·30	(-ve)	
							31·48	cu m
3.	**10cm thick cement** concrete flooring	Same as worked in (A) =				49·93	49 93	sq m
4.	**2cm thick patent** stone flooring	Same as worked in (A)=				54·30	54·30	sq m

To Calculate the length of centre line for the polygonal front portion correctly :—

Referring the fig. 2-24, $\tan\theta = \frac{1\cdot2}{1\cdot5} = \tan 38°40'$ $\therefore \theta = 38°40'$

$\therefore$angle $\phi = 180° - 38°40' - 90° = 51°20'$

($\because$ cd is perpendicular on cc′)

From the triangle abc, bc=·30m $\therefore$ ab=·30×tan 51°20′=·14m and half of this is the length of centre line which passes within this triangle=·07m and there are four such places at the two corners of the polygonal portion of the room.

Similarly it can be calculated that a′b′=·30× tan$\frac{38°40'}{2}$=·10m ; half of this is the lenght of centre line that passes within this triangle=·05m and there are four such portions at the other two corners.

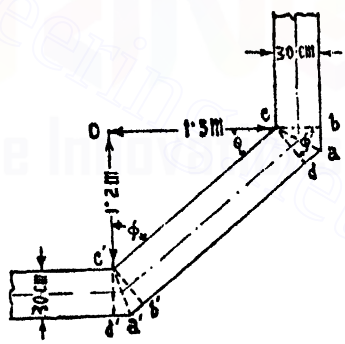


FIG. 2-25

$\therefore$Correct length of centre line for the polygonal front portion

$$=1{\cdot}5+\sqrt{(1{\cdot}2)^2+(1{\cdot}5)^2}+4\times{\cdot}07+4\times{\cdot}05=3{\cdot}90\text{m}$$

$\therefore$Difference between the correct and approximate methods (calculated before)

$$=3{\cdot}90-3{\cdot}76={\cdot}14\text{m}$$

In this case such small variation may be neglected for speedy calculation and practical purposes. But in the case of thicker section of a wall as well as for higher rate, the correct length should be preferred.

EXERCISES II

1. Give separately the units of measurement, units of rate and methods of measurement of the following items according to the recommendations of the Indian Standard Institute :

(i) Reinforced cement concrete (excluding reinforcement and shuttering) ; (ii) Precast reinforced cement concrete blocks ; (iii) Cutting holes through existing brickwork ; (iv) Expansion joints in concrete ; (v) Damp proof course ; (vi) R. C. chajja ; (vii) Asbestos cement sheet roofing ; (viii) Steel rolling shutters ; (ix) Flush timber door ; (x) Broken glass coping. ***Ans.—article 2·5.***

2. State the method of deduction for the following items according to the recommendations of the I. S. I.

(a) Earthwork in filling for different types of works, (b) Openings for brickwork in walls including openings like ventilators, joists etc.. (c) Volume occupied by reinforcement in R. C. C. work and also volume occupied by water pipes, conduits etc., (d) Openings for plastering on walls, (e) Openings in metal wire netting and (f) Honeycomb openings in honeycomb brickwork.

Ans.—See items 2, 3, 13, 57, 55 and 6 of the article 2-5.

3. (i) According to the recommendations of I. S. I. state the multiplynig factors for—(a) Painting the different types of doors and windows : (b) Gates, grilles, grantings. etc. ; (c) Roof battens.

(ii) For colour washing how will you take measurements for corrugation of—(a) corrugated steel sheets, (b) A. C. sheets, and (c) semi corrugated A. C. sheets.

Ans.—See items 61 and 59 of the article 2-5

4. Calculate from the fig. 2-26 the quantity of brickwork in the retaining wall.

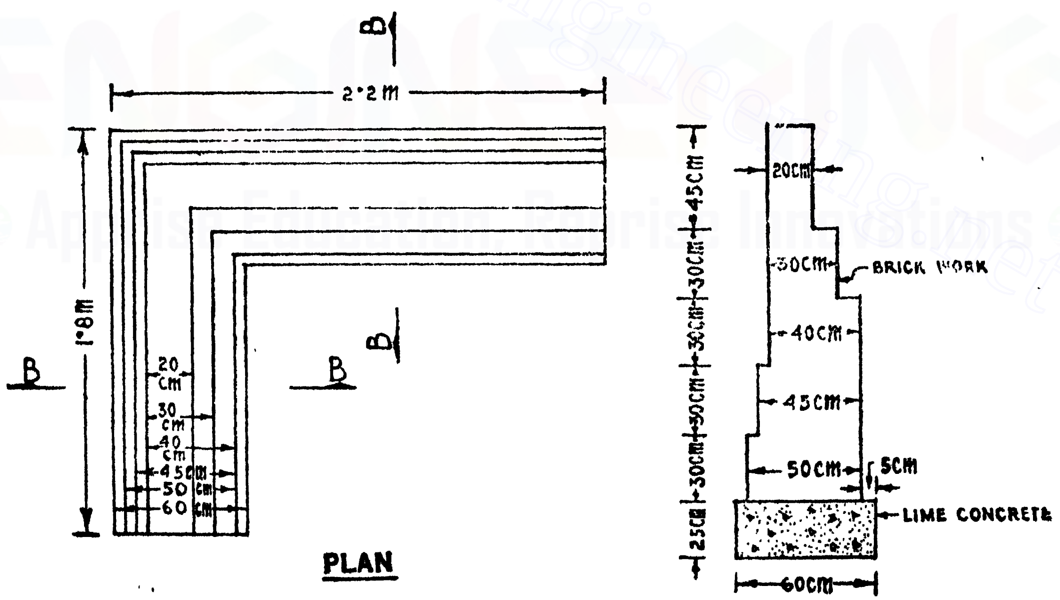


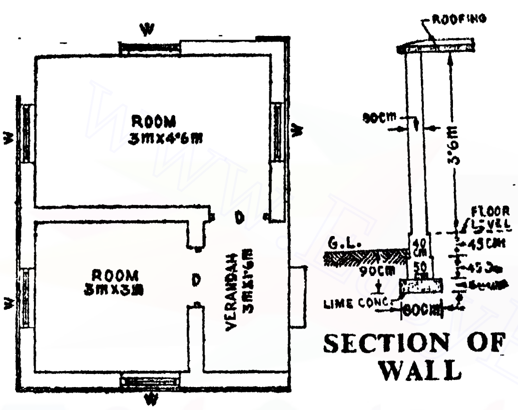
FIG. 2-26 **SECTION ON B-B**

Ans.—The respective lengths of 50cm to 20cm footings are 3·40, 3·35, 3·30, 3·40 and 3·50 metres : Quantity = 1·98 cu m.

5. Prepare detailed estimates of the quantities of the following items for a house sketched in the fig. 2-27. An abstract of cost is also to be prepared at the rates given against each.

(i) Earthwork in excavation for foundation @ Rs. 250% cu m.
(ii) Cement concrete in foundation @ Rs. 325 per cu m.
(iii) Masonry in foundation and plinth @ Rs. 200 per cu m.
(iv) Masonry in superstructure @ Rs. 210 per cu m.

(N. B. The quantity of work for the step may be excluded. Section of dwarf wall is same to that of main wall)



PLAN

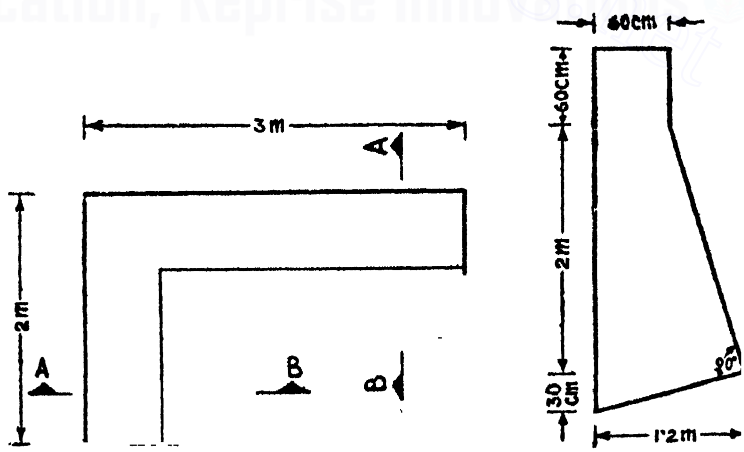
SECTION OF WALL

FIG. 2-27

W = 1·2m × 1·5m
D = 1·2m × 2·1m
Ht. of verandah opening = 2·5m
Lintel over doors, windows and verandah 15 cm thick and 15 cm bearing
(i) 21·31 cu m ; (ii) 7·13 cu m ; (iii) 12·27 cu m ; (iv) 25·97 cu m.

6. Fig. 2-28 shows the plan and section for birckwork of a retaining wall ; calculate the volume of work for payment.

(Hints : Divide the section into three parts (1) at bottom most part a triangle with sides of 30cm and 1·20m.) (2) at inner edge a triangle with sides of 60cm and 2m, (3) a rectangle of 60cm × 2·60m sides. Calculate then the individual areas and multiply them with their respective lengths measured along the C. G.). Quantity = 9·696 cu m.



PLAN

SECTION ON AB

FIG. 2-28

CHAPTER III

ESTIMATE OF BUILDINGS

3-1 Building—1. Detailed Estimate of a Single Roomed Building with walls of Standard Modular Bricks 20cm × 10cm × 10cm (nominal).

Prepare a complete detailed estimate of the cost of construction of the Magazine shown in the fig. 3-1 on the basis of present market rates. From the total amount arrived at on detailed estimate find out plinth area rate of the building.

Brickwork shall be 1st. class with cement mortar (1:4). Foundation concrete shall be of cement with brick ballast (1:3:6). Wood work for frames shall be of salwood and shatters of C. P. teak. Other specifications shall be followed as mentioned in the the drawing.

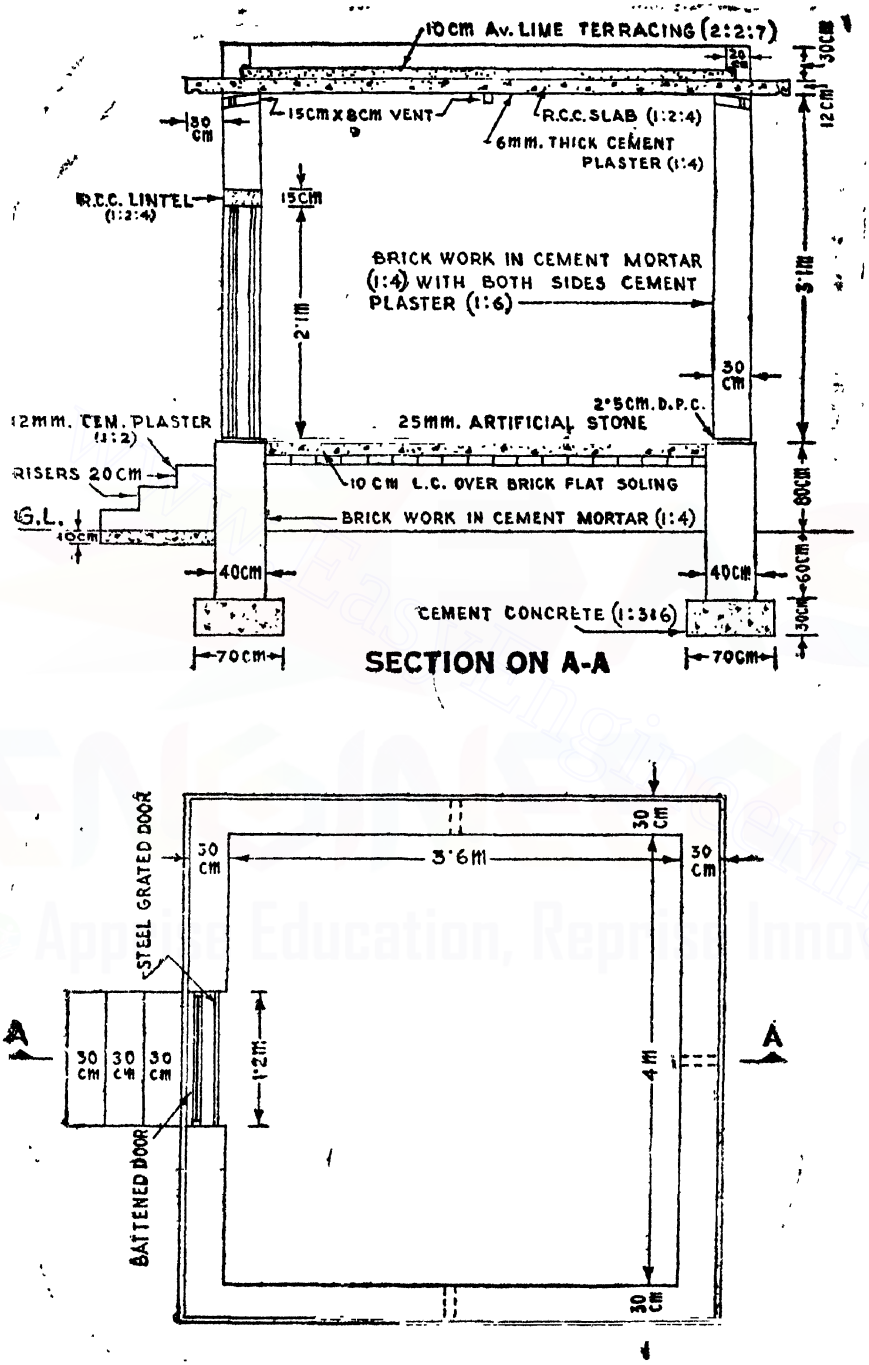
(A) Centre line method :—

Sum of centre lines=
2[(4m+·30m)+(3·6m+·30m)]=16·4m

(B) Long and Short wall method :—

Centre to centre distance—
Long walls=4m+·30m=4·30m
Short walls=3·6m+·30m=3·90m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory note
1.	**Earthwork in excavation**							
	(a) Foundation trenches							
	(A) By centre line method--	1	16·4	·70	·90	10·33		
	(B) By L & S wall method							
	Long walls ...	2	5·0	·70	·90			
	Short walls ...	2	3·2	·70	90			5·0=4·3+2+·70/2
	(b) Steps ...	1	1·2	·75	·10	0·09		3·2=3·9—2×·70/2
							10·42 cu m	·75=·9—·15(trench)
2.	**Earthwork in filling**							
	(a) Foundation trenches ...	⅙th	of excavation		(apx)	=2 08		·60=·80—·20
	(b) For plinth ...	1	3·9	3·5	·60	8·19		(L.C. and soling)
							11·27 cu m	
3.	**Cement concrete** (1:3:6)							
	(a) Foundation trenches							
	(A) By centre line method	1	16·4	·70	·30	3·44		
	(B) By L. & S wall method							
	Long walls ...	2	5·0	·70	·30			
	Short walls ...	2	3·2	·70	·30			*Not that the total length is same by any method*
	(b) Steps	1	1·2	·90	·13	0·11		
							3·55	cu m



PLAN
(SCALE = 1:66⅔)

FIG. 3-1

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4.	**Brickwork in cement mortar** (1:4) in foundation & plinth							
	(a) Walls—							
	(A) *By centre line method*—	1	16·4	·40	1·40	9·14		
	(B) *By L & S wall method*—							
	Long walls	2	4·7	·40	1·40			
	Short walls	2	3·5	·40	1·40			
	(b) Steps	1	1·2	·60 (av.)	·60	0·43	9·57 cu m	$·60=\frac{1}{2}(·90+·30)$
5.	**Brickwork in superstructure**							
	(a) Walls—							
	(A) *By centre line method*—	1	16·4	·30	3·1	15·25		$4·6=4·30+2\times\frac{·30}{2}$
	(B) *By L & S wall method*—							$3·6=3·90-2\times\frac{·30}{2}$
	Long walls	2	4·6	·30	3·1			
	Short walls	2	3·6	·30	3·1			No deduction for insertion of lime terracing to minimise the extra cost of curving of terracing at junction.
	(b) Parapet—							
	Long sides (out to out)	2	4·60	·20	·30	0·55		
	Short sides (in to in)	2	3·80	·20	·30	0·46		
	Deduction for—							
	Door opening	1	1·2	·30	2.1	0·76		30cm bearing. No deduction for vent holes
	R. C. lintel	1	1·8	·30	·15	0·08	15·42 cu m	
6.	**2·5cm thick D.P.C. (1:2:4)**							
	(A) *By centre line method*—	1	16·4	·30	—	4·92		
	(B) *By L. & S wall method*—							
	Long walls	2	4·6	·30	—			
	Short walls	2	3·6	·30	—			
	Deduction for—							
	Door Sill	1	1·2	·30	—	0·36	(-ve) 4·56 sq m	
7.	**R.C.C. work excluding reinforcement & shuttering**							
	Roof slab ...	1	5·2	4·8	1·2	2·95		
	Lintel ...	1	1·8	·30	·15	·05	3·04 cu m	
8.	**Shuttering, centering**							
	Roof bottom	1	5·20	4·80	—	24·96		$20=2(5·2+4·8)$
	edges	1	20·00	—	·12	2·40		Bearing of lintel is 30cm
	Lintel (sides) ...	2	1·8	—	·15	·54		
	,, bottom ...	1	1·2	·30	—	·36		
						28·26	28·26	sq m
9.	**10cm thick (av.) lime terracing**	1	4·4	4·0	—	17·60	17·60 sq m	$4·4=4·0+2\times·20$ (·20 bearing)

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
10.	**15cm × 8cm vent holes**	—	—	—	—	3	3 Nos.	
11	**12mm thick cement plaster (1:6)**							
	(a) Inside—Long sides	2	4·0	—	3·1	24·80		
	,, Short sides	2	3·6	—	3·1	22·32		
	(b) Outside—							
	(i) from G.L. to P.L.							
	Long sides	2	4·7	—	·85	7·99		4·7 = 4·0 + 2(·30 + ·05)
	Short sides	2	4·3	—	·85	7·31		·85 = ·80 + ·05 (offset)
	(ii) from P.L. to above including parapet outer							
	Long sides	2	4·6	—	3·4	31·28		3·4 = 3·1 + ·30
	Short sides	2	4·2	—	3·4	28·56		
	(iii) Parapet inside—							
	Long sides	2	4·2	—	·20	1·68		·20 = ·30 — ·10 (·10 for terracing).
	Short sides	2	3·8	—	·20	1·52		
	(vi) Parapet top—							
	Long sides (out to out)	2	4·6	—	·20	1·84		
	Short sides (in to in)	2	3·8	—	·20	1·52		
	Deduction for—							
	Door opening	1	1·2	—	2·1	2·52	(-ve)	According to I.S.I. for both faces deduction is for one side only
	Step rises	1	1·2	—	·80	0·96	(-ve)	
							125·25 sq m	
12.	**12mm thick cement plaster (1:2)** for steps—							
	rise	1	1·2	—	·80	0·96		
	treads	3	1·2	—	·30	1·08		
	sides	2	·60 (av.)	—	·60	0·72		·60 = ½(·30 + ·90)
							2·76 sq m	
13.	**6mm thick cement plaster (1:4)**							
	(a) Ceiling	1	4·0	3·6	—	14·40		
	(b) Cornice both faces							
	Long sides	2×2	5·2	·30	—	6·24		5·2 out to out
	Short sides	2×2	4·2	·30	—	5·04		4·2 in to in
	(c) Cornice edges							
	Long sides	2	4·2	·12	—	1·25		5·2 = 4·0 + 2 × ·30
	Short sides	2	4·8	·12	—	1·15		
							28·08	sq m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
14.	**White washing** three coats	same	as item	no.	11+13	=153·3	153·3 sq m	
15.	**10cm thick lime concrete** (1½:2:7) floor over brick flat soling	1	3·9	3·5	—	13·65	13·65 sq m	
16.	**2·5cm artificial stone** (1:2:4) flooring	1	4·0	3·6	—	14·40	14·40 sq m	
17.	**Sal wood work** in door frame	1	6·6	·10	·80	·0528	·0528 cu m	6·6=2(2·1+1·2)
18.	**Battened door** 25mm thick	1	1·07	—	1·97	2·108	2·103 sq m	1·07=1·2—2×·80 +2×·015 (for rebates)
19.	**Steel grated door**	1	1·2	—	2·1	2·52	2·52 sq m	
20.	**M.S. for R.C.C. work**	@ =	1% vol. ·030	of cu m	item(7) @ 78·5	2·36	quin.	Wt. of 1 cu m of M.S. bar=78·5 quintal
21.	**M S. clamps** 50mm × 6mm and 40cm long	2×3	—	—	—	6	6 Nos.	
22.	**Painting to wood work** Door and its frame	2¼	1·2	—	2·1	5·67	5·67 sq m	Multiplying factor as per I S.I.=2¼
23.	**Painting to steel door**	1	1·2	—	2·1	5·67	5·67 sq m	
24.	**Coal tarring** two coats in back of frames	1	6·6	—	·10	·66	·66 sq m	6·6 as in item (17)
25.	**75mm dia. Rainwater spouts**	1	1·0	—	—	1·0	1·0 rm	

ABSTRACT OF ESTIMATED COST OF BUILDING I

Sl. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs.	P.
1.	Earthwork in excavation ...	10·42	cu m	300·00	%cu m	31	26
2.	Earthwork in filling ...	11·27	cu m	250·00	%cu m	28	18
3.	Cement concrete (1:3:6) in foundation with brick ballast ...	3·35	cu m	262·00	cu m	877	70
4.	Brickwork (1:4) in foundation & plinth ...	9·57	cu m	235·00	cu m	2248	95
5.	Brickwork (1:4) in superstructure ...	15·42	cu m	240·00	cu m	3700	80

Total C.O.=6,886·89

Item No.	Description	Qu.	Unit	Rate Rs. P	Unit of Rate	Amount Rs.	P.
	B.F.					6886	89
6.	2·5 cm thick damp proof course (1:2:4)	4·56	sq m	9 20	sq m	41	95
7.	R.C.C. work (1:2:4) excluding reinforcement and shuttering ...	3·04	cu m	375	cu m	1140	00
8.	Shuttering and centering ...	28·26	sq m	14·00	sq m	395	64
9.	10 cm thick (av.) lime terracing (2:2:7)	17·60	sq m	32·00	sq m	563	20
10.	15 cm × 8 cm vent holes ...	3	Nos.	1·25	Each	3	75
11.	12 mm thick cement plaster (1:6) ...	125·22	sq m	5·25	sq m	657	40
12.	12 mm thick cement plaster (1:2) ...	2 76	sq m	8·10	sq m	22	30
13.	6 mm thick cement plaster (1:4) ...	28·08	sq m	4·60	sq m	129	16
14.	White washing three coats ...	153·30	sq m	0·75	sq m	114	97
15.	10 cm thick lime concrete (1½:2:7) floor over a brick flat soling ...	13·65	sq m	36·00	sq m	491	40
16.	2·5 cm thick artificial stone flooring (1:2:4) finished with neat cement ...	14·40	sq m	21·00	sq m	302	40
17.	Sal wood work for door frame ...	0·0528	cu m	3000·00	cu m	158	40
18.	25 mm thick C.P. teak wood battened door	2·108	sq m	200·00	sq m	421	60
19.	Steel grated door	2·52	sq m	250·00	sq m	630	00
20.	Mild steel bar	2·36	quin	550·00	quin	1298	00
21.	M.S. clamps (50 × 6) mm 40cm long ...	6	Nos.	2·00	Each	12	00
22.	Painting to steel grated door 2 coats (with oil bound paint) ...	5·67	sq m	5·80	sq m	32	88
23.	Painting to steel grated door 2 coats (with red lead paint) ...	2 52	sq m	7·80	sq m	19	65
24.	Coal tarring two coats ...	0 66	sq m	1·20	sq m	0	79
25.	75 mm dia. C.I. rain water spouts ...	2 0	r m	20·00	r m	40	00

Total = Rs. 13,362·38

Add 5% for contingency = Rs. 668·11

Add 2½% for W C. = Rs. 334·05

Grand Total = Rs. 14,364·54

Plinth area = 4·70 × 4·30 = 20·21 sq m

$\therefore$ Plinth area rate $= \dfrac{14364 \cdot 54}{20 \cdot 21} =$ Rs. 710·76/sq m

11

Building—2. Detailed Estimate of a two Roomed Building with walls of Traditional Bricks 25 cm × 12·5 cm × 7·5 cm (replacing 10″ × 5″ × 3″ as adopted in practice by P.W.D.) nominal and comparison of cost.

Prepare a detailed estimate of a building from the given plan and cross section as shown in the fig. 3-2. Adopt the local P.W.D. current schedule of rates and compare the cost of different portions as grouped below on percentage basis.

General Specifications—

(*a*) *Foundation and plinth* :—First class brickwork in cement mortar (1:4) over lime concrete (18:36:100).

(*b*) *Superstructure walls* :—First class brickwork in cement mortar (1:6) over 2·5 cm thick D.P.C. (1:2:4) and parapet walls shall be of cement mortar (1:4).

(*c*) *Roofing* :—The roof shall be 10 cm thick R.C.C. slab with stone chips (1:2:4) and 10 cm (av.) lime terracing (2:2:7). The R.C. slabs and beam shall be 1% reinforced.

(*d*) *All R.C.C. works except roofing* shall be 0·8% reinforced.

(*e*) *Flooring* :—Shall be 25 mm thick artificial stone with cement concrete 1:2:4) with stone chips finished with neat cement finishing at top. Under flooring shall be 7·5 cm thick lime concrete (1½:2:7) terracing over a brick flat soling.

(*f*) *Finishing* :—Outside walls upto plinth including plinth offset shall be 20 mm thick cement plaster finished smooth with neat cement. Inside and outside walls shall be 12mm cement plastered (1:6). R. C. slab and ceiling 6 mm cement plastered (1:4). Inside walls three coats white washed and outside two coats colour washed over a coat of white wash.

(*g*) *Doors and windows* :—Frames shall be of Sal wood, shutters of C.P. teak wood 2·5 cm thick panelled type design and shall be painted with two coats over priming coat. Back of door and window frames shall be painted with two coats of coal tar. Window grattings shall be 16mm dia. M.S. bar and M.S. clams for frames 50mm × 6mm flat 40 cm long. Iron works shall be painted two coats.

Centreline method :—

Calculation of centre line

For outer wall

$=2[(10{\cdot}25-{\cdot}50)+(6{\cdot}46-{\cdot}50)$ $=31{\cdot}44$m

Fornt wall of rooms—

$=(10{\cdot}25-{\cdot}50)$ ... $=9{\cdot}75$ m

Partition wall—

$=(3{\cdot}6+{\cdot}375)$ ... $=3{\cdot}975$m

Total $=45{\cdot}165$ m

say, $45{\cdot}16$ m

Note that the number of joints is four.

Long and Short wall method :—

Centre to centre distance of

Back and front walls of rooms and verandah front as long $=10{\cdot}25-{\cdot}50=9{\cdot}75$m

Partition and sides of rooms as short

$=3{\cdot}6+{\cdot}375=3{\cdot}975$ say $3{\cdot}97$m

Verandah side as short

$=1{\cdot}62+2\times\frac{{\cdot}375}{{\cdot}2}$

$=1{\cdot}995$ say $2{\cdot}00$ m

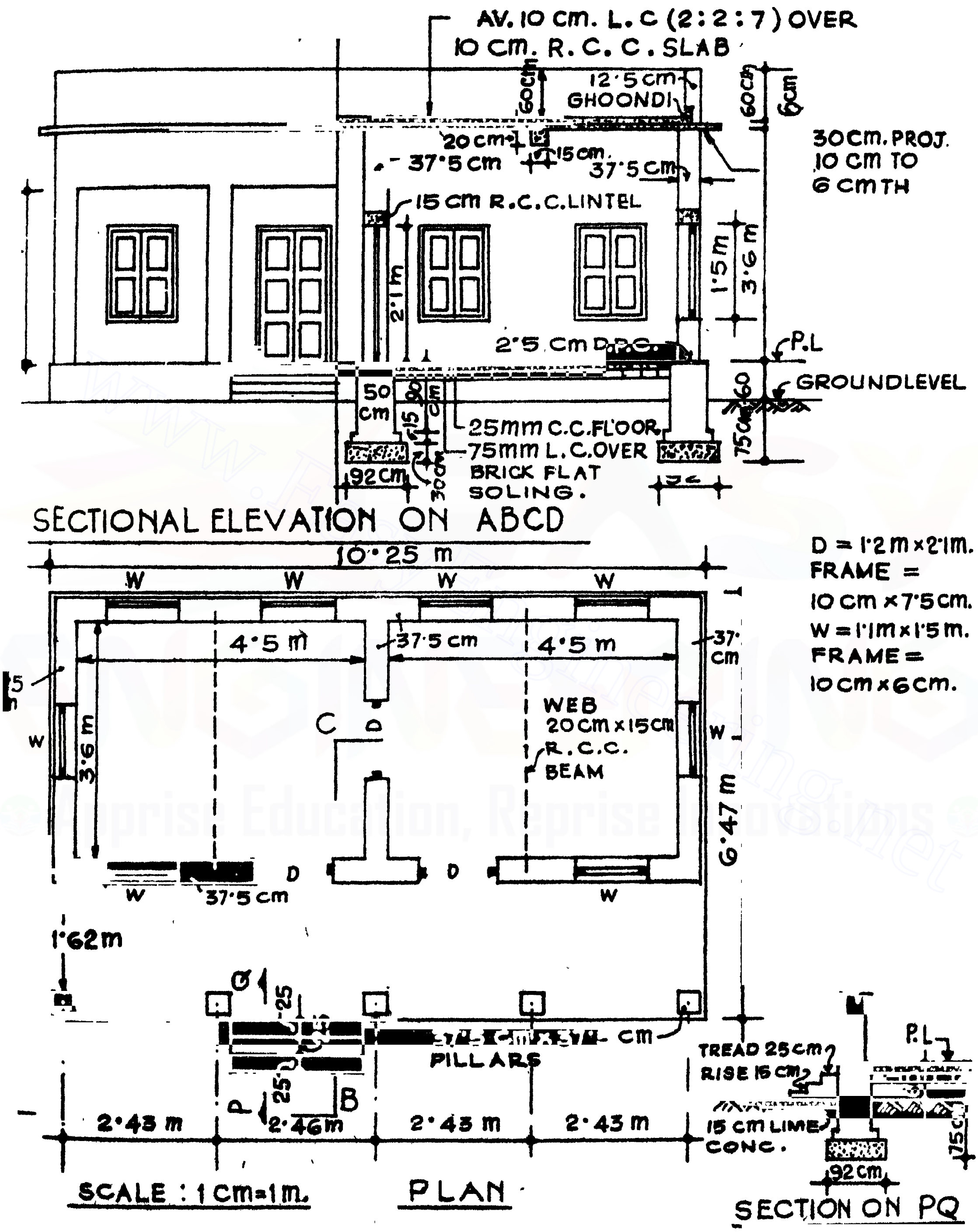

AV. 10 cm. L.C (2:2:7) OVER
10 cm. R.C.C. SLAB
12·5 cm
GHOONDI
60cm
6cm
30cm. PROJ.
10 cm TO
6 cm TH
20 cm
15 cm.
37·5 cm
15 cm R.C.C. LINTEL
1·5 m
3·6 m
2·1 m
2·5 cm D.P.C.
P.L
GROUNDLEVEL
50 cm
25mm C.C.FLOOR
75mm L.C. OVER
BRICK FLAT
SOLING.
92 cm
75cm
SECTIONAL ELEVATION ON ABCD
10·25 m
D = 1·2 m × 2·1 m.
FRAME =
10 cm × 7·5 cm.
W = 1·1 m × 1·5 m.
FRAME =
10 cm × 6 cm.
4·5 m
37·5 cm
37·5 cm
WEB
20 cm × 15 cm
R.C.C.
BEAM
3·6 m
6·47 m
C
D
1·62 m
PILLARS
TREAD 25 cm
RISE 15 cm
15 cm LIME
CONC.
P.L
2·43 m
2·46 m
B
P
Q
92 cm
SCALE : 1 cm=1 m.
PLAN
SECTION ON PQ

FIG. 3-2

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							
	(a) For foundation trenches							
	(A) By centre line method	1	43·32	·92	·75	29·89		$43{\cdot}32 = 45{\cdot}16 - 4 \times \frac{\cdot 92}{2}$ Note that total length is 43·32 m by any method
	(B) By Long & Short wall method							
	Back and front of rooms & verandah front as long walls ...	3	10·67	·92	·75			$10{\cdot}67 = 9{\cdot}75 + 2 \times \frac{\cdot 92}{2}$
	Partition and side of rooms short ...	3	3·05	·92	·75			$3{\cdot}05 = 3{\cdot}97 - 2 \times \frac{\cdot 92}{2}$
	Verandah sides, short ...	2	1·08	·92	·75			$1{\cdot}08 = 2{\cdot}00 - 2 \times \frac{\cdot 92}{2}$
		T.L.	43 32	·92	·75	29·89		
	(b) Steps ...	1	2·68	·61	·08	·13		$2{\cdot}68 = 2{\cdot}46 - {\cdot}375 + 2 \times {\cdot}075$
							30·02 cu m	
2.	**Earthwork in filling—**							
	(a) Foundation trenches ...	$\frac{1}{5}$th of excavation (approx.) =					6·00	
	(b) Plinth of rooms ...	2	4·37	3 47	·45	13·65		$4{\cdot}37 = 4{\cdot}5 - 2 \times {\cdot}0625$ (offsets)
	,, ,, verandah, ...	1	9·25	1·49	·45	6·20		
							25·85 cu m	
3.	**Lime concrete in foundation.**							
	(a) For trenches—							
	(A) By centre line method	1	43·32	·92	·30	11·96		
	(B) By Long & Short wall method							
	Back and front of rooms & verandah front as long walls ...	3	10·67	·92	·30			
	Partition and sides of rooms short ...	3	3 05	·92	·30			
	Verandah sides, short ...	2	1·08	·92	·30			
		T.L.	43·32	·92	·30	11·96		
	(b) Steps ...	1	2·08	·83	·08	·14		
							12·10 cu m	
4.	**1st class brickwork (1:4) in foundation and plinth**							
	(A) By centre line method							
	62 5 cm layer ...	1	43·91	·625	·15	4·12		$43{\cdot}91 = 45{\cdot}16 - 4 \times {\cdot}625/2$ (offset)
	50 cm layer ...	1	44·16	·50	·90	19·87		$44{\cdot}16 = 45{\cdot}16 - 4 \times {\cdot}50/2$
						23·99		

building 2 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	By long and short wall method—							
	Back and front of rooms & Verandah front as long walls 62·5 cm layer	3	10·38	·625	·15	2·92		10·38=9·75+2×·625/2
	50 cm layer	3	10·25	·50	·90	13·84		
	Partition and sides of rooms as Short walls 62·5 cm layer	3	3·34	·625	·15	·94		3·34=3·97—2×·625/2
	50 cm layer	3	3·47	·50	·90	4·68		
	Verandah sides, short wall 62·5 cm layer ...	2	1·37	·625	·15	·26		
	50 cm layer ...	2	1·50	·50	·90	1·35		
						23·99		
	(b) Steps ...	1	2·06	·50 (av)	·45	·46		.50=1/2(·25+·75)
							24·45 cu m	
5.	**1st. class brickwork** (1:6) in superstructure wall (*A*) *By centre line method.*	1	44·41	·375	3·6	59·96		44·41=45·16—4×·375/2
	(*B*) *By long and short wall method—*							
	Back and front of rooms & Verandh front as long walls	3	10·12	·375	3·6			10·12=9·75+2×·375/2
	Partition and sides of rooms as short walls	3	3·60	·375	3·6			
	Verandah sides as short walls	2	1·63	·375	3·6			1·63=2·00—2×·375/2
		T.L.	44·42	·375	3·6	59·96		
	Deduction for—							
	Verandah openings front	3	2·06	·375	2·7	6·26	(-ve)	
	,, ,, ,,	1	2·08	·375	2·7	2·11	,,	
	,, ,, sides	2	1·62	·375	2·7	3·28	,,	
	Door openings, D ...	3	1·2	·375	2·1	2·84	,,	
	Window openings W ...	8	1·1	375	1·5	4·95	,,	
	R.C. Lintel (Band) ...	1	45·02	·375	·15	2·53	,,	45·02=44·42+2×·30 44·42 is the total length of supert wall. ·30 is the lapping of Verandah lintel for bearing at a separate level on walls at each end.
							37·99 cu m	
6.	**12·5 cm thick Brickwork** (1:4) Parapet back an front outer to outer —	2	10·13	—	·60	12·16		
	Parapet sides (in to in) —	2	6·09	—	·60	7·31		
							19·47 sq m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
7.	**1·5 cm thick D.P.C.** (1:2:4)	1	44·41	·375	—	16·65		For L & S wall method take the total length
	Deductions for—							
	Door sills ...	3	1·2	·375	—	1·35	(-ve)	
	Verandah opendings fronts	3	2·06	·375	—	2·32	,,	
	,, ,, ,,	1	2·08	·375	—	·78	,,	
	,, ,, sides	2	1·62	·375	—	1·22	,,	
							10·98 sq m	
8.	**Cement concrete** (1:2:4) excluding reinforcement and shuttering							
	(a) For lintel (band) ...	1	45·02	·375	·15	2·53		
	(b) Cornice back & front (out to out)	2	10·73	·30	·08 (av.)	·52		10·73=10·25 —·125(offset) +2×·30
	,, Sides (in to in)	2	6·35	·30	·08	·30		
						3·35		
	(c) Roofing, slab ...	1	10·13	6·35	·10	6·43		
	Web of beams ...	2	4·20	·15	·20	·25		4·2=3·6+2×·30 30 cm bearing in wall at each side
						6·68	10·03 cu m	
9.	**Hire and labour charges** for centering & shuttering							
	(a) For lintel ...	2	45·02	—	·15	13·51		
	(b) Cornice back & front...	2	10·73	·30	—	6·44		
	Sides ...	2	6·35	·30	—	3·81		
	Edges, back & front ...	2	45·02	—	·06	5·40		
	,, back & front ...	2	10·73	—	·06	1·29		
	(c) Roofing, slab ...	2	4·5	3·6	—	32·40		
	Sides of beams ...	2×2	4·20	—	·20	3·36		
							66·21 sq m	
10.	**Mild steel reinforcement** including cutting, hooking, bending and binding							
		0·8 and =	%vol. 1%vol. $\left(\frac{\cdot 8 \times}{100}\right.$	of(a)+ of (c) $\frac{3\cdot35}{}$ +	(b) from $\frac{1\times6\cdot6}{100}$ =	(8) $\left.8\right)$ ×7 735kg.	850 7·35 qu.	wt. of 1 cu m of M.S. bar =7850 kg.

building 2 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
11.	**10 cm av. thick lime terracing** including rounding edges	1	10·00	6·22	—	62·20	62·20 sq m	10·00=2×4·5+3×·375—2×½×·125
12.	**Sal woodwork for—**							Door frames without sill. 2 verts+1 hor. 5·40=2×2·1+1·2 Window frames 2 verts and 3 hors.
	(a) Door frames ...	3	5·40	·10	·075	·1215		
	b) Window frames ...	8	6·30	·10	·06	·3024	·4239 cu m	
13.	**25 mm thick door and window shutters** of C P. teak wood							
	(a) Doors	3	1·08	2·03	—	6·58		1·08=1·2—2×·075 (frame) +2×·015—(rebates)
	(b) Windows	8	1·01	1·38	—	12·14	18·72 sq m	2·03=2·1—·075 +·015—·01 (bottom opening)
14.	**Mild steelwork for—**							
	(a) Window gratings 16 mm dia bars ...	8×9	1·50	@1·58kg/m=		170·64		
	(b) Clamps 50×6 mm flat 40 cm long end bifurcated							
	For Doors ...	3×6	—	—	—	18nos		
	Windows ...	8×4	—	—	—	32nos		
						50nos		
			@	2·kg each=		100	270·64 kg. =2·71 quintal	
15.	**20 mm thick cement plastering (1:4) finished smooth with cement punning**							
	(a) Plinth wall from 15 cm below G. L. including offsets							
	Back and front ...	2	10·25	—	·81	16·61		·81=·60+·15+·0623
	Sides ...	2	6·47	—	·81	10·48		
	(b) Steps,							
	Treads ...	3	2·08	·25	—	1·56		Rises of steps has been considered in plinth.
	Sides ...	2	·50 (av.)	—	·75	·75		
	Deduction for offset of verandah ...	1	14·36	·06	—	·86	(-ve) 2·854 sq m	Verandah offset has been included in floor finish.

ItemNo	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
16.	**12 mm thick cement plaster (1:6) on walls**							
	(a) Inside—(i) Rooms,							
	Long sides ...	2×2	4·5	—	3·6	64·80		
	Short sides ...	2×2	3·6	—	3·6	51·84		
	(ii) Verandah—							
	Room side upto verandah opening ...	1	10·13	—	2·70	27·35		10·13=10·25—·125 (offset)
	Room side above openings ...	1	9·38	—	·90	8·44		
	Verandah front above opening ...	1	9·38	—	·90	8·44		
	Verandah sides above openings ...	2	1·62	—	·90	2·92		
	(iii) Pillars ...	5×4	·375	·375	—	2·81		
	Top portion of openings							
	Front ...	3	2·06	·375	—	2·32		For both faces deduct one side as per I.S.I. Deduction for other window openings has been considered on the outside plastering as width of reveals is lesser on that side.
	Front ...	1	2·08	·375	—	7·8		
	Sides ...	2	1·62	·375	—	1·22		
	Deduction for openings							
	Doors (both faces)	1×3	1·20	—	2·10	7·56	(—ve)	
						161·04 sq m		
	(b) **Outside**—							
	Back only ...	1	10·13	—	3·6	36·47		
	Sides of rooms ...	2	4·35	—	3·6	31·32		
	Verandah front ...	1	10·13	—	·9	9·12		
	,, sides ...	2	2·00	—	·9	3·60		
	Parapet outside—							
	Back and front ...	2	10·13	—	·60	12·16		
	Sides ...	2	6·35	—	·60	7·62		
	Inside—							
	Back and front ...	2	9·88	—	·60	11·86		9·88=10·25—2×·0625—2×·125
	Sides ...	2	6·01	—	·60	7·21		
	Top, back & front ...	2	10·03	.125	—	2·51		
	Top sides ...	2	6·01	·125	—	1·50		
	Deduction for window openings ...	6	1·20	2·10	—	15·12	—ve	
						108·25 sq m	269·29 sq m	

Building 2 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
17.	**6mm thick cement plaster** (1:4) to R. C. C. work							
	Roof ceiling, Rooms	2	4·5	3·6	—	32·40		
	Verandah ...	1	9·38	1·62	—	15·20		
	Cornice both faces including edge—							
	Back and front out to out	2×2	10·73	·66	—	28·33		10·73=10·25—·125 (offset)+2×·30
	sides (in to in) ...	2×2	6·34	·66	—	16·74		
							92·67 sq m	
18.	**7 5cm thick lime concrete (1½:2·7) flooring** over a layer of brick flat							
	Rooms ...	2	4·47	3·47	—	30·33		4·37=4·5—·125 (offset)
	Verandah ...	1	9·25	1·49	—	13·63		
							43·96 sq m	
19.	**25mm thick artificial stone (1:2:4) flooring** finished with neat cement							
	Rooms ...	2	4·5	3 6	—	32·40		
	Verandah ...	1	9·25	2 06	—	19·60		
	Deduction for pillars ...	5	·375	·375	—	·70	—ve	
							50·76 sq m	
20.	**Whitewashing three coats**	same +roof	as inside ceiling	plaster & ver.	16(a item 17	161·04 47·60		
					=		208·64 sq m	
21.	**Two coats colour wash over a coat of whitewash**	same 16(b) +cor	as out nice ite	side m 17	plaster	108·25 45·07		
					=		153·32 sq m	According to I.S.I. multiplying factor is 2 times area of opening for both faces.
22.	**Painting to wood works** two coats							
	(a) Doors (panelled)	3×2	1·2	—	2·1	17·01		
	(b) Windows ,,	8×2	1·1	—	1·5	29·70		
							46·71 sq m	
23.	**Coal tarring two coats** to back of							
	(a) Door frames...	3	5·40	·10	—	1·62		
	(b) Windows ,, ...	8	5·20	·10	—	4·16		
							5·78 sq m	According to I.S.I. measurement is for one flat over all area excluding frames and no deduction for open spaces.
24.	**Painting to iron works** Window grantings	8	·98	—	1·38	10·82	10·82 sq m	
25.	**7 5cm. dia. C. I. rain water Spouts** painting complete	4	·90	—	—	3·6	3·6 metre	

ABSTRACT OF ESTIMATED COST OF BUILDING 2

Sl. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation of foundation trenches in any kind of soil including triming the side of trenches, levelling, dressing and ramming the bottom and bailing out normal seepage of water, rain water etc. depth of excavation not exceeding 1.5 meters and without shoring.	30·02	cu m	320·00	%cu m	96·06
2.	Earthwork in filling in foundation trenches or plinth including watering and ramming in 15 cm layers etc. with earth obtained from excavation.	25·85	cu m	260·00	%cu m	67·21
3.	Lime concrete with stone lime, surki and over burnt brick ballast i.e. Jhama metal (18:36:100) in foundation.	12·10	cu m	190 00	cu m	2,299·00
4.	Ist. class brickwork in cement mortar (1:4) in foundation and plinth	24·45	cu m	280·00	cu m	6,846·00
5.	Ist. class brickwork in cement mortar (1:6) in superstructure, ground floor.	37·99	cu m	250·00	cu m	9,497 50
6.	12 5 cm thick brickwork in cement mortar (1:4) in first floor.	19·47	sq m	33 00	sq m	642·51
7.	2·5 cm thick Damp-proof course with stone chips (1:2:4) with approved cement water-proofing compound.	10·98	sq m	13·00	sq m	142·74
8.	Cement concrete (1:2:4) with graded stone chips (20 mm down) excluding shuttering and reinforcement in ground floor.	10·03	cu m	410	cu m	4,112·30
9.	Hire and labour charges for providing stout props, centering and shuttering (upto 4 m staging) with hard wood at least 2·5 cm thick.	66·21	sq m	16·00	sq m	1,059 36
10.	Mild steel reinforcement including cutting, hooking bending and binding with 16 gauge black anneale wire as per drawing upto and including ground floor roof.	7·35	Qu.	600	quin.	4,410·00
				Total	C.O=	29,172·68

Sl. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P
		B. F.	...	...	...	29,172·65
11.	10 cm average thick lime terracing with slaked lime (2:2:7) laid to proper slope, thoroughly beaten and cured, including top finishing and rounding edges.	62·20	sq m	37·00	sq m	2,301·40
12.	Sal wood work in door and window frames fitted and fixed complete.	0·424	cu m	2700·00	cu m	1,144·80
13.	25 mm thick C. P. Teakwood panel shutters (with 12mm thick panel) of doors and windows as per design including fitting and fixing the same in position.	18·72	sq m	152·00	sq m	2,845·44
14.	M.S. round bar window gratings and clamps fitted and fixed in position.	2·71	Qun	530·00	Qun.	1,436·30
15.	20 mm thick cement plaster (1:4) with cement punning (19mm plaster and 1mm punning) including rounding off or chamfering corners as directed at ground floor.	28·54	sq m	11·00	sq m	313·94
16.	12 mm thick cement plaster (1:6) to wall including rounding off or chamfering corners as directed and roughening of concrete, surface including throuting, nosing and drip course where necessary at ground floor.	269·29	sq m	6·75	sq m	1,817·70
17.	6 mm thick cement plaster (1:4) to R.C.C work including roughening of concrete, surface rounding off or chamfering corners as directed and throuting, nosing etc. where necessary at ground floor.	92·67	sq m	5·45	sq m	505·05
18.	7·5cm thick terraced flooring of lime concrete with stone lime, surki and brick ballast (i.e. jhama chips) ($1\frac{1}{2}$:2:7) over a layer of brick flat soling of picked over burnt brick and filling joints with local sand.	43·96	sq m	22·00	sq m	967·12
19.	25mm thick grey artificial stone floor with cement concrete (1:2:4) with graded stone chips including 6mm thick skinning and smooth finishing at top made up with cement and rounding off corners, in ground floor.	50·76	sq m	23·00	sq m	1,167·48
20.	White washing three coats including cleaning and smoothening surface (5 parts of stone lime and 1 part of shell lime) ...	208·64	sq m	77·00	%sq m	160·65
	C. O.				...	41,832·56

Sl. No.	Description	Qu	nit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
		B. F.	...	...	...	41,832·56
21.	Two coats colour washing with pigment of any shade with a coat of white wash priming including cleaning and smoothening surface throughly to outside surface at ground floor. ...	153·32	sq m	87·00	%sq m	133·38
2.	Painting two coats to woodwork with ready mixed best quality oil bound paint of approved make and brand, including smoothening surface by sand paper two coats. ...	46·77	sq m	6·75	sq m	315·69
23.	Coal tarring two coats to back of door and window frames ...	5·78	sq m	1·60	sq m	9·29
24.	Painting to steel or iron surface two coats with superior quality alluminium paint of approved make iucluding smoothening surfaces by sand paper. ...	10·82	sqm	5·50	sq m	59·51
25.	7 5cm dia C.I. rainwater spouts including fitting and fixing in position and painting complete ...	3 6	m	24·00	m	86 40

Total = 42,436·78

Add 5% for contingency = 2,121·84

2½% for W. C. = 1,060·94

Grand Total = Rs. 45,619·56

Plinth area (including offsets)

$= 10·25 \times 6·47 = 66·32$ sq m

Plinth Area Rate $= \dfrac{45,919·56}{66·32} =$ Rs. 687·86/sq m

Comparative cost of the different portions of building 2 :—

(a) Cost upto plinth (including D.P.C.) = 22·27%	= Cost of Sl. nos. (1)+(2)+(3)+(4)+(7) = Rs. 96·06 + Rs.67·21 + Rs. 2299·00 + Rs. 6846·00 + Rs. 142·74 = Rs. 9,451·01 ∴ Percentage cost $= \dfrac{9451·01}{42,436·78} \times 100 = 22·27\%$
(b) Cost of brickwork from plinth to parapet = 23·90%	= Cost of Sl. nos. (5)+(6) = Rs.9497·50 + Rs.642·51 = Rs. 10,140·01 ∴ Percentage cost $= \dfrac{10,140·01}{42,436·78} \times 100 = 23·89\%$
(c) Cost of all R.C C.work including roofing = 28·20%	= Cost of Sl. nos. (8)+ 9)+(10)+(11)+(25 = Rs. 4,112 30 + Rs. 1059·36 + Rs. 4,410·00 + Rs. 2,301·40 + Rs. 86·40 = Rs.11,969·46 ∴ Percentage cost $= \dfrac{11969·46}{42436·78} \times 100 = 28·20\%$

(d) **Cost of flooring $=5{\cdot}03\%$**

$=$Cost of Sl. nos. (18) + (19) = Rs. 967·12 + Rs. 1,167·48 = Rs. 2,134·46

$\therefore$ Percentage cost $=\dfrac{2{,}134{\cdot}46}{42{,}436{\cdot}78}\times 100=5{\cdot}03\%$

(e) **Cost of doors and windows $=12{\cdot}80\%$**

$=$Cost of Sl. nos. (12)+(13)+(14)+(23) = Rs. 1,144·80 + Rs. 2845·44 + Rs. 1,436·30 + Rs. 9·24 = Rs. 5,435·78

Percentage cost $=\dfrac{5{,}435{\cdot}78}{42{,}436{\cdot}78}\times 100=12{\cdot}80\%$

(f) **Cost of plastering and finishing $=7{\cdot}80\%$**

$=$Cost of Sl. nos. (15)+(16)+(17)+(20)+(21)+(22)+(24) = Rs. 313·94 + Rs. 1,317·70 + Rs. 505·05 + Rs. 160·65 + Rs. 133·38 + Rs. 315·69 + Rs. 59·51 = Rs. 3,305·92

$\therefore$ Percentage cost $=\dfrac{3{,}305{\cdot}92}{42{,}436{\cdot}78}\times 100=7{\cdot}80\%$

Check :—Total percentage $=22{\cdot}27+23{\cdot}90+28{\cdot}20+5{\cdot}03+12{\cdot}80+7{\cdot}80=100$

Building—3. Detailed Estimate of a Two Roomed Building (with different section of walls) and comparison of cost for different portions.

Prepare a detailed estimate of a building from the given plan and sections as shown in the fig. 3-3. Adopt local P. W. D. rates.

General specification :—

Foundation and Plinth—Brickwork shall be 1st. class in cement mortar (1:4) over cement concrete 1:3.6 and brick flat soling

Damp proof course—D.P.C. shall be 2·5cm thick of cement concrete (1:2:4) with water proofing compound shall be used under superstructure walls and also under pillars and front verandah openings.

Superstructure—All brickworks shall be 1st. class in cement mortar (1:6). All R C C. works shall be with stone chips (1:2:4). The reinforcement in R.C.C work shall be of 0·8%

Roofing—Roof shall be 8cm thick lime terracing over 10cm R.C.C. slab (1:2:4)

Flooring—Floor shall be 2·5cm think C.C. (1:2:4) with stone chips, surface finished with neat cement finish over 10 cm thick lime concrete.

Doors and Windows—Frames (or chowkhats) shall be of sal wood providing with necessary iron clamps. Shutters shall be 40 mm thick panelled of Indian teak wood. Clerestory window shall be of 25 mm thick glazed.

Finishing—Outside walls upto plinth and including plinth offset and steps shall be 20 mm thick cement plastered (1:4) surface finished with neat cement. Other inside and outside walls shall be 12 mm thick cement plastered (1:6). Outside walls shall be colour washed over two coats of white wash and inside wall shall be three coats white washed. Wood work shall be painted two coats over a coat of priming.

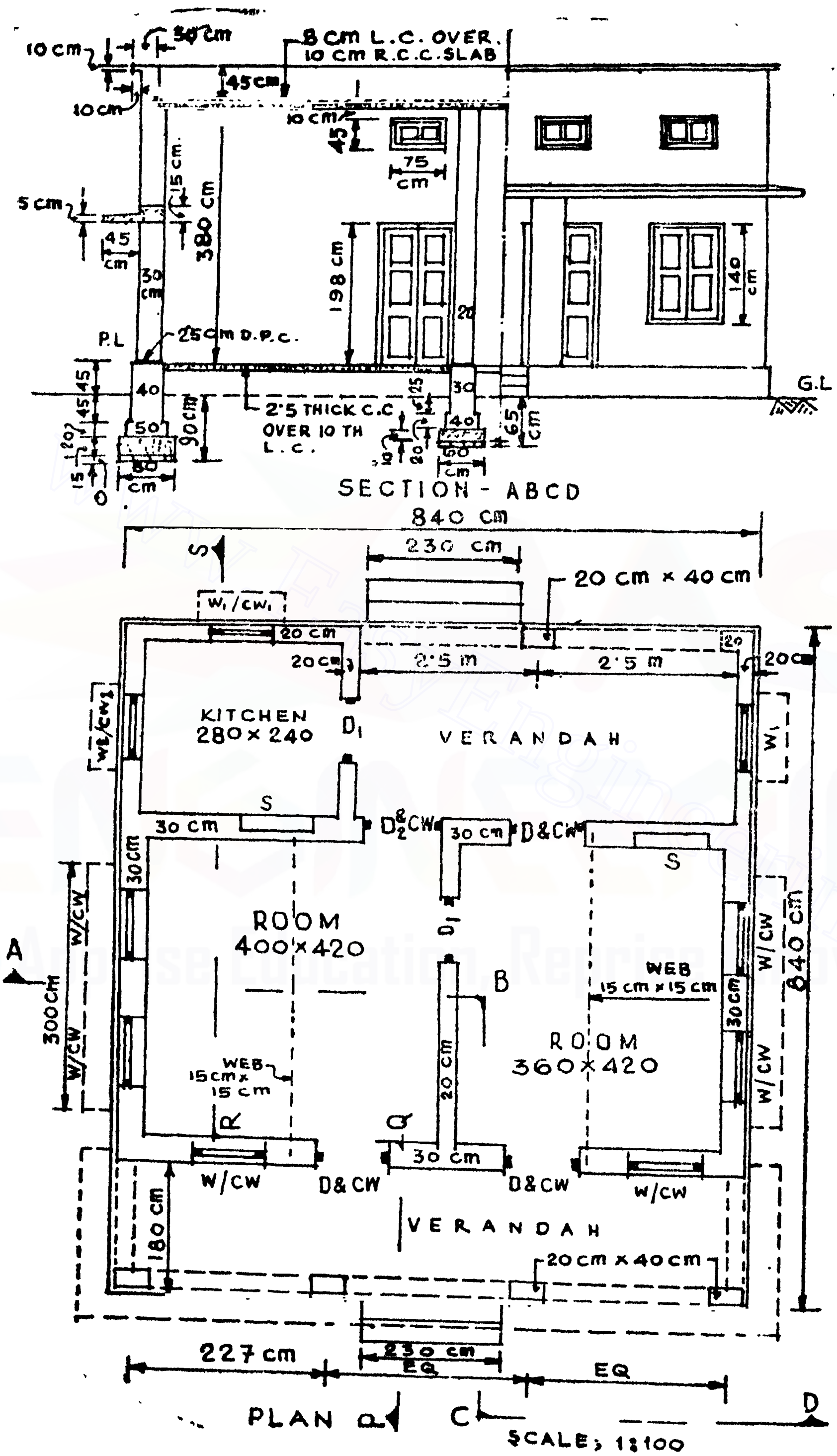


FIG. 3-3

DOORS :—
D = 1 m × 2m
D_1 = 90 cm × 2m

WINDOWS .
W = 1·1m × 1·2m
W_1 = 20 cm × 1·2
CW = 75cm × 45cm
CW_1 = 60cm × 45cm

SHELVE :-
S = 1·1m × 1·4m

FRAME :
D = 8 cm × 10 c
D_1 = —do—
W = —do—
W_1 = —do—
CW = 6cm × 5
CW_1 = —do

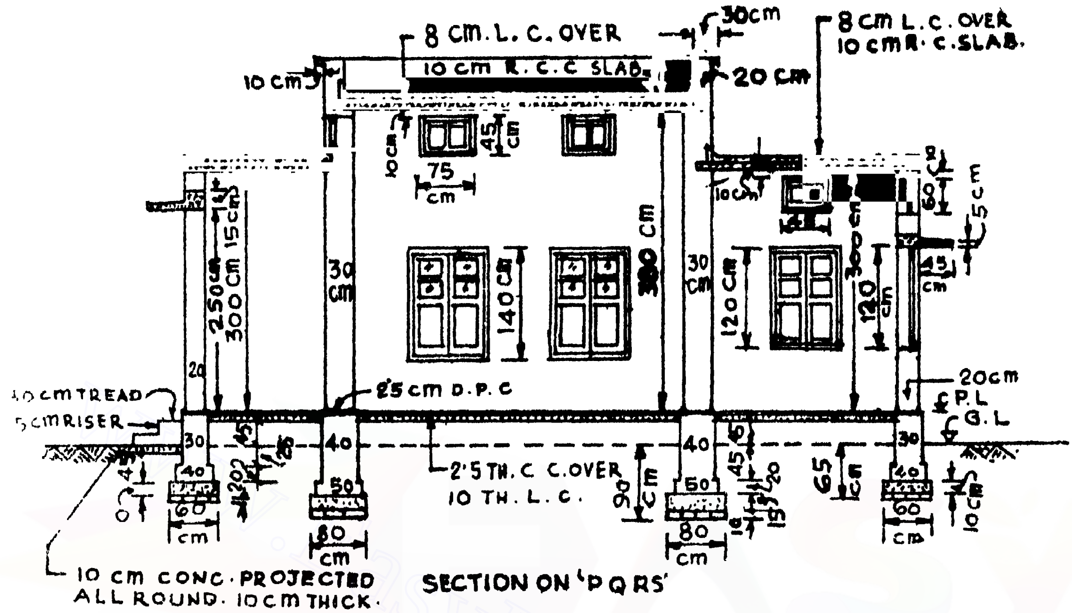


FIG 3-3

(A) Long and short wall method—

Centre to centre distance of—

Rooms—

Back & front as long $= 4+3{\cdot}6+{\cdot}20+2\times\frac{{\cdot}30}{2}$ $= 8{\cdot}1$m

Sides as short $= 4{\cdot}2+2\times\frac{{\cdot}30}{2}$ $= 4{\cdot}5$m

Partition (having different sec.) $= 4{\cdot}2+{\cdot}30$ $= 4{\cdot}5$m

Verandahs—

Entire back and front as long

$= (2{\cdot}8+{\cdot}20+2\times 2{\cdot}5)+2\times\frac{{\cdot}30}{2}$ $= 8{\cdot}2$m

Front verandah sides as short

$= 1{\cdot}8-\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2}$ $= 1{\cdot}85$m

Back vern. sides and kitchen front as short

$2{\cdot}4+\frac{{\cdot}30}{2}+{\cdot}$ $= 2{\cdot}65$m

(B) Centre line method—

Length of centre line for—

Main walls 30 cm

Outer walls of rooms =

$= 2[(4+{\cdot}20+3{\cdot}6+{\cdot}30)+(4{\cdot}2+{\cdot}30)] = 26{\cdot}20$m

20 cm walls

Partition of rooms $= (4{\cdot}2+{\cdot}30)$ $= 4{\cdot}5$m

Front and back of building—

$2[(2{\cdot}8+{\cdot}20+2\times 2{\cdot}5)+2\times\frac{{\cdot}20}{2}\ldots] = 16{\cdot}40$m

Front verandah sides—

$= 2(1{\cdot}8-\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2})$ $= 3{\cdot}70$m

Back verandah sides and walls and kitchen front

$= 3(2{\cdot}4+\frac{{\cdot}30}{2}+\frac{{\cdot}20}{2})$ $= 7{\cdot}95$m

Total $= 32{\cdot}55$m

Note that *the number of joints = 7 nos with main wall and 1 No. with 20 cm wall*

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							
	(a) For foundation trenches							
	(A) ***By long & short wall method***							
	Rooms—							
	Back and front as long	2	8·90	·80	·90			8·90=8·1+·80
	Sides as short ...	2	3·70	·80	·90			3·70=4·50—·80
		T.L.	=25·20	·80	·90	18·14		
	Partition as short ...	1	3·70	·60	·65			3·70=4·50—·80
	Verandahs—							
	Entire back and front, long	2	8·80	·60	·65			8·80=8·2+·60
	Front verandah sides, short	2	1·15	·60	·65			1·15=1·85—·60/2—·80/2
	Back vern. sides & kitchen front as short	3	1·95	·60	·65			1·95=2·65—·60/2—·80/2
		T.L.	=29·45	·60	·65	11·41		
	(B) ***By centre line method***							
	Outer walls of rooms...	1	25·2	·80	·90	18·14		
	20cm walls ...	1	29·45	·60	·65	11·41		29·45=32·55—7×·80/2—·60/2
	(b) Steps, front and back...	2	2·50	·55	·10	·28		·55=2×·30+·10+·30/2—·30
							29·83 cu m	
2.	**Earthwork in filling***							
	(a) For foundation trenches	=	$\frac{1}{6}$th of	excava	tion	(apx.) =5·97		
	b) Plinth filling							
	Room bigger ...	1	4·1	3·9	·35	5·60		4·1=4·2—2×·05 (offsets) ·35=·45—·10(L.C.)
	Room smaller ...	1	3·5	4·1	·35	5·02		
	Verandah front ...	1	8·0	1·5	·35	4·20		
	Verandah back ...	1	4·9	2·3	·35	3 94		
	Kitchen ...	1	2·7	2·3	·35	2·17		
							20·93 cu m	

* Accurately the volume is earthwork in excavation less volume of structure upto G. L.

Building 4 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
3.	**Brick flat soling**							
	(a) For foundation trenches *(A) By long & short wall method or centre line method*							
	Rooms— ...	1	25·20	·80	—	20·16		Concrete of 20 cm wall joins with 50cm brick layer of main wall.
	Verandahs ...	1	30·50	·60	—	18·30		$30{\cdot}50 = 32{\cdot}55 - 7\times\frac{\cdot 50}{2} - \frac{\cdot 60}{2}$
							38 46 sq m	
4.	**Cement concrete 1:3:6 in** foundation—							
	(a) Walls—							
	(A) By long & short wall method							
	Rooms—							
	Back and front as long ...	2	8·90	·80	·15			
	Sides as short ...	2	3·70	·80	·15			
		T.L	25·20	·80	·15	3·02		As the conc. of partition will joins with 50cm brick-work.
	Partition as short ...	1	4·00	·60	·10			4 00=4·5—·50
	Verandahs—							
	Entire back and front, Long ...	2	8·80	·60	·10			
	Front verandah sides, short	2	1·30	·60	·10			$1{\cdot}30 = 1{\cdot}80 - \frac{\cdot 50}{2} - \frac{\cdot 60}{2}$
	Back verandah, sides & kitchen front as short ...	3	2·10	·60	·10	1·83		
		T.L.	30·50	·60	·10	4·85		$2{\cdot}10 = 2\ 65 - \frac{\cdot 50}{2} - \frac{\cdot 60}{2}$
	(B) By centre line method							
	Outer walls of rooms	1	·20	·80	·15	3·02		
	Verandah & 20 cm walls	1	30·50	·60	·10	1·83		
						4 85		
	(b) Steps, back and front	2	2·50	·70	·10	1·33		
							6·18 cu m	
5.	**1st. class brickwork in foundation and plinth** with cement mortar (1:4)							
	(a) Walls—							
	(A) By long & short wall method							
	Rooms—							
	Back and front as long							
	Ist. footing ...	2	8·60	·50	·20	1·72		
	2n ,, ...	2	8·50	·40	·90	6·12		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
	Sides as short, 1st. footing	2	4·00	.50	·20	·80		4·00=4·50 −·50
	2nd footing	2	4·10	·40	·90	2·95		
	Partition as short							
	1st. footing	1	4·10	·40	·20	·33		4·10=4·50 —·40
	2nd footing	1	4·10	·30	·70	·86		1st. and 2nd footing of partition wall meet with 40cm brick layer of main wall
	Verandahs—							
	Entire back & front long							
	1st footing	2	8·60	·40	·20	1·38		
	2nd footing	2	8·50	·30	·70	3·57		
	Front veran. sides short							
	1st. footing	2	1·45	·40	·20	·23		1·45=1·85—2×·40/2
	2nd footing	2	1·50	·30	·70	·63		1·50=1·85—·40/2—·30/2
	Back verandah sides & kitchen front as short							
	1st. footing	3	2·25	·40	·20	·54		2·25=2·65—2×·40/2
	2nd footing	3	2·30	·30	·70	1·45		2·30=2·65—·40/2—·30/2
						20·58		
	(B) By centre line method—							
	Outer walls of rooms—							
	1st. footing 50 cm	1	25·20	·50	·20	2·52		40 cm and 30cm of verandah meet with 40 cm of main.
	2nd footing 40 cm	1	25·20	·40	·90	9·07		
	Veran. and 20 cm walls							
	1st. footing 40 cm	1	30·95	·40	·20	2·48		
	2nd footing 30 cm	1	31·00	·30	·70	6·51		30·95=32·55 —7×·40/2 —·40/2
						20·58		
	(b) Steps, front and back	2	2·30	·45 (av.)	·30	·62		31·00=32·55 —7×·40/2 —·30/2
							21·20 cu m	
6.	**2·5 cm thick D. P. C. of cement concrete (1:2:4)**							
	(B) By Long & Short wall method							
	Rooms—							
	Back and front as long	2	8·40	·30	—			
	Sides as short ...	2	4·20	·30	—			
		T.L.	25·20	·30	—	7·56		8·40=8·10 ·30+

Building 3 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.					7·56		
	Partitions as short	1	4·20	·20	—			
	Verandahs							
	Entire back and front, long	2	8·40	·20	—			
	Front verandah sides, short	2	1·60	·20	—			$1·60=1·85-\frac{·30}{2}-\frac{·20}{2}$
	Back verandah sides & kitchen front as short	3	2·40	·20	—			$2·40=2·65-\frac{·30}{2}-\frac{·20}{2}$
		T.L	31·40	·20		6·28		
						13·84		
	(*B*) *By centre line method*— For main walls	1	25·20	·30	—	7·56		
	For verandah & 20 walls	1	31·40	·20	—	6·28		
						13·84		31·40=31·00+7×·05+·05
	Deductions for— Door sills D	4	1·00	·30	—	1·20(-ve)		
	Door sills D_1	2	·90	·20	—	·36(-ve)		
	Back veran. openings	2	2·30	·20		·92(-ve)		
							11·36 sq m	
7.	**1st class brickwork in superstructure** with cement mortar (1:6)							
	(a) Walls—							
	(*A*) *By L. & S. wall method.* Rooms—							
	Back and front as long	2	8·40	·30	3·80			
	Sides as short	2	4·20	·30	3·80			
		T.L.	25·20	·30	3·80	28·73		
	Partition as short	1	4·20	·20	3·80	3·19		
	Verandahs—							
	Entire back & front, long	2	8·40	·20	3·00			
	Front verandah sides, short	2	1·60	·20	3·00			
	Back verandah sides and kitchen front as short	3	2·40	·20	3·00			
		T.L.	27·20	·20	3·00	16·32		
	(*B*) *By centre line method*—							4·20 is the clear distanc
	Outer walls of rooms ...	1	25·20	·30	3·80	28·73		$27·20=33·55$
	Partition wall ...	1	4·20	·20	3·80	3·19		$-7\times\frac{·30}{2}-\frac{·30}{2}$
	Verandahs and kitch. wall	1	27·30	·20	3·80	16·32		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory note
	(b) Parapet wall—							
	Back and front out to out	2	8·30	·20	·63	2·09		Height of parapet from the room height. 4·40=4·2+2×·1 (offsets)
	Sides inner to inner	2	4·40	·20	·63	1·11		
	Projections— Back and front out to out	2	8·50	·10	·10	·17		
	Sides in to in	2	4·80	·10	·10	·10		
						51·71		
	Deduction for—							
	(i) Door openings D	4	1·00	·30	2·00	2·40		
	,, ,, D_1	2	·90	·20	2 00	·72		
	Window ,, W	6	1·10	·30	1·40	2·77		
	,, ,, W_1	3	·90	·20	1·20	·65		
	Clearstory windows, CW	10	·75	·30	·45	1·01		
	,, ,, Cw_1	2	·60	·20	·45	·11		consider shelve depth=20 cm
	Shelve openings	2	1·10	·20	1·40	·62		
	Front verandah openings							
	Front ...	3	2·27	·20	2·50	3·41		
	Sides ...	2	1·60	·20	2·50	1·60		
	Back verandah openings	2	2·30	·20	2·50	2·30		
						15·59	-(—ve)	
	(ii) Lintel over doors D	4	1·30	·30	·15	·23		15 cm bearing considered.
	,, D_1	2	1·20	·20	·15	·07		
	Windows W rooms front	2	1·40	·30	·15	·13		
	,, W sides (comd.)	2	3·00	·30	·15	·27		
	W_1	3	1·20	·20	·15	·11		
	Over shelves S	2	1·30	·30	·15	·12		10 cm bearing considered.
	Clearstory window CW	10	·95	·30	·10	·29		
	,, ,, CW_1	2	·80	·20	·10	·03		
	Front verandah front	1	8·40	·30	·15	·38		Full bearing on pillars.
	,, ,, sides	2	1·80	·30	·15	·16		
	Back verandah back	1	5·20	·20	·15	·16		
						1·95 (—ve)	34·17 cu m	For sides 20 cm bearing in end wall.

Building 3 continued

n o.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
.	**R. C. C. work** (1:2:4) excluding centering and shuttering and reinfor cement							
	(a) Roof slab above rooms	1	8·10	4·50	·10	3·65		15 cm bearing considered.
	,, ,, Front verandah	1	8·30	1·95	·10	1·62		1·95=1·80+·15
	,, ,, Back verandah	1	8 30	2·75	·10	2·28		2·75=2·4+·20 +·15
	(b) Lintel	sam	e vol.	from	item (7ii)	1·25		
	(c) Beams (Web only) ...	2	4·70	·15	·15	·21		25 cm bearing considered.
	(d) Sun shades for—							
	Front verandah front	1	9·30	·45	·06	(av.)		9·30 is outer to outer=8·4+2 ×·45
	,, ,, sides	2	1·80	·45	·06			
	Over windows W (pair)	2	3·00	·45	·06			
	,, ,, W_1 ...	3	1·20	·45	·06			1·20 same as lintel.
		T.L.	22·50	·45	·06	·61	10·32 cu m	
).	**Centering and Shuttering** for R. C. C. works							
	(a) Roof slab over rooms	1	4·20	4·00	—	16·80		For shuttering no bearing and no wall supported area
	,, ,, ,, ,,	1	4·20	3·60	—	15·12		
	,, ,, ,, front verah.	1	8·00	1·60	—	12·80		
	,, ,, ,, back verah.	1	5·00	2·40	—	12·00		
	,, ,,	1	2·40	2·80	—	6·72		
	(b) Beams web bottom	2	4·20	·15	—	1·62		
	,, ,, sides	2×2	4·20	·15	—	2·52		
	(c) Lintels over—							
	Doors, D bottom ...	4×2	1·30	·15	—	1·56		1·00 is the clear opening.
	,, ,, sides ...	4	1·00	·30	—	1·20		
	D_1 bottom ...	2×2	1·20	·15	—	·72		
	,, ,, sides ...	2	·90	·20	—	·36		
	Windows W room front	2×2	1·40	·15	—	·84		
	,, ,, bottom	2	1·10	·30	—	·66		
	,, sides (combined)	2×2	3·00	·15	—	1·80		
	,, ,, bottom	2	1·10	·30	—	·66		
	C. O.					75·38		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	(b) Parapet wall—							
	Back and front out to out	2	8·30	·20	·63	2·09		Height of parapet from the room height. 4·40=4·2+2×·10 (off sets)
	Sides inner to inner	2	4·40	·20	·63	1·11		
	Projections— Back and front out to out	2	8·50	·10	·10	·17		
	Sides in to in	2	4·80	·10	·10	·10		
						51·71		
	Deduction for—							
	(i) Door openings D	4	1·00	·30	2·00	2·40		
	,, ,, D_1	2	·90	·20	2 00	·72		
	Window ,, W	6	1·10	·30	1·40	2·77		
	,, ,, W_1	3	·90	·20	1·20	·65		
	Clearstory windows, CW	10	·75	·30	·45	1·01		
	,, ,, Cw_1	2	·60	·20	·45	·11		consider shelve depth=20 cm
	Shelve openings	2	1·10	·20	1·40	·62		
	Front verandah openings							
	Front ...	3	2·27	·20	2·50	3·41		
	Sides ...	2	1·60	·20	2·50	1·60		
	Back verandah openings	2	2·30	·20	2·50	2·30		
						15·59	-(—ve)	15 cm bearing considered.
	(ii) Lintel over doors D	4	1·30	·30	·15	·23		
	,, D_1	2	1·20	·20	·15	·07		
	Windows W rooms front	2	1·40	·30	·15	·13		
	,, W sides (comd.)	2	3·00	·30	·15	·27		
	W_1	3	1·20	·20	·15	·11		
	Over shelves S	2	1·30	·30	·15	·12		10 cm bearing considered.
	Clearstory window CW	10	·95	·30	·10	·29		
	,, ,, CW_1	2	·80	·20	·10	·03		
	Front verandah front	1	8·40	·30	·15	·38		Full bearing on pillars.
	,, ,, sides	2	1·80	·30	·15	·16		
	Back verandah back	1	5·20	·20	·15	·16		
						1·95 (—ve)	34·17 cu m	For sides 20 cm bearing in end wall.

Building 3 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
8.	**R. C. C. work** (1:2:4) excluding centering and shuttering and reinforcement							
	(a) Roof slab above rooms	1	8·10	4·50	·10	3·65		15 cm bearing considered.
	,, ,, Front verandah	1	8·30	1·95	·10	1·62		1·95=1·80+·15
	,, ,, Back verandah	1	8·30	2·75	·10	2·28		2·75=2·4+·20 +·15
	(b) Lintel	same vol. from item (7ii)				1·25		
	(c) Beams (Web only) ...	2	4·70	·15	·15	·21		25 cm bearing considered.
	(d) Sun shades for—							
	Front verandah front	1	9·30	·45	·06	(av.)		9·30 is outer to outer=8·4+2 ×·45
	,, ,, sides	2	1·80	·45	·06			
	Over windows W (pair)	2	3·00	·45	·06			
	,, ,, W_1 ...	3	1·20	·45	·06			1·20 same as lintel.
		T.L.	22·50	·45	·06	·61		
							10·32 cu m	
9.	**Centering and Shuttering** for R. C. C. works							
	(a) Roof slab over rooms	1	4·20	4·00	—	16·80		For shuttering no bearing and no wall supported area
	,, ,, ,, ,,	1	4·20	3·60	—	15·12		
	,, ,, ,, front verah.	1	8·00	1·60	—	12·80		
	,, ,, ,, back verah.	1	5·00	2·40	—	12·00		
	,, ,,	1	2·40	2·80	—	6·72		
	(b) Beams web bottom	2	4·20	·15	—	1·62		
	,, ,, sides	2×2	4·20	·15	—	2·52		
	(c) Lintels over—							
	Doors, D bottom ...	4×2	1·30	·15	—	1·56		1·00 is the clear opening.
	,, ,, sides ...	4	1·00	·30	—	1·20		
	D_1 bottom ...	2×2	1·20	·15	—	·72		
	,, ,, sides ...	2	·90	·20	—	·36		
	Windows W room front	2×2	1·40	·15	—	·84		
	,, ,, bottom	2	1·10	·30	—	·66		
	,, sides (combined)	2×2	3·00	·15	—	1·80		
	,, ,, bottom	2	1·10	·30	—	·66		
	C. O.					75·38		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F.					75·38		
	Windows, W_1 sides ...	3×2	1·20	—	·15	1·08		
	„ „ bottom ...	3	·90	—	·20	·54		
	Clearstory windows CW	10×2	·95	—	10	1·90		
	„ „ bottom	10	·75	—	·20	1·50		
	„ „ CW	2×2	·80	—	·10	·32		
	bottom	2	·60	—	·20	·24		
	Shelve opening sides	2×2	1·30	—	·15	·78		Area of pillers, left out being small neglect.
	„ „ bottom	2	1·10	—	·20	·44		
	Front verandah front ...	1×2	8·40	—	·15	2·52		
	„ „ bottom	1×3	8·40	—	20	5·04		
	„ „ sides	2×2	1·80	—	·15	1·08		
	bottom	2	1·80	—	·20	·72		
	Back verandah back ...	1×2	5·20	—	·15	1·56		
	bottom	1	5·20	—	·20	1·04		
	(d) Sun shades—							
	Front verandah front	1	9·30	·45	—	4·19		
	„ „ sides	2	1·80	·45	—	1·62		
	Over windows W (pair)	2	3·00	·45	—	2·70		
	„ „ W_1	3	1·20	·45	—	1·62		21·90=9·30 +2×1·3+2× 3·00+3×1·20
	Edges of all sun shades	1	21·90	—	·05	1·10	10·537 sq m	

Building 3 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
10.	**Mild steel bars** for R. C. C. work including bending, binding etc.	@0·8%	vol. of =10·32 =8·10	item(8) × $\frac{1}{100}$	× 78·5		8·10 quin	Wt. of mild steel per cum =78·5 quintal.
11.	**8cm thick Lime concrete** in roof terracing including rounding edges.							Considered the clear surface area between parapets as the item includes rounding edges. The inserted portion has been accounted as brickwork for parapet.
	Roof over rooms	1	8·00	4·40	—	35·20		
	Roof over front verandah	1	8 40	1·80	—	15·12		
	Roof over back verandah	1	8·40	2·60	—	21·84		
							72·16 sq m	
12.	**Sal wood work** in door & window frames							Door frames 2 verts and 1 hors
	(a) Doors D ...	4	5·00	·10	·08	·1600		
	,, D_1 ...	2	4·90	·10	·08	·0784		
	(b) Windows W ...	6	6·10	·10	·08	·0230		5·00=2×2·00 +1·00
	,, W_1 ...	3	5·10	·10	·08	·1224		Window frames 2 verts and 3 hors
	(c) Clearstory Window CW ...	10	2·40	·06	05	·0720		
	CW_1 ...	2	2·10	·06	·05	·0126		
							·4684 cu m	6·10=2×1·4+ 3×1·1 CW frames 2 verts and 2 hors
13.	**40mm thick panelled** Shutters of Indian teak wood in door and windows with fittings							
	(a) Doors D ...	4	·87	—	1·95	6·79		·87=1·00—2× ·08 (frame)+2 ×·015 (ribets)
	,, D_1 ...	2	·77	—	1·95	3·00		1·95=2·0—·08 +·015—·005 (bottom gap)
	(b) Windows W ...	6	·97	—	1·22	7·10		1·22=1·4—3 ×·08+4 ×·015
	W_1 ...	3	·77	—	1 02	2·36		
							19·25 sq m	
14.	**25mm thick glazed** Shutters of Indian teak wood of C.W. Shutters							
	CW ...	10	·68	—	·38	2·58		
	CW_1 ...	2	·53	—	·38	·40		
							2·98 sq m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
15.	**16mm dia-window grating** bars including fitting fixing							
	(a) Windows W ...	6×8	1·4	—	—	67·2		
	,, W_1 ...	3×6	1·2	—	—	21·6		
	(b) Clearstory windows CW	10×3	·75	—	—	22·5		Barsare @ 10cm c/c vertically 6nos. in door 4nos. in window and 2 nos. clearstory window.
	CW_1	2×3	·60	—	—	3·6		
						114·9m @1·58	181·5kg 1·82	
16.	**M. S. clamp** 37·5cm long end bifurcated with 37×6mm flat iron							
	(a) For door frames	6×6	—	—	—	36		
	(b) Window frames	9×4	—	—	—	36		
	(c) Clearstory windows	12×2	—	—	—	24		
							96 nos.	
17.	**10 cm thick lime** concrete floor							
	Room bigger ...	1	4·10	3·90	—	15·29		
	Room smaller ...	1	4·10	3·50	—	14·35		4·10=4·2—2×·05 (offsets)
	Verandah front ...	1	7·90	1·50	—	11·85		
	Kitchen ...	1	2·30	2·70	—	6·21		
	Verandah back ...	1	4·90	2·70	—	13·23		
						61·63	61·63 sqm.	
18.	**25 mm thick cement** concrete (1:2:4) floor finished smooth with neat cement							
	Room bigger ...	1	4·2	4·0	—	16·80		
	Room smaller ...	1	4·2	3·6	—	15·12		
	Verandah front ...	1	8·4	1·8	—	15·12		
	Kitchen ...	1	2·4	2·8	—	6·72		
	Verandah back ...	1	5·0	2·6	—	13·00		
	Door sills D ...	4	1·0	·30	—	1·20		
	,, ,, D_1 ...	2	·90	·20	—	·36		
	Deduction for pillers	5	·40	·20	—	·40	(-ve)	
							67·92 sq m	

Building 3 continued

Item No.	Description	No.	L. m	B. m.	H. m	Qu.	Total	Explanatory notes
19.	**20 mm thick cement plastering** (1:4) finished with neat cement							
	(a) Plinth wall from G. L.—							
	Back and front ...	2	8·50	—	·50	8·5		·50=·45+·05 (offset)
	Sides ...	2	9·30	—	·50	9·3		
	(b) Steps back and front							
	Treads ...	2×2	2·3	—	·30	2·76		Rises of steps has been considered in plinth
	Sides ...	2×2	(·30+·60)/2	—	·30	·54	21·10 sq m	
20.	**12 mm thick cement plaster** (1:6)							
	(a) **Inside**—							
	(i) Rooms—							
	Biggerroom, long walls	2	4·2	—	3 8	31·92		
	,, ,, short wall	2	4·2	—	3·8	30·40		
	,, ,, ceiling	1	4·2	4·0	—	16·80		
	Smaller room, long walls	2	4·2	—	3·8	31·92		
	,, ,, short walls	2	3·6	—	3·8	27·36		
	,, ,, ceiling	1	4·2	3·6	—	15·12		
	Webs of R. C. beams	2×2	4·2	—	·15	2·52		
	Jambs, sills and soffits of shelves ...	2	5·0	·20	—	2·00		5·0=2(1·1+1·4)
	(ii) Kitchen—							
	Long walls ...	2	2·8	—	3·0	16·80		
	Short walls ...	2	2·4	—	3·0	14 40		
	Ceiling ...	1	2·8	2·4	—	6·72		
	(iii) Front verandah—							
	Front of rooms ...	1	8·4	—	3·0	25·20		
	Front above openings ...	1	8·0	—	·50	4·00		8·0=8·4−2×·20
	Sides above openings ...	2	1 6	—	·50	1·60		
	Ceiling ...	1	8·4	1·8	—	15·12		50=3·0—2·5
						241·88		
	(iv) Back Verandah—							
	Back portion of rooms	1	5·00	—	3·00	15·00		
	Long side above openings	1	5·00	—	·50	2·50		
	Side and kitchen front	2	2·40	—	3·00	14·40		
	Ceiling ...	1	5·00	2·6	—	13·00		2·6=2·4+·20
	C. O. ...					286·78		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...					286·78		
(v)	Pillars three sides							·80=·40+2× ·20
	Front pillars ...	4	·80	—	2·50	8·00		
	Back pillar ...	1	·80	—	2·50	2·00		Following I.S.I. for both faces deduct oneside.
	Deductions for—							
	Door openings, D	4	1·00	—	2·00	8·00	(—ve)	Deduction for other window openings has been made in outside plastering
	,, ,, D_1	2	·90	—	2·00	3·60	,,	
	Window openings W	2	1·10	—	1·40	3·08	,,	
	Clerestory window CW	6	·75	—	·45	2·02	,,	
	Ends of front verandah	2	·20	—	·50	·20	,,	
	Area of pillars ...	5	·40	·20	—	·40	,,	
							279·48 sq m	·50=3·0—2·5
	(b) Outside—							
(i)	Rooms with outside parapet							
	Sides of rooms ...	2	4·8	—	4·53	43·49		4·53=3·8+·10+·08+·45+·10 (projection)
	Front & back of rooms (above low roof) ...	2	8·4	—	1·35	22·68		1·35=4·53(as above) —3·0—·10—·08
(ii)	Verandah (as solid first)							
	Front verandah front...	1	8·4	—	3·18	26·71		
	Front verandah sides ...	2	1·8	—	3·18	11·45		
	Back verandah sides ...	2	2·6	—	3·18	16·54		2·6=2·4+·20
(iii)	Paraper inside over—							
	Back and front of rooms	2	8·2	—	·45	7·38		8·20=8·4 (as above)—2×·10 (parapet thickness)
	Sides of rooms ...	2	4·6	—	·45	4·14		
(iv)	Paraper top—							
	Back & front (out toout)	2	8·6	·30	—	5·16		8·6=8·4+2×·10 (projections)
	Sides (in to in) ...	2	4·4	·30	—	2·64		4·4=4·8+2×·10—·2×·30
(v)	Sun shades both faces—							
	Front verandah front...	1×2	9·30	·45	—	8·37		Dimensions are same as in item no (8d)
	,, ,, sides ...	2×2	1·80	·45	—	3·24		
	Over windows, W (pair)	2×2	3·00	·45	—	5·40		
	,, ,, W_1 ...	3×2	1·20	·45	—	3·24		
	Deductions for—							
	Window openings, W	4	1·1	—	1·4	6·16	(—ve)	
	,, ,, W_1	3	·90	—	1·2	3·24	,,	
	Clerestory openings, CW	4	·75	—	·45	1·35	,,	
	,, ,, CW_1	2	·60	—	·45	·54	,,	
	Front verandah openings							
	Front ...	1	6·80	—	2·50	17·00	,,	6·80=8·40—4×·40
	Sides ...	2	1·60	—	2·50	8·00	,,	
							124·15 sq m	
		Total =	inside 279·48	+outside +124·	15=		403·63 sq m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
21.	**White washing** three coats Inside walls and ceiling ...	Same	as item	(19a)	=		279·48 sq m	
22.	**Colour washing** two coats over a coat of whitewash Outside	Same	as item	(19b)	=		124·15 sq m	
23.	**Painting to wood work two** coats over a coat of priming							According to I.S.I multiplying factor for both faces is 2 times the area far panelled shutter.
	(a) panelled doors D ...	4×2	1·00	—	2·00	18·00		
	,, ,, D_1	2×2	·90	—	2 00	8·10		
	(b) Panelled windows W	6×2	1·10		1·40	20 79		
	,, ,, W_1	3×2	·90		1·20	7·29		
	(c) Glazed windows CW ...	10×1	·75	—	·45	3·38		
	,, ,, CW_1...	2×1	·60	—	·45	·54	58·10 sq m	Accorning to I S.I. multiplying factor is 1 for both faces of glazed shutter
24.	**Creosoting or solignum treatment** at back of frames (i. e. chowkhats)							
	Doors, D ...	4	5·00	·10	—	2·00		5·00=2(1·4+1·1) middle piece is not to be considered.
	Doors, D_1 ...	2	4·90	·10	—	·98		
	Windows W ...	6	5·00	·10	—	3 00		
	Windows W_1 ...	3	4 20	·10	—	1·26		4·2=2(·90+1 2)
	Clerestory windows CW ...	10	2·40	·06	—	1·44		
	,, ,, CW_1 ...	2	2·10	·06	—	·25	8·93 sq m	
25.	**Painting to iron works** two coats over a coat of priming							According to I.S.I measurement is taken for one flat overall area excluding frames and one time for allover sides.
	For window gratings, W ...	6	·94	—	1·24	6·99		
	W_1 ...	3	·74	—	1·04	2·31		
	Clerestory window gratings CW ...	10	·65	—	·35	2·28		
	CW_1...	2	·50	—	·35	·35	11·93 sq m	
26.	**100 mm dia. C. I. rain water spouts** with painting	6	·90	—	—	5·4 r m	5·4 r m	

ABSTRACT OF ESTIMATED COST OF BUILDING 3

Sl. No	Description	Qu.	Unit	Rate Rs P.	Unit of Rate	Amount Rs. P
1.	Earthwork in excavation of foundation trenches in any kind of soil including triming the side of trenches, levelling, dressing and ramming the bottom and bailing out normal seepage of water, rain water etc. depth of excavation not exceeding 1·5 meters and without shoring.	29·83	cu m	320·00	%cu m	95·45
2.	Earthwork in filling in foundation trenches or plinth including watering and ramming in 15 cm layers etc. with earth obtained from excavation.	20·93	cu m	260·00	%cu m	54·41
3.	Single overburnt brick flat soling including ramming and dressing bed to proper level and filling joints including cushioning as necessary with local sand. ...	38·46	sq m	14·00	sq m	538·44
4.	Cement concrete (1:3:6) in foundation with overburnt brick ballast (3cm down) ...	6·18	cu m	360·00	cu m	2,224·80
5.	Ist. Class brickwork in cement mortar (1:4) in foundation and plinth.	21·20	cu m	280·00	cu m	5,936·00
6.	2·5cm thick Damp-Proof Course with stone chips (1:2:4) with approved water proofing cement compound.	11·36	sq m	13·00	sq m	147·68
7.	Ist. class brickwork in cement mortar (1:6) in superstructure, ground floor. ...	34·17	cu m	250·00	cu m	8,542·50
8.	Cement concrete (1:2:4) with graded stone chips (20mm down) excluding shuttering and reinforcement in ground floor. ...	10·32	cu m	410·00	cu m	4,231·20
9.	Hire and labour charges for providing stout props, centering and shuttering (upto 4m staging) with hard wood at least 2·5cm thick.	105·37	sq m	16·00	sq m	1,685·92
	C. O.	...	...	...	...	23,456·40

Sl. No.	Description	Qu.	Unit	Rate Rs P.	Unit of Rate	Amount Rs. P
	B. F.	...	...	...	...	23,456·40
10.	Mild steel reinforcement including cutting, hooking, bending and binding with 16 gauge black anneale wire at every intersection as per drawing upto and including ground floor roof.	8·10	quin	600·00	quin	4,860·00
11.	8 cm thick lime terracing with slaked lime (2:2:7) laid to proper slope, thoroughly beaten and cured, including top finishing and rounding edges.	72·16	sq m	32·00	sq m	2,309·12
12	Sal wood work in door and window frames fitted and fixed complete. ...	0·4684	cu m	2700·00	cu m	1,264·68
13.	40 mm thick Indian teak wood shutter (with 19 mm thick panel) for doors and windows as per design (each panel consisting of single plank without joint) including fitting and fixing the same in position. ...	19·25	sq m	215·00	sq m	4,138·75
14.	25 mm thick Glazed shutter of windows with Indian teak wood as per design (with plain glass of 7·4 kg sq m) including fitting and fixing in position. ...	2·98	sq m	118·00	sq m	351·64
15.	M. S. round bar gratings of window fitted and fixed in holes of window frame complete.	1·82	quin	530·00	quin	964·60
16.	M. S. clamp for fixing door and window frames 37·5cm long end bifurcated and fixing in walls with cement concrete (1:2:4) with 37 × 6 mm flat. ...	96	nos.	2·50	Each	240·00
17.	10 cm thick terraced flooring of lime concrete with overburnt brick ballast (2·5 cm) surki and stone lime (7:2:1½) ...	61·63	sq m	37·00	sq m	2,280·31
18.	25 mm thick grey artificial stone floor with cement concrete (1:2:4) with 6 mm thick skinning and smooth finishing at top made up with cement and including rounding off corners. ...	67·92	sq m	23·00	sq m	1,562·16
19.	20 mm thick plaster with cement and sand (1:4) mortar to wall including rounding off or chamfering corners and racking out joints and neat cement punning about 1·5 mm thick	21·10	sq m	11·00	sq m	232·10
	C. O.	...	...	...	...	41,659·76

SL. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	B. F. ...	...	...	...	...	41,659·76
20.	12 mm thick plaster with cement and sand (1:6) mortar to wall including rounding off or chamfering corners and racking out joints including throating, nosing and drip course where necessary ...	403·63	sq m	6·75	sq m	2,724·50
21.	White washing three coats including cleaning and smoothening surface thoroughly (5 parts of stone lime and 1 part of shell lime in the finishing coat) ...	279·48	sq m	0·77	sq m	215·19
22.	Colour washing two coats of any shade including cleaning and smoothening surface thoroughly ...	124·15	sq m	1·60	sq m	198·64
23.	Painting to timber surface two coats (of any shade as directed) with best quality Synthetic Enamel painting oil bound paint and best quality of approved make and brand including smoothening surface by sand papering ...	58·10	sq m	6·75	sq m	392·17
24.	Creosote or solignum treatment by two coats to wood work ...	8 93	sq m	5·20	sq m	46·43
25.	Painting two coats with readymixed red-lead paint of approved make and brand, including smoothening surface ...	11·93	sq m	6·75	sq m	80·52
26.	100 mm dia. C. I. rain water spouts including fitting and fixing in position and painting complete ...	5·4	r m	24·00	r m	129·60

Total = 45,446·81

Add 5% for contingency = 2,272·34

$2\frac{1}{2}$% for W. C. = 1,136·17

Grand Total = Rs. 48,855·42

Plinth area (including offsets)

$= 7{\cdot}90 \times 9{\cdot}30 = 73{\cdot}47$ sq m

$\therefore$ Plinth Area Rate $= \text{Rs. } \dfrac{48{,}855{\cdot}42}{73{\cdot}47}$

= Rs. 664·97/sq m

(i.e. Rs. 61·77/sq ft)

Comparative cost of the different portions of building 3 :-

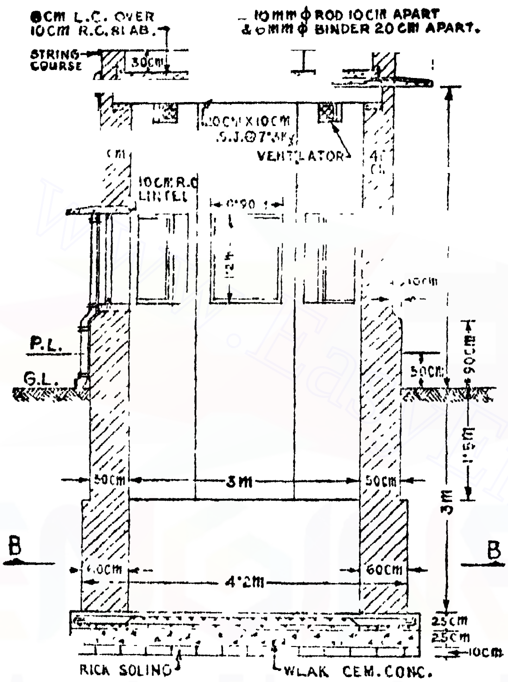
(a) Cost upto plinth (including D. P. C.) =19 80%	=Cost of sl. nos. (1)+(2)+(3)+(4)+(5)+(6) =Rs. 95·45+Rs. 54 41+Rs. 538·44+Rs. 2,224·80+Rs. 5,936·00+Rs. 147·68 =Rs. 8,996·78 ∴ Percentage cost$=\frac{8,996·78}{45,446·81}\times100=19·80\%$
(b) Cost of brickwork from plinth to parapet =18·80%	=Cost of sl. no. (7)=Rs. 8,542·50 ∴ Percentage cost$=\frac{8,542·50}{45,446·81}\times100=18·80\%$
(c) Cost of all R. C. C. work including roofing =29·07%	=Cost of sl. nos. (8)+(9)+(10)+(11)+(26) =Rs. 4,231·20+Rs. 1,685·92+Rs. 4,860·00+Rs. 2,309·12+Rs. 129·60=Rs. 13,215·84 ∴ Percentage cost$=\frac{13,215·84}{45,446·81}\times100=29·07\%$
(d) Cost of flooring =8·45%	Cost of sl. nos. (17)+(18)=Rs. 2,280 31+Rs. 1,562·16 =Rs. 3,842·47 ∴ Percentage cost$=\frac{3,342·47}{45,446·81}\times100=8·45\%$
(e) Cost of door and windows =15·32%	=Cost of sl. nos. (12)+(13)+(14)+(15)+(16) =Rs. 1,264·68+Rs. 4,138·75+Rs. 351·64+Rs. 964·60+Rs. 240·00=Rs. 6,959·67 ∴ Percentage cost$=\frac{6,959·67}{45,446·81}\times100=15·31\%$
(f) Cost of plastering and finishing =8·56%	Cost of sl. nos. (19)+(20)+(21)+(22)+(23)+(24)+(25) =Rs. 232·10+Rs. 2,724·50+Rs. 215·19+Rs. 198·64+Rs. 392·17+Rs. 46·43+Rs. 80·52=Rs. 3,889·55 ∴ Percentage cost$=\frac{3,889·55}{45,446·81}\times100=8·55\%$

Check :—Total percentage=19·80+18·80+29·07+8·45+15·32+8·55=100

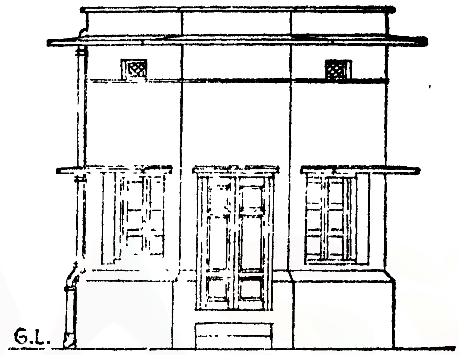
3-4 **Pump-House** (***Using standard modular bricks***) :—Estimate the quantity of works of the following items from the Pump-House shown in the fig. 3-4A.

(1) Earthwork in excavation, (2) Brickwork in foundation and plinth, (3) Brickwork in superstructure, (4) R. C. slab in roof, (5) 15mm thick cement plaster to internal walls, (6) 15mm thick cement plaster to ceiling.

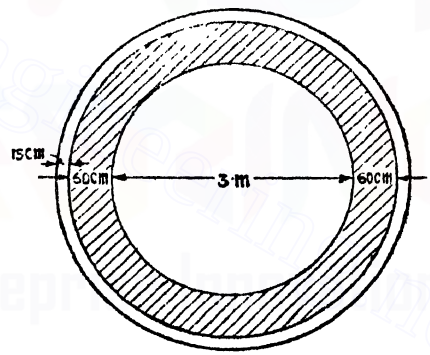
Size of windows = ·90m × 1·2m. Door = 1·1m × 1·9m



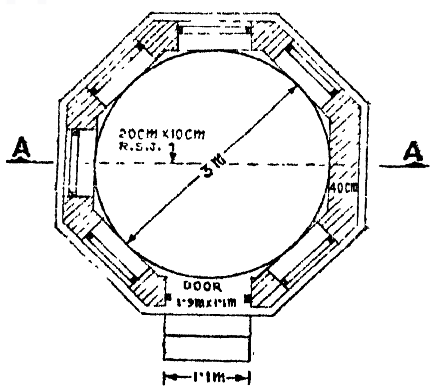
SECTION ON A-A



ELEVATION



SECTIONAL PLAN AT B-B



SECTIONAL PLAN AT WINDOW SILL

FIG. 3-4A

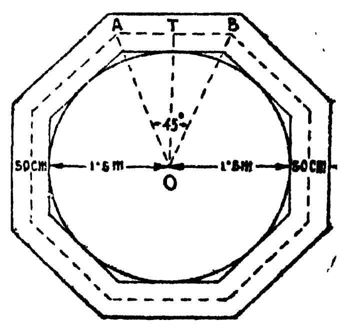


FIG. 3-4B

Scale 1cm = 1m

To calculate the centre line following the fig. 3-4B, $OT = 1{\cdot}5 + \frac{{\cdot}50}{2} = 1{\cdot}75$m. Now, from the triangle OAT, $AT = OT \times \tan \frac{45^\circ}{2}$ $\therefore$ $AB = 2AT = 2(OT \times \tan \frac{45^\circ}{2})$

$= 2(1{\cdot}75 \times \tan 22^\circ 30') = 1{\cdot}45$m

$\therefore$ Total length of centre line for 50cm thick wall of the octagon $= 8 \times 1{\cdot}45 = 11{\cdot}60$m

Similarly the total length of centre line for 40cm thick wall $= 8(2 \times 1{\cdot}7 \tan 22^\circ 30') = 11{\cdot}27$m

Thus the total length of centre line for parapet wall $= 8(2 \times 1{\cdot}75 \tan 22^\circ 30') = 11{\cdot}60$m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**	1	$\pi \times \left(\frac{4{\cdot}5}{4}\right)^2 \times$		3·6	57·25	57·25 cu m	4·5=3+2×·60 +2×·15
2.	**Brickwork in foundation and plinth**—							3·6=3·0+2× ·25+·10
	(a) 60cm wall (circular) ...	1	π×3·6	·60	1·5	10·18		3·6 is mean dia.
	(b) 50cm wall (octagonal)	1	11·60	·50	2·0	11·60		
	(c) Steps (with tread of 30cm) ...	1	1·10	·45 (av.)	·30	0·15		$·45=\frac{1}{2}(·30+·60)$
							21·93 cu m	Chamfer 10 cm rise considered square
3.	**Brickwork in superstructure**							
	(a) 50cm wall (octagonal)	1	11·60	·50	·50	2·90		3·00=4·0—·90 — 10
	(b) 40cm wall (octagonal)	1	11·27	·40	3·00	13·52		
	(c) 30cm parapet wall (octagonal) ...	1	11·60	·30	·40	1·38		
	Deduction for—							
	Door in 50cm wall ...	1	1·10	·50	·50	0·28	(-ve)	The door is in two walls of 50 cm and 40 cm
	„ „ 40cm wall ...	1	1·10	·40	1·40	0·62	„	
	Windows ...	6	·90	·40	1·2	2·59	„	
	Lintel (with 15cm bearing)						„	
	Over door ...	1	1·40	·40	·10	0·06	„	
	„ windows ...	6	1·20	·40	·10	0·39	„	
							14·86 cu m	
4.	**10cm R.C. roof slab** with full bearing (Length of one outer edge of 40cm wall of the octagonal roof $=2 \times 1{\cdot}90 \tan\frac{45^\circ}{2} = 1{\cdot}574$)	8	½×1·5	74×1·	90	11·96	11·96 sq m	1·90 is the perpendicular dist. from centre to the outer edge= 1·5+·40, 8 nos. for eight triangles.
5.	**15cm thick cement plaster to internal walls**—							
	(a) For circular portion	1	π×3·0	—	1·5	14·14		
	(b) For octagonal portion (one side =2×1·5× tan 22°30′=1·24) ...	8	1·24	—	5·5	54·56		
	Deduction for door ...	1×½	1·1	—	1·9	1·04	(-ve)	5·5=4+1·5
	„ „ windows	6×½	·90	—	1·2	3·24	„	½ time for one side
							64·42 sq m	
6.	**15mm thick plaster to ceiling**	8	½×1·2	4×1·5		7·44	7·44 sq m	1·24 as calculated in 5.(b).

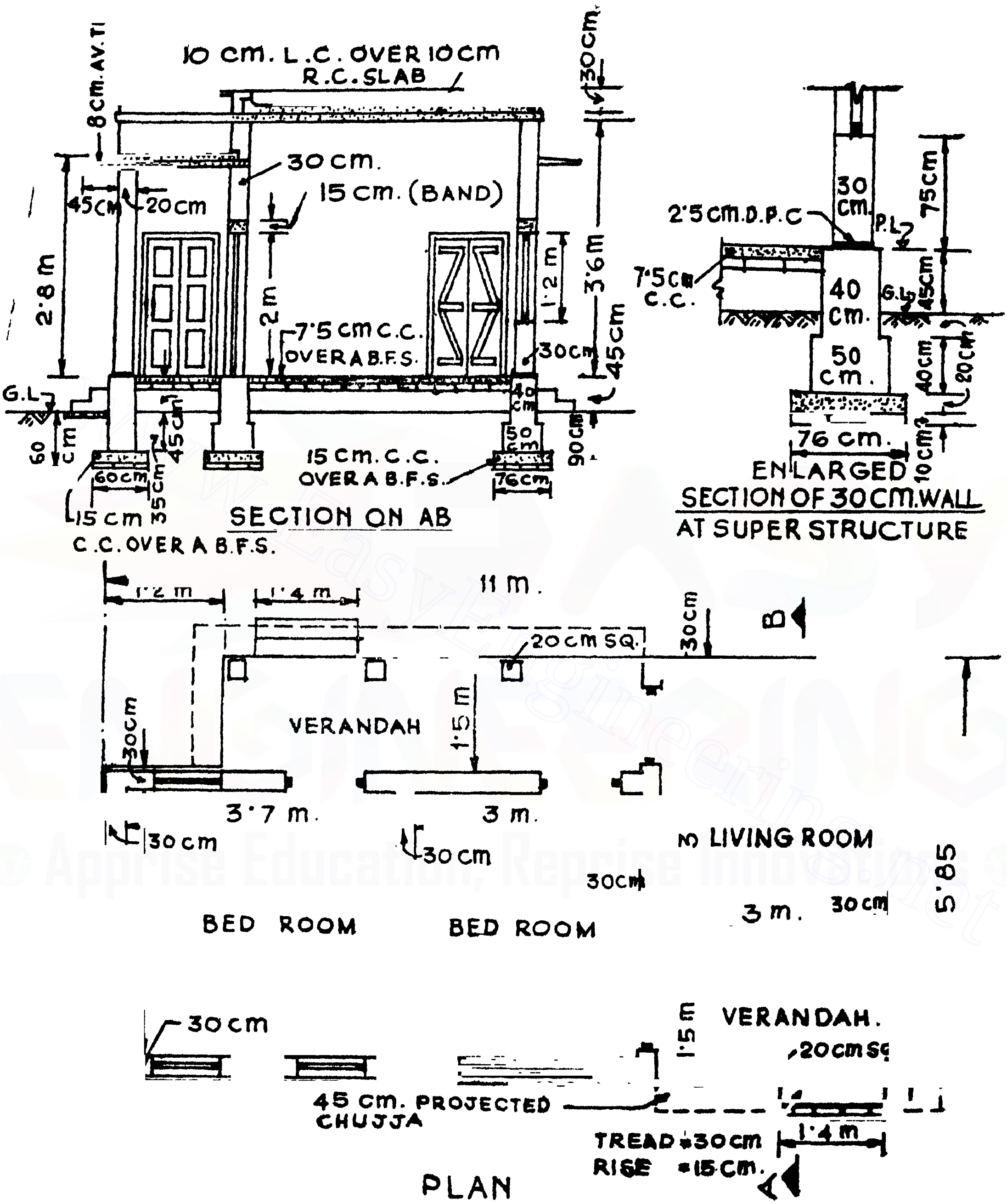


FIG. 3-5

Doors = 1·00 × 2·00

Window (small) = ·90 × 1·20

" (large) = 1·80 × 1·30

Building—4. Quantity Estimate for main items of a building.

Estimate the quantities of the following items from the drawing shown in fig. 3-5.

(1) Earthwork in excavation for foundation trenches, (2) Cement concrete (1:3:6) in foundation, (3) 1st. class brickwork with cement mortar (1:4) in foundation and plinth, (4) 2·5 cm thick D. P. C. with cement concrete (1:2:4), (5) 1st. class brickwork in superstructure (1:6), (6) 10 cm thick brickwork (1:4) in parapet walls, (7) 7·5 cm thick cement concrete (1:2:4) floor over a brick flat soling, (8) Cement concrete (1:2:4) at roof slab and lintel, (9) Centering and shuttering for roof slab and lintel, (10) M. S. reinforcement for roof slab (with 1%) and lintel (with ·08%), (11) 8 cm (av.) thick and 45cm projected R. C. chajja.

(A) Centre line Method—

Centre line length for—

(a) Main walls of 30cm

Outer walls of rooms

$=2[(11-\cdot40)+(5\cdot85-\cdot40)]$ $=32\cdot10$ m

Partition between bed and living rooms

$=(3\cdot7+\cdot30)-(1\cdot5+\frac{\cdot30}{2}-\frac{\cdot40}{2})$ $=2\cdot55$m

Partition between bed rooms

$=3\cdot7+\cdot30$ ... ... $=4\cdot00$m

Total $=38\cdot65$m

Number of joints = 4 Nos.

(b) Verandah walls (having different sec)

Front verandah—

Front $=3\cdot35-\frac{\cdot30}{2}+\frac{\cdot30}{2}$ $=3\cdot35$m

Side $=1\cdot5-\frac{\cdot30}{2}+\frac{\cdot30}{2}$ $=1\cdot50$m

Back $=11-1\cdot2-3-\cdot30-\cdot35+\frac{\cdot30}{2}-\frac{\cdot30}{2}$ $=6\cdot15$m

Side $=1\cdot5-\frac{\cdot50}{2}+\frac{\cdot50}{2}$ $=1\cdot50$m

Total $=12\cdot50$m

Number of joints = 4 nos. with main wall.

(B) Long and short wall Method

Centre to centre distance for—

Bed rooms (combined)—

Back and front as long walls

$=(3\cdot7+\cdot30+3\cdot0)+\cdot30=7\cdot3$m

Sides and partition as short walls

$=3\cdot7+\cdot30=4$m

Living room—

Back and front as short walls

$=3+\cdot30=3\cdot30$m

Right side as long wall

$=1\cdot5+\frac{\cdot30}{2}-\frac{\cdot40}{2}=1\cdot45$m

Left side. verandah portion as long-short

$=1\cdot5+\frac{\cdot30}{2}-\frac{\cdot40}{2}=1\cdot45$m

Front verandah—

Front as long-short

$=(3+\cdot30)-\frac{\cdot30}{2}+\frac{\cdot30}{2}=3\cdot35$m

Side as short wall

$=1\cdot5-\frac{\cdot30}{2}+\frac{\cdot30}{2}=1\cdot5$ m

Back verandah—

Back as long-short

$=(11-1\cdot2-3-\cdot30-\cdot35)+\frac{\cdot30}{2}-\frac{\cdot30}{2}=6\cdot15$m

Side as short wall $=1\cdot5-\frac{\cdot30}{2}+\frac{\cdot30}{2}=1\cdot5$m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earth work in excavation in foundation**							
	(A) By centre line method							
	(i) Main walls ...	1	37·13	·76	·90	25·40		37·13=38·65—4×·76/2
	(ii) Verandah walls ...	1	10·98	·60	·60	3·95		10·98=12·50—4×76/2
	(iii) Steps ...	2	1·60	·55	·10	·18		Projection of conc. 10cm and thickness 10cm considered.
							29·53 cu m	
	(B) By L. & S. wall Method							
	Bed rooms—							
	Back and front as long	2	8·06	·76	·90			8·06=7·3+·76
	sides and partition as short	3	3·24	·76	·90			
	Living room—							
	Back and front as short ...	2	2·54	·76	·90			2·54=3·30—·76
	Right side as long ...	1	4·76	·76	·90			
	Left side verandah portion as long-short ...	1	1·45	·76	·90			For long-short wall length remains constant.
		T.L.	=37·13	·76	·90	25 40		
	Front verandah—							
	Front as long-short ...	1	3 35	·76	·60			
	Side as short ...	1	·74	·76	·60			
	Back verandah—							
	Back as long-short ...	1	6·15	·76	·60			
	Side as short ...	1	·74	76	·60			
		T.L.	=10·98	·76	·60	3·95		
	Steps	2	1·60	·55	·1 0	·18		
							29·53 cu m	
2.	**Cement concrete in foundation** (1:3:6)							
	(A) By center line Method							
	(i) Main walls ...	1	37·13	·76	·20	5·64		
	(ii) Varandah walls ...	1	11·50	·60	·15	1·04		Since conc. meets with 50cm layer of main
	(iii) Steps ...	2	1·60	·70	·10	·22		11·50=12·50—4×·50/2
							6·90 cu m	

Building 4 continued

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	(B) By L. & S. wall method							
	Bed Rooms—							
	Back and front as long ...	2	8·06	·76	·20			
	Sides and partition as short ...	3	3·24	·76	·20			
	Living Room—							
	Back and front as short ...	2	2·54	·76	·20			
	Right side as long ...	1	4·76	·76	·20			
	Left side vern. portion as long-short ...	1	1·45	·76	·20			
		T.L.	37·13	·76	·20	5 64		
	Front verandah—							
	Front as long-short ...	1	3·40	·60	·15			3·40=3·35 +·60/2—·50/2
	Side as short ...	1	·95	·60	·15			·95=1·5—·60/2 —·50/2
	Back verandah—							
	Back as long-short ...	1	6·20	·60	·15			6·20=6·15+ ·60/2—·50/2
	Side as short ...	1	·95	·60	·15			
		T.L.	11·50	·60	·15	1·04		
	Steps ...	2	1·60	·70	·10	·22	6·90 cu m	
3.	**Brickwork in foundation and plinth (1 : 4)**							
	(A) By centre line method							
	(i) Main walls 50 cm layer	1	37·65	·50	·40	7·53		37·65=38·65—4×·50/2
	Main walls 40 cm layer	1	37·85	·40	·65	9·84		For lower part no change over 11·50 as conc. &30cm brick-work meets with the same layer of 50 cm.
	(ii) Verandah 30 cm layer							
	(a) Lower part coincides with 50cm layer of main	1	11·50	·30	·15	·52		
	(b) -do upper part meets with 40 cm layer of main	1	11·70	·30	·65	2·28		But the upper part meets with different layer 40 cm of main wall
	(iii) Steps ...	2	1·45	·45 (av.)	·30	·38	20·55 cu m	11·70=12·50—4×·40/2
	(B) By L. & S. wall method							
	Bed Rooms—							
	Back and front as long							
	50 cm layer ...	2	7·80	·50	·40	3·12		
	40 cm layer ...	2	7·70	·40	·65	4·00		
	Sides and partition as short							
	50 cm layer ...	3	3·50	·50	·40	2·10		
	40 cm layer ...	3	3·60	·40	·65	2·81		
	C. O. ...					12·03		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.					12·03		
	Living Room—							
	Back and front as short							
	50 cm layer ...	2	2·80	·50	·40	1·12		
	40 cm layer ...	2	2 90	·40	·65	1·51		
	Right hand side as long							
	50 cm layer ...	1	4·50	·50	·40	·90		
	40 cm layer ...	1	4·40	·40	·65	1·14		
	Left side veran. portion as long-short							
	50 cm layer ...	1	1·45	·50	·40	·29		
	40 cm layer ...	1	1·45	·40	·65	·38		
	Front verandah—							
	Front as long-short							
	30 cm layer							
	(a) Lower part which coincides with 50 cm layer of main wall ...	1	3·25	·30	·15	·15		3·25=3·35+·30/2−·50/2
	(b) Upper part which coincides with 40 cm layer of main wall ...	1	3·30	·30	·65	·65		3·30=3·35+·30/2—·40/2
	Sides as short 30 cm layer							
	(a) Lower part which coincides with 50 cm layer of main wall ...	1	1·10	·30	·15	·05		1·10=1·5—·30/2—·50/2
	(b) Upper part which coincides with 40 cm layer of main wall ...	1	1·15	·30	·65	·22		
	Back verandah—							
	Back as long-short							
	30 cm layer							
	(a) Lower part which coincides with 50 cm layer of main wall ...	1	6·05	·30	·15	·27		
	(b) Upper part which coincides with 40 cm layer of main ...	1	6·10	·30	·65	1·19		
	Side as short 30 cm layer							
	(a) Lower part ...	1	1·10	·30	·15	·05		
	(b) Upper part ...	1	1·15	·30	·65	·25		
	Steps ...	2	1·4	·45 (av.)	·30	·30	20·55	cu m

Building 4 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4.	**2·5cm thick D. P. C.**							
	(*A*) *By centre line method.*							
	(i) Main walls ...	1	33·05	·30	—	11·42		38·05=38·65—4×·30/2
	(ii) Pillars ...	5	·30	·30	—	·45		
	Deductions for door openings ...	6	1·00	·30	—	1·80	(-ve)	
							10·07 sqm	
	(*B*) *By L. & S. wall method*							
	Bed Rooms—							
	Back and front as long ...	2	7·60	·30	—			7·60=7·3+·30
	Sides and partition as short ...	3	3·70	·30	—			3·70=4—·30
	Living Room—							
	Back and front as short	2	3·00	·30	—			
	Right side as long ...	1	4·30	·30	—			
	Left side verandah portion as long-short ...	1	1·45	·30	—			
		T.L	38·05	·30	—	11·42		
	Pillars ...	5	·30	·30	—	·45		
	Deductions for door openings ...	6	1·00	·30	—	1·80	(-ve)	
							10·07 sq m	
5.	**1st class brickwork in superstructure** (1:6)							
	(*A*) *By centre line method.*							
	(i) Main walls ...	1	38·05	·30	3·60	41·09		
	(ii) Pillars ...	5	·30	·30	2 80	1·26		
	Deductions for—							
	Door openings ...	6	1·00	·30	2·00	3·60	(-ve)	
	Window small ...	7	·90	·30	1·2	2·27	,,	
	,, large ...	2	1·80	·30	1·2	1·30	,,	
	Band lintel ...	1	38·05	·30	1·5	1·71	,,	
							33·47 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	(*B*) *By L. & S. wall method*							
	For rooms ...		38·05	·30	3·60	41·09		38·05 is the total length as that for D.P.C.
	Pillars ...		·30	·30	2·80	1·26		
	Deductions for—							
	Door openings ...		1·00	·30	1·2	·36 (-ve)		
	Windows small ...		·90	·30	1·2	2·27		
	large ...		1·80	·30	1·2	1·30		
	Band lintel ...		38·05	·30	·15	1·15		
							36 71 cu m	
	10cm thick brickwork (1:4) **in parapet walls** (For both the systems)							
	Back and front (outer to outer)		10·90		·30	6 54		10·90=11·00—2×·05
	Sides (inner to inner)		5·55		·30	3·33		5·55=5·85−2 ·05—2×·10
							9·8 sq m	
7.	**7·5 cm thick cement concrete floor** over a brick flat soling							
	Adjacent bed & living ...	2	3·60	2·90		20·88		
	Bed room bigger ...	1	3·60	3·60		12 96		
	Verandah front ...	1	3 05	1·15		3·51		
	—do—back ...	1	5·80	1·15		6·67		
							44 02 sq m	
8.	**Cement concrete** (1:2:4) for R C C. works—							
	(i) Roof slab for—							
	Rooms floor area ...		3·7	3·7	·10	1·37		
			3·7	3·0	·10	2·22		
	„ walls „ ...		38·05	·30	·10	1·14		
	Verandah floor area—							
	Front ...		3·60	1·75	·10	·63		
	Back ...		6·40	1·75	·10	1·12		
	(ii) Band lintel (for main wall)		38·05	·30	·15	1·71		
							8·19 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
9.	**Centering & Shuttering** for R. C. works							
	i) For roof slab— Over Rooms ...	1	3·7	3·7	—	13·69		
	„ „ ...	2	3·7	3·0	—	22·20		
	Edges, long sides ...	2	10 90	·10	—	2·18		10·90=11—2×·05
	„ short sides ...	2	5·75	·10	—	1·15		
	Over verandah, front	1	3·0	1·5	—	4·50		
	„ „ back	1	6·1	1·5	—	9·15		6·1=11·0—1·2—3—2×·30—2×·05
	(ii) Lintel sides ...	2	38·05	- -	·15	11·42	64·29 sq m	
10.	**M.S. reinforcement** For roof slab (1%) ..		(8·19—1·71) / 100		×78·5	=5·01		Wt. of M.S. bar =78·5 q/cu m
	For lintel (·08%) ...		1·71×·8 / 100		×78·5	=1·07	6·03 quin	
11.	**R.C. chajja 8 cm** (av.) thick & 45 cm projected including reinforcement and shuttering At verandah front— Long side ...	1	3·75	—	—	3·75		3·75=3·0+·30+·45
	Short side ...	1	1·45	-	—	1·45		
	At verandah, back— Long side ...	1	6·55	—	—	6 55		
	Short side ...	1	1·45	—	—	1·45	13·20	r.m.

ABSTRACT OF QUANTITIES OF BUILDING 5

Sl. No.	Description of item	Quantities
1.	Earthwork in excavation for foundation trenches	... 29 53 cu m
2.	Cement concrete (1:3:6) in foundation	... 6·90 cu m
3.	1st class brickwork with cement mortar (1:4) in foundation and plinth	.. 20·55 cu m
4.	2·5 cm thick D.P.C. with cement concrete (1:2:4)	... 10·07 sq m
5.	1st class brickwork (1:6) in superstructure	... 36·71 cu m
6.	10 cm thick brickwork (1:4) in parapet walls	... 9·87 sq m
7.	7·5 cm thick cement concrete (1:2:4) floor over a brick flat soling	... 44·02 sq m
8.	Cement concrete (1:2:4) at roof slab and lintel	... 8·19 cu m
9.	Centering and shuttering for roof slab and lintel .	... 64·29 sq m
10.	M. S. reinforcement for roof slab and lintel	... 6·03 quintal
11.	8 cm (av.) thick and 45 cm projected R. C. Chajj	... 13·20 rm

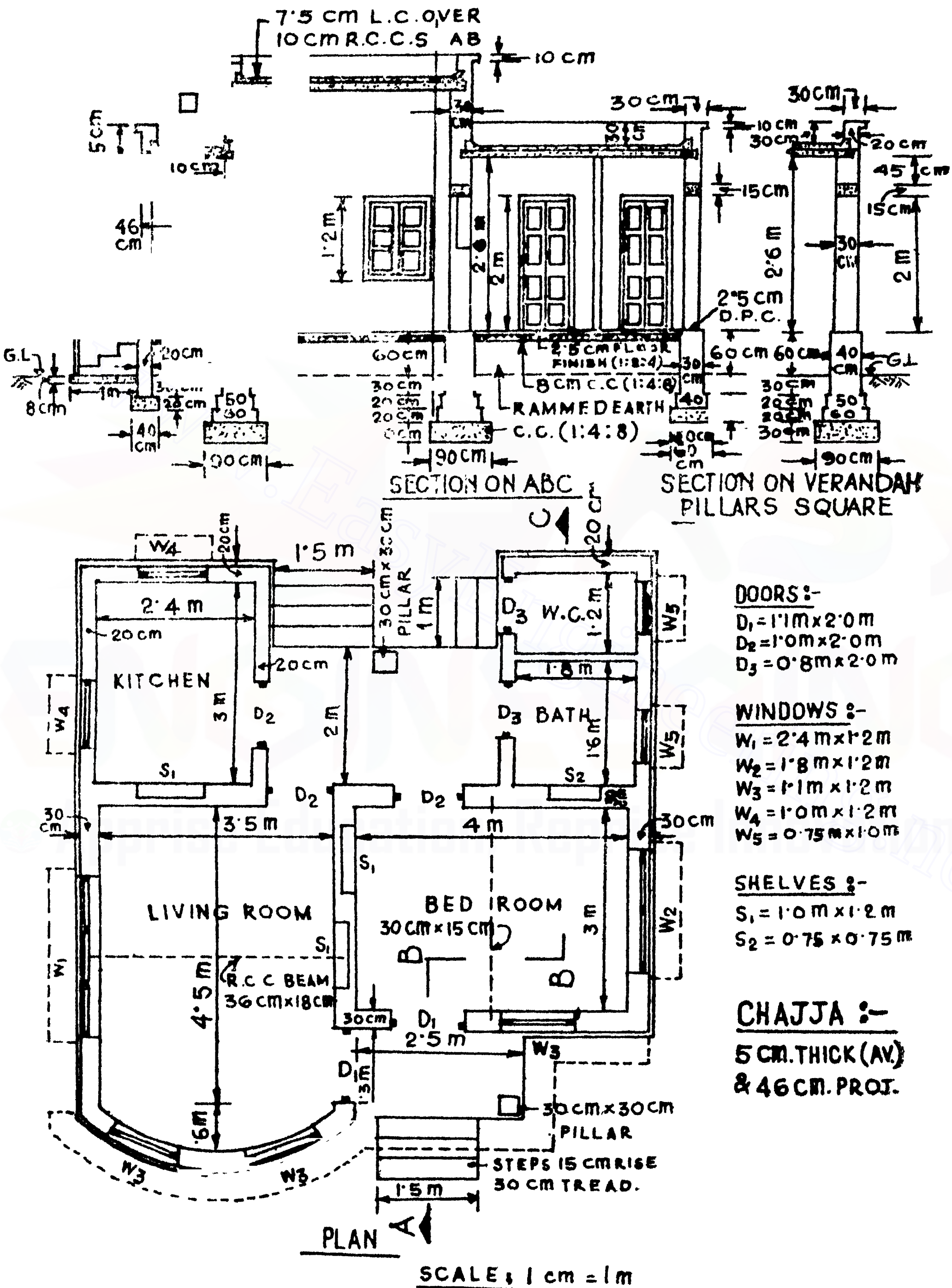

7·5 cm L.C. OVER 10 cm R.C.C.S AB
10 cm
30 cm
20 cm
45 cm
15 cm
2·6 m
2 m
1·2 m
2·5 cm D.P.C.
2·5 cm FLOOR FINISH (1:2:4)
8 cm C.C (1:4:8)
RAMMED EARTH
C.C. (1:4:8)
60 cm
90 cm
100 cm
46 cm
G.L
SECTION ON ABC
SECTION ON VERANDAH PILLARS SQUARE
KITCHEN
W.C.
BATH
LIVING ROOM
BED ROOM
30 cm x 30 cm PILLAR
R.C.C BEAM 36 cm x 18 cm
STEPS 15 cm RISE 30 cm TREAD.
DOORS :-
D1 = 1·1 m x 2·0 m
D2 = 1·0 m x 2·0 m
D3 = 0·8 m x 2·0 m
WINDOWS :-
W1 = 2·4 m x 1·2 m
W2 = 1·8 m x 1·2 m
W3 = 1·1 m x 1·2 m
W4 = 1·0 m x 1·2 m
W5 = 0·75 m x 1·0 m
SHELVES :-
S1 = 1·0 m x 1·2 m
S2 = 0·75 x 0·75 m
CHAJJA :-
5 cm. THICK (AV.)
& 46 cm. PROJ.
PLAN
SCALE : 1 cm = 1 m

FIG. 3-5

3-5. Building—5. Estimate the quantities of the following items of works from the building shown in the fig. 3-5.

(1) Earthwork in excavation, (2) Lime concrete in foundation, (3) First class brick-work in cement mortar (1:4) in foundation and plinth, (4) First class brickwork in cement mortar (1:6) in superstructure walls, (5) 2·5 cm thick D.P.C. and (6) Cement concrete with stone chips (1:2:4) for R.C.C. works.

(A) Centre line Method :—

Centre line length.—

(a) For 30cm walls at superstructure—

Living Room—Curved front

Rise upto centre of wall = ·6 + ·15 = ·75m

Span from centre to centre of walls 2a = 3·8m

$\therefore$ Length of half chord, $b = \sqrt{(1\cdot9)^2 + (\cdot75)^2} = 2\cdot04$

$\therefore$ Length of mean arc $= \dfrac{8b - 2a}{3} = \dfrac{8 \times 2\cdot04 - 3\cdot8}{3} = 4\cdot17$

$\therefore$ Centre line for living room—
$4\cdot17 + 2(4\cdot5 + \cdot15) + (3\cdot5 + \cdot30) = 17\cdot27$ m

Bed room $= 2(4 + \cdot30) + (3 + \cdot30) = 11\cdot90$m

Total length of centre line = 29·17m

Number of joining places = 2 Nos.

(b) For 20cm walls at superstructure

Kitchen $= 2(3 + \cdot15 + \cdot10) + (2\cdot4 + \cdot20) = 9\cdot10$m

Bath and W. C. Combined—

$= 2(1\cdot8 + \cdot10 + 1\cdot2) + \cdot15 + \cdot10 + (1\cdot8 + \cdot20) = 8\cdot70$m

Total length of centre line = 17·80m

Number of joining places = 4 Nos. (*with main*)

(c) For verandah dwarf walls—

Front verandah :—

Front side $= (2\cdot5 + \frac{\cdot30}{2} - \cdot05 - \frac{\cdot30}{2}) = 2\cdot45$m

Side $= (1\cdot3 + \frac{\cdot30}{2} - \cdot05 - \frac{\cdot30}{2}) = 1\cdot25$m

Back verandah—

Total length $= (\cdot30 \times 3 + 3\cdot5 + 4) - (\cdot20 \times 4 + 2\cdot4 + 1\cdot8) = 3\cdot4$m

$\because$ Centre line length $= 2 \times \frac{1}{2}(3\cdot4 + \cdot20) = 3\cdot6$m

Total length of centre line = 7·30m

Number of joining places = 4 Nos. (*2 Nos. with main, 2 Nos. with 20cm walls*)

Deduction for the length covered by two pillars @ 90cm shall be made. Pillar shall be measured separately.

(B) Long and Short wall method—

Centre to centre distance for—

Living Room—

Curved front = 4·17m (as calculated in method A)

Sides as long walls = 4·5 + ·15 = 4·65m

Back as short wall = 3·5 + ·30 = 3·80m

Bed Room—

Right hand side as long wall = 3 + ·30 = 3·30m

Back & front as short walls = 4 + ·30 = 4·30m

Kitchen

Back and front as long-short walls = 3 + ·15 + ·10 = 3·25m

Side as short wall = 2·4 + ·20 = 2·60m

Bath and W. C. combined—

Front and back as long-short walls = $(1\cdot8 + \cdot10 + 1\cdot2) + \cdot15 + \cdot10 = 3\cdot35$m

Side (of W. C. only) as short wall = 1·8 + ·20 = 2·0m

Front verandah (for dwarf wall)—

Front as short wall $= (2\cdot5 + \frac{\cdot30}{2} - \cdot05 - \frac{\cdot30}{2}) = 2\cdot45$m

Side as short wall $= (1\cdot3 + \frac{\cdot30}{2} - \cdot05 - \frac{\cdot30}{2}) = 1\cdot25$m

Back verandah for dwarf wall—

Total length $= (\cdot30 \times 3 + 3\cdot5 + 4) - (\cdot20 \times 4 + 2\cdot4 + 1\cdot8) = 3\cdot4$m

$\therefore$ Centre distance from pillar to wall as short walls $= \frac{1}{2}(3\cdot4 + \cdot20) = 1\cdot8$m

Item No.	Description	No.	L. m	B m	H. m	Qu.	Total	Explanatory notes.
1.	**Earthwork in excavation**							
	(A) By centre line method—							
	(a) 30 cm walls at superstructure		28·27	·90	1·00	25·44		28·27=29·17
	(b) 20 cm walls „ „		16·00	·60	·70	6·72		—2×·90/2
	(c) Verandah dwarf walls ..		4·00	·40	·50	0·80		16·00=17·80—4
	(d) Verandah pillars ..		·90	·90	1·00	1·62		×·90/2
	(e) Steps front and back ..		1·70	·90	·08	0·24		4·00=7·30—2×
	(f) Steps front of W. C. ..		1·00	·25	·08	0·02		90/2—2×·60/2
							34·84 cu m	—2×·90
	(B) By Long & Short wall method							(for pillars)
	(a) 30cm walls at superstructure							5·10=4·65+·90/2
	Living Room –							2·90=3·80—2×
	Curved front ...	1	4·17	·90	1·00			·90/2
	Sides as long walls ...	2	5·10	·90	1·00			
	Back as short wall ...	1	2·90	·90	1·00			
								4·20=3·30+2
								×·30/2
	Bed room—							*T. L. is same as*
	Right side as long wall ...	1	4·20	·90	1·00			*(A). a.*
	Back & front as short walls	2	3·40	·90	1·00			
		T.L	28·27	·90	1·00	25·44		
	(b) 20cm walls at superstructure							·10=3·35+·60/2
	Kitchen—							—·90/2
	Back & front as long-short		3·10	·60	·70			2·00=2·60—2×
	Side as short wall ...		2·00	·60	·70			·60/2
								3·20=3·35+
	Bath & W. C. combined—							·60/2—·90/2
	Front & back as long-short		3·20	·60	·70			*T.L. is same as*
	Side as short wall ...		1·40	·60	·70			*(A). b.*
		T.L.	16·00	·60	·70	6·72		
	(c) Verandah dwarf walls							1·55=2·45—2
	Front verandah—							×·90/2
	Front as short wall		1·55	·40	·50			·35=1·25—2
	Side as short wall		·35	·40	·50			× 90/2
	Back verandah –							
	From pillar to wall short	2	1·05	·40				*T.L. is same as*
		T.L.	4·00	·40	·50	0·80		*(A).c.*
	(d) Verandah pillars	2	·90	·90	1·00	1·62		
	(e) Steps front and back	2	1·70	·90	·08	0·24		
	„ „ front of W. C.	1	1·00	·25	·08	0·02		
							34·84 cu m	Total quantity is same by any method.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
2.	**Lime concrete in foundation**							
	(A) By centre line method							
	(a) 30cm walls at superstructure	1	28·27	·90	·30	7·63		$16{\cdot}60 = 17{\cdot}80 - 4 \times \frac{{\cdot}60}{2}$
	(b) 20cm walls at superstructure	1	16·60	·60	·20	1·99		(conc. joins with 60cm of main wall)
	(c) Verandah dwarf walls ...	1	5·40	·40	·20	0·43		
	(d) Verandah pillars ...	2	·90	·90	·30	0·49		
	(e) Steps front and back ...	2	1·70	1·00	·08	0·27		
	,, front of W. C. ...	1	1·10	·70	·08	0·06		
							10·87 cu m	
	(B) By Long & Short wall method							
	(a) 30cm walls at superstructure							
	Living Room—							
	Curved front ...	1	4·17	·90	·30			
	Sides as long walls ...	2	5·10	·90	·30			
	Back as short wall ...	1	2·90	·90	·30			
	Bed Room—							
	Right side as long wall ...	1	4·20	·90	·30			
	Back & front as short walls	2	3·40	·90	·30			
		T.L	28·27	·90	·30	7·63		T.L. is same as (A). a.
	(b) 20cm walls at superstructure							
	Kitchen—							
	Back & front as long-short	2	3·25	·60	·20			$3{\cdot}25 = 3{\cdot}25 + \frac{{\cdot}60}{2} - \frac{{\cdot}60}{2}$
	Side as short wall ...	1	2·00	·60	·20			
	Bath & W.C. combined—							
	Front & back as long-short	2	3·35	·60	·20			$3{\cdot}35 = 3{\cdot}35 + \frac{{\cdot}60}{2} - \frac{{\cdot}60}{2}$
	Side as short wall ...	1	1·40	·60	·20			
		T.L.	16·60	·60	·20	1·99		T.L. is same as (A). b
	(c) Verandah dwarf walls							
	Front Verandah—							$1{\cdot}95 = 2{\cdot}45 - 2 \times \frac{{\cdot}60}{2}$
	Front as short walls ...	1	1·95	·40	·20			$\cdot75 = 1{\cdot}25 - 2 \times \frac{{\cdot}50}{2}$
	Side as short wall ...	1	·75	·40	·20			
	Back verandah—							
	From pillar to walls short	2	1·35	·40	·20			
		T.L.	5·40	·40	·20	0·43		T.L. is same as (A). c.
	(d) Verandah pillars ...	2	·90	·90	·30	0·49		
	(e) Steps front and back ...	2	1·70	1·00	·08	0·27		
	,, front of W. C. ...	1	1·10	·70	·08	0·06	10·87 cu m	Total quantity is same by any method.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
3.	**Brickwork in cement mortar 1:4) in foundation and plinth**							
	A) By centre line method							
	a) 30cm walls at superstructure							
	1st footing 60cm ..		28·57	·60	·20	3·43		28·57=29·17–2×·60/2
	2nd footing 50cm ..		28·67	·50	·20	2·27		28·67=29·17–2×·50/2
	Plinth wall 40 cm ..		28·77	·40	·90	10·35		
	b) 20cm walls at superstructure							
	1st footing 40cm ..		16·80	·40	·20	1·34		
	Plinth wall 20cm ...		17·00	·30	·20	4·59		16·80=17·80—4×·50/2
	c) Verandah dwarf walls ...		5·80	·20	·90	1·04		40cm brick joints with 50cm of main wall
	(d) Verandah pillars—							
	1st footing 60 cm ..		·60	·60	·20	0·14		5·80=7·30—2×·40/2—2×·30/2—2×·40 (pillar)
	2nd footing 50 cm ...		·50	·50	·20	0·10		
	Plinth wall 40 cm ..		·40	·40	·90	0·29		
	(e) Steps front and back ..		1·50	(·30+ 90)/2	45	0·81		
	,, front of W.C. ..		1·0	(·30+ 60)/2	·40	0·18		
							24·10 cu m	
	(B) By long & short wall method—							
	(a) 30cm walls at superstructure							
	Living Room –							
	Curved front							
	1st footing 60 cm ..		4·17	·60	·20	0·50		
	2nd footing 50 cm ..		4·17	·50	·20	0·42		
	Plinth wall 40 cm ..		4·17	·40	·90	1·50		
	Sides as long walls –							
	1st footing 60 cm ..		4·95	·60	·20	1·19		4·95=4·65+·60/2
	2nd footing 50 cm ..		4·90	·50	·20	0·98		4·90=4·65+50/2
	Plinth wall 40 cm ..		4·85	·40	·90	3·49		
	Back as short wall—							
	1st footing 60 cm ..		3·20	·60	·20	0·38		3·20=3·80—2×60/2
	2nd footing 50 cm ..		3·30	·50	·20	0·33		
	Plinth wall 40 cm ..		3·40	·40	·90	1·22		
	Bed Room—							
	Right side as long wall							
	1st footing 60 cm ..		3·90	·60	·20	0·47		3·90=3·30+2×·60/2
	2nd footing 50 cm ..		3·80	·50	·20	0·38		
	Plinth wall 40 cm ..		3·70	·40	·90	1·33		
	Back & front as short wall							
	1st footing 60 cm ..	2	3·70	·60	·20	0·89		3·70=4·30—2×·60/2
	2nd footing 50 cm ..	2	3·80	·50	·20	0·76		
	Plinth wall 40 cm ..	2	3·90	·40	·90	2·81		
	C.O.					16·65		

Building 5 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F. ...					16·65		
	(b) 20cm walls at superstructure							
	Kitchen—							
	Back & front as long-short							
	1st footing 40cm ...		3·20	·40	·20	0·51		
	Plinth wall 30cm ...		3·20	·30	·90	1·75		$3{\cdot}20=3{\cdot}25+\frac{{\cdot}40}{2}-\frac{{\cdot}50}{2}$
	Side as short wall							
	1st footing 40cm ...		2·20	·40	·20	0·18		
	Plinth wall 30cm ..		2·30	·30	·90	0·62		$2{\cdot}20=2{\cdot}60-2\times\frac{{\cdot}40}{2}$
	Bath & W. C. combined							
	Back & front as long-short							
	1st footing 40cm ..	2	3·30	·40	·20	0·53		
	Plinth wall 30 cm..	2	3·30	·30	·90	1·78		$3{\cdot}30=3{\cdot}35+\frac{{\cdot}40}{2}-\frac{{\cdot}50}{2}$
	Side as short wall							
	1st footing 40 cm...	2	1·60	·40	·20	0·13		$1{\cdot}60=2{\cdot}0-2\times\frac{{\cdot}40}{2}$
	Plinth wall 30 cm...	2	1·70	·30	·90	0·46		
	(c) Verandah dwarf walls							
	Front verandah							
	Front plinth as short		2·05	·20	·90	0·37		2·05 = 2·45 — 2 × ·40/2
	Side „ „		·85	·20	·90	0·15		·85 = 1·25 — 2 × ·40/2
	Back verandah							1·45 = 1·8 — ·40/2 — ·30/2
	From pillar to walls short		1·45	·20	·90	0·52		
	(d) Verandah pillars ..		same	as in	(A)d =	0·53		
	(e) Steps ..		same	as in	(A)c =	0·99		
							24·10 cu m	
	Brickwork in cement mortar (1:6) in superstructure walls—							
	(i) *(A) By Centre line method*							
	(a) 30 cm walls ...		28·87	·30	3·60	31·18		28·87 = 29·17 — 2 × ·30/2
	(b) 20 cm walls ..		17·20	·20	3·60	8·94		17·20 = 17·80 — 4 × ·30/2
	(c) Verandah pillars ...		·30	·30	2·00	0·36		
	(d) Wall above lintel front ver	1	3·45	·30	·45	0·47		
	„ „ back veran.	1	3·40	·30	·45	0·46		
						41·41		*For parapet see next sub-item (ii) and deductions for openings are after (ii)*
	(i) *(B) By Long & Short method*							
	(a) 30cm walls—							
	Living room							
	Curved front ..		4·17	·30	3·60			
	Sides as long walls ...		4·80	·30	3·60			
	Back as short wall ..		3·50	·30	3·60			
	Bed room							
	Right side as long wall		3·60	·30	3·60			*T.L. is same as in (4A)-a*
	Back & front as short		4·00	·30	3·60			
			28·87	·30	3·60			

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F. ..					41·41		
	(b) 20 cm walls— Kitchen							
	Back & front as long-short		3·20	·20	2·60			3·20=3·25+ 20/2 —·30/2
	Side as short wall ..		2·40	·20	2·60			
	Bath and W C. combined Front & back as long-short		3·30	·20	2·60			3·30=3·35+·20/2 —·30/2
	Side as short wall ...		1·80	·20	2·60			T.L. is same as (4A) b.
		T. L	17·20	·20	2·60			
	(c) Verandah pillars ..		·30	·30	2·0			
	(d) Wall above lintel front veran.		3·45	·30	·45			
	,, ,, ,, back veran.		3·40	·30	·45			
	(ii) Brickwork in parapet by any method							
	(a) Over main rooms—							For 4·33 :—
	Entire back(out to out)..		8·30	·20	·48			Span=3·9 Rise=·8
	Front curved ..		4·33	·20	·48			
	Front bed room (out to out) ..		4·30	·20	·48			4·60=4·5+·10
	Side (left) on living ..		4·60	·20	·48			
	Side (right) on living ..		1·20	·20	·48			3·20=3·0+·20
	Side (right) on bed ..		3·20	·20	·48			
	(b) Over low roof –							
	Kitchen ..		3·20	·20	·48			
	—do— ..		2·40	·20	·48			
	—do— ..		1·25	·20	·48			
	Back verandah ..		3·40	·20	·48			1·25= 3·20—(2·0+·05)
	Bath and W.C. ..		3·30	·20	·48			
			2·00	·20	·48			
	Front verandah ..		2·45	·20	·48			
	,, ...		1·05	·20	·48			
			44·72	·20	·48	4·29		
	Deductions for—							
	Doors D₁ ..		1·1	·30	2·0	1·32	(-ve)	
	,, in 30 cm D₂ ...		1·0	·30	2·0	1·20		
	,, (in 20 cm) D₂ ...		1·0	·20	2·0	0·40		
	,, ... D₃ ...		·8	·20	2·0	0·64		
	Windows... W₁...		2·4	·30	1·2	0·86		
	,, ... W₂...		1·8	·30	1·2	0·65		
	,, ... W₃...		1·1	·30	1·2	0·19		
	,, ... W₄...		1·0	·30	1·2	0·48		
	,, ... W₅...		·75	·20	1·0	0·30		
	Shelves ... S₁...		1·0	·20	1·2	0·48		
	,, ... S₂...		·75	·20	·75	0·11		
	C.O.					38·07		

Building 5 continued

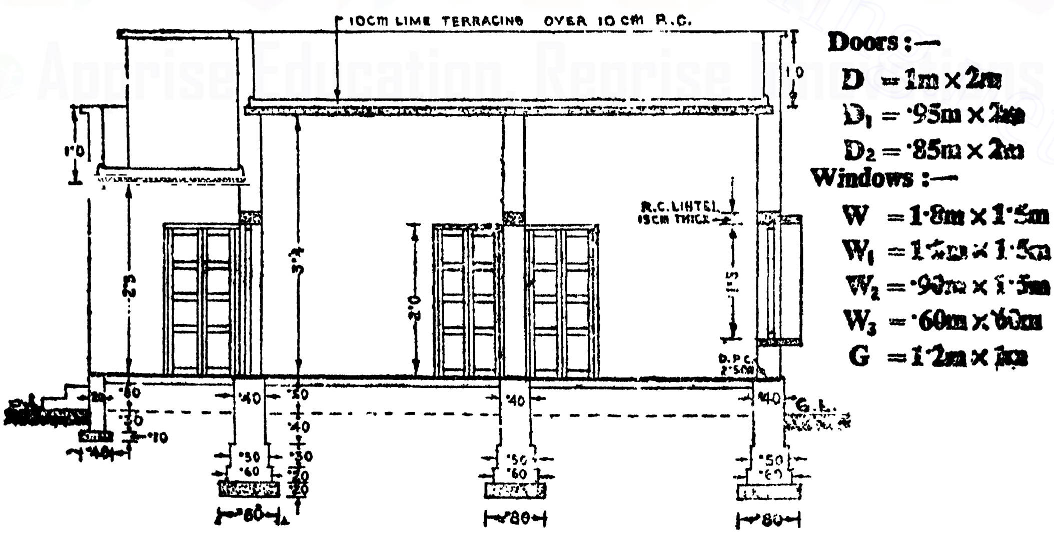
Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F ...					38·07		
	Lintels in 30cm walls ...	1	28·67	·30	·15	1·29	(-ve)	28·67 is the total
	„ „ 20cm walls ...	1	17·20	·20	·15	0·52	„	length by L and S
	„ „ verandah front	1	3·60	·30	·15	0·16	„	wall method.
	„ „ „ back	1	3·40	·30	·15	0·15	„	
							35·95 cu m	
5.	**2·5 cm thick D.P.C.**							
	(a) For 30cm walls ...	1	28·67	·30	—	8·60		
	(b) For 20cm walls ...	1	17·20	·20	—	3·44		
	(c) Pillars ...	2	·30	·30	—	0·18		
	Deduction for—							
	Door opening D_1 ...	2	1·1	·30	—	0·66	(-ve)	
	„ „ D_2 (in 30cm)	2	1·0	·30	—	0·60	„	
	„ „ D_2 (in 20cm)	1	1·0	·20	—	0·20	„	
	„ „ D_3 ...	2	·8	·20	—	0·32	„	
6.	**Cement concrete for R.C.C. works** (1:2:4)						10·44 sq m	
	(a) Beams for—							
	Living room ...	1	4·10	·18	·26	0·19		30cm bearing.
	Bed room ...	1	3·60	·15	·20	0·11		Area of beams is for web only.
	(b) Roof—							
	Living room—							
	Segmental portion ...	1	$\frac{2}{3}$ × 3·7	× 7	·10	0·17		Area of segment
	Rectangular portion	1	4·6	3·7	·10	1·70		=2/3 span × h (apx.)
	Bed room	1	4·3	3·2	·10	1·38		4·3=4+·10+·20
	Kitchen ...	1	3·2	2·6	·10	0·83		
	Bath & W.C. combd.	1	3·3	2·0	·10	0·66		
	Verandah front ...	1	2·2	1·0	·10	0·22		2·2=2·5—·1—·2
	„ back ...	1	3·8	1·7	·10	0·65		3·8=3·4+2×·20
	(c) Lintel on—							
	30cm walls ...	1	28·67	·30	·15	1·29		
	20cm walls ...	1	17·20	·30	·15	0·52		
	Verandah front ...	1	3·6	·30	·15	0·16		
	„ back ...	1	3·4	·30	·15	0·15		span=3·5+·60=4·1
								1/2 span=2·05
	(d) Chajja for—							Rise upto centre =·6+·23=·83
	Curved front ...	1	4·53	·46	·05	0·10		
	Front or bed room ...	1	5·55	·46	·05	0·13		$b=\sqrt{(2·05)^2+(·83)^2}$ =2·21
	(e) Sunshade over—		1·30					
	Window W_1 ...	1	2·60	·46	·05	0·06		Mean arc=
	„ W_2 ...	1	2·00	·46	·05	0·05		$\frac{8\times2·21—4·1}{3}$ =4·53
	„ W_3 ...	3	1·30	·46	·05	0·09		
	„ W_4 ...	2	1·20	·46	·05	0·05		
	„ W_5 ...	2	·95	·46	·05	0·04		
							8·55 cu m	

ABSTRACT OF QUANTITIES OF BUILDING—5

Sl. No.	Discription of Item	Quantity
1.	Earthwork in excavation	34·84 cu m
2.	Lime concrete in foundation	10·87 cu m
3.	First class brickwork in cement mortar (1:4) in foundation and plinth	24·10 cu m
4.	First class brickwork in cement mortar (1:6) in superstructure walls	35·95 cu m
5.	2·5cm thick D.P C	10·44 sq m
6.	Cement concrete with stone chips for R.C.C. works (1:2:4)	8 55 cu m

3-6. Building—6. Estimate the following quantities from the drawing shown in the figures 3-6 and 3-6A.

(1) Earthowrk in excavation in foundation, (2) Lime concrete in foundation, (3) First class brickwork in cement mortar (1.4) in f undation and plinth, (4) 2·5cm thick Damp proof course, (5) First class brickwork in cement mortar (1:6) in supersructure. (steps may be neglected).



SECTION ON AB

FIG. 3-6

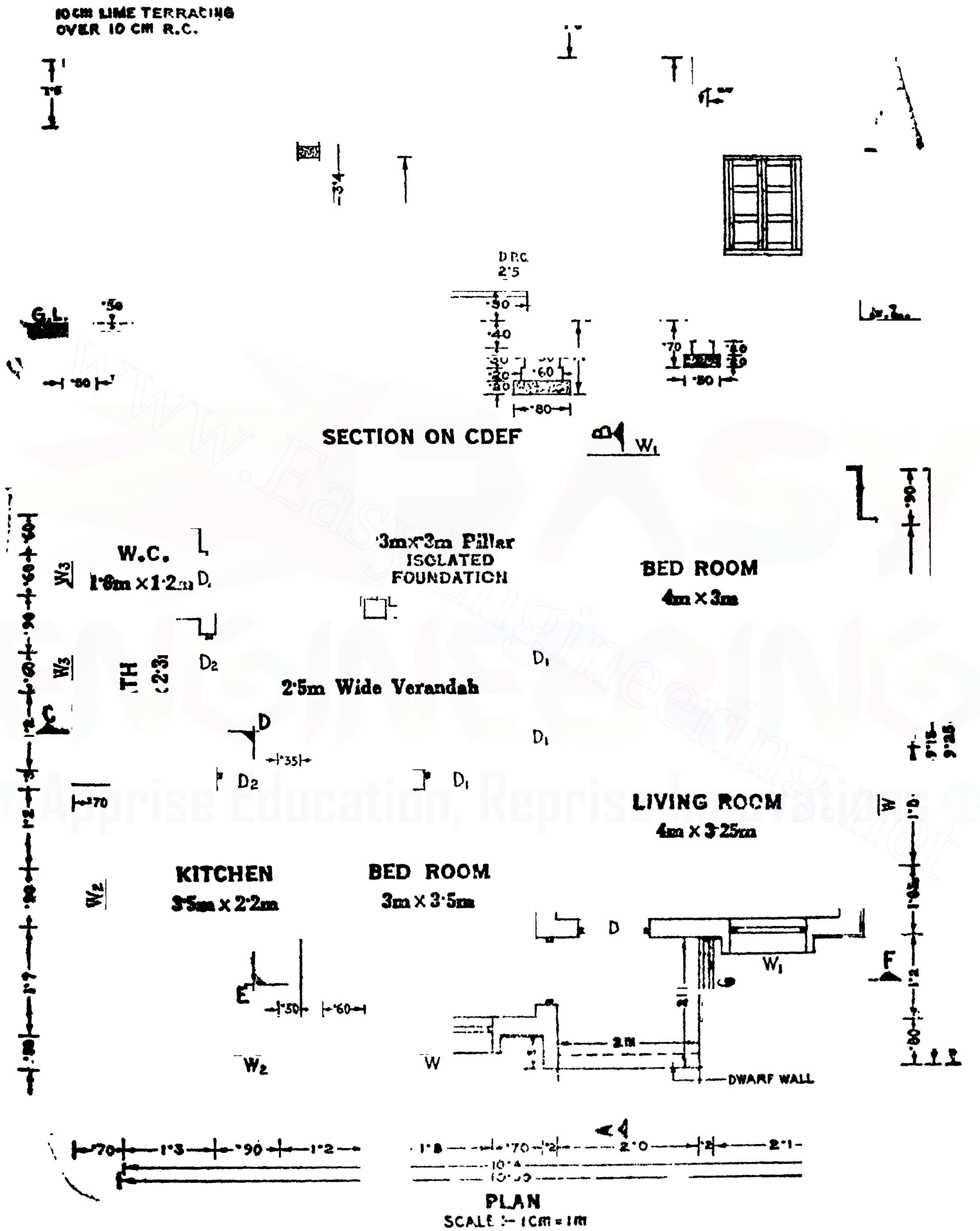

10 CM LIME TERRACING
OVER 10 CM R.C.
G.L.
D.P.C.
2·5
SECTION ON CDEF
W.C.
1·6m × 1·2m
3m×3m Pillar
ISOLATED
FOUNDATION
BED ROOM
4m × 3m
2·5m Wide Verandah
LIVING ROOM
4m × 3·25m
KITCHEN
3·5m × 2·2m
BED ROOM
3m × 3·5m
DWARF WALL
PLAN
SCALE :- 1CM = 1M

FIG. 3-6A

(A) Centre line Method :—

Centre line length =

(a) For 30cm walls at superstructure :—

Outer walls (of rooms and kitchen)
$=2[(10{\cdot}40-{\cdot}30)+(9{\cdot}15-{\cdot}50-{\cdot}30)]=36{\cdot}90$

Partition walls between—
Bed & Kitchen $=(3{\cdot}5+{\cdot}30)=3{\cdot}80$. Joints=2
Rooms $=(4{\cdot}0+{\cdot}30)$ $=4{\cdot}30$. Joints=2
Bed and living room
$=[(3{\cdot}5-1{\cdot}2)+\frac{{\cdot}30}{2}-\frac{{\cdot}30}{2}$ $=2{\cdot}30$ Joints=2

Total=47·30m, Joints=6nos

(b) For 20 cm walls at superstructure :—
Bath and W.C.

Back $=(2{\cdot}3+{\cdot}20+1{\cdot}2)+{\cdot}20$ $=3{\cdot}90$m
Front $=[(2{\cdot}3+{\cdot}20+1{\cdot}2)+\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2}]$ $=3{\cdot}95$m
Joints=1 with main
Side of W.C. $=2(1{\cdot}6+{\cdot}20)$ $=3{\cdot}60$ m
Joints=2 with 20 cm
Portion of bath side $=({\cdot}70-\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2})$ $={\cdot}75$m
Joint=1 with main

Front Verandah

Right side $=(2+\frac{{\cdot}30}{2})$ $=2{\cdot}15$m
Joints I no. with main+footing offset for all round footing

Thus, left side portion $({\cdot}50+\frac{{\cdot}30}{2})=0{\cdot}65$m
Total $=15{\cdot}00$m

Total numder of joints with main wall=4 and with 20 cm wall 2nos+2nos footing offset of 20 cm wall.

(c) For Verandah dwarf walls :—
Front verandah front $=(2{\cdot}0+{\cdot}20)=2{\cdot}20$m
Joints 2nos with20cm

Back verandah as if there is no pillar first Verandah length
$=(10{\cdot}40+{\cdot}70)-(4+2\times{\cdot}30+1{\cdot}6+2\times{\cdot}20)$
$=4{\cdot}50$m

Centre line length $=(4{\cdot}50+{\cdot}15+{\cdot}10)=4{\cdot}75$m
Number of joint=1 no. with main and I with 20 cm and less the length covered by a pilla foundation

Total=6·95m

Total nos. of joints=I with main 3 with 20cm and length covered by a pillar foundation.

(B) Long and Short Wall Method :—

Centre to centre distance for—

Living and bed rooms (attached) :—

Long walls

$=(3{\cdot}25+{\cdot}30+3{\cdot}00)+2\times\frac{{\cdot}30}{2}=6{\cdot}85$m

Short walls (3 nos.) $=4{\cdot}0+{\cdot}30$ $=4{\cdot}30$m

Kitchen and bed room (attached) :—

Back and front as long-short walls
$=(3{\cdot}0+2{\cdot}2+{\cdot}30)+2\times\frac{{\cdot}30}{2}=5{\cdot}8$m

Common and kitchen side (2 nos.) as short
$=(3{\cdot}5+{\cdot}30)=3{\cdot}8$m

Bed room portion with front verandah as long-short $=(2-{\cdot}50)+\frac{{\cdot}30}{2}-\frac{{\cdot}30}{2}=1{\cdot}50$m

Bath and W. C. :—

Back as long $=(2{\cdot}3+{\cdot}2+1{\cdot}2)+2\times\frac{{\cdot}20}{2}=3{\cdot}9$m
Front as long-short wall
$=(2{\cdot}3+{\cdot}2+1{\cdot}2)+\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2}=3{\cdot}95$m
Sides of W. C. as short (2 nos.)
$=1{\cdot}6+{\cdot}20$ $=1{\cdot}80$m

Portion of bath side as short

$={\cdot}70-\frac{{\cdot}20}{2}+\frac{{\cdot}30}{2}=0{\cdot}75$m

Front verandah :—

Right side as long-short
$=2{\cdot}0+\frac{{\cdot}30}{2}-\frac{{\cdot}20}{2}=2{\cdot}05$m

Left side portion as long-short
$={\cdot}50+\frac{{\cdot}30}{2}-\frac{{\cdot}20}{2}=0{\cdot}55$m

Front dwarf wall as short
$=2+{\cdot}20$ $=2{\cdot}20$m

Back verandah length :—

$=(10{\cdot}40+{\cdot}70)-(4+2\times{\cdot}30+1{\cdot}6+2\times{\cdot}20.)$
$=4{\cdot}50$m

Centre to Centre length as if there is no pillar $=4{\cdot}5+{\cdot}15+{\cdot}10=4{\cdot}75$m less pillar footing

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Farthwork in excavation for** foundation trench							
	(A) By centre line method—							
	(a) 30cm walls at superst. ...		44·90	80	1·10	39·51		44·90=47·30—6× ·80/2
	(b) 20cm walls at superst. ...		13·20	50	·70	4·62		13·20=15·00—4× ·80/2—2×·50/2+ 2×·15
	(c) Verandah dwarf walls ...		5·00	40	·30	0·50		5·00=6·95—·80/2 —3×·50/2—·80
	(d) Back verandah sq. pillar		·80	80	1·10	0·70	45·43 cu m	
	(B) By Long and short wall method							
	(a) 30cm walls at superst.							
	Living & bed (attached)							
	Long walls		7·65	80	1·10			7·65=6·85+2× ·80/2
	Short walls		3·50	80	1·10			
	Kitchen & bed (attached)							
	Back and front as Long-short		5·80	·80	1·10			5·80=5·80+·80/2 —·80/2
	Common and kitchen side Short walls		3·00	·80	1·10			
	Bed room portion with front verandah as Long-short		1·50	·80	1·10			
		T.L	44·90	·80	1·10	39·51		*Note :—T.L. is same as in method (A).(a)*
	(b) 20cm walls at superst.							
	Bath and W.C.—							
	Back as Long wall		4·40	·50	·70			3·80=3·95+·50/2 —·80/2
	Front as Long-short wall		3·80	·50	·70			0·10=·75—·50/2— ·80/2
	Sides of W.C. as short		1·30	·50	·70			
	Portion of bath side as short		0·10	·50	·70			
	Front Verandah—							
	Right side as Long-short		1·90	·50	·70			
	Left side portion as Long-short		0·40	·50	·70			
		T.L.	13·20	·50	·70	4·62		*Note :—T.L. is same as in method (A). (b).*
	(c) Verandah dwarf walls							
	Front Verandah—							
	Front as Short wall...		1·70	·40	·30			
	Back Verandah—	1	3·30	·40	·30			·30=4·75—·80/2— ·50/2—·80
			5·00	·40	·30	0·50		*Note :—T.L. is same as in method (A).(c).*
	(d) Back verandah sq. pillar		·80	·80	1·10	0·70	45·43 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
2.	**Lime concrete in foundation**							
	(A) By centre line Method—							
	(a) 30cm walls at superst.	1	44·90	·80	·20	7·18		13·80=15·00—4×·50/2—2×·50/2+2×·15 (offset)
	(b) 20cm walls at superst.	1	13·80	·50	·20	1·38		5·90=6·95—·40/2
	(c) Verandah dwarf walls	1	5·90	·40	·10	0·24		·3×·30/2—·40
	(d) Back verandah pillar	1	·80	·80	·20	0·13		
							8·93 cu m	
	(B) By long and short wall Method							
	(a) 30cm walls at superst.							
	Living and bed (attached)							
	Long walls ...	2	7·65	·80	·20			
	Short walls ...	3	3·50	·80	·20			
	Kitchen and bed (attached)							
	Back and front as long-short	2	5·80	·80	·20			
	Common and kitchen side							
	Short walls ...	2	3·00	·80	·20			
	Bed room portion with front verandah as Long-short ...	1	1·50	·80	·20			
		T.L.	44·90	·80	·20	7·18		
	(b) 20cm walls at superst.							
	Bath and W. C.—							3·95=3·95+·50/2 — 60/2
	Back as Long wall ...	1	4·40	·50	·20			concrete meets wih ·50 layer of·30wall
	Front as Long short wall ...	1	3·95	·50	·20			
	Side of W. C. as Short ...	2	1·30	·50	·20			0·25=·75—·50/2
	Portion of bath side as Short	1	0·25	·5	·20			—·50/2
	Front verandah—							
	Right side as Long-short ...	1	2·05	·50	·20			*Note—T.L is same (as in method (A), (b).*
	Left side portion Long-short	1	0·55	·50	·20			
		T.L.	13·80	·50	·20	1·38		
	(c) Verandah dwarf wall—							1·90=2·20—2×·30/2
	Front verandah—							concrete meets with ·30and·40 layer of ·20 & ·30 walls respectively
	Front as short ...	1	1·90	·40	·10			
	Back Verandah—	1	4·00	·40	·10			4·00=4 75—·40/2 —·30/2—·40
		T.L.	5·90	·40	·10	0·24		
	(d) Back verandah pillar	1	·80	·80	·20	0·13		
							8·93 cu m	*Note :—T.L. is same as in method (A).(c).*

Building 5 continued

Item No.	Description	No.	L m	B m	H. m	Qu.	Total	Explanatory notes
3.	**1st class brickwork in cement mortar in foundation and plinth**							
	(A) By centre line method—							
	a) 30cm walls at superstructure							
	1st footing 60 cm ...	1	45·50	·60	·20	5·46		45·50=47·30—6×60/2
	2nd footing 50cm ...	1	45·80	·50	·30	6·87		45 80=47·30—6×50/2
	plinth wall 40cm ...	1	46·10	·40	·90	16·60		
	(b)20cm walls at superstructure							
	1st footing 30cm (i) Bottom portion which meets with 50cm of main	1	13·80	·30	·10	0·41		Same length as con.c work because conc and bottom layer of 30cm brick work meet with the same0 footing 14·00=15·0—4×·40/2+2×·052
	(ii) Top portion which meets with 40cm of main ...	1	14·00	·30	·10	0·42		
	plinth wall 20cm ...	1	14·00	·20	·80	2·24		
	(c) Verandah dwarf walls ...	1	6·05	·20	·80	0 94		6·05=6·95—·40/2—ε×·20/2—·40
	(d) Back verandah pillar—							
	1st footing 60cm ...	1	·60	·60	·20	0·07		
	2nd footing 50cm ...	1	·50	·50	·30	0·08		
	plinth wall 40cm ...	1	·40	·40	·90	0·14	33·23 cu m	
	(B) By long & short wall method—							
	a) 30cm wall at superstructure							
	Living & bed (attached)							
	Long walls 1st footing 60cm	2	7·45	·60	·20	1·79		7·45=6·85 +2×·60/2
	,, ,, 2nd footing 50cm	2	7·35	·50	30	2·21		
	,, ,, plinth wall 40cm	2	7·25	·40	·90	5·22		
	Short walls 1st footing 60cm	3	3·70	·60	·20	1·33		3·70=4·30—2×·60/2
	,, ,, 2nd footing 50cm	3	·80	·50	·30	1·71		
	,, ,, plinth wall 40cm	3	3·90	·40	·90	4·21		
	Kitchen & bed (attached)							
	Back & front as long-short							
	1st footing 60cm	2	5·80	60	·20	1·39		5·80=5·80+·60/2—·60/2
	2nd footing 50cm	2	5·80	·50	·30	1·7		
	plinth wall 40cm	2	5·80	·40	·90	4·17		
	Common and Kitchen side shor							
	1st footing 60cm	2	3·20	·60	·20	0·77		3·20=3·80—2×·60/2.
	2nd footing 50cm	2	3·30	·50	·30	0·99		
	plinth wall 40cm	2	3·40	·40	90	2·45		
	C.O.					27·98		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.					27·98		
	Bed room portion with front verandah as long-short							
	1st footing 60cm		1·50	·60	·20	0·18		1·50=1·50+·60/2—·60/2
	2nd footing 50cm		1·50	·50	·30	0·23		Total length of 60 cm layer after adding=45·50
	plinth wall 40cm		1·50	·40	·90	0·54		which is same as in method (A) (a)
	(b) 20 cm wall at superstructure Bath and W.C.—							
	Back as long wall							
	1st footing 30cm	...	4·20	·30	·20	0·25		
	plinth wall 20cm	...	4·10	·20	·80	0·65		
	Front as long-short wall							
	1st footing 30cm	...						
	(i) bottonm portion	...	3·85	·30	·10	0·12		3·85=3·95+·30/2—·50/2
	(ii) top portion	...	3·90	·30	·10	0·12		3·90=3·95+·30/2—·40/2
	plinth wall 20cm	...	3·85	·20	·80	0·62		3·85=3·95+·20/2—·40/2
	Sides of W.C. as short wall							
	1st footing 30cm	...	1·50	·30	·20	0·18		
	plinth wall 20cm	...	1·60	·20	·80	0·51		
	Portion of bath sides as shrot							
	1st footing 30cm							
	(i) bottom portion	...	·35	·30		0·01		·35=·75—·30/2—·50/2
	(ii) top portion	...	·40	·30		0·01		·40=·75—·30/2—·40/2
	plinth wall 20cm	...	·45	·20		0·07		·45=·75—·20/2—·40/2
	Front verandah—							
	Right side as long-short wall							
	1st footing 30cm							
	(i) bottom portion	...	1·95		·10	0·06		1·95=2·05+·30/2—·50/2
	(ii) top portion	..	2·00		·10	0·06		
	plinth wall 20cm	.	1·95		·80	0·31		
	Left side as long-short wall							
	1st footing 30cm							
	(i) bottom portion	.	·45	·30	·10	0·01		·45=·55+·30/2-·50/2
	(ii) top portion	..	·50	·30	·10	0·02		
	plinth wall 20cm	..	·45	·20	·80	0·07		
	(c) Verandah dwarf wall— Front verandah—							
	Front as short	..	2·00	·20	·80	0·32		2·00=2·20—2×20/2
	Back verandah	..	4·05		·80	0·32		4·05=4·75—·40/2—·30/2—·40
	(d) Back verandah pillar—							
	1st footing 60cm	..	·60	·60	·20	0·07		
	2nd footing 50cm	..	·50	·50	·30	0·08		
	plinth wall 40cm	..	·40	·40	·90	0·14		
							33·25	

Building 6 continued

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4.	**2·5 cm thick Damp proof course**							D.P.C. may be laid to the full width of the plinth or of the superstructure as specified in the drawing.
	(A) By centre line method—							
	(a) 30 cm walls at superst.	1	46·40	·30	—	13·92		
	(b) 20 cm walls at superst.	1	14·20	·20	—	2·84		
	(c) Back verandah pillar	1	·30	·30	—	·09		
						16·85		14·20=15·00—4×·30/2—2×20/2
	Deduction for—							
	Door openings D	2	1·00	·30	—	·60		
	D_1	3	·95	·30	—	·85		
	D_2	1	·85	·30	—	·25		
	D_3	2	·85	·20	—	·34		
						2·04	14·81 sq m	
	(A) By L and S wall method—							
	(a) 30 cm walls at superst.							
	Living & bed (attached)—							
	Long walls.	2	7·15	·30	—			7·15=6·85+2×·30/2
	Short walls	3	4·00	·30	—			4·00=4·30—2×·30/2
	Kitchen & bed (attached)—							
	Back & front as long-short	2	5·80	·30	—			
	Common & kitchen side short ...	2	3·50	·30	—			
	Bed room portion with front verandah long-short	1	1·50	·30	—			
		T.L.	46·40	·30		13·92		
	(b) 20 cm walls at superst.							3 90=3·95+20/2—·30/2
	Bath and W.C.—							
	Back as long wall ...	1	4·10	·20	—			·50=·75—·20/2—·30/2
	Front as long-short ...	1	3·90	·20	—			
	Side of W. C. as short	2	1·60	·20	—			2·00=2·05+·20/2—·30/2
	Portion of bath side short	1	·50	·20	—			
	Front verandah—							
	Right side as long-short	1	2·00	·20	—			
	Left side as long-short	1	·50	·20	—			
		T.L.	14·20	·20	—	2·84		
	(c) Back verandah pillar	1	·30	·30	—	·09		
						16·85		
	Deduction for— Door openings	same	as by	centre	line me	thod= 2·04	-ve 14·81	sq m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
5.	**Ist. class brickwork in superstructure in cement mortar**							
	(B) By centre line method							
	(a) 30 cm walls ...	1	46·40	·30	3·40	47·33		
	(b) 20 cm walls ...	1	14·20	·20	2·50	7·10		
	(c) Back verandah ... sq. pillar	1	·30	·30	2·50	·22		
	(d) Parapet walls—							
	(i) Over main walls of 30 cm							
	Back and front out to out	2	10·40	·20	1·00			
	Sides in to in ...	2	8·75	·20	1·00			
	(ii) Over 20 cm walls—							
	Front verandah front ...	1	2·00	·20	1·00			
	Right hand side ...	1	2·00	·20	1·00			2·00 is into in
	Left hand side ...	1	·50	·20	1·00			
	Back verandah ...	1	4·50	·20	1·00			
	Back of bath and W.C.	1	3·00	·20	1·00			3·00 = 1·2 + 1·6 + ·20
	Outside of W. C. ...	1	2·00	·20	1·00			2·00 = 1·6 + 2 × ·2(
	Front of W.C. ...	1	1·20	·20	1·00			
	Portion of bath of kitchen	1	·70	·20	1·00			
			54·20	·20	1·00	10·84		
	Deduction for—							
	Door openings, D	2	1·00	·30	2·00	1·20	(-ve)	
	D_1	3	·95	·30	2·00	1·71	,,	
	D_2	1	·85	·30	2·00	·51	,,	
	D_2	2	·85	·20	2·00	·68	,,	
	Window openings, W	3	1·80	·30	1·50	2·43	,,	
	W_1	2	1·20	·30	1·50	1·08	,,	
	W_2	2	·90	·30	1·50	·81	,,	
	W_3	2	·60	·20	·60	·14	,,	
	Grill openings, G	1	1·20	·30	1·00	·36	,,	
	Lintel in main wall (cont.)	1	46·40	·30	·15	2·09	,,	
	,, in 20 cm walls—							20 cm bearing considered
	Over doors, D_2	2	1·25	·20	·15	·08	,,	
	,, windows W_3	2	1·00	·20	·15	·06	,,	4·90 = 4·50 (as calculated first) + 2 × ·20
	,, grill opening, G	1	1·60	·20	·15	·05	,,	
	Verndah opening front	1	2·40	·20	·15	·07	,,	
	,, ,, back	1	4·90	·20	·15	·15	,,	
							54·07	cu m

Note—By L and S wall method the length for brickwork in superstructure is same as that worked out for D.P.C. only the height of wall shall be put in the height column.

ABSTRACT OF QUANTITES (BUILDING 6)

1.	Earthwork in excavation in foundation	45·43 cu m
2.	Lime concrete in foundation	8·93 cu m
3.	1st. class brickwork in cement motar (1 : 4) in foundation and plinth	33·23 cu m
4.	2·5 cm thick damp proof course	14·81 cu m
5.	1st. class brickwork in cement motar (1 : 6) in superstructure	54·07 cu m

3-7 Building—7. From the drawing of a Residence as shown in the fig. 3-7 take out the quantities for the following items of work :—

(1) Earthwork in excavation for foundation, (2) Concrete work in lime mortar for foundation, (3) Coursed Rubble Stone (C. R.S.) masonry in lime mortar for foundation and basement, (4) Plain concrete with stone chips (1:2:4) for R.C.C. works.

Note :—Omit step work in the take out.

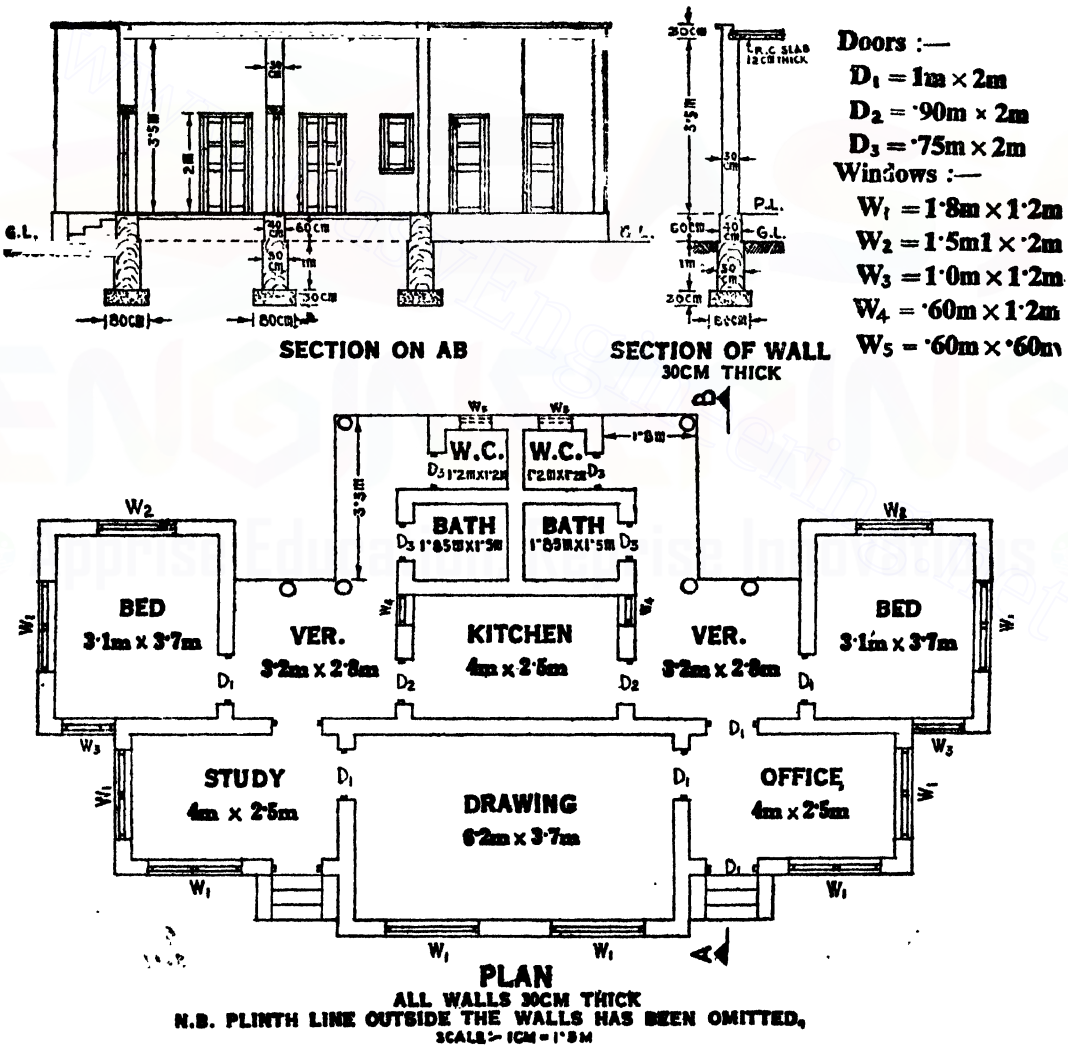


FIG. 3-7

Specification :— *Foundation*—Concrete in lime and Coursed Rubble Stone masonry in lime. *Basement*—Coursed Rubble Stone masonry in lime. *Roofing*—R.C.C. 12cm thick, *Doors and Windows*—C.P. wood.

(A) Long and short wall method—

Centre to centre distance :—

Bed to Bed rooms —

Entire continuative as long wall
$=2(3{\cdot}1+3{\cdot}2)+4{\cdot}0+4\times{\cdot}30+2\times{\cdot}30/2=18{\cdot}1$m

Drawing room—

Long wall (1 no)$=6{\cdot}2+{\cdot}30=6{\cdot}50$m
Short walls (2 nos)$=3{\cdot}7+{\cdot}30=4{\cdot}00$m

Office and Study (2 units) —

Long walls as long-short ($1\times2=2$ nos.)
$=4+{\cdot}30=4{\cdot}30$m
Short walls ($1\times2=2$nos)$=2{\cdot}5+{\cdot}30=2{\cdot}80$m

Bed rooms (2 units)—
Long walls as long-short ($2\times2=4$ nos)
$=3{\cdot}7+{\cdot}30=4{\cdot}0$m
Short walls ($1\times2=2$ nos)$=3{\cdot}1+{\cdot}30=3{\cdot}4$m

Kitchen—

Long wall (1 no)$=4+{\cdot}30=4{\cdot}3$m
Short walls (2nos)$=2{\cdot}5+{\cdot}30=2{\cdot}8$m
Baths (combined)—
Long wall (1 no)$=(2\times1{\cdot}85+{\cdot}30)+{\cdot}30=4{\cdot}3$m
Short walls (3 nos)$=1{\cdot}5+{\cdot}30=1{\cdot}8$m

W. C. (combined)—

Long wall (1no)$=(2\times1{\cdot}2+{\cdot}30)+{\cdot}30=3{\cdot}0$m

Short walls (3 nos)$=1{\cdot}2+{\cdot}30=1{\cdot}5$m
Verandahs (2 units)—
(i) Fronts of W C. and Bath as long walls
(2 nos)$=3{\cdot}5+{\cdot}40/2=3{\cdot}5$m
Short walls (2 nos)$=1{\cdot}8-{\cdot}80/2-{\cdot}40/2$
$=1{\cdot}75$m

(ii) Front of room (2 nos)
Actual length$=3{\cdot}2-[(1{\cdot}8+{\cdot}30+1{\cdot}2)$
$-(1{\cdot}85+{\cdot}30)]=2{\cdot}50$m
∴ Centre to centre distance as
Short wall$=(2{\cdot}05+{\cdot}30/2-{\cdot}40/2)=2{\cdot}00$m

(B) Centre line method—
Centre line length—
Entire continuative wall from Bed to Bed
$=2(3{\cdot}1+3{\cdot}2)+4{\cdot}0+4\times{\cdot}30+2\times{\cdot}30/2=18{\cdot}10$
Drawing room—
Long side$=6{\cdot}2+{\cdot}30$ $=6{\cdot}50$
Short sides$=2(3{\cdot}7+{\cdot}30)$ $=8{\cdot}00$
Joints$=2$ nos,
Office and Study (2 units)—
Long sides$=2(4+{\cdot}30)$ $=8{\cdot}60$
Short side$=2(2{\cdot}5+{\cdot}30)$ $=5{\cdot}60$
Joints$=4$ nos
Bed rooms (2 units)—
Long sides$=2\times2(3{\cdot}7+{\cdot}30)$ $=16{\cdot}00$
Short sides$=2(3{\cdot}1+{\cdot}30)$ $=6{\cdot}80$
Joints$=2\times1=2$ nos
kitchen—
Long side$=(4+{\cdot}30)$ $=4{\cdot}30$
Short side$=2(2{\cdot}25+{\cdot}30)$ $=5{\cdot}60$
Joints$=2$ nos.
Baths (combined)
Long side$=(2\times1{\cdot}85+{\cdot}30)+{\cdot}30$ $=4{\cdot}30$
Short side$=2(1{\cdot}5+{\cdot}30)$ $=3{\cdot}60$
Joints$=2$ nos.
Partition$=(1{\cdot}5+{\cdot}30)$ $=1{\cdot}80$
Joints$=2$ nos.
W. C. (combined)—
Long side$=(2\times1{\cdot}2+{\cdot}30)+{\cdot}30$ $=3{\cdot}00$
Short sides$=2(1{\cdot}2+{\cdot}30)$ $=3{\cdot}00$
Joints$=2$ nos
Partition$=(1{\cdot}2+{\cdot}30)$ $=1{\cdot}50$
Joints$=2$ nos
Verandah (2 units)—
Fronts of W.C. and bath
$=2(3{\cdot}5+{\cdot}40/2-{\cdot}40/2)=7{\cdot}00$
Short side$=2(1{\cdot}8+{\cdot}30/2-{\cdot}40/2)$ $=3{\cdot}50$
Joints$=1\times2=2$ nos.
(ii) Front of room actual length
$=3{\cdot}2-[(1{\cdot}8+{\cdot}30+1{\cdot}2)-(1{\cdot}85+{\cdot}30)]=2{\cdot}05$
Centre line length$=2(2{\cdot}05+{\cdot}30/2-{\cdot}40/2)$
$=4{\cdot}00$
Joints$=2$ nos
Total$=111{\cdot}20$m
Number of joints$=22$ nos.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation for foundation**							
	(A) By L. & S. wall method							
	Bed to Bed rooms—							
	Entire continuative as long...	1	18·90	·80	1·30			18·90=18·10+2×80/2
	Drawing room—							
	Long wall ...	1	7·30	·80	1·30			7·30=6·50+2×·80/2
	Short walls ...	2	3·20	·80	1·30			3·20=4·00—2×·80/2
	Office and Study (2 units)—							
	Long wall as long-short ...	1×2	4·30	·80	1·30			4·30=4·30+·80/2—·80/2
	Short wall ...	1×2	2·00	·80	1·30			
	Bed rooms (2 units)—							
	Long walls as long-short ...	2×2	4·00	·80	1·30			4·00=4·00+·80/2—·8 0/2
	Short walls ...	1×2	2·60	·80	1·30			
	Kitchen—							5·10=4·3+2×·80/2
	Long wall ...	1	5·10	·80	1·30			
	Short walls ...	2	2·00	·80	1·30			
	Baths (combined) —							
	Long wall ...	1	5·10	·80	1·30			
	Short walls ...	2	1·00	·80	1·30			
	W.C. (combined)—							
	Long wall ...	1	3·80	·80	1·30			
	Short walls ...	3	0·70	·80	1·30			
	Verandahs (2 units)—							
	(i) Fronts of W.C. & bath							
	Long wall ...	1×2	4·30	·80	1·30			
	Short walls ...	1×2	0·95	·80	1·30			
	(ii) Front of rooms as							
	Short wall ...	1×2	1·20	·80	1·30			
			102·40	·80	1·30	106·50	106·50	cu m
	(B) By Centre line method—	1	102·40	·80	1·30	106·50	106·50 cu m	102·40=111·20—22×·80/2
2.	**Concrete work in lime mortar for foundation**							
	(A) By L. & S. wall method							
	Bed to Bed rooms—							
	Entire continuative as long	1	18·90	·80	·30			
	Drawing rooms—							
	Long wall ...	1	7·30	·80	·30			
	Short walls ...	2	3·20	·80	·30			

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	Office and study (2 units)							
	Long wall as Long-short ...	1×2	4·30	·80	·30			
	Short walls ...	1×2	2·00	·80	·30			
	Bedrooms (2 units)—							
	Long walls as Long-short ...	2×2	4·00	·80	·30			
	Short walls ...	1×2	2·60	·80	·30			
	Kitchen—							
	Long wall ...	1	5·10	·80	·30			
	Short walls ...	2	2·00	·80	·30			
	Baths (combined —							
	Long wall ...	1	5·10	·80	·30			
	Short walls ...	3	1·00	·80	·30			
	W.C. (combined)—							
	Long wall ...	1	3 80	·80	·30			
	Short walls ...	3	0·70	·80	·30			
	Verandahs (2 units) —							
	(i) Front of W.C. and bath—							
	Long wall ...	1×2	4·30	·80	·30			
	Short wall ...	1×2	0·95	·80	·30			
	(ii) Front of room—							
	short wall ...	1×2	1·20	·80	·30			
			120·40	·80	·30	24 58	24·58	cu m
	(B) By Centre line method—	1	102·40	·80	·30	24·58	24·58	cu m
3.	**Coursed Rubble Stone** (C.R.S.) **masonry in lime mortar** for foundation and basement							
	(A) By L. & S. wall method							
	Bed to bed rooms—							
	Entire continuative as long							
	1st footing 50 cm ...	1	18·60	·50	1·00	9·30		
	Plinth wall 40 cm ...	1	18·50	·40	·60	4·44		18·60=18·10+2 × ·50/2 18·50=18·10+2 × ·40/2
	Drawing room—							
	Long wall—							
	1st footing 50cm ...	1	7 00	·50	1·00	3·50		
	Plinth wall 40cm ...	1	6·90	·40	·60	1·65		7·00=6·50+2 × ·50/2
	Short wall—							
	1st footing 50 cm ...	2	3·50	·50	1·00	3·50		3·50=4·00—2 × ·50/2
	Plinth wall 40cm ...	2	3·60	·40	·60	1·73		

building 7 continued

Item No.	Description	No.	L. m	B m	H. m	Qu.	Total	Explanatory notes
	Office and Study (2 units)—							
	Long wall as Long-short							
	1st footing 50 cm ...	1×2	4·30	·50	1·00	4·30		4·30=4·30+·50/2
	Plinth wall 40cm ...	1×2	4·30	·40	·60	2·06		—·50/2
	Short walls							
	1st footing 50 cm ...	1×2	2·30	·50	1·00	2·30		2·30=2·80—2×
	Plinth wall 40cm ...	1×2	2·40	·40	·60	1·15		·50/2
	Bed rooms (2 units)—							
	Long walls as long-short							
	1st footing 50 cm ...	2×2	4·00	50	1·00	8·00		4·00=4·00+·50/2
	Plinth wall 40 cm ...	2×2	4·00	·40	·60	3·84		—·50/2
	Short walls—							
	1st footing 50 cm ...	1×2	2 90	·50	1·00	2·90		2·90=3·40—2×
	Plinth wall 40 cm ...	1×2	3·00	·40	·60	1·44		50/2
	Kitchen—							
	Long wall							
	1st footing 50cm ...	1	4·80	·50	1·00	2·40		4·80=4·3+2×
	Plinth wall 40 cm ...	1	4·70	·40	·60	1·13		·50/2
	Short walls—							
	1st footing 50 cm ...	2	2·30	·50	1·00	2·30		2·30=2·80—2×
	Plinth wall 40 cm ...	2	2·40	40	·60	1·15		·50/2
	Baths (combined)—							
	Long walls							
	1st footing 50 cm ...	1	4·80	50	1·00	2·40		4·80=4·30+2×
	Plinth wall 40 cm ...	1	4·70	40	·60	1·13		50/2
	Short walls							
	1st footing 50 cm ...	3	1·30	·50	1·00	1·95		1·30=1·80—2×
	Plinth wall 40 cm ...	3	1·40	·40	·60	1·01		·50/2
	W. C. (combined)—							
	Long walls							
	1st footing 50 cm ...	1	3·50	·50	1·00	1·75		3·50=3·00+2×
	Plinth wall 40 cm ...	1	3·40	40	·60	0·82		50/2
	Short walls							
	1st footing 50 cm ...	3	1·00	50	1·00	1·50		1·00=1·50—2×
	Plinth wall 40 cm ...	3	1·10	·40	·60	0·79		·50/2

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	Verandahs (2 units) (i) Front of W. C. and bath							
	Long walls—							
	1st footing 50 cm ...	1×2	4·00	·50	1·00	4·00		4·00=3·50+2×·50/2
	Plinth wall 40cm ...	1×2	3 90	·40	·60	1·87		
	Short walls—							
	1st footing 50 cm ...	1×2	1·25	·50	1·00	1·25		1·25=1·75—2×·50/2
	Plinth wall 40 cm ...	1×2	1·35	·40	·60	0·65		
	(ii) Front of room as—							
	Short wall—							
	1st footing 50 cm ...	1×2	1·50	·50	1·00	1·50		
	Plinth wall 40 cm ...	1×2	1·60	·40	·60	0·77	78·48 cu m	1·50=2·00—2×·50/2
	(B) By centre line method—							
	1st footing 50 cm ...	1	105·70	·50	1·00	52·85		105·70=111·20—·50×22
	Plinth wall 40 cm ...	1	106·80	·40	·60	25·63	78·48 cu m	106·80=111·2—·40×22
4.	**Plain concerete with stone chips (1 : 2 : 4) for R. C. C. works in roofing.**							
	(i) From front of Drawing room to Verandah and Bed to Bed rooms entire front as a rectangle (covering the offset spaces first)							18·1=2(3·1+3·2)+4·0+4×·30+2×·15 (bearings) 6·80=3·7+2·8+·30+·15—·15
	(ii) Back portion (Verandah Baths and W. C.'s) ...	1	18·10	6·80	.12	14·77		
	(iii) Portions left out over back part of bed rooms ...	1	3·30	6·60	·12	2·61		3·3=3·3+·15—·15 6·6=2(1·8+1·2)+3×·30—2×·15
	Deduction for offset spaces (as considered before)	2	1·20	3·40	·12	0·98		1·20=3·7—2·8+·15+·15
	(a) Fronts of Bed rooms	2	3·0	4·0	·12	2·88-ve		3·0=18·1—(2×4·0+6·2+2×·30+2×·15
	(b) Fronts of Study and Office ...	2	4·3	2·2	·12	1·24-ve	14·24 cu m	4·0=3·7+2×·15

3-8. A Modern Building—Fig. 3-8 shows the plan and sections of a modern building. Estimate the quantities of the following items of work :--

(1) Earthwork in excavation for foundation trenches, (2) Cement concrete (1:3:6) in foundation, (3) 1st. class brickwork in cement mortar (1 : 4) in foundation and plinth, (4) Sand filling in plinth, (5) 2 cm thick damp proof course in cement concrete (1:2:4) and (6) 1st. class brickwork in cement mortar (1:6) for superstructure walls (N.B. Neglect steps).

(A) Centre line Method :—

Centre line length—

(i) For main Walls :—

Guest room with latrine

=2[(4·60+·40)+(4+·40)] =18·80 m

Bed room 4m × 4m with latrine blocks

=2[(7·40+·4)+(4+·40)] =24·40 m

Back of staircase wall

=(2·5+·40) Joint=2nos. =2·90 m

Bed room 4m × 4·5m (three sides)

=(4+·40)+2(4·5+·40) Joint=2nos.=14·20m

Drawing and dining room—

(a) Portion with front verandah

$=(1{\cdot}9+{\cdot}10-\frac{\cdot 50}{2}+\frac{\cdot 40}{2})$ Joint=1no. =1·95m

(b) Back & Front=2(4·5+·40) =9·80 m
Joint=1no.

(c) Side with garage=5·5+·40 =5·90 m

Garage (three sides)

$=(5{\cdot}95-\frac{\cdot 50}{2}+\frac{\cdot 40}{2})+2(3+{\cdot}50)$ =12·90 m
Joint=2nos.

Kitchen & Pantry combined (3 sides

=2(3+·40)+(2·5+·10+2·0+·40) =11·80 m
Joint=2nos.

Total=102·65 m

Number of joints=10nos.

(ii) For dwarf walls—

Front verandah—

$\text{Front}=(1{\cdot}9+{\cdot}10-\frac{\cdot 20}{2}+\frac{\cdot 40}{2}$ =2·1 m
Joint=1no.

$\text{Side}=(2{\cdot}0-\frac{\cdot 20}{2}+\frac{\cdot 40}{2})$ Joint=1no. =2·1 m

Back verandah=(3·45+·50)
Joint=2nos. =3·95 m

Total=8·15 m

Number of joints=4nos. with main wall.

(iii) For Toe walls (of stairs)—

$\text{Main stair}=(1{\cdot}25+\frac{\cdot 40}{2})$ Joint=1no =1·45 m

$\text{At garage}=({\cdot}60+\frac{\cdot 40}{2})$ Joint=1no. =·80 m

Total =2·25 m

Number of joints=2 *nos.*

(B) Long and Short wall method—

Centre to centre distances—

(i) For main walls :

Guest room with latrine :

Long walls=(3+·10+1·5)+·40 =5 0 m

Short walls=4+·40 =4·40 m

Bed room 4m × 4m with latrine blocks :

Long walls=(4+·10+1·2+ 10+2·0)+·40
=7·8 m

Short walls=4+·40 ... ... =4·40 m

Staircase :—

Bed room 4m × 4·5m :—

Back & front Short walls=4·5+·40=4·90 m

Side as long wall=4+·40 ... =4·40 m

Drawing and dining room :—

Portion with front verandah as

Long-short=(1·9+·10)- ⁰+ =1·95 m

Side with garage Long wall=5·5+·40=5·90 m

Back and front Short walls=4·5+·40=4 90 m

Garage :—

Back and front Short walls=3·0+·50=3·50m

$\text{Side as Long wall}=5{\cdot}95-\frac{\cdot 50}{2}+\frac{\cdot 40}{2}=$ 5·90m

Kitchen and Pantry

Long wall=(2 5+·10+2·0)+·40 =5·0m

Short sides as Short walls=3+·40 =3·40m

(ii) *For dwarf walls* :

Front verandah :—

Step side as

$\text{Long-short}=(1{\cdot}9+{\cdot}10)-\frac{\cdot 20}{2}+\frac{\cdot 40}{2}$ =2·10 m

$\text{Front side as short}=2{\cdot}0+\frac{\cdot 40}{2}-\frac{\cdot 20}{2}$ =2·10m

Back verandah as :—

Short wall=3·45+·50 =3·95 m

(iii) *For Toe walls* (of stairs) :—

Main stair Short one end=$1{\cdot}25+\frac{\cdot 40}{2}$=1·45m

At garage Short one end=$\cdot 60+\frac{\cdot 40}{2}$ =·80m

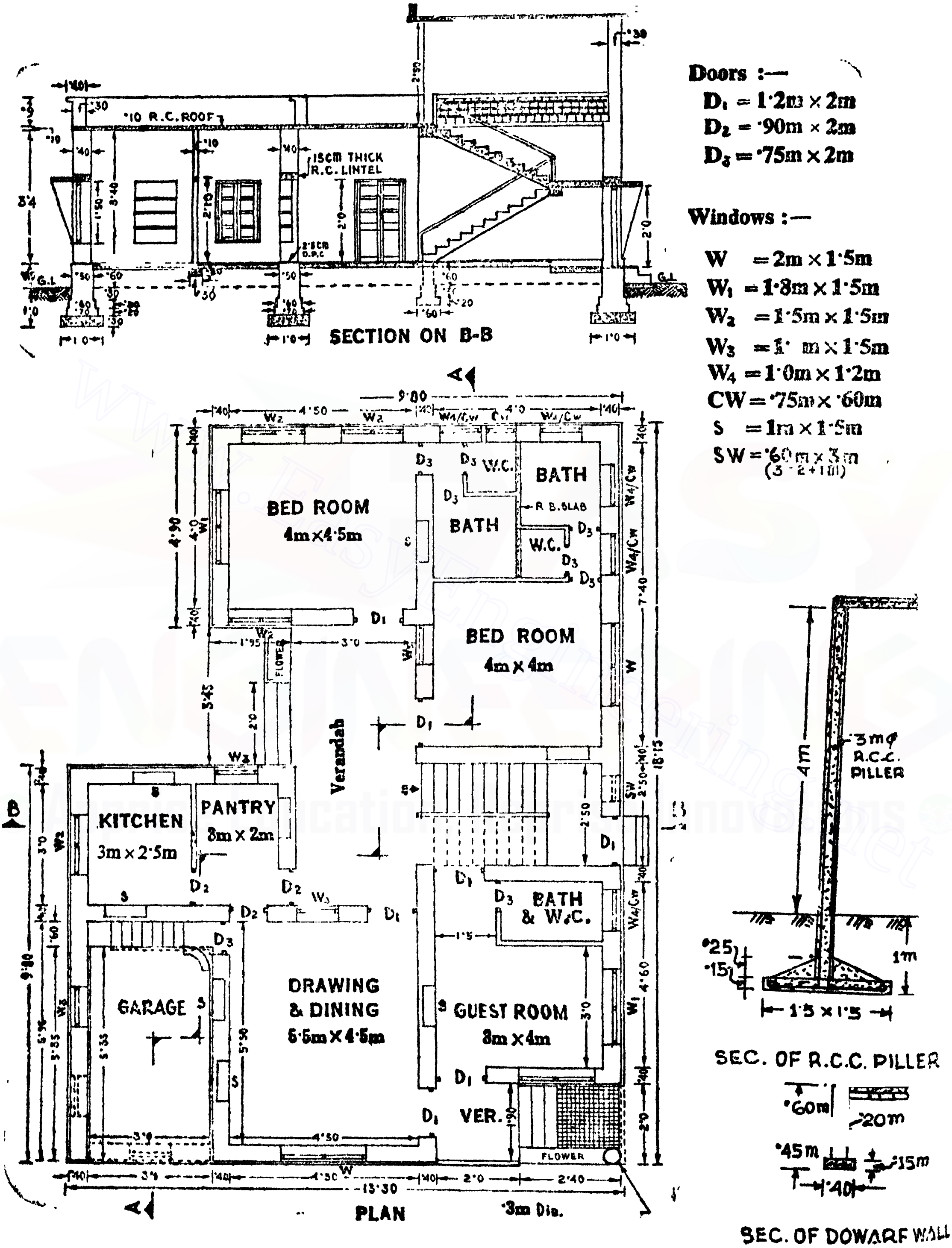
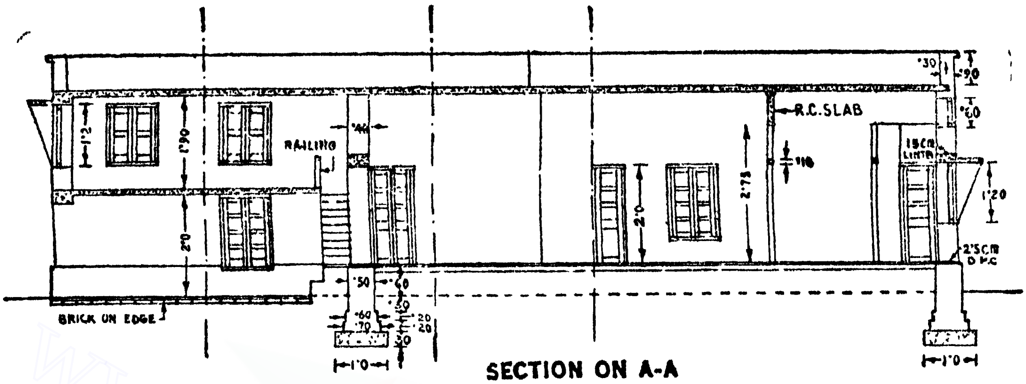

·10 R.C. ROOF
15cm THICK R.C. LINTEL
2·5cm D.P.C
G.L
SECTION ON B-B
Doors :—
D1 = 1·2m × 2m
D2 = ·90m × 2m
D3 = ·75m × 2m
Windows :—
W = 2m × 1·5m
W1 = 1·8m × 1·5m
W2 = 1·5m × 1·5m
W3 = 1 m × 1·5m
W4 = 1·0m × 1·2m
CW = ·75m × ·60m
S = 1m × 1·5m
SW = ·60m × 3m
BED ROOM
4m×4·5m
BATH
W.C.
R B.SLAB
BED ROOM
4m × 4m
Verandah
KITCHEN
3m × 2·5m
PANTRY
3m × 2m
GARAGE
DRAWING & DINING
5·5m × 4·5m
BATH & W.C.
GUEST ROOM
3m × 4m
VER.
FLOWER
PLAN
·3m Dia.
·3mφ R.C.C. PILLER
4m
1·5 × 1·5
SEC. OF R.C.C. PILLER
SEC. OF DOWARF WALL

FIG. 3-8



SECTION ON A-A

SCALE : 1cm=1·5m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation for foundation trenches**							97·65=102·65 —10×1 0/2
	(*A*) *By Centre line method*—							6·15=8·15—4 ×1·0/2
	(i) For main wall ...	1	97·65	1·00	1·00	97·65		
	(ii) For dwarf walls ...	1	6·15	·40	·45	1·11		
	(iii) For Toe walls ...	1	1·25	·60	·50	0·38		1·25=2·25—2 ×1·0/2
	(iv) For column footing	1	1·50	1·50	1·00	2·25		
	Less garage front	1	2·50	1·00	1·00	2·50	(-ve) 98·89 cu m	2·5=3·5−2×1·0/2
	(*B*) *By L. & S. wall method*—							
	(i) For main walls—							
	Guest room with latrine							
	Long walls ...	2	6·00	1·00	1·00			6·00=5·0+2×½×1·0
	Short walls ...	2	3·40	1·00	1·00			
	Bed room 4m×4m with latrines							
	Long walls ...	2	8·80	1·00	1·00			
	Short walls ...	2	3·40	1·00	1·00			3·40=4·40—2×½×1·0
	Staircase back as Short wall ...	1	1·90	1·00	1·00			
	Bed room 4m×4·5m Back and front as Short walls ...	2	3·90	1·00	1·00			
	Side as Long wall ...	1	5·40	1·00	1·00			
	C.O.		58·30					

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.		58·30					
	Drawing and dining room—							
	Portion with front veran.							1·95=1·95+
	Long-short ...	1	1·95	1·00	1·00			1·0/2—1·0/2
	Side with garage as							
	Long wall ...	1	6·90	1·00	1·00			
	Back and front as							
	Short walls ...	2	3·90	1·00	1·00			
	Garage—							
	Back as Short ...	1	2·50	1·00	1·00			
	Side as Long ...	1	6·90	1·00	1·00			
	Kitchen and Pantry—							
	Long wall ...	1	6·00	1 00	1·00			
	Short walls ...	2	2·40	1·00	1·00			
		T.L.	95·15	1·00	1 00	95·15		
	(ii) For dwarf walls—							
	Front verandah							1·80=2·10+
	Step side as long short	1	1·80	·40	·45			·40/2—1·0/2
	Front side as Short ...	1	1·40	·40	·45			1·40=2·10—
	Back verandah as							40/2—1 0/2
	Short wall ...	1	2·95	·40	·45			
		T.L	6·15	·40	·45	1·11	.	2 95=3·95—2 ×
	(iii) For Toe walls—							1·0/2
	Main stair as							0·95=1·45—
	Short one end	1	0·95	·60	·50			1 0/2
	Garage stair as							
	Short one end	1	30	·60	·50			0 30=·88—
		T.L.	1·20	·60	·50	0·38		1 0/2
	(iv) For column of sq. footing	1	1·50	1 50	1·00	·25		
2.	**Lime concrete in foundation**						101 39 cu m	
	(A) By Centre line method—							
	(i) For main walls— ...	1	95·15	1·00	·30	28·54		6·95=8·15—
	(ii) For dwarf walls ...	1	6·95	·40	·15	0·42		4 × 60/2
	(iii) For Toe walls ...	1	1·65	·60	·20	0 19		concrete meets
	(iv) Partition of Kitchen & Pantry	1	2·90	·30	·20	0 17		with 60cm layer of brickwork
	Less garage front	1	2 50	1·00	·30	0·75	-(ve)	1·65=2·25—2
	(B) By L. & S. wall method						29·27 cu m	×·60/2
	(i) For main walls—							
	Guest room with latrine							
	Long walls ...	2	6·00	1·00	·30			
	Short walls ...	2	3·40	1·00	·30			
	Bed room 4m × 4m with lats.							
	Long walls ...	2	8·80	1·00	·30			
	Short walls ...	2	3·40	1·00	·30			
	Staircase back as							
	Short wall ...	1	1·90	1·00	·30			
	C. O. ...		45·10					

Modern Building 9 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F.		45·10					
	Bed room 4m × 4·5m							
	Back and front as							
	Short walls ...	2	3·90	1·00	·30			
	Side as Long wall ...	1	5·40	1·00	·30			
	Drawing and dining room—							
	Portion with front verandah							
	Long-short ...	1	1·95	1·00	·30			
	Side with garage as							
	Long wall ...	1	6·90	1·00	·30			
	Back and front as							
	Short walls ...	2	3·90	1·00	·30			
	Garage—							
	Back as Short ...	1	2·50	1·00	·30			
	Side as Long ...	1	6·90	1·00	·30			
	Kitchen and Pantry—							
	Long wall ...	1	6·90	1·00	·30			
	Short walls ...	2	2·40	1·00	·30			
		T.L.	95·15	1·00	·30	28·55		
	(ii) For dwarf walls :—							
	Front verandah—							
	Step side as long short ...	1	2·00	·40	·15			$2·00 = 2·10 + \frac{·40}{2} - \frac{·60}{2}$
	Front side as Short ...	1	1·60	·40	·15			$1·60 = 2·10 - \frac{·90}{2} - \frac{·60}{2}$
	Back verandah as Short wall	1	3·35	·40	·15			
		T.L.	6·95	·40	·15	0·42		
	(iii) For Toe walls—							$3·35 = 3·95 - 2 \times \frac{·60}{2}$
	Main stair as Short one-end	1	1·15	·60	·20			
	Garage stair as Short one end	1	·50	·60	·20			
		T.L.	1·65	·60	·20	0·19		$1·15 = 1·45 - \frac{·60}{2}$
	(iv) Partition of Kitchen & Pantry	1	2·90	·30	·20	0·17		$·50 = ·80 - \frac{·60}{2}$
3.	**First class brickwork in cement mortar (1:4) in foundation and plinth**						30·08 cu m	
	(A) By Centre Line Method—							99·15 = 102·65 —10 × 70/2
	(i) For main walls—							
	1st footing 70 cm ...	1	99·15	·70	·20	13·88		
	2nd footing 60 cm ...	1	99·65	·60	·20	11·96		
	3rd footing 50 cm ...	1	100·15	·50	·90	45·07		
	(ii) For dwarf walls— ...	1	7·15	·20	·90	1·29		1·75 = 2·25—2 × ·50/2
	(iii) For Toe walls—							40 cm and 30cm footings meet with the 50cm of main wall.
	1st footing 40cm ...	1	1·75	·40	·30	0·21		
	2nd footing 30cm ...	1	1·75	·30	·60	0·32		
	C. O. ...					72·73		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...					72·73		
	Deduction for garage							
	1st footing 90 cm ...	1	2·80	·70	·20	·39		
	2nd footing 60 cm ...	1	2·90	·60	·20	·35		
	Front plinth wall ...	1	3·00	·50	·90	1·35	(-ve)	
	(B) By L. & S. wall method						70·64 cu m	
	1) For main walls—							
	Guest room with latrine							
	Long walls—							
	1st footing 70 cm ...	2	5·70	·70	·20	1·60		5·70=5·0+2 × ·70/2
	2nd footing 60 cm ...	2	5·60	·60	·20	1·34		
	3rd footing 50 cm ...	2	5·50	·50	·90	4·95		
	Short walls—							
	1st footing 70 cm ...	2	3·70	·70	·20	1·04		3·70=4·40—2 × ·70/2
	2nd footing 60 cm ...	2	3·80	·60	·20	0·91		
	3rd footing 50 cm ...	2	3·90	·50	·90	3·51		
	Bed room 4m × 4m with latrines							
	Long walls—							
	1st footing 70 cm ...	2	8·50	·70	·20	2·38		8·50=7·80+2 × ·70/2
	2nd footing 60 cm ...	2	8·40	·60	·20	2·02		
	3rd footing 50 cm ...	2	8·30	·50	·90	7·47		
	Short walls—							
	1st footing 70 cm ...	2	3·70	·70	·20	1·04		3·70=4·40—2 × ·70/2
	2nd footing 60 cm ...	2	3·80	·60	·20	0·91		
	3rd footing 50 cm ...	2	3·90	·50	·90	3·51		
	Staircase back as							
	Short wall—							
	1st footing 70 cm ...	1	2·20	·70	·20	0·31		2·20=2·90—2 × ·70/2
	2nd footing 60 cm ...	1	2·30	·60	·20	0·28		
	3rd footing 50 cm ...	1	2·40	·50	·90	1·08		
	Bed room 4m × 4·5m – Back and front as							
	Short walls—							
	1st footing 70 cm ...	2	4·20	·70	·20	1·18		4·20=4·90—2 × ·70/2
	2nd footing 60 cm ...	2	4·30	·60	·20	1·03		
	3rd footing 50 cm ...	2	4·40	·50	·90	3·96		
	Side as Long wall							
	1st footing 70 cm ...	1	5·10	·70	·20	0·71		5·10=4·40+2 × ·70/2
	2nd footing 60 cm ...	1	5·00	·60	·20	0·60		
	3rd footing 50 cm ...	1	4·90	·50	·90	2·21		
	Drawing and dining room Portion with front verandah							
	Long-short—							
	1st footing 70 cm ...	1	1·95	·70	·20	0·27		1·95=1·95+ ·70/2—·70/2
	2nd footing 60 cm ...	1	1·95	·60	·20	0·23		
	3rd footing 50 cm ...	1	1·95	·50	·90	0·88		

Modern Building continued

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	Side with garage as Long wall							
	1st footing 70 cm ...	1	6·60	·70	·20	0·92		6·60=5·90+2× ·70/2
	2nd footing 60 cm ...	1	6·50	·60	·20	0·78		
	3rd footing 50cm ...	1	6·40	·50	·90	2·88		
	Back as Short							
	1st footing 70 cm ...	2	4·20	·70	·20	1·18		4·20=4 90—2× ·70/2
	2nd footing 60 cm ...	2	4·30	·60	·20	1 03		
	3rd footing 50 cm ...	2	4·40	·50	·90	3 96		
	Garage—							
	Back Short as							
	1st footing 70 cm ...	1	2·80	·70	·20	0·39		2·80=3·50—2× ·70/2
	2nd footing 60 cm ...	1	2·90	·60	·20	0·35		
	3rd footing 50 cm ...	1	3·00	·50	·90	1·35		
	Side as Long wall							
	1st footing 70 cm ...	1	6·60	·70	·20	0·92		6 60=5 90+2× ·70/2
	2nd footing 60 cm ...	1	6·50	·60	·20	0·78		
	3rd footing 50 cm ...	1	6·60	·50	·90	2·88		
	Kitchen and Pantry—							
	Outside as Long wall—							
	1st footing 70 cm ...	1	5·70	·70	·20	0·80		5·70=5·00+2× ·70/2
	2nd footing 60 cm ...	1	5·60	·60	·20	0·67		
	3rd footing 50 cm ...	1	5·50	·50	·90	2·47		
	Short walls—							
	1st footing 70 cm ...	2	2·70	·70	·20	0·76		2·70=3·40—2× ·70/2
	2nd footing 60 cm ...	2	2·80	·60	·20	0 67		
	3rd footing 50 cm ...	2	2·90	·50	·90	2 61		
	(ii) For dwarf walls—							
	Front verandah							
	Step side as Long-short	1	1·95	·20	·90	0·35		1·95=2·10+·20/2 —·50/2
	Front side as Short	1	1·75	·20	·90	0·32		1·75=2·10—·20/2 —·50/2
	Back verandah side as Short wall ...	1	3·45	·20	·90	0·62		
	(iii) For Toe walls—							
	Main stair as short one end							
	1st footing 40 cm ...	1	1·20	·40	·30	0·14		
	2nd footing 40 cm ...	1	1·20	·30	·60	0·22		1·20=1·45—·50/2
	Garage stair as short one end							40cm and 30cm footings of toe wall meet with 50cm footing of main wall
	1st footing 40 cm ...	1	0·55	·40	·30	0·07		
	2nd footing 30 cm ...	1	0·55	·30	·60	0·10		
							70·64	cu m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4.	**Sand filling in Plinth**							
	Guest room with latrine	1	3·90	4·50	·42	7·37		·42= 60—·08 (L.C.)—·10 (brick flat)
	Main stair hall with portion (of 5cm) of verandah ...	1	4·40	2·40	·42	4·44		
	Bed room 4m × 4m with lats.	1	7·30	3·90	·42	11·96		4·40=(4·0+·40 +·05)—·05 (for one side offset)
	Bed room 4m × 4·5m ...	1	3·90	4·40	·42	7·21		
	Drawing and dining room ...	1	5·40	4·40	·42	9·98		
	Kitchen and Pantry ...	1	4·50	2·90	·42	5·45		
	Back verandah ...	1	6·85	2·75	·42	5·91		6·85=(3·45+·05 +·40+3·0)—·05
	Front verandah ...	1	1·75	1·75	·42	1·29		
	Deduction for							
	Toe wall of main stair ...	1	1·25	·30	·42	0·16	(-ve)	
							53·45 cu m	
5.	**2 cm thick Damp Proof Course**							
	(A) By centre line method—							
	(i) For main walls only	1	100·65	·40	—	40·26		100·65=102 65 —10 × ·40/2
	Deduction for—							
	Garage front ...	1	8·10	·40	—	1·24		
	Door openings, D_1 ...	7	1·20	·40	—	3·36		
	,, ,, D_2 ...	2	·90	·40	—	0·72		
	,, ,, D_3 ...	2	·75	·40	—	0·60		
							34 34 cu m	
	(B) By L. & S. wall method—							
	(i) For main walls only							
	Guest room with latrine							
	Long walls ...	2	5·40	·40	—			
	Short walls ...	2	4·00	·40	—			5·40=5·0+2× ·40/2
	Bed room 4m × 4m with lats.							
	Long walls ...	2	8·20	·40	—			
	Short walls ...	2	4·00	·40	—			8·20=7 8+2 × ·40/2
	Staircase back as Short wall	1	2·50	·40	—			2·50=2·90—2 × ·40/2
	Bed room 4m × 4·5m—							
	Back and front as Short walls ...	2	4·50	·40	—			
	Side as Long wall ...	1	4·80	·40	—			4·50=4·90—2 × ·40/2
	Drawing and dining room—							
	Portion with front veran. Long-short ...	1	1·95	·40	—			
	Side with garage as Long wall ...	1	6·30	·40	—			6·30=5·90+2 × ·60/2
	Back and front Short wall ...	2	4·50	·40	—			
	Garage—Short walls ...	2	3·10	·40	—			
	Side as Long wall ...	1	6·30	·40	—			
	Kitchen and pantry							
	Long wall ...	1	5·40	·40	—			
	Short walls ...	2	3·00	·40	—			
	C. O. ...		100·65	·40	—	40 26		

Modern Building continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	C. O. ...					40 26		
	Deduction for—							
	Door sills D_1 ...	7	1·20	·40	—	3·36		
	,, ,, D_2 ...	2	90	·40	—	0·72		
	,, ,, D_3 ...	2	·75	·40	—	0·60		
	Garage front ...	1	3·10	·40	—	1·24		
							34·34 sq m	
	1st class brickwork in cement motar (1:6) for superstructure walls							
	(i) For mainwalls—							
	(A) *By Centre line method—*	1	100·65	·40	3·40	136·88		Deductions for front opening of garage & others are at end.
	(B) *By L. & S. wall method*							
	Guest room with latrine							
	Long walls ...	2	5 40	·40	3·40			
	Short walls ...	2	4·00	·40	3·40			
	Bed 4m × 4m with latrines							Lengths are same as in item no. 5
	Long walls ...	2	8 20	·40	3·40			
	Short walls ...	2	4·00	·40	3 40			
	Staircase back as Short wall	1	2·50	·40	3·40			
	Bed room 4m × 4·5m							
	Back and front as Short walls ...	2	4·50	·40	3 40			
	Side as Long wall ...	1	4·80	·40	3·40			
	Drawing and dining room portion with front verandah							
	Long-short ...	1	1 95	·40	3·40			
	Side with garage as Long wall ...	1	6·30	·40	3·40			
	Back and front as Short walls ...	2	4·50	·40	3·40			
	Garage—Short walls ...	2	3.10	·40	3·40			
	Side as Long wall ...	1	6.30	·40	3·40			
	Kitchen and pantry —							
	Long wall ...	1	5·40	·40	3·40			
	Short walls ...	2	3·00	·40	3·40			
		1 .L	100·65	·40	3·40	136·88		
	(ii) Parapet wall (for both methods)							
	(a) Right side (in to in)—							
	Front to 1st stair wall ...	1	6·75	·30	·90	1 82		6·75=(2·0+·40 +4·6+·05)—·30
	2nd stair wall to back ...	1	7·55	·30	·90	2·04		
	(b) Extreme back, out to out...	1	9·70	·30	·90	2·62		
	(c) Back of kitchen & pantry, out to out ...	1	5·70	·30	·90	1·54		5·70=5·45—·05 +·30
	B. F. ...						145·04	

Item No	Description	No.	L. m	B m	H m	Qu.	Total	Explanatory notes
	B. F. ...					145 04		
	(d) Front part of bed room of 4m × 4·5m out to out...		2·20	·30	·90	·59		2·20=1·93–... +...
	(e) Left side, (in to in)—							
	Garage and kitchen ...		9·10	·30	·90	2·46		
	Side of back verandah ...		3·45	·30	·90	0·93		9·10=9·80 – 2(·05+·3...
	Side of room 4m × 4·5m ...		4·20	·30	·90	1·13		3·45=3·55+... ×...
	(iii) For stair room (for both methods)—							
	Sides ...		4·35	·20	2·50	6·53		4·35=(4·0+... —·50
	Back ...		3·20	·30	2·50	2·40		3·20=2·5+2(·05+·30)
	Deduction for—							
	(a) Door openings, D_1 ...		1·20	·40	2·0	6·72(–ve)		
	" " D_2 ...		·90	·40	2·0	1·44 "		
	" " D_3 ...		·75	·40	2·0	1·20 "		
	(b) Window openings, W ...		2·0	·40	1·5	2·40 "		
	" " W_1 ...		1·8	·40	1·5	3·24 "		
	" " W_2 ...		1·5	·40	1·5	3·60 "		
	" W_3 ...		1·0	·40	1·0	2·40 "		
	" W_4 ...		1·0	·40	1·2	3·84 "		
	(c) Clerestory window, cw...		·75	·40	·60	1·08 "		
	(d) Garage front opening ...		3·10	·40	1·40	1·74 "		1·40=2·0–·6 i.e from P.L. to roof of garage
	(e) Shelve openings, S ...		1·00	·30	1·00	2·40 "		
	(f) Staircase opening Sw							
	In 40 cm wall ...		·60	·40	2·00	0·48 "		
	In 30 cm wall ...		·60	·40	1·00	0·24 "		
	(g) Lintel ...		100·65	·40	·15	6·05 "		For method (...) 100·65 is the total length form item ...
	(h) For bearing of garage roof in wall—							
	Long sides (out to out)		6·10	·20	·20	0·49 "		
	Back (in to in) ...		3·10	·20	·20	0·12 "	21·64 cu m	Bearing of ... is considered 20 cm.
7.	**10cm thick brickwork in party walls** (for both methods)—							
	Guest room Long side ...		2·50		2·75	6·88		
	Short side ...		1·50		2·75	4·13		
	Bed rooms latrines							
	Long sides ...		2·00		2·75	11·00		
	Short sides ...		2·00		2·75	11·00		
	" " ...		1·20		2·75	6·60		
	Between kitchen & pantry		3·00		3·40	10·20		
						49·81		
	Deduction for—							
	Door openings D_2		·90		2·0	1·80(–ve)		10 cm bearing is considered
	D_3		·75		2·0	9·00 "		
	Lintels over doors D_2		1·10		·10	0·11 "		
	D_3		·95		·10	·57 "		
						11·48	38·33	sq m

ABSTRACT OF QUANTITIES (Building 3-8)

Sl. No.	Description	Quantity
1.	Earth work in excavation for foundation trenches	101·39 cum
2.	Cement concrete (1 : 3 : 6) in foundation	30·08 cum
3.	1st class brickwork in cement mortar (1 : 4) in foundation and plinth	71·83 cum
4.	Sand filling in plinth..	53·45 cum
5.	2 cm thick damp proof course in cement concrete (1 : 2 : 4) ...	34·34 sqm
6.	1st class brickwork in cement mortar (1:6) for superstructure walls...	121 68 cum
7.	,, ,, ,, ,, 10cm thick ,, ...	38·38 sqm

3-9. Estimate from Line Plan of a Building. Some times it becomes necessary to determine quickly an approximate estimate of a building from the line plan without the detailed drawing of the same. In such cases the section of walls are drawn and position of doors and windows are shown on the line plan. The estimate in this case may be prepared with the help of "**Crossing Method**" as described in the article 2-8. In this method calculate the overall perimeter of the walls having the same section and subtract from this four times the thickness of wall to obtain the actual centre line length. In order to prepare quickly an approximate estimate the length of interior walls from the inner dimensions of rooms may simply be added with the above actual centre line length.

As no deductions for the number of joints for the inner walls are made in the above procedure, the estimate of works upto plinth level will be a little excess than the accurate estimate. In case of different sections of walls the inner lengths of smaller section walls are added separately and consider this as the centre line length without considering the number of joints. ***Note that the estimate for all other items in the above procedure is as accurate as that of centere line or Long and Short wall method.***

Example :—Building 3-9—Estimate quickly the quantities of the following items of works and also calculate the cost of each item separately from the line plan of a building as shown in fig. 3-9.

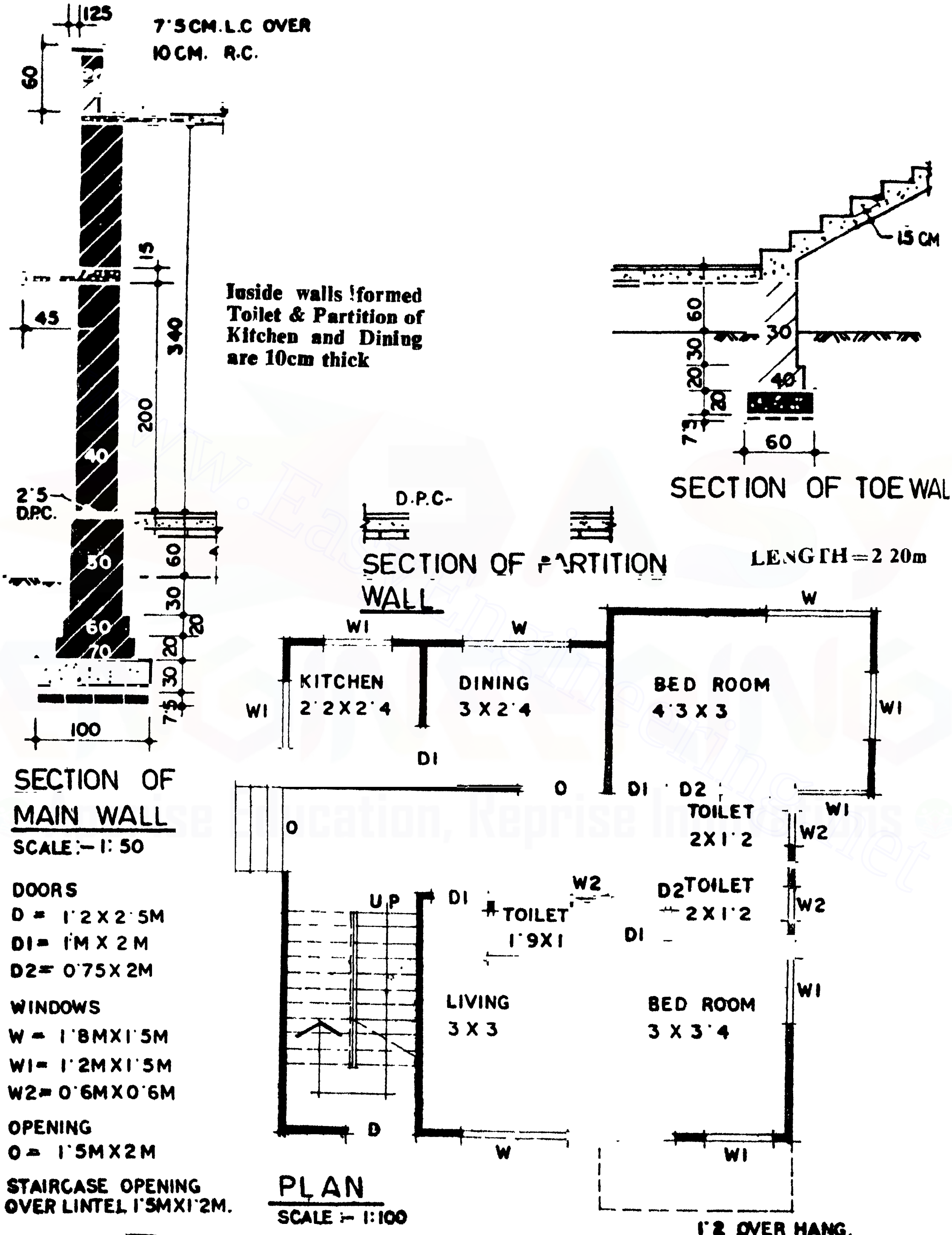
1. Brick flat soling with over burnt bricks, 2. Cement concrete in foundation (1:3:6) 3. 1st. class brickwork in cement mortar (1:4) in foundation and plinth, 4. Damp proof course (1:2:4) under superstructure walls, 5. 1st class brickwork in cement mortar (1:6) in superstructure, 6. R. C. C. work in staircase, lintels, roof slab (1:2:4) excluding reinforcement and shuttering, 7. Shuttering for R. C. C. work in item 6, 8. Mild steel work with one percent reinforcement in R.C.C. works as in item 6, 9. Lime concrete (2:2:7) in roof terraching, 10. 12mm cement plaster (1:6), 11. 7·5cm thick lime concrete floor (2:2:7) over a brick flat, 12. 2·5cm thick I.P.C. (1:2:4) over lime concrete.

To calculate the centre line for main walls—

Over all perimeter, Front + Back = 2(2·2 + 3 + 4 3 + 3 × ·40 + ·10) = 21·60m
Sides = 2(3 + 1·2 + 1·2 + 3·4 + 3 × ·40 + 2 × ·10) = 20·40m
= 42 00m

∴ Centre line length of outer walls = 42·00 − 4 × ·40 = 40·40m
For remaining walls (approxi. length) Living room = 2(3 + 1 + 0·1 +) + 3 = 11·20m
Back bed room 3 + 2·4 = 5·40m
Fronts of kitchen & Dining = 2·2 + 3 + ·1 = ... = 5·30m
Total length for main wall = 62·30m

Centre line length for parapet walls = 42 00 − 4 × ·20 = 41·20m
Partition walls for living room = 1·9 + 1 = 2·9
Walls of Toilets = 2 2 + 1·2) = 6·4
— do —Kitchen & Dining = 2·4
Total = 11·7m



ROOM HT. = 2·5M

FIG 3-9

Building 9 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Brick flat soling**							
	Main walls ...	1	62·30	1·00	—	62·30		
	Toe wall ...	1	2·20	·60	—	1·32		
							63·62 sq m	
2.	**Cement concrete in foundation**							
	Main walls ...	1	62·30	1·00	·30	18·69		
	Toe wall ...	1	2·20	·60	·20	·20		
							18·89 cu m	
3.	**First class brickwork in foundation and plinth**							
	Main walls :—							
	1st footing ...	1	62·30	·70	·20	8·70		
	2nd footing ...	1	62·30	·60	·20	7·47		
	Plinth wall ...	1	62·30	·50	·90	28·03		
	Toe wall :—							
	1st footing ...	1	2·20	·40	·20	·18		
	2nd footing ...	1	2·20	·30	·90	·59		
							44·97 cu m	
4.	**2·5 cm thick D.P.C.**							
	Main walls	1	62·30	·40	—	24·92		
	Partition walls	1	11·70	·10	—	1·17		
	Deduction for—							
	Door sills							
	D	1	1·2	·40	—	·48	(-ve)	
	D_1	3	1·0	·40	—	1·20	-do-	
	D_1	2	1·0	·10	—	·20	-do-	
	D_2	3	·75	·10	—	·23	-do-	
	Openings O	2	1·5	·40	—	1·20	-do-	
							22·78 sq m	
5.	**First class brickwork in superstructure**							
	(a) Main walls	1	62·30	·40	3·40	84·72		
	Parapet walls	1	41·20	·20	·60	4·94		
	Staircase room (Mumty) Living room side	1	4·50	·20	2·5	2·25		4·50=3+1·9+·10+·40
	Extra ht. over parapet—							1·9=2·5—·60
	Front ...	1	2·20	·20	1·90	·84		
	Left side ...	1	4·50	·20	1·90	1·71		
	C. O.					94·46		

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...					94·46		
	Deductions for—							
	Door openings							
	D in 50cm wall	1	1·2	·50	·50	·30	(-ve)	
	in 40cm wall	1	1·2	·40	2·0	·96	(-ve)	
	D_1	3	1·0	·40	2·0	2·40	(-ve)	
	Window openings							
	W	3	1·8	·40	1·5	3·24	(-ve)	
	W_1	6	1·2	·40	1·5	4·32	(-ve)	
	W_2	3	·6	·40	·6	·43	(-ve)	
	Openings O	2	1·5	·40	2·0	2·40	(-ve)	
	Stair case opening	1	1·5	·40	1·2	·72	(-ve)	
	Lintel ...	1	62·30	·40	·15	3·74	(-ve)	
							75·95 cu m	
	(b) 10cm thick partition wall	1	11·70	—	3·40	39·78		
	Deductions for —							
	Doors D_2 ...	3	·75	—	2·0	4·50	(-ve)	
	Lintel ...	1	11·70	—	·20	2·34	(-ve)	
							32·94 sq m	
6	**R. C. C. work excluding reinforcement and shuttering**							
	(a) For roof slab over—							
	Front portion including corridor but excluding overhang ...	1	6·40	9·80	·10			6·40=3·4+2×1·2+2×·10+·40
	Overhang ...	1	3·80	1·20	·10			9·80=2·2+3·0+3·0+4×·40
	Back portion—							
	Bed room including walls ...	1	3·80	5·10	·10			5·10=4·3+2×·40
	Kitchen+Dining ...	1	5·70	3·20	·10			5·70=2·2+3·0+·10+·40
			19·70	19·30	·10	38·02		3·20=2·4+2×·40
	(b) Lintel for							
	Main walls ...	1	62·30	·40	·15	3·74		
	Partition walls ...	1	11·70	·10	·20	·23		
	(c) Stair case							No deduction for stair opeing to cover the stair roof.
	Base on Toe wall	1	1·10	·30	·30	·10		
	Waist slab of flights	2	3·29	1·10	·15	1·09		
	Landing ...	1	2·20	1·25	·15	·41		
	Steps ...	20	1·10	$\frac{1}{2}$ × ·26	·16	·44		3·29= $\sqrt{(1\cdot80)^2+(2\cdot60)^2}$
	(d) Sunshades over							
	Windows W ...	3	2·0	·45	·07	·19		
	W_1 ...	6	1·4	·45	·07	·26		
	W_2 ...	2	·8	·45	·07	·05		
							44·53	cu m

Building 9 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
7.	**Shuttering for—**	same as		deduction				
	Over door opening	from (4)			—	3·31		
	Windows W	3	1·8	·40	—	2·16		
	W₁	6	1·2	·40	—	2·88		
	W₂	3	·6	·4	—	·72		
	(a) Roof slab ...	1	19·70	19·30	—	380·21		
	Edges ...	1	42·00	—	·10	4·20		42·00 is the perimeter
	Less area of main walls	1	62·30	·40	—	24·92	(-ve)	
	(b) Lintel for main walls	2	62·30	—	·15	18·69		
	Partition walls	2	11·70	—	·20	4·68		
	(c) Stair case							
	Base on Toe wall	2	1·10	—	·20	·44		
	Waist slab of flight	2	3·29	1·1	—	7·34		3·29 same as in 6(c)
	Landing ...	1	2·20	1·5	—	3·30		
	Steps rises ...	20	1·10	—	·16	3·52		
	(d) Sunshades over ...							
	Windows W ...	3	2·0	·45	—	2·70		
	Edges ...	3	2·90	—	·07	6·1		2·90=2·0+2×·45
	Windows W₁	6	1·4	·45	—	3·92		
	Edges ...	6	2·30	—	·07	·97		
	Windows W₂ ...	2	·8	·47	—	·91		
	Edges ...	2	1·74	—	·07	·24		
							415·88 sq m	
8.	**Mild steel work** with 1% reinforcement to concrete ...	=	$\frac{38·02}{100}$	×1=	·3802	cum		Wt. of mild steel per cu m =78·5q
				=	·3802	×78·5	29·85 quintal	
9.	**7·5 cm thick Lime conc. in roof terracing** (considering same as R. C. slab first) ...	1	19·70	19·30	—	300·21		
	Less area of parapet	1	39·60	·20	—	7·92	-ve)	
							292·29 sq m	
10.	**12 mm thick cement plaster** to inside and out side of							
	Main walls ...	2	62·30	—	3·40	423·64		
	Partition walls ...	2	11·70	—	3·40	79·56		
	Plinth wall (out side) ...	1	42·00	—	·70	29·40		42·00 is the perimeter under G.L. 1·63=·60+·25+·60+·07+·10
	Parapet both sides ...	2	42·00	—	1·63	136·92		
	Stair case room remaining over parapet ...	2	4·50	—	2·5	22·50		
	" " ...	2	6·70	-	1·90	25·46		
	Deduction—							
	Door openings D	1	1·2	—	2·5	3·00	(-ve)	
	D₁	5	1·0	—	2·0	10·00	(-ve)	
	D₂	3	·75	—	2·0	4·50	(-ve)	
	C. O. ...					699·98		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B F. ...					699 98		
	Window openings							
	W	3	1·8	—	1·5	4 50	(-ve)	
	W_1	6	1·2	—	1·5	10·80	(-ve)	
	W_2	3	·6	—	·6	1·08	(-ve)	
	Openings...O ...	2	1·5	—	2·0	6·00	(-ve)	
	Staircase opening ...	1	1·50	—	1·2	1·80	(-ve)	
							675·80 sq m	
11.	**7·5 cm thick lime concrete floor over a brick flat**							
	Living room ...	1	2 90	2·90	—	8·41		
	Front bed inclu. toilets	1	5·90	2 90	—	17·11		
	Back bed room ...	1	4 20	2·90	—	12·18		
	Kitchen & Dining ...	1	2·30	5·20	—	11·96		
	Corridor ...	1	1 40	5·20	—	7·28		5·90=3·4+1·2 +1·2+2×·10 −2+·05.
							56·94 sq m	
12.	**2·5 cm thick I. P. C. (1:2:4) over lime concrete**							
	Living room ...	1	3·00	3·00	—	9·00		1·40=3·4+1·2 +1·2+2×·10 −(3+1+·1+·40)—2×·05
	Front bed room including toilets ...	1	6·00	3·00	—	18·00		
	Back bed-room ...	1	4·30	3·00	—	12·90		
	Kitchen & Dining ...	1	2·40	5·30	—	12·72		
	Corridor	1	1·50	5·30	—	7·95		
	Less area of partition walls	1	11·70	·10	—	1 17	(-ve)	
							59·40	sqm

ABSTRACT OF QUANTITIES (Building 3-9)

Sl. No.	Description	Quantity
1.	Brick flat soling with overburnt bricks	63·62 sq m
2.	Cement concrete in foundatian (1 : 3 : 6)	18·89 cu m
3.	1st Class brickwork in cement mortar (1:4) in foundation and plinth ...	44·97 cu m
4.	Damp proof course (1:2:4) under superstructure walls ...	22·78 sq m
5.	1st. Class brickwork in cement mortar (1:6) superstructure 76·67 cu m...	32·94 sq m
6.	R. C. C. work (1 :2:4) excluding reinforcement and shuttering ...	44·53 sq m
7.	Shuttering for R.C.C. work in item no. 6	415·88 sq m
8.	Mild steel work with one percent reinforcement in R.C.C. work ...	29·85 qu „
9.	7·5 cm thick lime concrete (2:2:7) in roof terracing	292·29 sq m
10.	12 mm thick cement plaster (1:6) to walls	675·80 sq m
11.	7·5 cm thick lime concrete floor over a brick flat	56·94 sq m
12.	2·5 cm thick I.P.C. (1:2:4) over lime concrete	59·40 sq m

3-10 Detailed Estimate of a Two Storied Residential Building having a foundation for future extension upto three stories along with cost per storey. (The detailed estimate of this building when built up with R. C. frame structure has been prepared in the R. C. chapter and compaired the cost there.)

General Specifications :—(*a*) *Foundation and Plinth* :—First class brickwork in cement mortar (1 : 4) over cement concrete (1:3:6), (*b*) *Filling* :—Foundation trenches and plinth shall be filled up by loose earth and coarse sand respectively. (*c*) *Damp-Proof-Course* :—shall be of cement concrete (1:2:4) with water proofing compound under superstructure, (*d*) *Superstructure* :—shall be of first class brickwork in cement mortar (1:6), (*e*) *R. C. Works* :—shall be with stone chips reinforced with an average of 1% reinforcement, (*f*) *Flooring* :—shall be of 25 mm thick Marbulite work with precast tiles set in lime mortar (1:3) in floor of all rooms, staircase, dado upto 30 cm height but except for kitchen and store, the floor of kitchen, store and space under 1st flight of staircase shall be of 2·5 cm thick patent stone, (*g*) *Door and Window* :—All wood-work shall be of Indian Teak wood. All door shutter shall be 3·75 cm thick shutter and 19mm thick panel. All windows excepting for the lavatories and staircase shall be 3·75 cm thick Fixed-Louvre shutter. Glazed shutter of 3·75 cm thick shall be fixed for the windows of lavatory and staircase and also as a double shutters for the windows of bed, and dining. All windows shall be fitted with ornamental Grill with 30 mm × 6 mm flats. All wood-work and window grills shall be painted two coats with Synthetic Enamel Paint or Oil bound paint (*h*) *Finishing* :—Inside and outside walls shall be 12 mm thick cement plaster (1:6)· Ceilings Staircase railing, outside of staircase, sun shades shall be 6 mm thick cement plastered (1:4) Outside walls from 10cm below G. L. to plinth and dado of Store and Kitchen upto 60 cm height and Staircase railing upto 30 cm height shall be provided with neat cement punning about 1·5 mm thick over the 12mm thick plastered surface. Inside walls shall be dry Distempering with a coat of priming. Outside walls shall be two coats of Decorative cement based paint. (*i*) *Rainwater Pipes or Down Pipe* :—Shall be 10cm dia. conforming to I. S. 1626–1960 and painted two coats.

Calculation of Centre-line for Ground floor walls :

(*a*) *Main walls of 40cm*

Centre line length of outside walls $= 2[(14{\cdot}3 - 2 \times \frac{{\cdot}50}{2}) + (7{\cdot}9 - 2 \times \frac{{\cdot}50}{2})] = 42{\cdot}40$ m.

Front walls of bed rooms	$= (3{\cdot}1 + {\cdot}40 + 3{\cdot}5) + 2 \times \frac{{\cdot}40}{2}$	$= 7{\cdot}40$ m (joints = 2nos)
Partition between bed rooms	$= 4{\cdot}2 + 2 \times {\cdot}40/2$	$= 4{\cdot}60$ m (joints = 2nos)
Kitchen walls with passage	$= 2(3 + {\cdot}1 + 1{\cdot}1) + 2 \times \frac{{\cdot}40}{2}$	$= 9{\cdot}20$ m (joints = 3nos)
Staircase inside wall	$= (2{\cdot}1 + {\cdot}40 + 3{\cdot}1) + 2 \times \frac{{\cdot}40}{2}$	$= 6{\cdot}00$ m (joints = 1no)
		Total length = 69·60 m, joints = 8 nos.

(*b*) 20 cm wall of store and Lav. $= 2{\cdot}8 + {\cdot}40 = 3{\cdot}20$ m (joints = 2nos)

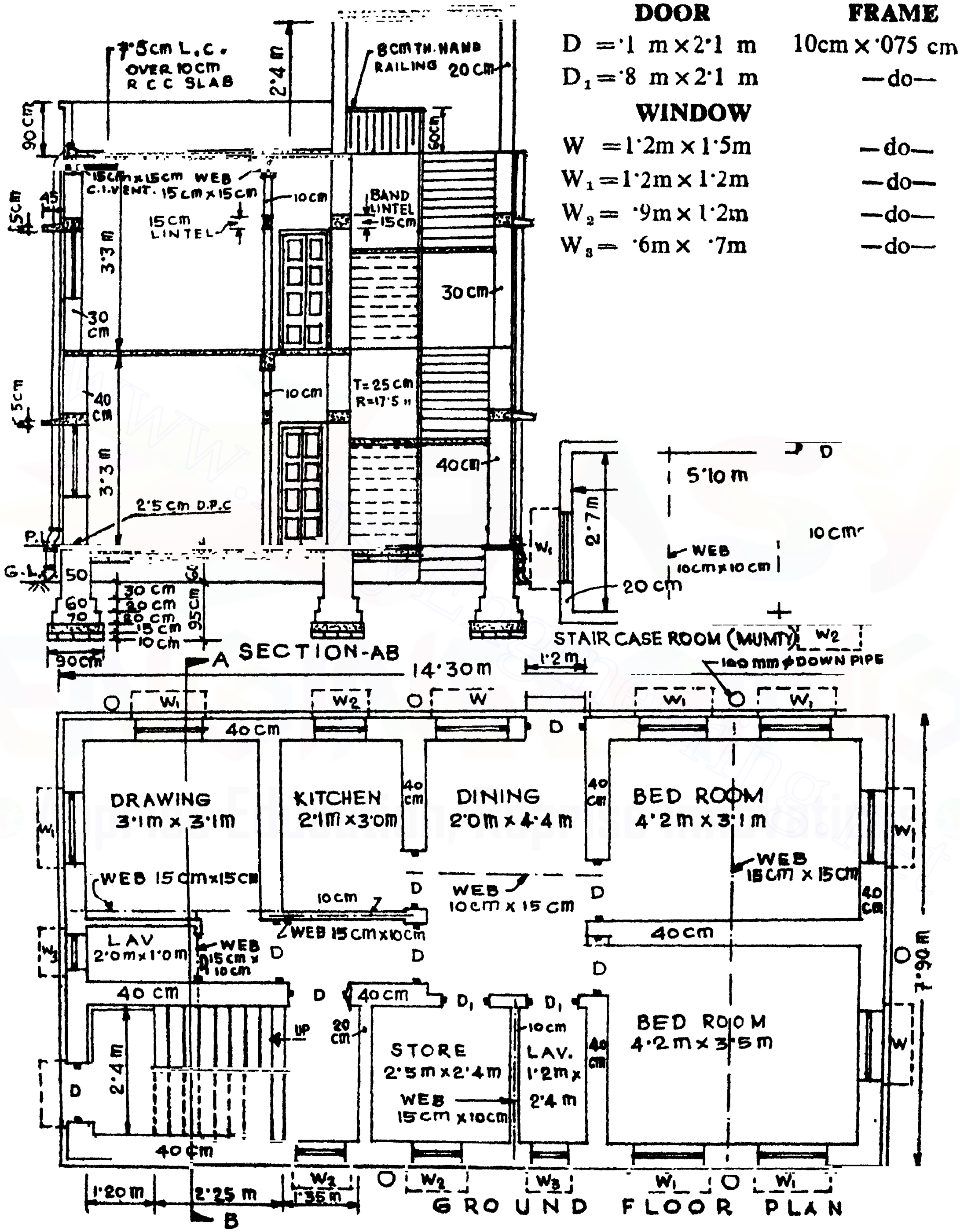
Store at staircase side $= 2{\cdot}4 + {\cdot}40 = 2{\cdot}80$ m (joints = 2 nos)

Total = 6·00 m joints = 4 nos.

(*c*) Toe wall $= 2{\cdot}4 + {\cdot}40 = 2{\cdot}8$ m (joints = 2 nos)

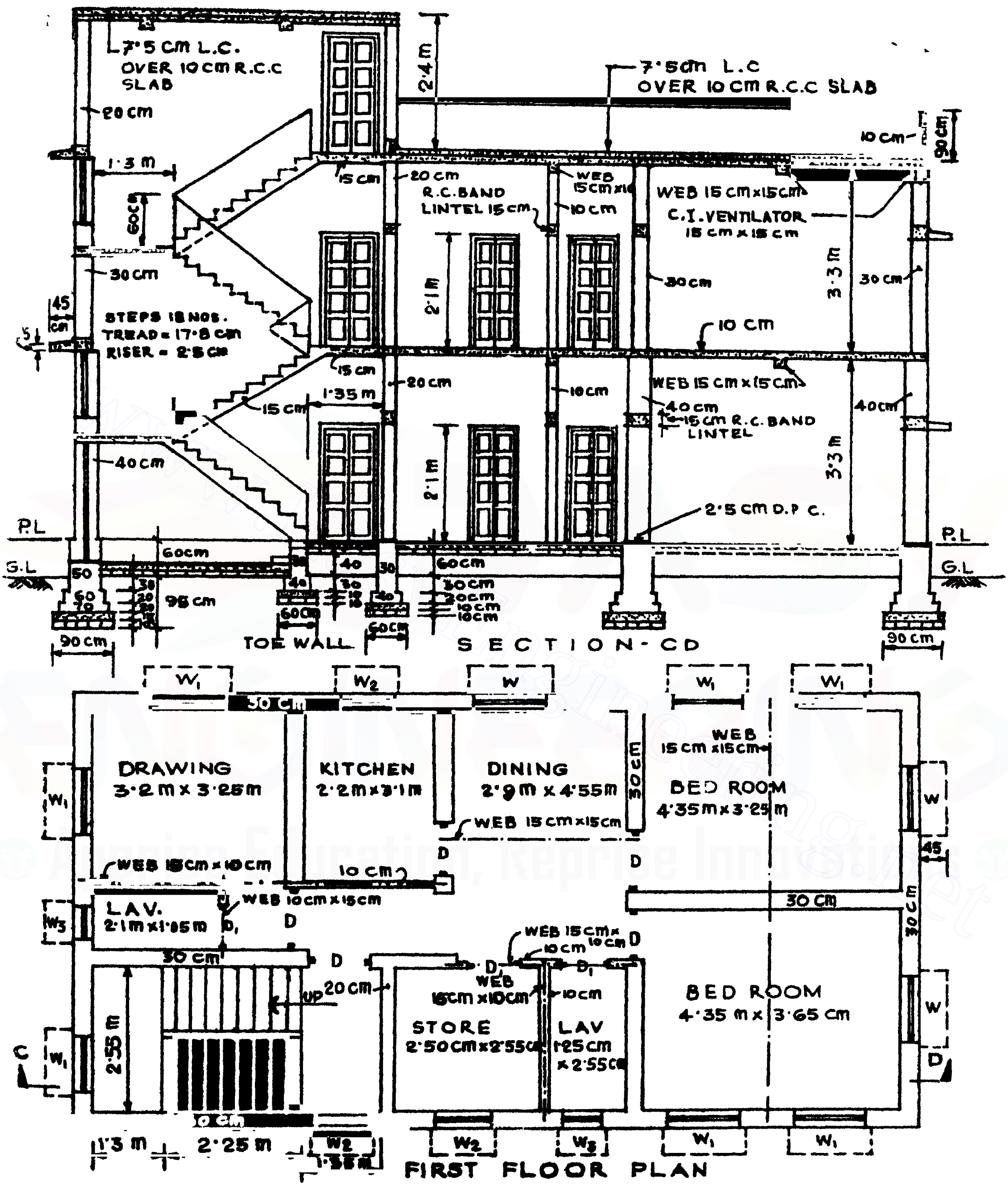
Centre line for 1st. floor walls :—Centre line length for the first floor walls should be the same length of 69·60 as calculated for ground floor walls when both the ground-floor and first floor walls are symmetrical along a same centre line. But since the outside walls of first floor is excentric outwardly by $\frac{1}{2}$(40cm—30 cm) = 5 cm an increment to all such walls which join with the outside walls shall be made. For corners, since two excentric walls join, the increment shall be considered as twice. Investigating the plan of first floor it reveals that there are 6 joints with inside and outside walls. For four corners, joints shall be $4 \times 2 = 8$ nos. Therefore the total number shall be $6 + 8 = 14$ and $14 \times {\cdot}05 = {\cdot}70$ m shall be increased along with the centre line length of ground floor.

Thus simply centre line length of ground floor $= 69{\cdot}60 + {\cdot}70 = 70{\cdot}30$m. But the actual number of joints should be the same as that for ground floor i.e. 8 nos.



DOOR
FRAME
D = ·1 m × 2·1 m
10cm × ·075 cm
D₁ = ·8 m × 2·1 m
—do—
WINDOW
W = 1·2m × 1·5m
—do—
W₁ = 1·2m × 1·2m
—do—
W₂ = ·9m × 1·2m
—do—
W₃ = ·6m × ·7m
—do—
7·5cm L.C. OVER 10cm R C C SLAB
2·4 m
8cm TH. HAND RAILING
20 cm
90 cm
60cm
15cm × 15cm WEB
C.I. VENT. 15 cm × 15 cm
10 cm
BAND LINTEL 15cm
15 cm LINTEL
3·3 m
30 cm
T = 25 cm
R = 17·5
40 cm
3·3 m
2·5 cm D.P.C
P.L
G.L
50
60
70
30 cm
20 cm
20 cm
15 cm
10 cm
95cm
90cm
SECTION-AB
5·10 m
2·7 m
WEB 10cm × 10 cm
10 cm
20 cm
STAIR CASE ROOM (MUMTY)
1·2 m
14·30 m
100 mm φ DOWN PIPE
DRAWING 3·1m × 3·1m
KITCHEN 2·1m × 3·0m
DINING 2·0m × 4·4 m
BED ROOM 4·2 m × 3·1 m
WEB 15 cm × 15 cm
WEB 10cm × 15 cm
WEB 15 cm × 10 cm
LAV 2·0m × 1·0m
WEB 15 cm × 10 cm
STORE 2·5m × 2·4m
WEB 15 cm × 10 cm
LAV. 1·2m × 2·4 m
BED ROOM 4·2 m × 3·5 m
UP
2·4 m
7·90 m
1·20 m
2·25 m
1·35 m
GROUND FLOOR PLAN

FIG 3 10



NOTE :—FRONT OF THE BUILDING IS AT LEFT

Quantity Estimate for Ground Floor :—

Item No.	Description	No	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							66·00=69·60—8×·90/2
	Main walls ...	1	66·00	·90	·95	56·43		4·20=6·00—4×·90/2
	20 cm walls ...	1	4·20	·60	·70	1·76		
	Toe walls ...	1	1·90	·60	·50	·57		
	Steps	1	1·20	·45	·10	·05		
							58·81 cu m	·45=(2×·30+·40/2)+·10 (projection) —·90/2
2.	**Earthwork in filling** by loose earth of foundation trench	1/6	th. of	exca	vation	11·76	11·76 cu m	
3.	**Sand filling for plinth**							
	Bed rooms ...	2	4·10	3·20	·42	11·02		
	Dining ...	1	4·10	2·70	·42	4·65		
	Store & Lav. ...	1	3·70	2·50	·42	3·89		3·70=(1·2+·10+2·5)—·10
	Kitchen upto stair ...	1	4·10	2·00	·42	3·44		
	Drawing ,, ,, ...	1	4·10	3·00	·42	5·17		
	Staircase ...	1	1·30	2·30	·42	1·26		
							29·52 cu m	1·30=1·35+·05
4.	**Single layer brick flat soling**							4·60=6·00—4×·70/2
	Main walls ...	1	66·00	·90	—	59·40		2·20=2·80—2×·60/2
	20cm walls ...	1	4·60	·60	—	2·76		·70=2×·30+·10 (for projection)
	Toe wall ...	1	2·20	·60	—	1·32		
	Steps	1	1·20	·70	—	·84		
							64·32 sq m	
5.	**Cement concrete (1:3:6) in foundation** for—							
	Main walls ...	1	66·00	·90	·15	8·91		
	20 cm walls ...	1	4·60	·60	·10	·28		
	Toe wall ...	1	2·20	·60	·10	·13		
	Steps	1	1·20	·70	·10	·08		
							9·40 cu m	
6.	**First class brickwork in** cement mortar (1:4) in foundation and plinth							
	Main walls,							
	1st. footing 70 cm	1	66·80	·70	·20	9·35		66·80=69·60—8×·70/2
	2nd footing 60 cm	1	67·20	·60	·20	8·06		
	Plinth wall 50 cm	1	67·60	·50	·90	30·42		
	20 cm walls,							
	1st. footing 40 cm	1	4·80	·40	·20	0·38		
	Plinth wall 30 cm	1	5·00	·30	·90	1·35		
	Toe wall,							
	1st. footing 40 cm	1	2·30	·30	·40	0·28		
	Steps under stair	1	1·20	·30	·20	0·07		The door under staircase has a height of 60 cm in plinth.
	Step	1	1·20	·45 (av.)	·40	0·22		
	Deduction for door in plinth	1	1·00	·50	·60	0·30	-ve	
							23·04 cu m	

Building 10 continued

Item No.	Description	No.	L. m	B. m.	H. m	Qu	Total	Explanatory notes
7.	**2·5 cm thick Damp Proof Course** (1:2:4) for—							
	Main wall ...	1	68·00	·40	—	27·20		$68{\cdot}00 = 69{\cdot}60 - 8 \times \frac{\cdot 40}{2}$
	20 cm wall ...	1	5·20	·20	—	1·04		
	Deduction for—							
	Door sill D ...	8	1·00	·40	—	3·20	(—ve)	
	,, ,, D_1 ...	2	·80	·20	—	·32	,,	
							24·72 sq m	
8.	**First class brickwork** in superstructure (1:6) for—							
	Main walls ...	1	68·00	·40	3·30	89·76		
	20 cm walls ...	1	5·20	·20	3·30	3·43		
	Deduction for—							
	Door openings D	7	1·00	·40	2·10	5·88	(—ve)	
	Door understair	1	1·00	·40	1·50	·60	,,	Part of the door under stair is in supt. wall
	Door ... D_1	2	·80	·20	2·10	3·36	,,	
	Window openings W	3	1·20	·40	1·50	2·16	,,	
	,, ,, W_1	7	1·20	·40	1·20	4·03	,,	
	,, ,, W_2	3	·90	·40	1·20	1·30	,,	
	,, ,, W_3	2	·60	·40	·70	0·34	,,	
	R.C. band lintel ...	1	68·00	·40	·15	4·08	,,	
	,, ,, ,, in 20 cm	1	5·20	·20	·15	0·16	,,	5·20=2·8+2·4
							71·04 cu m	
	10 cm thick brickwork (1:3) with H.B. wire netting							
	Kitchen ...	1	2·10	—	3·00	6·30		
	Drawing room lav.							
	Long wall ...	1	2·10	—	3·00	6·30		3·00=3·30−·15 (for lintel height)—·15 (beam over the wall)
	Short wall ...	1	1·00	—	3·00	3·00		
	Partition between lav. & Store	1	2·40	—	3·00	7·20		
	Deduction for Door D_1	1	·80	—	2·10	1·68	(—ve)	
							21·12 sqm	
	Cement concrete (1:2:4) excluding shuttering and reinforcement							
	(a) Roof slab including staircase first	1	14·20	7·80	·10	11·08		
	Less area of staircase ...	1	5·20	2·80	·10	1·46	(—ve)	2·80=2·40+·40
						9·62		
	(b) Web of beams for—							
	Bed rooms ...	1	7·80	·15	·15	·18		For bed rooms continious beam with full bearings
	Dining	1	3·60	·15	·15	·08		
	Over 10 cm wall of—							
	Kitchen ...	1	2·80	·10	·15	·04		
	Drawing long	1	3·80	·15	·15	·09		1·3=1·1+·20 (bearing)
	,, short	1	1·30	·10	·15	·02		
	Partition between lav. & store	1	2·80	·10	·15	·04		2·8=2·40+2×·20
	C. O.					10·07		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...	...	...	...	...	10·07		$2{\cdot}69=\sqrt{2{\cdot}25^2+1{\cdot}50^2}$
	(c) Staircase—							
	Base on Toe wall ...	1	1·15	·30	·20	·07		$1{\cdot}50=\frac{3{\cdot}30}{2}-{\cdot}15$
	Waist slab of flights ...	2	2·69	1·60	·15	1·29		(for landing slab)
	Landing (lower) ...	1	1·60	3·20	·15	·77		
	Landing (at 1st floor)	1	1·55	3·20	·15	·74		
	Steps ...	18	1·20	·25	·175	·47		3·20=2·4+2× ·40(full bearing)
	Staircase railing ...	2	2·69	·08	·60	·26		Hand rail is of separate material.
	(d) R. C Lintel—							
	Band linted in main wall	1	68·00	·40	·15	4·08		
	,, ,, in 20cm wall	1	5·20	·20	·15	·16		
	,, ,, in 10cm wall of Kitchen ...	1	2·10	·10	·15	·03		
	Drawing lav. long side	1	2·10	·10	·15	·03		see item no. (8)
	,, ,, short side	1	1·00	·10	·15	·02		
	Partition of lav. & store	1	2·40	·10	·15	·04		
	(e) Sunshades over —							
	Windows, W & W_1	9	1·50	·45	·05			
	W & D (combined)	1	2·80	·45	·05			
	Window, W_2	3	1·20	·45	·05			
	,, W_8	2	·90	·45	·05			
			22·10	·45	·05	·50		
							18·53 cum	
11.	**Centering and shuttering** for R. C. C. works							
	(a) Roof slab (including first area of staircase)...	1	14·20	7·70	—	109·34		
	Outer edges ...	1	43·80		·10	4·38		
	Inner edges for staircase opening ...	1	16·00	—	·10	1 60		
	Deduct stair opening	1	5·20	2·80	—	14·56	(-ve)	10cm walls are built up after roof slab, so no deduction
	,, area of 40cm wall	1	68·00	·40	—	27·20	(-ve)	
	,, ,, ,, 20cm ,,	1	5·20	·20	—	1·04	,,	
	(b) Web of beams for—							
	Bed rooms ...	1×2	7·80	—	·15	2·34		7·80=3·4+3·2 +3×·40
	Dining ...	1×2	3·60	—	·15	1·05		3·60=2·8+2× ·40
	Kitchen ...	1×2	2·80	—	·15	0·84		
	Lav. of drawing ...	1×2	3·80	—	·15	1·14		
	,, ,, ,, ...	1×2	1·30	—	·15	0·39		Side shuttering includes bearing area.
	Over partition of lav. and store ...	1×2	2·80	-	·15	0·84		
	C. O.					80·16		

Building 10 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
	B. F. ...	...	...	...	...	80·16		
	(c) Staircase—							
	Base on Toe wall ...	1 × 2	1·15	—	·20	0·46		
	Waist slab of flights ...	2	2 69	1·20	—	6·46		
	Edges...	2	2·69	—	·15	·81		
	Landing at (lower) ...	1	1·20	2·40	—	2·88		
	Edges...	1	6·40	—	·15	0 96		6·40 = 2 × 1·60 + 3·2; see (10c)
	Landing at 1st floor	1	1·35	2·40	—	3·56		
	Edges...	1	3 30	—	·15	0·50		
	Steps (rises only) ...	18	1·20	—	·175	3·78		
	Railing (both sides) ...	2 × 2	2·69	—	·60	6·45		
	(d) R. C. lintel							
	Band lintel for main wall ...	2	68·00	—	·15	20·40		
	,, ,, for 20cm wall	2	5·20	—	·15	1·56		
	,, ,, for 10cm wall of kitchen... ...	2	2·10	—	·15	·63		
	Drawing room lav.—							
	Long wall ...	2	2·10	—	·15	·63		
	Short wall ...	2	1·00	—	·15	·30		
	Partition of Lav. & Store ...	2	2·40	—	·15	·72		
	Over door & window—							
	in 40cm wall	1	23·90	·40	—	9·56		23 90 = 8 × 1·00 + 10 × 1·20 + 3 × ·90 + 2 × ·60
	in20cm wall	1	1·60	·20	—	·32		
	(e) Sun shades over—							
	Window W & W_1 ...	9	1·50	·45	—	6·08		
	Edges	9	2·40	—	·05	1·08		2·40 = 1·50 + 2 × ·45
	Window W & D(comb.)	1	2·80	·45	—	1·26		
	Edges	1	3 70	—	·05	·18		
	Window W_2 ...	3	1·20	·45	—	1·62		
	Edges	3	2·10	—	·05	·31		
	Window W_3 ...	2	·90	·45	—	·81		
	Edges	2	1·80	—	·05	·18		
	Staircase door D ...	1	1·30	·45		·58		
	Edges ...	1	2·20	—	·05	·11		
							152·33 sqm	
12.	**Mild Steel reinforcement** including cutting, hooking, bending & binding	@ =	1%vol 18·53	of con × $\frac{1}{100}$	crete 78·5 =	14·55	14·55 quin	Although there is no reinforcement in step but the vol. being small has not been deducted from the total vol. of conc.
13.	**Indian Teakwood work for frames of—**							
	Door, D ...	8	6·20	·10	·075			6·60 = 3 × 1·20 + 2 × 1·50
	,, D_1 ...	3	5·80	·10	·075			6·00 = 3 × 1·20 + 2 × 1·20
	Window W ...	3	6·60	·10	·075			3 verts & 2 hors.
	,, W_1 ...	7	6·00	·10	·075			
	,, W_2 ...	3	4·20	·10	·075			
	,, W_3 ...	2	2·60	·10	·075			
			145·60	·10	·075	1·092	1·092 cum	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
14.	**Indian Teak wood panelled shutters** 3·75cm thick shutters with 19mm thick panel.							
	Door D ...	8	·88	—	1·95	13·73		·88=1·00—2 × ·075+2 × ·015 (rebate)
	,, D_1 ...	3	·68	—	1·95	3·98		
							17·71 sqm	
15.	**3·75cm thick Fixed—** Louver shutters for windows							
	W ...	3	1·08	—	1·335	4·33		1·335=1·5—3 × ·075+4 × ·015
	W_1 ...	6	1·035	—	1·08	6·71		
	W_2 ...	2	·78	—	1·08	1·68		
							12·72 sqm	
16.	**3·75cm thick Glazed shutters** for windows—							6nos. except staircase window
	W ...	3	1·08	—	1·335	4·33		
	W_1 ...	7	1·035	—	1·08	7·82		
	W_2 ...	1	·78	—	1·08	·84		
	W_3 ...	2	·48	—	·58	·56		
							13·55 sqm	
17.	**M.S. Ornamental Grill** with 30 × 6mm flats for windows							
	W ...	3	1·05	—	1·275	4·02		1·05=1·2—2 × ·075
	W_1 ...	7	·975	—	1·05	7·17		1·275=1·5—3 × ·075
	W_2 ...	3	·75	—	1·05	2·36		·975=1·2—3) × ·075 (3 verts
	W_3 ...	2	·45	—	·55	·50		
							14·05 sqm	
18.	**M.S. Clamp 37·5cm long end** bifurcated with 37 × 6 mm flat							
	For door frames ...	11 × 6	—	—	—	66		
	Window ...	15 × 4	—	—	—	60		
							126 nos.	
19.	**Anodised Alluminium hand rail** with 15cm leg for—							
	Staircase railing	2	2·69	—	—	5·38	5·38 rm	
20	**7·5cm thick Terraced flooring** in lime concrete ($1\frac{1}{2}$: 2 : 7) over a brick flat for—							
	Bed room	1	4·10	3·00	—	12·30		
	,, ,, ...	1	4·10	3·40	—	13·94		
	Dining	1	2·70	4·30	—	11·61		
	Drawing & lav. ...	1	4·10	3·00	—	12·30		
	Kitchen with passage	1	2·70	4·10	—	11·07		
	Store & lav. (combined)	1	3·60	2·30	—	8·28		
	Staircase room ...	1	3·60	2·30	—	10·58		
							80·08 sqm	

Building 10 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
21.	**Marbulite work** for—							
	(a) Floors, Bed room ...	1	4·20	3·10	—	13·02		
	,, ,, ...	1	4·20	3·50	—	17·70		
	Dining ...	1	2·80	4·40	—	12·32		
	Drawing & Lav.	1	4·10	3·10	—	12·71		4·10=4·20—·10 excluding 10 cm wall area.
	Passage (kitchen)	1	2·10	1·10	—	2·31		
	Lav. (store side)	1	2·40	1·20	—	2·88		
	Entrance under stair ...	1	3·45	1·15	—	3·97		3·45=2·25 +1·20 (portion under 1st. landing)
	Under 2nd landing ...	1	1·20	2·30	—	2·76		
	Steps of staircase, treads ...	18	1·20	·25	—	5 40		
	rises ...	18	1·20	—	·175	3·78		
	Landing (lower)	1	2·40	1·20	—	2·88		
	Landing 1st. floor	1	2 40	1·35	—	3·24		
	Rises of landing	2	2·40	—	·15	·72		
	Door sills for D ...	8	1·00	·40	—	3·20		
	,, ,, D_1 ...	2	·80	·20	—	·32		
	,, ,, D_1 ...	1	·80	·10	—	·08		
	(b) Dado for—							
	Bed room ...	1	14·60	—	·30			
	,, ,, ...	1	15·40	—	·30			
	Dining ...	1	14 40	—	·30			12·40=2(3·1 +3·1)
	Drawing ...	1	12·40	—	·30			
	Lav. (drawing) ...	1	6·00	—	·30			
	Front of lav. ...	1	1·10	—	·30			5·80=2(2·1+ 2×·40)
	Passage ...	1	5·80	—	·30			
	Lav. (storeside) ...	1	7·20	—	·30			
	Entrance ...	1	4·65	—	·30			
	Under 2nd landing	1	5·10	—	·30			4·65=2×1·2 +2·25
	Stair flights ...	2	2·69	—	·30			
	Landing (lower)	1	4·80	—	·30			5·10=2×1·35 +2·4
	,, 1st floor	1	5·10	—	·30			
			101·93	—	·30	30·58		
	Deduction for—							No deduction for door opening to cover the area of jams.
	Area of steps	18	½×·25	—	·175	·39	—(ve)	
							104·46 sqm	
22.	**2·5 cm thick grey artificial stone floor** with cement concrete (1 : 2 : 4) with skinning							
	Kitchen ...	1	3·00	2·10	—	6·30		
	Store ...	1	2·50	2·40	—	6·00		
	Under 1st flight ...	1	3·45	1·20	—	4·14		3·45=2·25+1·20
							16·44	sq m

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
23.	**12mm thick cement plaster (1 : 6) to wall.**							
	(a) Inside—Bed room ...	1	14·60	—	3·00	43·80		3·00=3·30—·30 (for dado.)
	—do— ...	1	15·40	—	3·00	46·20		
	Dining ...	1	14·40	—	3·00	43·20		
	Kitchen ...	1	10·20	—	2·70	27·54		Dado of kitchen is 60 cm.
	Drawing ...	1	12·40	—	3·00	37·20		
	Lav. (drawing) ...	1	6·00	—	3·00	18·00		
	Fronts of lav. ...	2	1·10	—	3·00	6 60		6·40=2(2·1 +1·1)
	Passage ...	1	6·40	—	3·00	19·20		
	Lav. (store) ...	1	7·20	—	3 00	21·60		
	Store ...	1	9·80	—	2·70	29·40		2·70 as stair dado has been counted twice for two flights
	Staircase room ...	1	14·40	—	2·70	38·88		
	Deduction for openings—							
	Door D ...	8	1·00	—	2·10	16·80	(-ve)	
	D_1 ...	3	·80	—	2·10	5·04	,,	
	(b) Outside—					309·78		
	Upto plinth from 1st. floor ...	1	44·00	—	3·30	145·20		44 00=2(7·8 +14·2)
	From P. L. to 10 cm below G. L. ...	1	44·40	—	·75	33·30		44·40=2(7·9 +14·3)
	Steps, treads ...	1×2	1·20	·30	—	·72		
	,, Sides ...	2	·45 (av.)	—	·40	·36		
	Deduction for openings							
	Windows W	3	1·20	—	1·50	5·04	(-ve)	
	,, W_1	7	1·20	—	1·20	10·08	,,	
	,, W_2	3	·90	—	1·20	3·24	,,	
	,, W_3	2	·60	—	·70	·84	,,	
							469·80 sq m	
24.	**Neat cement punning** about 1·5mm thick							
	From P. L. to 10cm below G. L. ...	1	44·40	—	·75	33·30		As cement punning is provided for one side of the door no deduction is made, considering extra cost of labour and area of jambs left out
	Dado for kitchen ...	1	10·20	—	·60	6·12		
	Store... ...	1	9·80	—	·60	5·88		
	Steps treads ...	1×2	1·20	·30	—	·72		
	Steps sides... ...	2	·45 (av).	—	·40	·36		
							46·38 sq m	
25.	**6mm thick cement plaster** (1:4)							
	(a) Roof slab... ...	same as item 11 (a) =				66·38		
	(b) Web of beams for—							
	Bed room ...	1×2	3·10	—	·15	·93		
	,, ,, ...	1×2	3·50	—	·15	1·05		
	Dining ...	1×2	2·80	—	·15	·84		
	C. O.	...	...	...		69·20		

Building 10 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
	B. F.					69·20		
	(c) Staircase—							
	Under waist slab ...	2	2·69	2·40		12·91		
	Underside of 1st. landing	1	1·20	2·40		2·88		
	„ „ 2nd „	1	1·35	2·40		3·24		1·13 = ·30 (inside) + ·08 (top) + ·75 (out side)
	Sides of staircase railing	2	2·69		1·13	6·99		
						95·22		
	(d) Sun shades... ...	Double the area of 11 (e) ... =				24·42		12·21 is the summation of 11 (e)
		Less once area of edges ...				1·86	(-ve)	
							117·78	sq m
26.	**Dry Distempering to interior walls and ceiling**	same as 23 (a) =				309·78		
		25(a)+(b)+(c)				95·22		
							405 sqm	
27.	**Decorative Cement based paint two coats for outside plaster**	same as 22 (b)				160·02		
		+ 25 (d)				22·56		
							182·58	
28.	**Painting on timber surface**							
	(a) Panelled doors, D ...	[illegible]	1·00		2·10	37·80		For panelled shutter multiplying factor for both sides = 2¼ times
	„ „ D_1 ...	3×2¼	·80		2·10	11·34		
	Fixed-Louvred window							
	W	3×3	1·50		1·50	16·20		
	W_1	6×3	1·20		1·20	25·92		For louvred shutter multiplying factor for both side = 3 times.
	W_2	2×3	·90		1·20	6·48		
	(c) Glazed shutter window							
	W	3×1	1·20		1·50	5·40		
	W_1	7×1	1·20		1·20	10·08		
	W_2	1×1	·90		1·20	1·08		For glazed shutter multiplying factor for both sides = 1 time
	W_3	2×1	·60		·70	·84		
							115·14 sqm	
29.	**Painting two coats on metal surface**							
	Window Grill, W	3×1	1·05		1·275	4·02		Multiplying factor for both sides = 1 time
	„ „ W_1	7×1	·975		1·05	7·17		
	„ „ W_2	3×1	·75		1·05	2·36		
	„ „ W_3	2×1	·45		·55	·50		For dimensions see (17)
							14·23 sqm	
30.	**100 mm dia., asbestos cement down pipes, painted complete**		4·00			24·00	24 00 rm	
31.	**C. I. Ventilator 15cm × 15cm with two coats of painting**	14				14	14	nos.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**First class brickwork** in cement mortar (1:6)							
	Main walls ...	1	66·70	·30	3·30	66·03		
	20cm walls ...	1	2·55	·20	3·30	1·65		
	Staircase room three sides ...	1	13·60	·20	2·40	6·53		
	Deduction for :—							$66{\cdot}70 = 70{\cdot}30 - 8 \times \frac{{\cdot}20}{2}$ $13{\cdot}60 = 2(5{\cdot}1 + {\cdot}1 + {\cdot}20) + 2{\cdot}70$
	Door openings D	6	1·00	·30	2·10	3·78		
	Staircase „ „ D	1	1·00	·20	2·10	·42	(-ve)	
	Window openings W	3	1·20	·30	1·50	1·62	„	
	„ „ W_1	7	1·20	·30	1·20	3·02	„	
	„ „ W_2	3	·90	·30	1·20	·97	„	
	„ „ W_3	2	·60	·30	·70	·25	„	
	Stair room „ „ W_1	1	1·20	·20	1·20	·29	„	
	„ „ „ W_2	1	·90	·20	1·20	·22	„	
							63·64 cu m	
2.	**10 cm thick first class brick work** in cement mortar (1:3) with H. B. wire netting							
	Kitchen ...	1	2·20	—	3·00			3·00=3·30—·15 (for lintel)—·15 (for beam over wall)
	Drawing room lav.							
	Long wall ...	1	2·20	—	3·00			
	Short wall ...	1	1·05	—	3·00			
	Front of lav. & store ...	1	2·90	—	3·00			
	Partition between lav. & store	1	2·55	—	3·30			
			10·90	—	3·00	32·70		
	Deduction for door D	3	·80	—	2·10	5·04	(-ve)	
							27·66 sq m	
3.	**Cement concrete** (1:2:4) excluding shuttering and reinforcement							
	(a) Roof slab ...		Same ground	as floor	in 10(a)=	9·62		
	Staircase room roof	1	5·30	3·10	·10	1·64		
	(b) Web of beams for							
	Bed rooms	1	7·80	·15	·15	·17		20 cm bearing considered.
	Dining ...	1	3·50	·15	·15	·08		
	Over 10 cm wall of							
	Kitchen	1	2·80	·10	·15	·04		
	Drawing long	1	3·60	·15	·15	·08		
	„ short	1	1·25	·10	·15	·02		
	Front of store & lav.	1	3·30	·10	·15	·05		
	Partition of store & lav.	1	2·85	·10	·15	·04		
	C. O. ...	...	...	...	...	11·74		

Building 10 continued

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
B. F.	...	...	...	...	11·74		
(c) Staircase—							
Waist slab of flights	2	2·69	2 75	·15	2·22		2·69 same as that ground floor 2·75=2·55 +2×·1 (insertion in wall)
Landing (lower)	1	1·60	3·15	·15	·76		
Landing (2nd floor)	1	1·55	0 15	·15	·73		
Steps ...	18	1·275	$\frac{\cdot 25}{2}$	·175	·50		
Railing of staircase	2	2·69	·08	·60	·25		
,, at 2nd floor	1	1·58	·08	·60	·08		
(d) R. C band lintel in—							
Main wall... ...	1	66·70	·30	·15	3·0		
20 cm wall... ...	1	2·55	·20	·15	·08		
10 cm wall... ...	1	10·90	·10	·15	·08		
Staircase room... ...	1	13 60	·20	·15	·41		
(e) Sunshades Over—							
Windows W & W_1	10	1·50	·45	·05			
W_2	4	1·30	·45	·05			
W_3	2	·90	·45	·05			
Staircase room door	1	1·30	·45	·05			
	T.L.	23·30	·45	·05	·52		
						20·37	cum
Centering and shuttering for R. C. C. works.							
(a) Roof slab (including first area of staircase) ...	1	14·20	7·70	—	109·34		
Edges of roof slab (outer)	1	43·80	—	·10	4·38		
,, ,, ,, ,, (inner)	1	16·00	—	·10	1·60		Inner edge due to stair room opening
Less area of stair room	1	5·20	2·80	—	14 56	(-ve)	
,, ,, ,, 30 cm wall	1	66·70	·30	—	20·01	,,	
,, ,, ,, 20 cm wall	1	2 55	·20	—	·51	,,	
Stair room roof ...	1	5·30	3·10	—	16·43		
Edges	1	16·80	—	·10	1·68		
Less area of 20 cm wall	1	13 60	·20	—	2·72	(- ve)	No deduction for 10 cm wall as this wall is built up after roof slab.
(b) **Web** of beams for—							
Bed rooms ...	1×2	7·80	—	·15			
Dining ...	1×2	3·50	—	·15			
Kitchen ...	1×2	2 80	—	·15			
Drawing long ...	1×2	3·60	—	·15			
,, short ...	1×2	1·25	—	·15			
Front of store & lav.	1×2	3·30	—	·15			
Partition of store & lav. ...	1×2	2·85	—	·15			
	T.L.	50·20	—	·15	7·53		
C. O. ...	...	...	...	...	103·16		

Item No	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
	B. F. ...	...	...	...	...	103·16		
	(c) Staircase—waist slab ...	2	2·69	1·28	—	6·89		
	Edges ...	2×2	2·69	—	·15	1·61		
	Landing (lower) ...	1	1·30	—	2·55	3·32		6·35=2×1·60
	Edges ...	1	6·35	—	·15	·95		+3·15 (see 3c)
	steps (rises) ...	18	1·275	—	·175	4·02		
	Railing (both sides)	2×2	2·69	—	·60	6·46		
	,, 2nd floor	1×2	1·53	—	·60	1·90		
	(d) R. C. Lintel—							
	Band in main wall ...	2	66·70	—	·15	20·01		
	,, ,, 20 cm ,, ...	2	2·55	—	·15	·77		
	,, in 10 cm ...	2	10·90	—	·15	3·27		
	Lintel in stair room ...	2	13·60	—	·15	4·08		
	Over opening of Door D	6	1·00	·30	—	1·80		
	,, D	1	1·00	·20	—	·20		
	Window W & W_1	10	1·20	·30	—	3·60		
	W_2	3	·90	·30	—	·81		
	W_3	2	·60	·30	—	·36		
	Stair room ... W_1	1	1·20	·20	—	·24		
	W_2	1	·90	·20	—	·18		
	(e) Sun shades ...	Same floor	(apx) II	as (e)	in ground ... =	24·42		
							188·06	sq m
5.	**M. S. reinforcement** including, cutting, hooking, bending and binding	@ con	1% crete=	volume 20·37	of $\times \frac{1}{100}$ =	×78·5 15·99	15·99	sq m
6.	**7·5 cm thick lime** terracing on roof (2 : 2 : 7)	1	14·00	7·6	—	106·40	sq m	To cover stair case roof no deduction
7.	**Indian Teak wood work** for frames of—							
	Door D ...	7	6·20	·10	·075			
	,, D_1 ...	3	5·80	·10	·075			
	Window W ...	3	6·60	·10	·075			
	,, W_1 ...	8	6·00	·10	·075			
	,, W_2 ...	4	4·20	·10	·075			8 nos. including
	,, W_3 ...	2	2·60	·10	·075			stair room
		T.L.	150·60	·10	·075	1·13	1·13 cu m	
8.	**Indian Teak wood panelled shutters** 3·75 cm thick with 19mm thick panel							
	Door, D ...	7	·88	—	1·95	12·01		6 nos. except staircase and stair room.
	,, D_1 ...	3	·68	—	1·95	3·98		
							15·99 sq m	
9.	**3·75 cm thick Fixed**—Louver shutters for—							3 nos. W_2 including stair room.
	W ...	3	1·08	—	1·335	4·32		
	W_1 ...	6	1·035	—	1·08	6·71		
	W_3 ...	3	·78	—	1·08	2·53	13·56	sq m

Building 10 continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
10.	**3.75 cm thick Glazed shutters** of windows— ... W ...	3	1·08	—	1·335	4·33		
	W_1 ...	8	1·035	—	1·08	8·94		
	W_2 ...	2	·78	—	1·08	1·68		
	W_3 ...	2	·48	—	·53	·56		
							15·51 sq m	
11.	**M.S. Ornamental Grill** with 30mm × 6mm flats							
	For window, W ...	3	1·05	—	1·275	4·02		
	W_1 ...	8	·975	—	1·05	8·19		
	W_2 ...	4	·75	—	1·05	3·15		
	W_3 ...	2	·45	—	·55	·50		
							15·86 sq m	
12.	**M S. clamp 37·5 cm long** end bifurcated with 37mm × 6mm flat							
	For door frames ...	10 × 6	—	—	—	60		
	Window " ...	17 × 4	—	—	—	68		
							128 nos.	
13.	**Anodised Alluminium hand rail** with 15cm leg							
	For 1st floor ...	2	2·69	—	—	5·38		
	At 2nd floor ...	1	1·58	—	—	1·58		
							6·96 rm	
14.	**25mm thick Mosaic work** with precast tiles							
	(a) Floor of Bed room ...	1	4·35	3·25	—	14·14		
	" " ...	1	4·35	3·65	—	15·88		
	Dining ...	1	4·55	2·90	—	13·20		
	Drawing & lav. ...	1	4·40	3 20	—	14·08		
	Passage (kitchen) ...	1	2·20	1·20	—	2·64		
	Lav. (store side) ...	1	2·25	1·26	—	2·81		
	Stair case—							
	Landing (lower) ...	1	2·55	1·30	—	3·32		
	Landing (2nd floor) ...	1	2·55	1·35	—	3·44		
	Rises of landings ...	2	2·55	—	·15	·77		
	Steps treads ...	18	1·28	·25	—	5·76		
	" rises ...	18	1·28	—	·175	4 03		
	Door sills D ...	6	1·00	·30	—	1·80		
	" " D_1 ...	3	·80	·10	—	·24		
	(b) Dado for—							
	Bed room ...	1	15·20	—	·30			
	" " ...	1	16·00	—	·30			
	Dining ...	1	14·90	—	·30			
	Lav. (drawing) ...	1	6·30	—	·30			
	Front of lav. ...	1	1·15	—	·30			
			53·55	—	·30	16·07		
	C. O. ...	...	...	...		98·18		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...	...	...	...	...	98·18		
	Passage ...	1	5·60	—	·30			5·60=2(2·2+2
	Lav. (store side) ...	1	7·60	—	·30			×·30) two sides
	Railing of staircase ...	2	2·69	—	·30			only as other
	,, at 2nd floor ...	1	1·58	—	·30			two sides are
	Landing lower ...	1	5·15	—	·30			covered by door
	,, at 2nd floor ...	1	5·25	—	·30			openings.
			30·56	—	·30	9·17		5·15=2·55+2
	Deduction for area of steps	18	½ ×	·25—	1·75	·39	(-ve)	×1·3 No deduc-
							106 96 sqm	tion for door openings to cover the area of jambs.
15.	**2·5 cm thick grey artificial stone floor (1:2.4)**							
	Kitchen ...	1	3·10	2·20	—	6·82		
	Store ...	1	2·50	2·55	—	6·38		
	Staircase room ...	1	5·10	2·70	—	13 77		
							26·97 sqm	
16.	**12 mm thick cement plaster to wall.**							
	(a) Inside—Bedroom ...	1	15·20	—	3·00			
	,, ,, ...	1	16·00	—	3·00			
	Dining ...	1	14·90	—	3·00			
	Drawing ...	1	12·90	—	3·00			
	Lav. (drawing)	1	6 30	—	3·00			
	Fronts lav. ...	2	1·15	—	3·00			
	Passage ...	1	6·60	—	3·00			
	Lav. (store) ...	1	7·60	—	3·00			
			81·80	—	3·00	245·40		
	Kitchen ...	1	10·60	—	2·70	28·62		
	Store ...	1	10·10	—	2·70	27·27		
	Staircase ...	1	14·90	—	2·70	40·23		Dado of kitchen
	Staircase room	1	15·60	—	2·10	32·76		and store is
	Deduction for Door D	7	1·00	—	2·10	14·70	(-ve)	60 cm
	D_1	3	·80	—	2·10	5·04	,,	
						363·54		
	(b) Out side— Upto top level of Parapet from 1st. floor	1	44·00	—	4·20	184·80		4·20=3·30+·90
	Inside of parapet walls—							
	Long sides ...	2	14·00	—	·80	22·40		·80=·90−·10
	Short sides ...	2	7 60	—	·80	12·16		(L.C.)
	Top of parapet walls							14·20 is out to
	Long sides ...	2	14·20	—	·10	2·84		out.
	Short sides ...	2	7·60	—	·10	1·52		2·60=2·40+·10
	Stair room out side ...	1	17·20	—	2·60	44·72		+·10

Building to continued

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
			B.	F.	...	268·44		
	Deduction for—							
	Parapet wall as not requ. for stair case room ...	1	8·50	—	·80	6·80	(—ve)	
	Window openings W ...	3	1·20	—	1·50	5·40	,,	
	W_1 ...	8	1·20	—	1·20	11·52	,,	
	W_2 ...	4	·90	—	1·20	4·32	,,	
	W_3 ...	2	·60	—	·70	·84	,,	601·00=total o
	Door of stair case room D	1	1·00	—	2·10	2·10	,,	(a)+(b)
						237·46	601·00	sq m
17.	**Neat cement punning**							
	Dado for kitchen ...	1	10·60	—	·60	6·36		
	Store ...	1	10·10	—	·60	6·06		
	Stair case room ...	1	15·60	—	·30	4·68		
							17·10 sq m	
18.	**6mm thick cement plaster**							
	(a) Roof slab ...	Sa	me as	4 (a)	apx.	69·67		
	(b) Web of beams for—							
	Bed rooms ...	1×2	3·25	—	·15	·98		Beams over
	,, ,, ...	1×2	3·65	—	·15	1·10		walls and lintels
	Dining ...	1×2	2·90	—	·15	·87		are included in
	(c) Staircase ...	Sa	me as	4 (c)	apx.=	25·35		12mm plaster-
	d) Sun shades ...	,,	,,	4 (e)	,, =	24·42		ing.
							122·39 sq m	
19.	**Decorative cement based paint** for outside plaster	Sa	me as	16 (b)	=	237·46		
			+18	(d)	=	24·42		
20.	**Dry Distempering** to interior wall, ceiling	Sa	me as	16 (a'	=	72·62	261·88	sq m
			+18	(a)+(b)	=	363·54	436·16	sq m
21.	**Painting on timber**							
	(a) Panelled Doors, D	7×2¼	1·00	—	2·10	33·08		
	,, ,, D_1	3×2¼	·80	—	2·10	11·34		
	(b) Fixed-Louver window							
	W ...	3×3	1·20	—	1·50	16·20		
	W_1 ...	6×3	1·20	—	1·20	32·40		
	W_2 ...	3×3	·90	—	1·20	9·72		
	(c) Glazed shutters for—							
	W	3×1	1·20	—	1·50	5·40		
	W_1	8×1	1 20	—	1·20	11·52		
	W_2	2×1	·90	—	1·20	2·16		
	W_3	2×1	·60	—	·70	84		
							122·66	sq m
22.	**Painting two coats** on metal surface							
	Window Grill W ...	3×1	1·05	—	1·275	4·02		
	W_1 ...	8×1	·975	—	1·05	8·19		
	W_2 ...	4×1	·75	—	1·05	3·15		
	W_3 ...	2×1	·45	—	·55	·50		
23.	**100mm dia Down pipe**	6	3·50	—	—	21·00	15·86	sq m
24.	**C. I. Ventilator** ...	14	—	—	—	—	21·00	r m
							14	nos.

ABSTRACT OF ESTIMATED COST FOR GROUND FLOOR OF BUILDING-10

SL. No.	Description	Quantity	Unit	Rate Rs. P	Unite of Rate	Amount Rs. P.
1.	Earth work in excavation of foundation trenches in any kind of soil including triming the side of trenches, levelling, dressing and ramming the bottom and bailing out normal seepage of water, rain water etc. depth of excavation not exceeding 1·5 meters and without shoring.	58·81	cum	320·00	%cu m	188·19
2.	Earthwork in filling in foundation trenches with good earth, in layers not exceeding 15cm including watering and ramming etc. layer by layer, with earth obtained from excavation of foundation.	11·76	cum	260·00	%cu m	30·57
3.	Sand filling in plinth in layers not exceeding 15cm and consolidating same by thorough saturation with water and ramming complete, including supplying sand.	29·52	cum	40·00	cu m	1,180·80
4.	Single flat soling of overburnt bricks including ramming and dressing bed to proper level, and filling joints including cushioning as necessary with local sand.	64·32	sqm	18·00	sq m	1,157·76
5.	Cement concrete (1:3:6) with graded brick ballast (3cm down).	9 40	cum	325·00	cu m	3,055·00
6.	1st class brickwork in cement mortar (1:4) in foundation and plinth	23 04	cum	280 00	cu m	6,451 20
7.	2·5 cm thick Damp-Proof Course with stone chips (1:2:4) with approved water proofing compound.	24·72	sqm	13·00	sq m	321·36
8.	1st class brickwork in cement mortar (1:6) in superstructure.	71·04	cum	250·00	cu m	17,760·00
9.	10cm thick brickwork in cement mortar (1:3) with H. B. netting of approved quality in every third layer.	21·12	sqm	38·00	sq m	802·56
10.	Cement concrete (1:2:4) with graded stone chips (20mm down) excluding shuttering and reinforcement.	18·53	cum	410 00	cu m	7,597 30
11.	Hire and labour charges for providing stout props, centering and shuttering (upto 4m) with hard wood at least 2·5 cm thick.	152·33	sqm	16·00	sq m	2,437·28
	C. O.	...	...	...	...	40,982·02

SL. No.	Description	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	B. F.	...	...	...	...	40,982·02
12.	M. S. reinforcement including cutting requisite length, hooking and bending to correct shape, placing in proper position and binding with 16 gauge black anneale wire at every intersection as per drawing and direction.	14·55	quin	600·00	quin	8,730·00
13.	Indian Teak wood work in door and window frames fitted and fixed complete including protective coat of painting at the contact surfaces of the frames.	1·092	cum	600·00	cum	6,552 00
14.	3·75 cm thick 1st class Indian Teak wood panel shutters with 19mm thick panel of doors and windows as per design (each panel consisting of single plank without joint including fitting and fixing same in position and including the cost of hinges and fittings.	17·71	sqm	200·00	sqm	3,542·00
15.	3·75 cm thick Fixed-Louvre shutters of windows with 1st class Indian Teak wood as per design including fitting and fixing same in position and including the cost of hinges and fittings.	12·72	sqm	195·00	sqm	2,480·40
16.	3·75 cm thick Glazed shutters of windows with 1st class Indian Teak wood, as per design (with ordinary glass (of 7·4kg./sq m) including fitting and fixing shutter in position and including the cost of hinges and other fittings.	13·55	sqm	140 00	sqm	1,897·00
17.	M. S. Ornamental Grill with 30mm × 6mm flats for windows fitted and fixed in position with necessary screws.	14 05	sqm	110·00	sqm	1,545·50
18.	M. S. clamp for fixing door and window frames 37·5 cm long end bifurcated and fixing in walls with cement concrete (1:2:4)	126	Nos.	2·65	Each	333·90
19.	Supplying, fitting and fixing Anodised Alluminium hand rail 100mm × 6mm thick with 15cm long leg.	5·38	rm	80·00	rm	430·40
20.	7·5 cm thick Terraced flooring of lime concrete with stone lime surki and over burnt brick ballast (2·5 cm) laid to proper slope, thoroughly beaten and curied.	80·08	sqm	32·00	sqm	2,562·55
	C. O.	...	...	...	...	69,055·77

SL. No.	Description	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	B. F.	...	...	...	...	69,055·77
21.	Marbulite work in floor, dado, skirting, staircase etc. including cost of tiles laid in patterns as directed including necessary under lay and high polishing complet 25mm thick floor and 19mm thick dado in position.	104·46	sqm	75 00	sqm	7,834·50
22.	25mm thick grey artificial stone in floor, dado, etc. with cement concrete (1:2:4) with graded stone chips laid in panels wlth 6mm thick skinning and smooth finishing at top made up with cement and including rounding corners.	16·44	sqm	23·00	sqm	378·12
23.	12mm thick plaster with cement and sand (1:6) motar to wall including rounding off or chamfering corners as directed and racking out joints including throating, nosing and drip course where necessary.	469·80	sqm	6·75	sqm	3,171·15
24.	Neat cement punning about 1·5mm thick in wall, dado etc.	46·38	sqm	2·50	sqm	115·95
25.	6mm thick plaster with (1:4) cement mortar to wall, ceiling ete, including rounding off or chamfering corners as directed and roughening of concrete surface including throating, nosing and drip course where necessary.	117·78	sqm	5·45	sqm	641·90
26.	Dry Distempering to interior walls or ceiling, with a coat of priming including washing, cleaning and smoothening surface.	405	sqm	2·35	sqm	951·75
27.	Decorative cement based paint of approved quality (two coats) after preparing bed including scrapingthe surface thoroughly on concrete or plastered surface as per Manufacturers specification.	182·58	sqm	2·75	sqm	502 10
28.	Painting two coats (any shade as directed) on timber surface with best quality Synthetic Enamel paint or oil bound paint of best quality of approved make and brand including smoothening surface by sand papering etc.	115·14	sq m	7·00	sqm	805 98
	C. O.	...	...	...	...	83,457·22

SL. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P
	B. F.	...	...	...	...	83,457 22
29.	Painting two coats with superior quality alluminium paint of approved make and brand including smoothening surfaces by sand papering etc. on steel surface.	14·23	sq m	5·50	sq m	78·26
30.	100 mm dia. Down pipe consisting of asbestos cement pipes and necessary head or Y junction, bends or single or double junction, offsets, shoe etc. conforming to I. S. 1626-1960 with I. S. certification mark including caulking joints with tarred gusket and grouting with cement mortar and providing necessary cowl, grating etc. fitted and fiixed in position with necessary clamps, nails etc. and painting two coats.	24·00	rm	18·00	rm	432·00
31.	C. I. Ventilator 15cm × 15cm of approved type including fitting and fixing in position, and cutting holes, setting in cement mortar (1:4) mending damage to wall and painting two coats of approved brand and shade.	14	nos	3·00	Each	42·00

... ... Total = 8,4009·48

Add 10% cost of building for water supply and sanitation... = 8,400 95

Add 9% ,, ,, ,, Electrification works ... = 7,560·85

Total = 99,971·28

Add 5% for Contingency ... ... 4,998·50

Add 2½% ,, Workcharged Establishment 2,499·28

Grand Total = 1,07,469·12

Say Rs. 1,07,469 00

Plinth area = 14·3m × 7·9m = 112·97 sq m

Plinth area rate including the cost of water supply and sanitation and electrification works $= \dfrac{\text{Rs. } 1{,}07{,}469}{112\cdot97 \text{ sq m}}$ = Rs.951·30 per sq m

Comparative cost of different portions of Ground floor on percentage basis :—

Work value of the building excluding water supply, sanitation and electrification = Rs. 84,009·48 say Rs. 84010·00

(i) Cost of foundation and plinth including D. P. C. (items 1 to 7) = Rs. 12,384·88

∴ Comparative cost = Rs. 12.384·88 ÷ Rs. 84,010 = 0·147 i.e. 14·7%

(ii) Cost of brickwork in superstructure (items 8 to 9) = Rs. 18.562·56

∴ Comparative cost = Rs. 18,562·56 ÷ 84,010 = 0·221 i. e. 22·1%

(iii) Cost R. C. C. works including roofing (itemes 10, 11, 12) = Rs. 18,751·78

∴ Comparative cost = Rs. 18,751·78 ÷ Rs. 84,010 = 0·223 i. e. 22·3%

(iv) Cost of Door and Windows (items 13 to 18) = Rs. 16,350·88

∴ Comparative cost = Rs. 16,350·88 ÷ Rs. 84,010 = 0·195 i. e. 19·5%

(v) Cost of flooring (items 20 to 22) = Rs 10,775 17

∴ Comparative cost = Rs. 10,775·17 ÷ Rs. 84.010 = 0·128 i. e. 12·8%

(vi) Cost of plastering, finishing, rain water pipes, stair railing items (23to31 & 19) = Rs. 7,171·49

∴ Comparative cost = Rs. 7 171·49 ÷ Rs. 84,010 = 0 086 i. e. 8·6%

Check Total = 100

ABSIRACT OF ESTIMATED COST FOR FIRST FLOOR OF BUILDING-10

Note—Star mark by the side of sl. no. indicates higher rate fov additional storey.

SL. No.	Description	Qu	Unit	Rate Rs. p.	Unit of Rate	Amount Rs. P.
*1.	First class brickwork in cement mortar (1:6)	63·54	cum	256·00	cu m	16,266·24
*2.	10cm think first class brickwork in cement mortar (1:3) with H. B. wire netting	27·66	sq m	40·80	sq m	1,128·52
*3.	Cement concrete(1:2:4) excluding shuttering and reinforcement with stone chips	20·37	cum	416·00	cu m	8,473·92
*4.	Hire and labour charges for centering and shuttering	188·06	sq m	17·50	sq m	3,291·05
*5.	M. S. reinforcement including cutting requisite length, hooking & bending etc.	15·99	qu	603·50	quin	9,649·96
6.	7·5 cm think lime terracing on roof with slaked lime (2 : 2 : 7) laid to proper slope thoroughly beaten and cured, including top finishing, shaping and finishing at mouths of rain water pipe, etc.	106·40	sqm	33·50	sq m	3,458·00
7.	1st class Indian Teak wood work for frames	1·130	cum	6,000·00	cu m	6,780·00
8.	3·75 cm think 1st class Indian Teak wood panel shutters with 19mm thick panel	15·99	sqm	200·00	sq m	3,198·00
9.	3·75cm thick Fixed-Louver shutters with 1st. class Indian Teak wood	13·56	sqm	195·00	sq m	2,644 20
10.	3·75 cm thick Glazed shutters of windows with 1st. class Indian Teak wood as per design	15·51	sqm	140·00	sq m	2,171·40
11.	M.S. Ornamental Grill with 30mm×6mm flats	15·86	sqm	110·00	sq m	1,744·60
12.	M S. clamp for fixing frames 37·5cm long	128	nos	2·65	Each	339·20
13.	Anodised Alluminium hand rail	6·96	rm	80·00	rm	556·80
14.	Marbulite work with precast tiles 25mm thick floor and 19mm thick dado	106·96	sqm	76·00	sq m	8,128 95
15.	25mm thick grey artificial stone with 6mm thick skinning and smooth finishing	26·97	sqm	23·50	sq m	633·79
16.	12mm thick cement plaster (1:6) to wall	601·06	sqm	6·90	sq m	4,146·90
	C. O.	...	...	...	...	72,611·53

SL. No	Description	Qu.	Qunit	Ra e Rs. P.	Unite of Rate	Amount Rs. P.
	B. F.					72,611·53
17.	Neat cement punning about 1·5mm thick	17·10	sq m	2·50	sq m	42·75
*18.	6mm thick plaster with (1:4) cement motar...	122·36	sq m	5·55	sq m	679·26
*19.	Decorative cement based paint two coats	261·88	sq m	2·80	sq m	733·26
20.	Dry Distempering to interior wall ceiling with a coat of priming	436·16	sq m	2·35	sq m	1,024·97
21.	Painting two coats with best quality Synthetic Enamel paint on timber surface	122·66	sq m	7·00	sq m	8,58·62
22.	Painting two coats on metal surface	15·86	sq m	5·50	sq m	87·23
23.	100mm dia. Down pipe of asbestors cement	21·00	rm	18·00	rm	378·00
24.	C. I. Ventilator. ...	14	nos	3·00	Each	42·00
		...	...	...	Total	75,457·6

Add 10% cost of building for Watersupply and Sanitation ...	=	7,645·762
Add 9% ,, ,, ,, Electrification works ...	=	6 881·18
Total	=	90,984·56
Add 5% for Contingency	=	4,549·22
Add 2½% ,, Workcharged Establishment	=	2,274·61
Grand Total	=	97,808·39

Plinth area =112·97 sqm (same as ground floor) Say Rs. 97,808·00

Plinth area rate including the cost of watersupply and sanitation and electrification

works $= \text{Rs. } \dfrac{97{,}808}{112{\cdot}97 \text{ sq m}} = \text{Rs } 865{\cdot}78$ per sq m

Plinth area rate of the two storied building=Rs. 951·30+Rs.865·78

=Rs. 1,817·08 per sq m

Estimated cost of the two stried building =Rs. 1,07,469·00+Rs. 97,808·00

=Rs. 2,05,277·00

Comperative cost of different storey of the bailding on percentage basis :-

$$\frac{\text{Cost of second storey}}{\text{Cost of first storey}} = \frac{\text{Rs. } 97{,}808}{\text{Rs. } 1{,}07469} = 0{\cdot}91$$

Cost of 2nd storey is **91%** to that of first storey of the building.

3.11, Renovation Estimate for an old Building :—

The owner of an old two storied building intends to renovate the following items and quantities of works through a contractor. Prepare the necessary schedule of items and estimate for the contract adopting local P. W. D. rates.

(a) The old terraced roof over 1st. floor consisting of M. S. tee rafters and tiles shall be dismantled and 10cm thick R. C. slab with 0·8% reinforcement shall be laid over the R. S. J. beams for an area 97 sqm,

(b) The R. S. J. beams shall be encased for 20cm × 50rm by cement concrete,

(c) The old artificial stone flooring shall be dismantled and marbulite work with precast tiles over lime concrete terracing under floor upto 5cm think shall be provided for an area 60 sqm at floor and with dado 78sqm,

(d) Outside walls shall be 12mm thick newly plastered after removing the old plaster and two coats of Decorative cement based paint shall be applied for an area of 450 sqm,

(e) Panel door and window shutters shall be painted two coats of Synthetic paint with a priming coat after removing the old paint for 30 sq m,

(f) The 10 cm dia. C. I. down water pipes shall be renewed and painted for 50 rm with 6 nos. C. I. Y-junctions.

DESCRIPTION OF WORK AND ABSTRACT OF COST FOR THE GIVEN QUANTITIES

SL. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Dismantling terraced roof in any floor taking out carefully tiles with tees, sorting and stacking serviceable materials at site and removing rubbish within a lead of 75 metre	97	sq m	3·00	sq m	291·00
2.	Hire and labour charges for providing stout props centering and shuttering upto 4m with hard wood 2·5cm thick and striking out same upto the roof of first floor (consider 10% less of 97 sqm for wall area)	87·3	sq m	17·50	sq m	1,527·75
3.	Cement concrete (1:2:4) with graded stone chips excluding shuttering and reinforcement upto roof of 1st. floor (Quantity=97 × ·10=9·7 cum)	9·7	cu m	410·00	cu m	3,977·00
4.	M. S. reinforcement for R. C. C. work including supply of rods, initial straightening and cutting requisite lenght, hooking and bending to correct shape, placing in proper position and binding with 16 gauge black anneale wire at every intersection complete. Quantity=(97 × ·10 × ·8/100) × 78·5=6·09q.	6·09	quin	600·00	quin	3,654·0
5.	Encasing R. S. joist beam with 16 B. W. G. wire netting and cement concrete (1:2:4) with overburnt brick ballast including finishing with 12mm thick cement plaster (1:4)	10	sq m	40·00	sq m	400 0
	C. O.	...	...	...	...	9,893·

SL. No.	Description	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
6.	Dismantling artificial stone flooring upto 5cm thick by careful chiselling without damaging the base and removing rubbish within a lead of 75 metre.	B. F.	...	...	...	9893·75
		60	sqm	2·50	sqm	150·00
7.	Under flooring with lime concrete (1½:2:7) terracing beaten including filling up depressions and levelling up properly upto 5cm thick in 1st. floor.	60	sqm	10·00	sqm	600·00
8.	Marbulite work with precast tiles set in lime motar (1:3) in floor, dado laid in pallern including necessary underlay and including corners and high polishing complete 25mm thick in floor and 19mm thick in dado portion in first floor in any other colour except green.	78	sqm	76·00	sqm	5,928·00
9.	Striping off worn out plaster and racking out joints of walls upto any height in any floor including removing rubbish and stacking within the compound.	450	sqm	0·90	sqm	405·00
10.	12mm thick plaster to wall with cement and sand mortar (1:6) including rounding off or chamfering corners upto 1st floor.	450	sqm	6·90	sqm	3,105·00
11.	Decorative cement based paint on plastered surface including scraping the surface thoroughly and preparing bed upto 1st floor.	450	sqm	2·80	sqm	1,260·00
12.	Removing old paint from blistered painted surface with application of soda or any approved chemical paint remover and exposing the original surface including cleaning and thorough washing to remove all traces of the removing agent.	30	sqm	1·80	sqm	54·00
13.	Painting to timber surface two coats with best quality Synthetic Enamel paint including smoothening the surface by sand papering.	30	sqm	7·00	sqm	210·00
14.	Renewing 10 cm dia. C. I. pipe only of down pipe fitting and fixing in position and painted two coats.	50	rm	26·00	rm	1300·00
15.	Renewing 10cm dia. C. I. Y-junction of down pipe fitted and fixed in position and painted two coats.	6	nos.	16·00	Each	96·00
					Total=	23,005·75
					Add 5% for contingency=	1,150·28
					Add 2½% far W.C. =	575·14
					Grand Total=	24,731·17

3-12. Draw up a preliminary estimate of a building including the cost of wat supply, sanitation and electrification.

The different sub-heads to draw up a preliminary or approximate estimate have bee diagramatically shown below. It excludes the cost of land which is widely variable fro place to place.

Preliminary estimate.

(1) Cost of building structure (from plinth area rate or cubic rate.) (2) Cost of water supply. (3) Cost of sanitation. (4) Cost of electrification

(1) **Cost of building structure**—To estimate the cost of building structure multipl the plinth area by the local plinth area rate. The plinth area should be calculated taking external dimensions of the building at the plinth. Court yard and other open are should not be included in the plinth area. At the beginning, when plan of a building not yet been prepared or available determine the total floor area of all the rooms, corridor verandah, kitchen, W.C. and bath etc. according to requirement of the owner and $\frac{1}{6}$th. the total areas thus found, may be added for walls and waste to gate the approximate tot plinth area. For one roomed or small building add $\frac{1}{4}$th of the total floor area instead $\frac{1}{6}$th. as stated above.

Cube Rate Estimate—The method of estimating building cost by the cubic metr of volume is more accurate in general, than the method of estimating costs by plint area. Because cost of buildings depends not only on their plinth area but also or their respective height. The best way of estimating costs by the cubic rate is to find the volume of the building (length × breadth × height) and then multiply the volume by the local cubic rate. Length and breadth should be measured external to external excluding plinth offset, corbelling, string course etc. The height should be measured from the to of the flat roof (or half way of the sloped roof) to half of the depth of the foundatio below the plinth. Parapet is not to be included.

The rate of the plinth area or cubic estimate depends upon the standard of specifica tion and location of the site. The latter one influences the cost of building materials and labour. For instance, cost of bricks, sand, stone chips etc., as well as daily wages of labourer may be lesser in many district towns in comparison to their costs in capital towns. The plinth area or cubic rate also depends upon the planning and arrangement of rooms. I the total length of the walls within the specific area be increased by making less spaciou rooms, the rate will have to be increased proportionately and vice-versa.

However, for plinth area method an average rate of Rs. 775 (or Rs. 72 per s ft.) may be recommended for construction of ordinary one storeyed building in distr towns with R. C. roof but without any provision of staircase and construction of upp storeys. For capital and industrial towns where cost of labour and materials (brick sand, stone chips, woods etc.,) is rather higher this rate may be recommended for Rs. 81 per sq m (or Rs. 75 per sq ft). Thus for one storeyed building with staircase an foundation for upper construction upto three storeys, the rate should be taken as Rs. 87 per sq m. (or Rs. 81 per sq ft.) and Rs. 890 per sq m (or Rs. 83 per sq ft.) for district an capital towns respectively. The rates as mentioned above are variable from time to tim according to variation in the cost of materials etc. The rates includes 10% contractor profit. For metropolitan towns the above mentioned rates should be increased by 5%

(2) **Cost of water Supply** :—Where water is to be tapped from street pipe lines within a distance, say upto 15m from property line and may be stored in an overhead storage tank (placed on the roof) by pressure of street pipe line water an amount of 4 to $4\frac{1}{2}$ percent of the cost of the building structure including loyalty charge for pipe connection (Rs. 300/-usually) may be recommended. This includes the cost of a storage tank with necessary arrangement to place the same on the roof, fitting fixing of showerbaths, wash basins, tap connections etc., Cost of expensive fittings has not been considered in the above cost.

In case where water is to be pumped to the overhead tank after collecting the same in an underground storage tank from street pipe line, a further amount of Rs. 3,500 should be provided for purchase of pump and motor ($\frac{1}{2}$ H. P.) and for construction of the underground storage tank over and above $3\frac{1}{2}$ to 4 percent cost of the building for internal plumbing.

Thus in case where water is to be supplied by sinking a tube-well (40mm dia. depth upto 90m) the cost of underground storage tank, service connection and loyalty charge does not arise. But due to the cost of the tube well along with the pump, mortar, ½ H. P.) etc., an amount Rs. 7,000 should be provided for in addition to 4% of the cost of building structure for internal plumbing. Thus where supply of water is to be provided by constructing a surface well (1·2m dia. depth 15m) fitted with pump and motor an amount Rs. 6,000 in addition to 4% of the cost of building (for internal plumbing) should be provided for. For hard rocky area the cost of a well should be estimated separately.

(3) **Cost of Sanitation** :—In sewered areas where the sewer line lies within a distance say, upto 30m from privy, an exces of 5% of the cost of building structure may be recommended for buildings whose cost of structure is upto Rs. 80,000 say (this includes cost of 4 nos. inspection pits, master trap etc.). For buildings involving a cost more than Rs. 80,000, 4 to 4 $\frac{1}{2}$ percent of the cost of the building should be considered.

In absence of sewer line 8% of the cost of the building structure involving cost upto Rs. 60,000/-and 7% for costs above Rs. 60,000/-may be recommended to provide a septic tank, soak pit and all other sanitary works.

For sewered areas the total cost of Watersupply and, Sanitation may be recommended 10% of the cost of the building structure

(4) **Cost of Electrification** :—Cost of electrification depends on the type of wiring, specification and location of service line from main meter point. **For first class work of T. S. wiring an amount equivalent to 9% of the cost of building structure may be recommended.** This excludes the cost of fans, bulbs etc. To include all such costs 12% of the estimated cost of the building may be considered fair.

Or, $100\text{ P}=60000+20\text{P}+15\text{P} \therefore \text{P}=\frac{60000}{65}=923\cdot08$ sq m i.e. plinth area $=923\cdot08$ sq m

Cost of building having 923·08 sq m plinth area @ Rs. 400·00 per sq m = Rs. 3,69,232·00

Cost of Water supply @ 5% of building cost = Rs. 3.69, 232 × $\frac{5}{100}$ ... = Rs. 18,461·60

Cost of Sanitation @ 6% of building cost = Rs. 3.69,232 × $\frac{6}{100}$ ... = Rs. 22,153·92

Cost of Electrification @ 10% of building cost = Rs. 3,69, 232 × $\frac{10}{100}$ ... = Rs. 36,923·20

Cost of approach road and boundary wall @ 3% of building cost = Rs. $\frac{3,69,232 \times 3}{100}$

= Rs. 11,076·96

Total cost = Rs. 4,57,847·68

Contingencies 5% of the total = Rs. 22,892·38

Work charged $2\frac{1}{2}$% of the total = Rs. 11,446·19

Grand Total = Rs. 4,92,186·25

3-13. Approximate estimate of the quantities of (a) bricks, (b) sand and (c) cement required to construct a proposed building.

Many private parties become eager to estimate the approximate quantities of the above mentioned materials directly from the plan or line sketch of a building. The calculation may be done following some "Thumb-rules" which are described below. Quantities which are to be calculated following these "Thumb-rules" may vary by 10% (5% as contingency), because such quantities depend on the general specification of the work, arrangement of rooms, openings for doors and windows and section of partition walls etc.

(*a*) *Bricks*—Applying the "Thumb-rule" let us assume the area of the walls to be $\frac{1}{5}$th of the total floor area and the calculation shall be bricks at the rate of 2150 nos. per sqm of the wall area for a proposed one storeyed building. But if the foundation is designed for future extension upto 3 storeys this number should be increased by 270 nos. per sq m. Thus, only for a upper storey, bricks should be considered as 1350 nos. sq m of the wall area.

To put it otherwise, the number of bricks may be taken as two and half times the cost of construction (excluding water supply, sanitation and electrification) of the building. The first method should be preferred keeping in view the fact that the cost of a building with a particular plan, design and specification varies in different localities.

(*b*) *Quantity of sand*—Quantity of sand should be calculated from a "Thumb rule" as 0·5 cu m per sq m of the plinth area for a single storeyed building. For a upper storey the quantity of sand should be considered as 0·45 cu m per sq m of the outer area. This is inclusive of the wastage.

The quantity of sand as estimated above does not include R.C.C works and for this, the quantity of coarse sand should be considered as $\frac{1}{5}$th of the total volume of fine sand.

Quantity of cement—In general where provisions for R.C.C. roof, lintel, cement plastering, flooring there is to be cement concrete foundation, and in all brick works where cement mortar is to be applied $6\frac{3}{4}$ bage per sq m of the plinth area for a single storeyed building may be recommended. For a upper storey construction only, the quantity of cement may be estimated as 5 bags per sq m of the outside area.

3-14. Comparative cost of the different portions of domestic buildings.

Detailed estimates for three different buildings 2, 3 and 10 along with comparative costs of the different portions has been prepared previously. Now a comparison of percentage cost for these different portions of the above mentioned buildings has been shown below to get some practical informations and to allocate the percentage costs for other buildings.

Name of the portion	Cost on percentage basis			Remarks
	Building 2	Building 3	Building 10	
(a) From foundation to plinth including D.P.C.	22·28	19·80	14·7	The foundation and plinth walls for buildings (2) and (3) are thicker than the normal for single storied buildings.
(b) Brickwork from plinth to parapet	23·89	18·80	22·1	For smaller height of verandah walls the cost for building (3) is less than buildings (2) or (10).
(c) All R.C.C. works including roofing	28·20	29·08	22·3	The roofing of building (10) does not include lime terracing and parapet walls and also the allocation of costs for (d) and (e) is more due to special provisions.
(d) Flooring	5 03	8·45	12·8	The flooring of building (10) includes Marbulite work
(e) Doors and windows	12·80	15·32	19·5	Building (3) provides clearstory window and building (10) provides with double window shutters.
(f) Plastering and finishing	7·80	8·55	8 55	Building (10) provides cement based wash to outside walls.
Total percentage				

Now a days there is a demand for modern buildings having all the provisions of Marbulite floor, double window shutters and nicely looked finishing as provided in building 10. So allocation of percentage cost for the different portions may be followed accordingly.

Rough comparative cost of the different portions of a domestic building.

In order to get a general idea about the progress of work according to investment, the diagram given below showing the comparative cost of the different portions of the main structure, may be seen.

Total cost 100%(excluding water supply, sanitation and electrification)

- Cost of foundation and plinth 18%
  - Cost upto G.L. 13%
  - Cost from G. L. to P.L. and D.P.C. 5%
- Cost of brickwork from plinth to roof 23%
- Cost of R.C.C. works except roofing 6%
- Cost of roofing 20%
  - Cost of R.C.C. roof 15%
  - Cost of lime terracing 5%
- Cost of flooring 6%
- Cost of doors and windows 18%
- Cost of plastering and finishing 9%

Explanatory notes :—

Foundation—includes the provision for further construction upto three storeys.

R.C.C. works except roofing includes R. C. lintel. chajja and one or two verandah R.C.C. pillars

R.C.C. roof—includes R C.C. roof and beams.

Flooring—includes patent stone flooring

Doors and windows—The percentage cost has been allocated considering sufficient number of doors for easy access and ventilation along with 1st. class fittings.

Plastering and finishing—includes inside and outside plastering, white and colour washing, painting to wood and iron works etc.

3-15. How to prepare a brief report of a project—Estimates are usually accompanied with a report of the whole project which gives a brief information mainly to the following points as shown diagramatically below.

REPORT

- (1) General
  - (a) Brief history of the area concerned with reference to the project
  - (b) Necessity & object of the project.
- (2) Description of accommodation or works provided
- (3) Selection of site
  - (a) Area of land.
  - (b) Nature of land.
  - (c) Orientation.
- (4) General specification in brief and basis of design, rates
- (5) Provisions made
  - (a) Electricity
  - (b) Water supply
  - (c) Sanitation
  - (d) compound wall
- (6) Total cost and how to be financed

3·16. Sub-work :—In the case of a large work consisting of several buildings or small works or groups thereof or distinct unit each of them is termed as sub-work. For example a polytechnic building may consist of several distinct units, such as (a) Main building (b) Work-shop and Laboratories, (c) Hostel building, (d) Staff quarters, (e) Internal roads, (f) Compound wall etc., and each is sufficiently large and distinct shall be estimated separately. Accounts of expenditure shall be kept separate. Thus in case of a water-supply project which may consist of (a) Head works, (b) Treatment plant, (c) Pump and pumping machinery, (d) Reservoirs and (e) Distribution system and each of the distinct unit shall be termed as sub-work.

3·17. Summary of Estimated Cost:—This is a summation of abstracts of estimated costs for different sub-works involved in a project work and is drawn up separately. Such a summary page in prepared when a project contains different sub-works. Abstracts of estimated cost for the sub-works are prepared individually and all are summed up showing distinctly the name of each sub-work and the estimated amount against each of them under a heading summary of Estimated cost for the project. From such a summary page the sanctioning authority also gets a primary information of the detailed estimate.

3·18. Working Drawing :—This is a set of documentary drawings required for the execution and construction of the works. For building construction this includes foundation plan, plan of different floors, roof plan, longitudinal and cross sections, elevations, architectural and structural details including details of reinforcement completely dimensioned and bearing all the indications required for construction. In the working drawing the site plan and general drainage arrangement are also provided.

3·19. Site Plan :—This is a general layout of site drawn in line diagram to a small scale with respect to the surrounding plots of land and adjoining roads to locate the site and to show the means of access. In the site plan, the orientation of the building along with the North direction line is shown. The position of water and sewer lines etc. may also be provided in the site plan. In the working drawings site plans are drawn to a scale of 1cm=5m to 1cm=40m.

3·20. Index Plan :—The general layout of a new colony or town showing the position of roads, market, hospital, park etc., along with the different plots of land with plot or building number are shown in single lines. Such a plan is normally fixed on the entrance or in central park of a new colony for the guidance of outsiders. The necessity of Index plan are to get a general idea of the whole project and to locate any plot of land.

3·21. Key Plan :—A building project may comprise of a number of buildings or blocks as in the case of staff quarters and the plans of all the buildings can not be accommodated on one sheet, a key plan at a small scale is drawn. The particular building or block whose details are drawn on a separate sheet is shown by shading on the key map.

3·22. Schedule :—In order to show more clearly than do drawings and specifications schedule, for different parts of a building viz, door window, R. C. footing, column, beam, slab etc. are provided. This is a tabular form where all particulars are shown. For an example a schedule of doors shows the symbol, and size of door, thickness and type of shutters, size of frames etc.

3·23. External Services :—The estimate of a building is prepared considering the cost of building structure, cost of internal watersupply, sanitation and electrification works. But the allocation of cost for external services if any should be provided in the total estimate. The External Services includes (1) Clearing site, including the demolishing of any old building. Damage of existing roads or adjacent property may occur due to construction of the building, (2) Forming site approach roads, paths, (3) Fences, gates, boundary wall, shades etc., (4) Laying of water supply, drainage, electric cables, gas mains, fire main lines from the property line to service main, (5) Turfing or planting trees etc.

The cost of external services may vary from 5% to 20% on buildings depending upon the existing amenities and position of land.

3-24. Prime Cost :—Prime cost is the net cost or purchase cost of articles at shop, and refers to the supply of the articles only and not to the carrying out of work. No profit for such supply of materials is allowed. But the cash discount if any during purchase (upto 3%) of materials and the actual cost of carriage may be allowed to a contractor. The owner or the Engineer-in charge should have the right to call for the accepted accounts from the merchants or manufacturers in respect of those items. During preparation an estimate it is not always possible to specify the exact type or brands of materials required as in the case of door and window or watersupply and sanitary fittings according to the choice of the owner. The owner may supply such articles or may instruct a contractor to purchase such articles for the work. The fitting and fixing charge are paid separately. In order to execute such items of work a reasonable amount is provided in the estimate as Prime cost.

3-25. Day Work :—During execution of a project there may be certain types of works which are not included in the schedule and can not be paid by measurements viz., special type of architectural works, dismantling partition wall under water, taking out root of trees during earthwork in excavation for foundation trenches etc. are paid costing on the basis of actual quantity of materials and labour hour required to complete the job and is denoted as 'Day Work.' A list of various classes of workmen engaged on the work and the rate per hour are recorded. Similarly a list of materials required for the work are prepared. The prices are to include, cost of materials, labour, overhead, supervision charges and profit.

3-26. Provisional Sum :—Provisional sum is an amount arbitrarily provided by an experienced estimater in the total estimated cost of a project to carry out some special type of work whose details can not be known at the time of preparing the estimate beside the original work. Such special works viz. installation of lift, shifting of water lines, sewer lines or electric cables are done through licenced contractor or through the respective departments engaged by the owner as a separate tender. The Engineer-in-charge should be given the right to order any test or weighing he considers necessary, but in case where the amount of testing is likely to be considerable a provisional sum should be provided in the estimate to cover the cost.

3-27. Index of building cost :—The cost of construction of a building is compared based on the datum=100 for a carried back specified year and forward to the present date. Thus the index indicates the comparison of cost in percentage basis. If 1970 is based with datum=100, the index for 1960 should be 40 and for 1979 should be 170. So the above index indicates the cost of a building as at 1960 was 60% less and 1979 is 70% above the the cost during 1970.

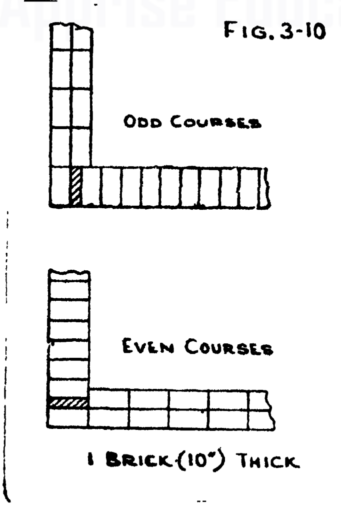
Public Works Department, architects and builders should keep a record of the buildings they erect giving the date, estimated and actual cost per sqm. When applying records of work executed some years earlier to proposed works, due regard should be had to the current level of building costs and the estimate should be adjusted accordingly.

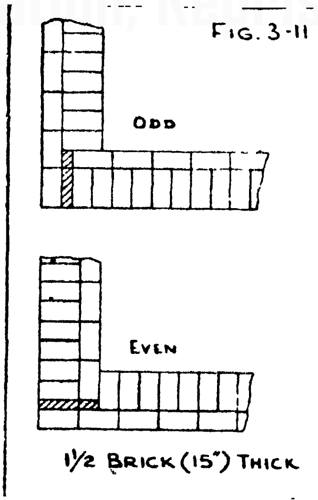
3-28. Dimensions of rooms for residential buildings—This depends upon the standard of living and income of the individual. No hard and fast rule can therefore be fixed for the layout of the plan of a building ; but the following informations may be helpful for general guidance.

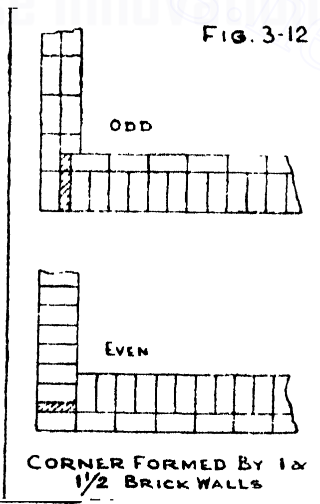
Type of Room	Standard type	Ordinary type
Bed Room	4m × 5m (14′ × 16′)	3m × 3·5m (10′ × 12′)
Drawing Room	4m × 5m to 5·5m × 6m (14′ × 16′ to 18′ × 22′)	3·5m × 3·5m (12′ × 12′)
Dining Room	3m × 3·5m to 4m × 5m (10′ × 12′ to 14′ × 16′)	3m × 3·5m (10′ × 12′)
Office Room	3m × 3·5m (10′ × 12′)	×
Guest Room	3m × 3·5m (10′ × 12′)	×
Kitchen	3m × 3·5m (10′ × 12′)	2·5m × 3m (8′ × 10′)
Store	3m × 3m (10′ × 10′)	2·5m × 2·5m (8′ × 8′)
Dressing	2·5m × 3m (8′ × 10′)	×
Bath & W.C. (comb.)	2·5m × 3m (8′ × 10′)	×
Bath	1·8m × 2·5m (6′ × 8′)	1·2m × 1·8m (4′ × 6′)
Latrine	1·2m × 1·8m (4′ × 6′)	1·2m × 1·2m (4′ × 4′)
Servants Room	3m × 3m (10′ × 10′)	×
Garage	3m × 5·5m (10′ × 18′)	×

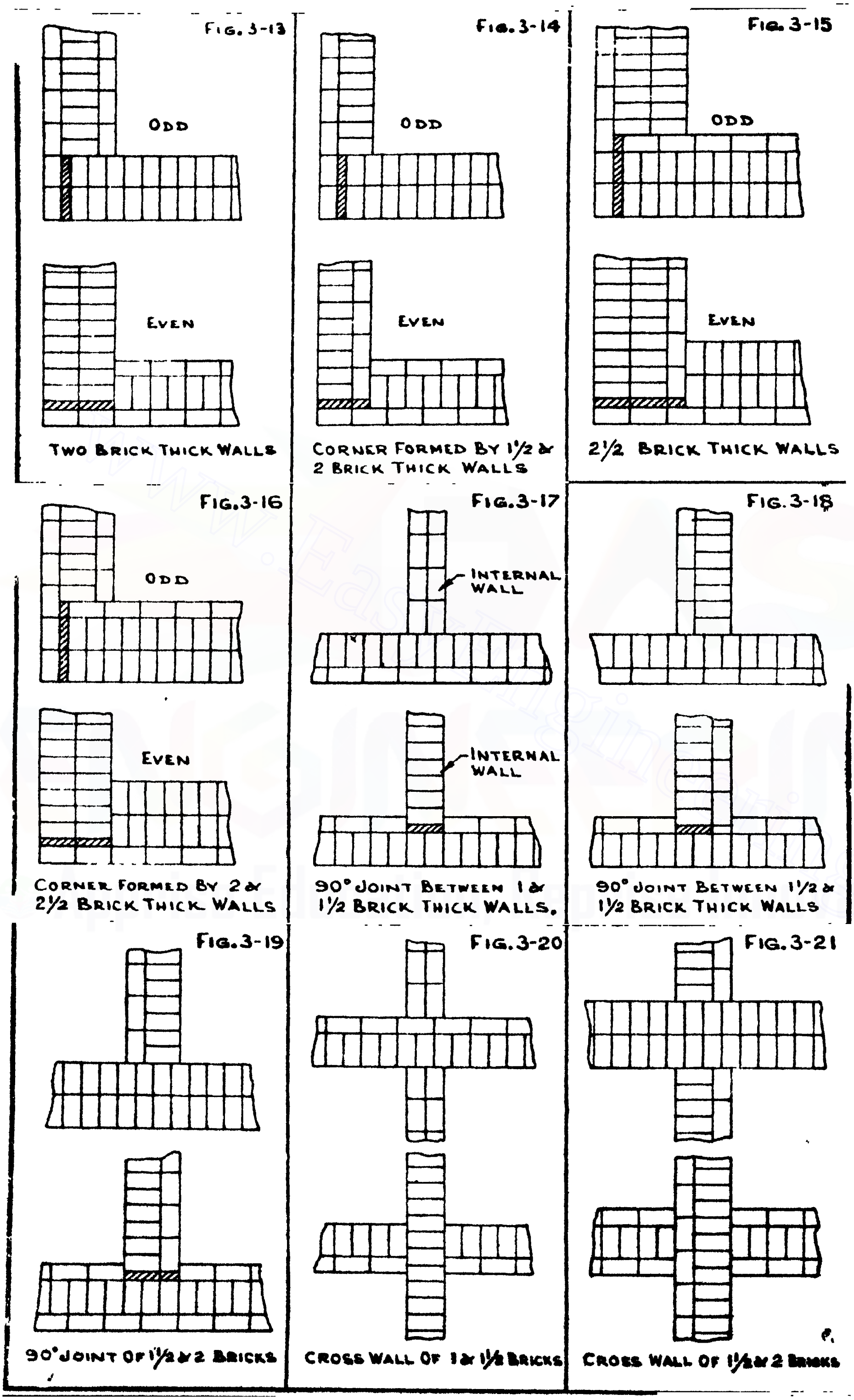
The width of staircase for standard type may be 1·5m to I m (5′ to 3′-6″) clear and for ordinary type 90cm (3′-0″) clear. The width of verandah 2·5m to 3m (8′ to 10′) for standard type and 1·2m to 1·88m for ordinary type. Height of main room 3·7m for standard type and 3·4m for ordinary type. Height of other rooms (in case of different heights) 3m for standard type and 2·75m for ordinary type.

3-29 Comparison the cost of construction of a corner, partion and cross walls.





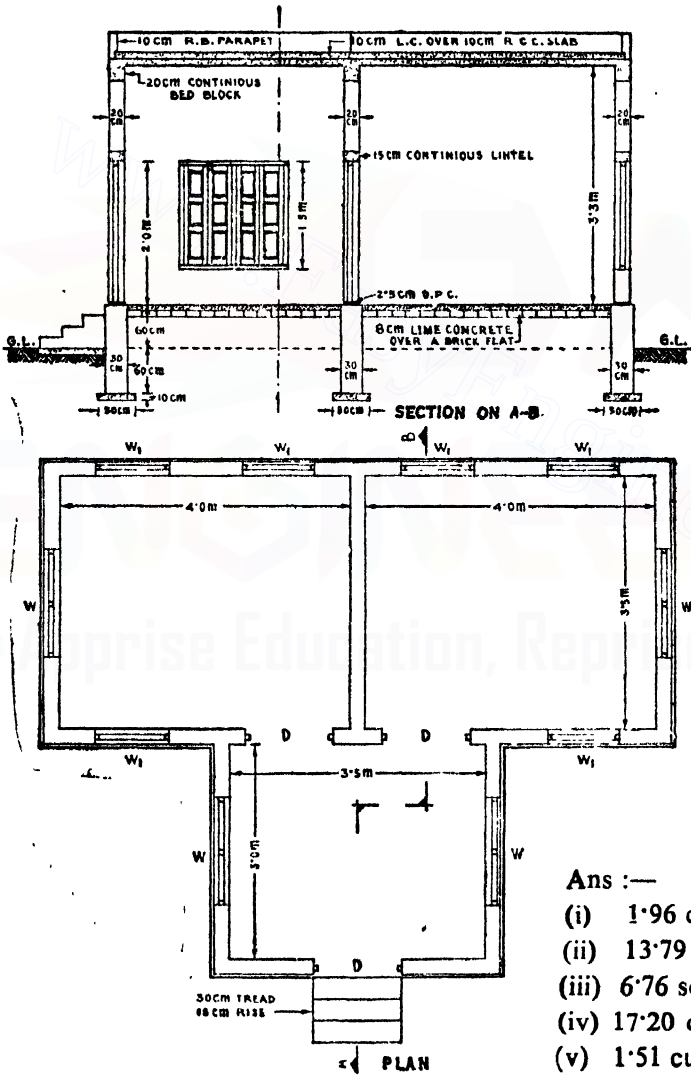




For a corner wall contruction closer brick is required in every layer as has been shown from fig. 3-10 to 3-16. But for a partition wall the same is required only in alternate layers (fig) 3-17 to 3-19. and in a cross wall there is no requirement of any closer brick (fig. 3-20 to 3-21) Because to form closer brick extra labour is required and materials are also wasted for extra joints, corner walls therefore cost more than that of partition walls and cross wall is least costly as that of a straight wall.

EXERCISE—3

Example—1. Calculate from the drawing of the building as shown in the fig. 3-22 the quantities and the cost of the following items of works at the rate noted against the items :—(1) Cement concrete (1:3:6) in foundation @ Rs. 250 per cu m, (ii) Brickwork in foundation and plinth @ Rs. 180 per cu m, (iii) 2·5 cm thick D.P.C. @ Rs. 9·00 per sq m, (iv) Brickwork in superstructure @ Rs. 250 per cu m,, (v) R.C.C. for bed block @ Rs. 325 per cu m.



Note : The bed block 20cm × 20cm shall be of R. C. monolithic with the roof slab and shall be continuous over all the walls to act as a member of resistance against earthquake.

D = 2m × 1·2m
W = 1·5m × 1·5m
W_1 = 1m × 1·5m

Ans :—
(i) 1·96 cu m, Rs. 490·00 with steps
(ii) 13·79 cu m, Rs. 2482·30 -do-
(iii) 6·76 sq m, Rs. 60·80
(iv) 17·20 cu m, Rs. 4300·00
(v) 1·51 cu m Rs. 490·80

FIG. 3-22

Scale : 1cm=1m

Example—2 Prepare detailed estimate of the quantities of the items as follows, for a house shown in fig 3-23. An abstract of cost is also to be prepared at the rates given against each—(i) Earthwork in excavation for foundation and plinth @ Rs. 2.80 per cu m. (iii) Masonry in superstructure, @ Rs. 188 per cu m.

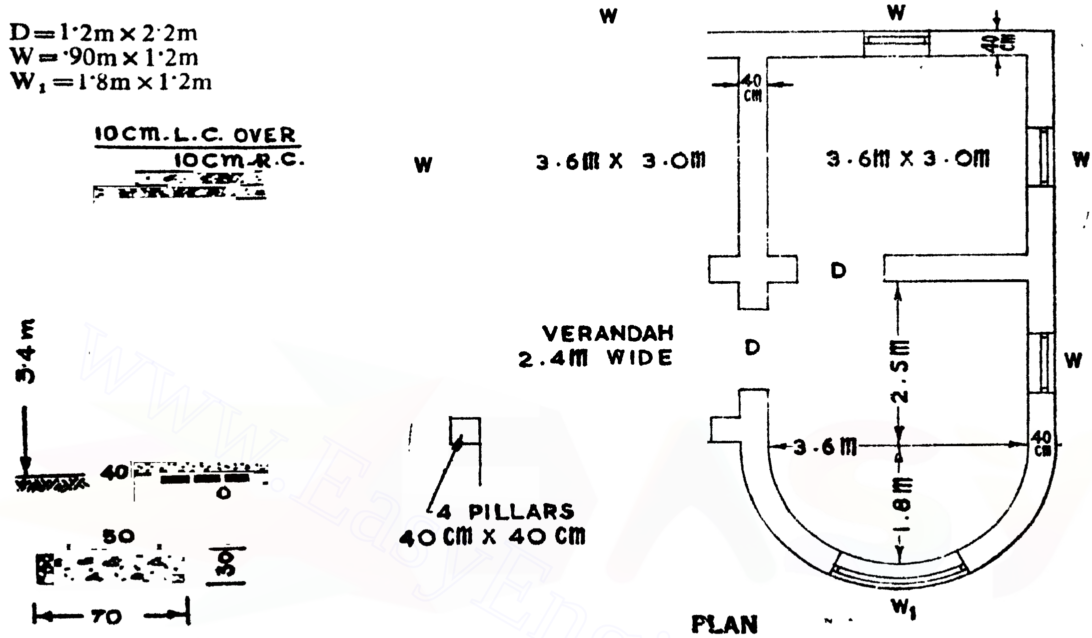


FIG. 3-23

Ans :—(i) 26·57 cu m (ii) 9·50 cu m (iii) 46·88 cu m

Example—3 Estimate the quantities of work of the following items for construction of the building shown in the fig. 3-24.

(a) Farthwork in excavation in foundation ; (b) Brickwork above ground level, (c) 8 cm thick cement concrete floor over a brick flat, (d) 8 cm lime concrete terracing over roof, (e) 10 cm R.C. roof, (f) 12 mm thick cement plastering.

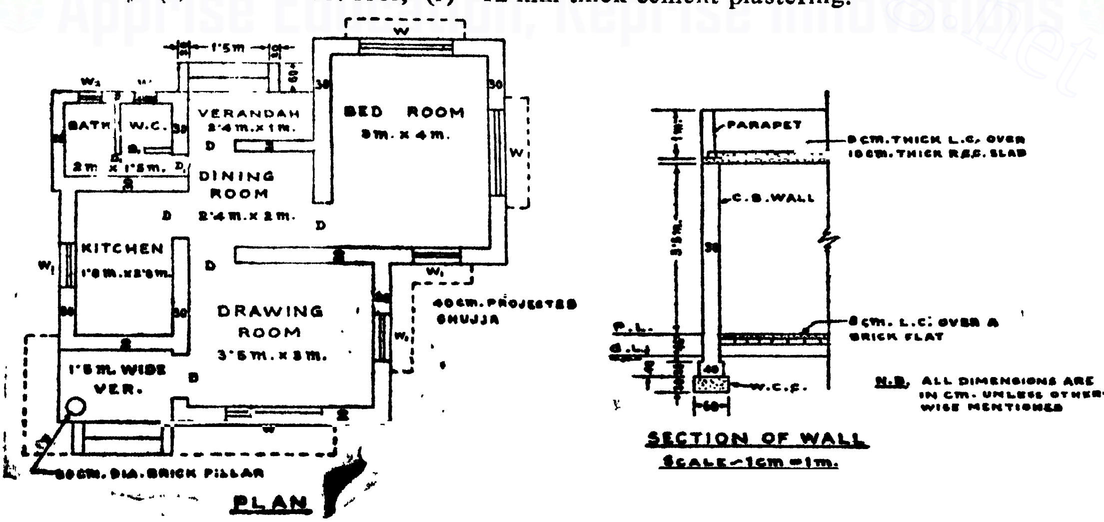


FIG. 3-24

Example—4. Estimate the quantities of the following items of work of the building the given drawings as shown in the fig. 3-25. (1) Earthwork in excavation in jation. (2) Lime concrete in foundation, (3) First class brickwork (1 : 6) in founda- and plinth, (4) 2·5 cm D.P.C., (5) First class brickwork in superstructure, (6) Cement rete in R.C.C. work for roof slab, lintel and beams, (7) Wood work for door and dow frames.

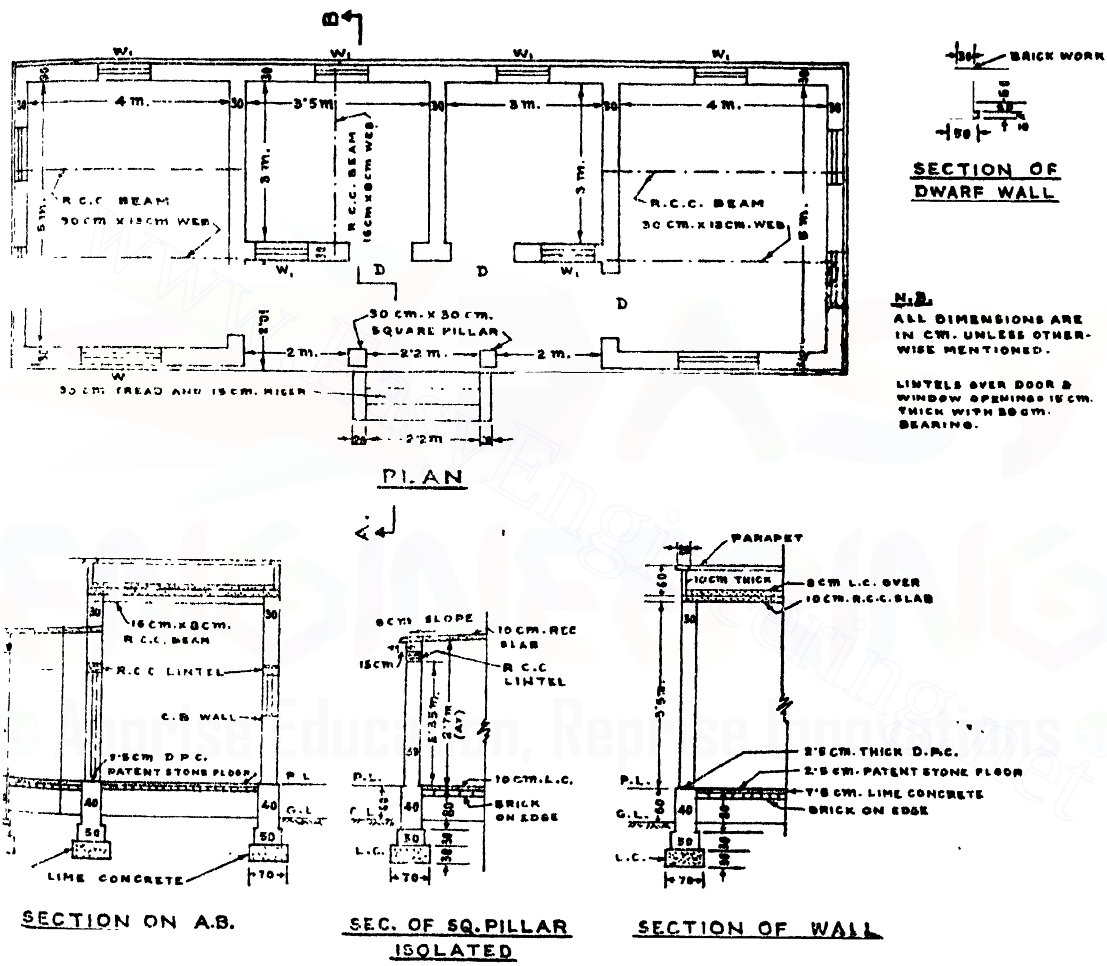


FIG. 3-25

Schedule for Doors and windows :—

Size	Frame	Description
2m × 1·2m	10cm × 8cm	Panelled
1·5m × 1·5m	,,	,,
1·2m × 1m	[illegible] cm	[illegible]

Ans :—(1) 32·39 cu m
(2) 12·29 cu m
(3) 27·30 cu m
(4) 15·27 sq m
(5) 53·11 cu m
(6) 11·261 cu m
(7) 0·474 cu m

Example—2 Prepare detailed estimate of the quantities of the items as follows, for a house shown in fig 3-23. An abstract of cost is also to be prepared at the rates given against each—(i) Earthwork in excavation for foundation and plinth @ Rs. 2.80 per cu m, (iii) Masonry in superstructure, @ Rs. 188 per cu m.

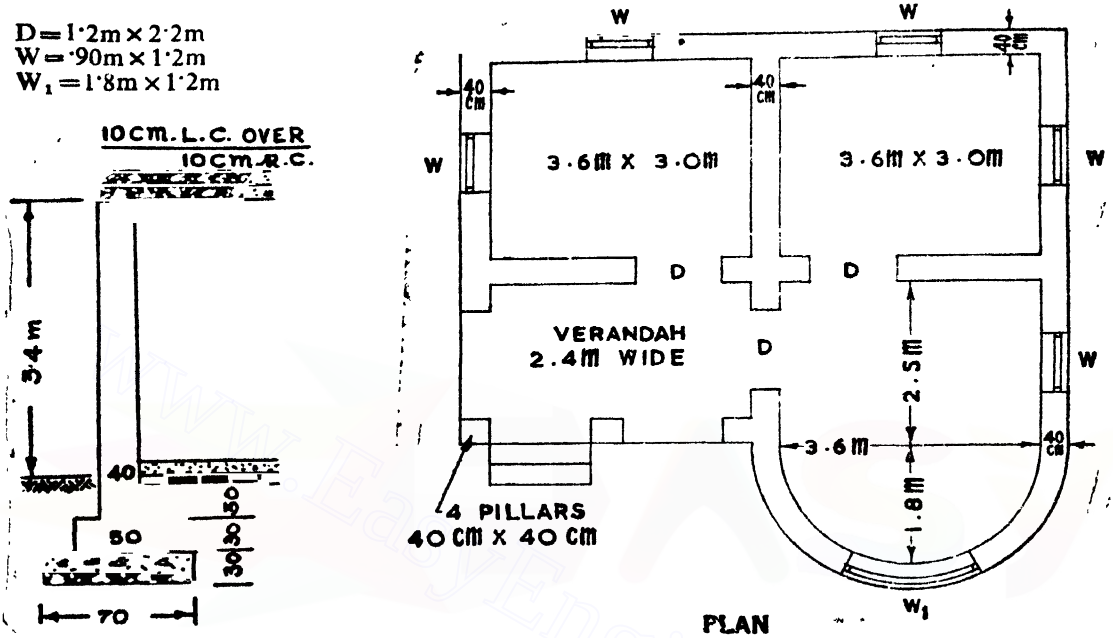


FIG. 3-23

Ans :—(i) 26·57 cu m (ii) 9·50 cu m (iii) 46·88 cu m

Example—3 Estimate the quantities of work of the following items for construction of the building shown in the fig. 3-24.

(a) Earthwork in excavation in foundation ; (b) Brickwork above ground level, (c) 8 cm thick cement concrete floor over a brick flat, (d) 8 cm lime concrete terracing over roof, (e) 10 cm R.C. roof, (f) 12 mm thick cement plastering.

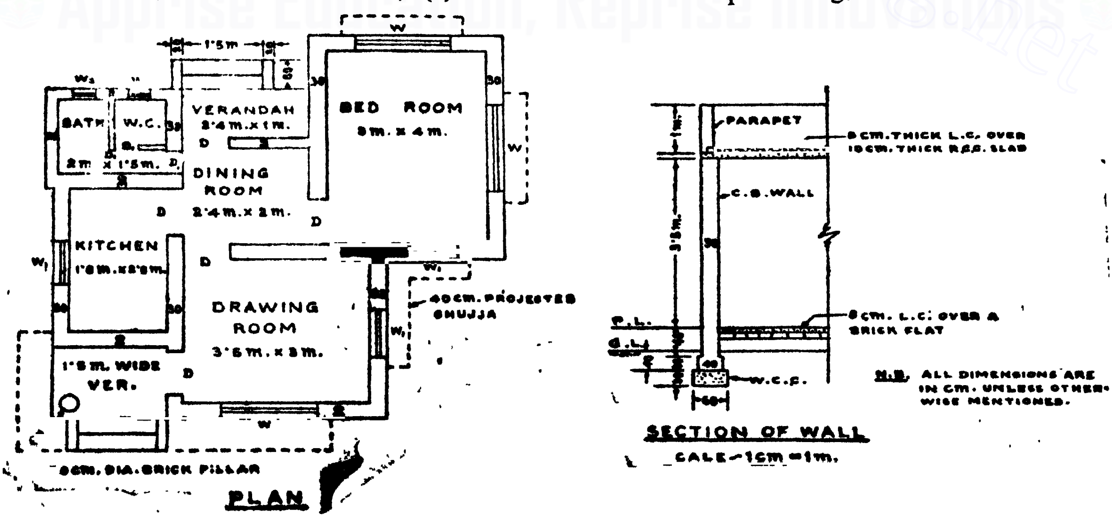


FIG. 3-24

Example—4. Estimate the quantities of the following items of work of the building n the given drawings as shown in the fig. 3-25. (1) Earthwork in excavation in ıdation, (2) Lime concrete in foundation, (3) First class brickwork (1 : 6) in founda- and plinth, (4) 2·5 cm D.P.C., (5) First class brickwork in superstructure, (6) Cement crete in R.C.C. work for roof slab, lintel and beams, (7) Wood work for door and ndow frames.

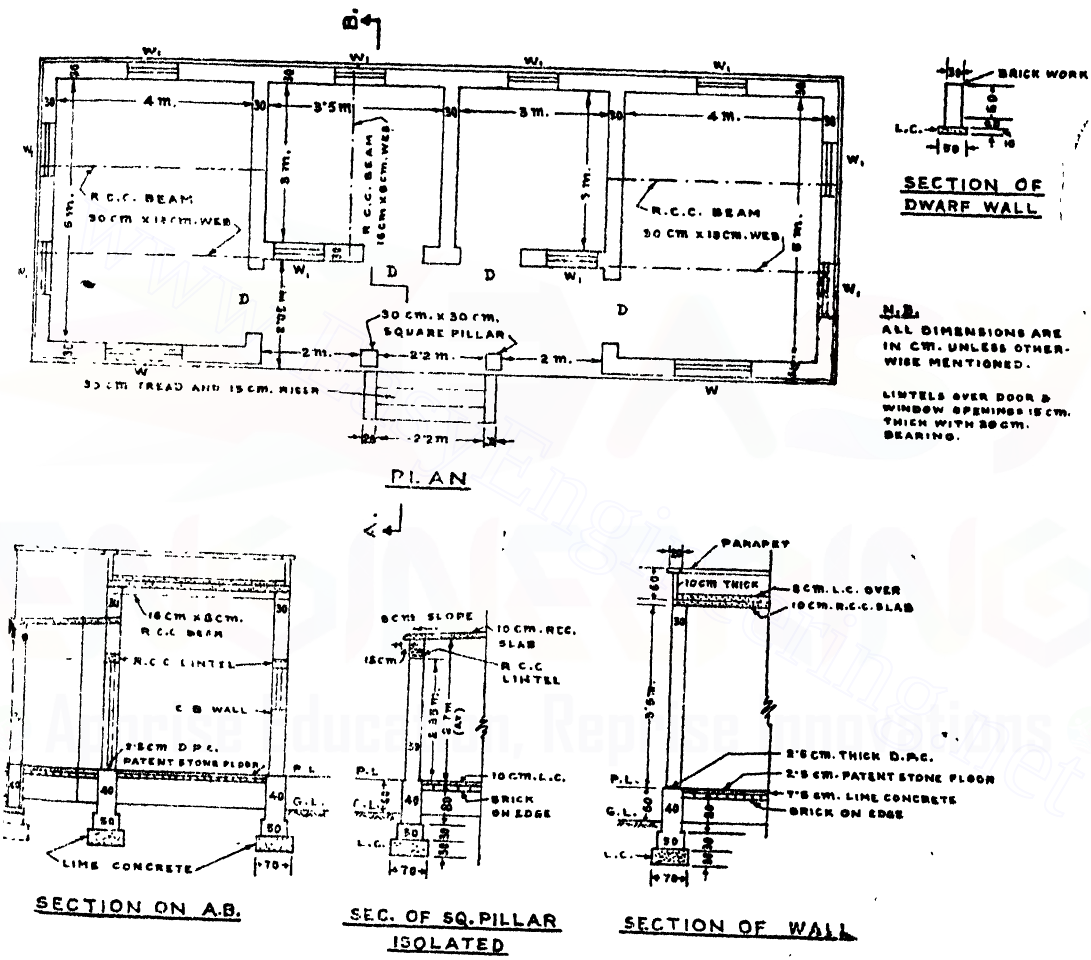


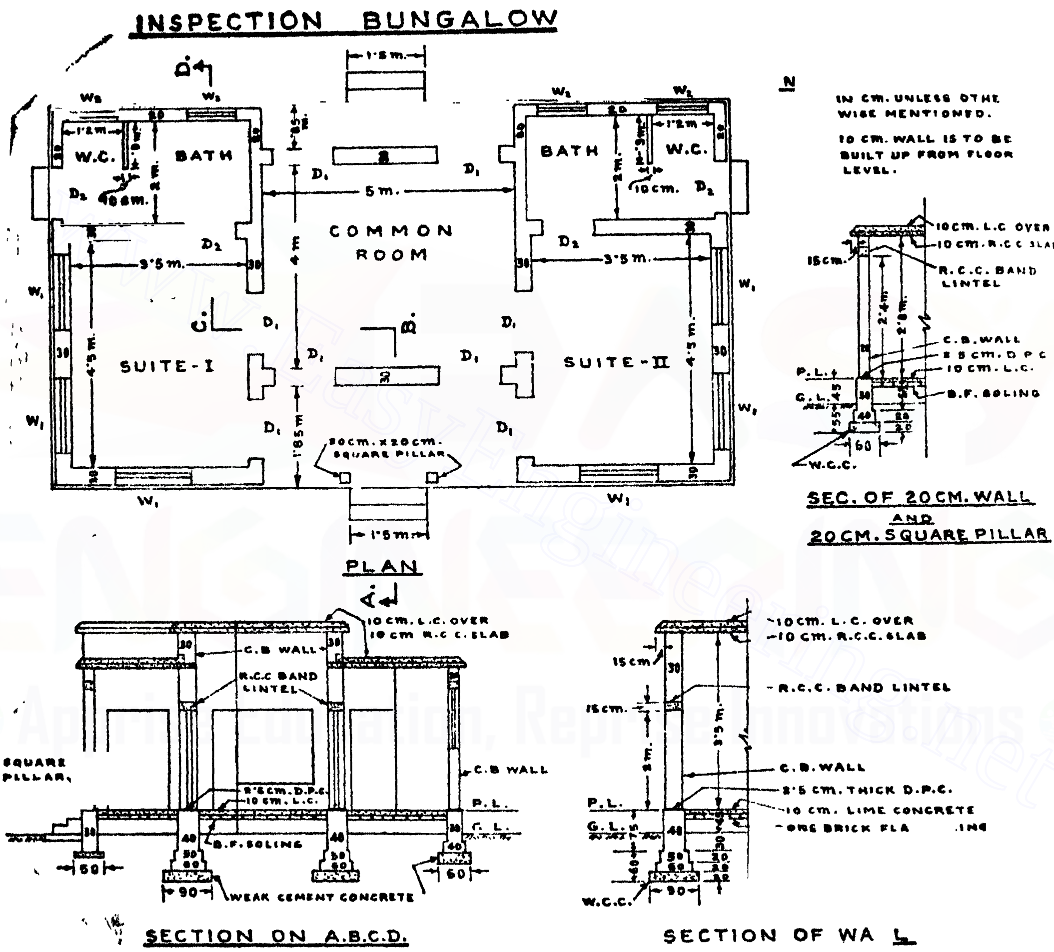
FIG 3-25

Schedule for Doors and windows :—

[illegible]e	Size	Frame	Description
[illegible]	2m × 1·2m	10cm × 8cm	Panelled
	1·5m × 1·5m	"	"
	1·2m × 1m	[illegible] cm	C[illegible]

Ans :—(1) 32·39 cu m
(2) 12·29 cu m
(3) 27·30 cm m
(4) 15·27 sq m
(5) 53·11 cu m
(6) 11·261 cu m
(7) 0·474 cu m

Example—5 Estimate the following items of work from the fig. 3-26 for an Inspection Bungalow ;—(a) Earthwork in excavation for foundation, (b) C. C. (1:3:6) using 25 mm to 40 mm hard stone aggregates for foundation, (c) First class brick masonry in foundation and plinth (1:6), (d) Dressed Sal wood work in frames (chowkats) fitted and fixed complete, (e) 40 mm thick Teak wood work in panelled door and window shutters (f) 10 cm thick lime terracing with brick ballast (khoa) over R. C. C. roof.



Schedule **FIG 3-26**

Type	Size	Frame	Description
D_1	2m × 1·2m	10cm × 8cm	Panelled
D_2	2m × 1m	,,	,,
W_1	1·5m × 1·5m	,,	,,
W_2	1·2m × 1m	8cm × 6cm	Glazed

Scale : 1cm = 1½m

Ans :—(a) 41·56 cu m

Example – 6. Estimate the quantities of work of the following items for construction of the building shown in the fig. 3-27.

(a) Earth work in excavation in foundation, (b) Lime concrete in foundation & (c) Brick masonry up to plinth level.

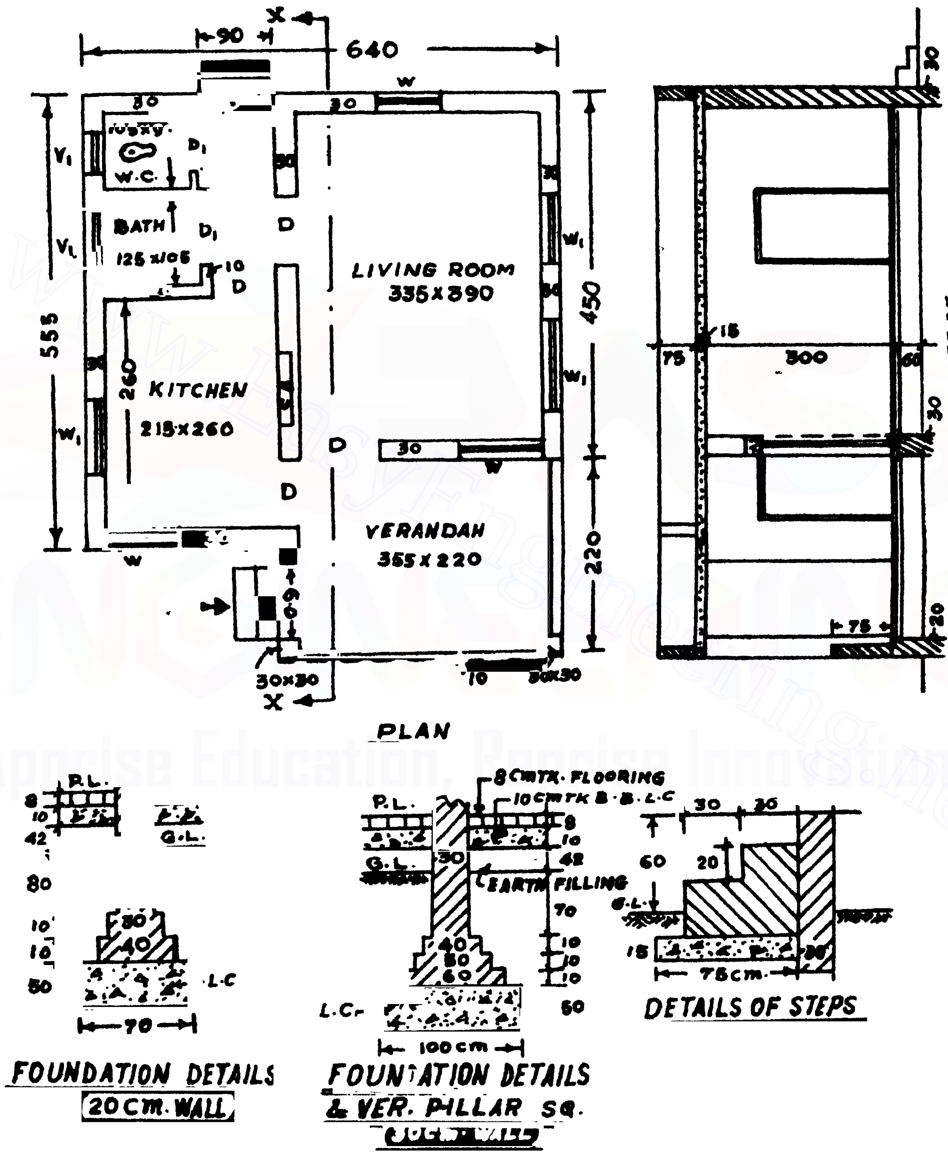
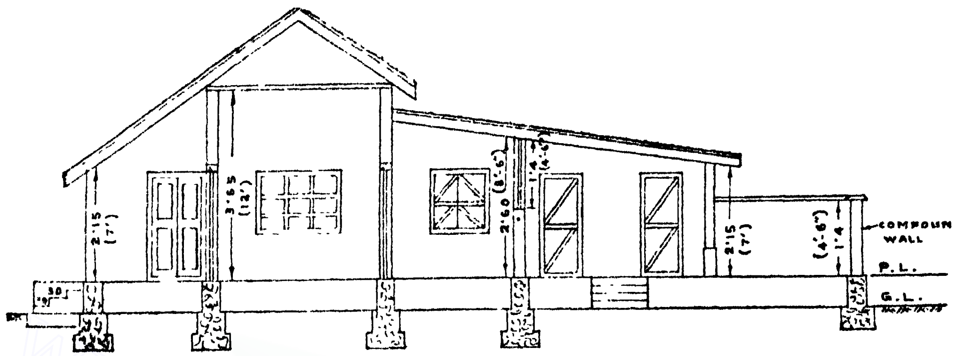


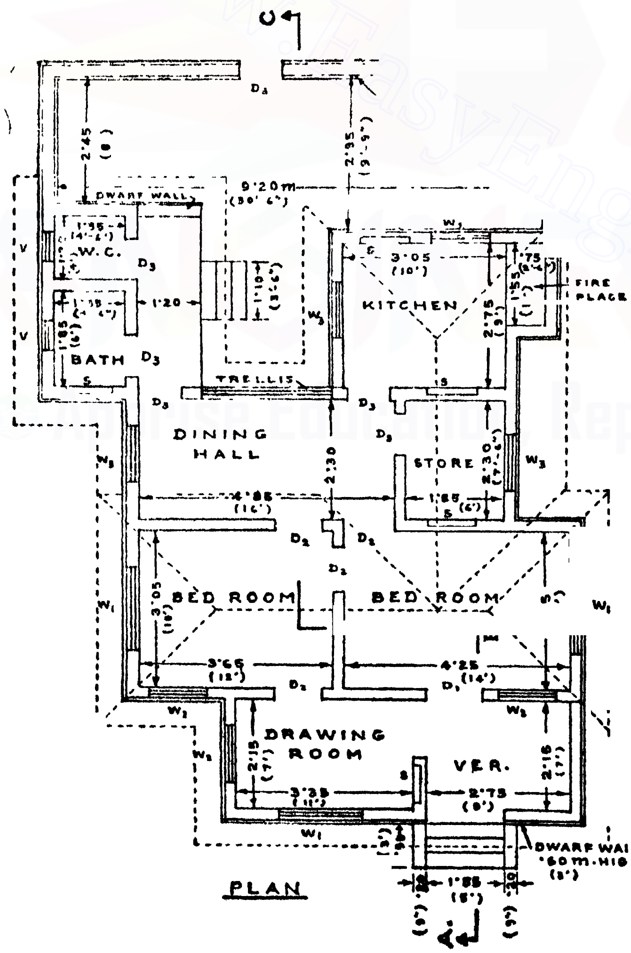
Fig. 3-27

Example —7. Estimate the quantity of the following items of work required in the construction of the building as per the given drawing.

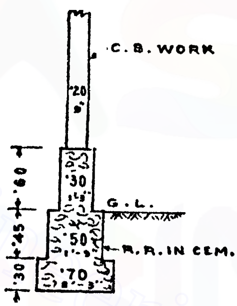
(a) Earthwork in excavation for the foundation, (b) Brickwork in cement mortar (1:5) for the superstructure and the compound wall, (c) Flooring.



CROSS SECTION ABC



PLAN



N.B.—The plinth line has been shown on the plan.

Doors :—

D_1—Fully Panelled 110cm × 210m

D_2— ,, ,, 90cm × 210cm

D_3—Ledged braced 110cmX120cm

Windows—

W_1—Window with 3 leaves 110cm × 120cm

W_2—Panelled 110cm × 120cm

W_3—Ledged and planked 110cm × 120cm

Ventilator—

V—Glazed fixed 90cm × 60cm

Wall Shelf—S=90cm × 120cm

Scale : 1 cm=1⅓m FIG. 3-28

CHAPTER—IV

REINFORCED CEMENT CONCRETE WORKS

4·1. Cement—The suitable types of cement for reinforced concrete works are—

(a) Normal setting or ordinary Portland Cement

(b) Rapid-hardening Portland Cement

(c) High alumina Cement

(d) Blast furnace Portland Cement.

(*a*) *Normal Setting or Ordinary Portland Cement*—This is made from thoroughly burnt mixtures of lime stone and clay. A small quantity of Jypsum being added to retard the time of setting. Its initial setting time is not less than 30 minutes and final setting time not more than 10 hours. The compressive strength of mortar cubes (1 part cement 3 parts sand) should not be less than 115kg/cm^2 at three days and 175kg/cm^2 at 7 days.

(*b*) *Rapid Hardening Portland Cement*—The main physical difference between ordinary and rapid hardening Portland cement is the greater fineness of the latter. The specified setting times of both ordinary and rapid hardening Portland cement are the same, but the minimum compressive strengths of mortar cubes at one day is equal to that of ordinary cement at 3 days. The more rapid rate of hardening of concrete made with this cement facilitates to remove shuttering earlier. It gains the same compressive strength in 4 days as that of ordinary cement in 28 days. The cost of this cement is nearly 10 percent more than ordinary cement.

(*c*) *High-alumina Cement*—This cement is characterised primarily by its rapid hardening qualities due mainly to the increased proportion of alumina. The minimum requirement of alumina is 32 percent for High-Alumina cement where as in Portland cement the amount of this constituent is generally about 5 percent. The specified fineness is between that of ordinary and rapid-hardening Portland cement. Initial setting must take place between two and six hours, and final, setting within two hours after the initial set. Although slow in setting, but hardens vary rapidly and has a higher ultimate strength than ordinary cement. Compressive strength of concrete made with this cement becomes as strong in about 1 day as a full matured concrete made with ordinary cement. Beyond 44°C the strength of this cement drops down as that ordinary cement. High-alumina cement is costly in comparison to that of Portland cement but it prevents the concrete from attacks of Sea-water and many other corrosive liquids. It is used when saving of time is of great importance.

(*d*) *Blastfurnace Portland Cement*—The fineness, setting-times and tensil and compressive strengths are the same as that of ordinary Portland cement, but the requirements for this cement include a slag content between 35 and 65 percent.

Besides the above there are other types of cement which are not used in ordinary construction viz.

(*e*) *Quick-setting Portland Cement*—The initial setting time is 5 minutes and final setting time not more than 30 minutes. This is used for construction in running water. Although this cement sets so earlier but it hardens as nearly the same rate as ordinary cement.

(*f*) *Low-heat Portland Cement*—The initial setting time of this cement is not less than I hour and final setting time not more than 10 hours. Although this cement develops strength at a slower rate than ordinary cement, its ultimate strength is the same as ordinary cement. Used for mass construction such as bridge aboutments, dams etc., where it is necessary to avoid cracking due to heat generation.

Cement of other special kinds, such as Sulphate resistance, Air-entraing-cement are also manufactured.

4-2. **Aggregates**—Coarse aggregate adove 5·5mm size and fine aggregate (sand) must be clean, hard, of minimum porosity and free from excessive quantities of dust. Gravels. crushed hard stone or crushed boulders are the common materials for the coarse aggregate for structural concrete. Broken bricks are also sometimes used for economy and where great strength is not essential.

4-3. **Size and Grading of Aggregate**—The size and grading of aggregate depend upon the type of the structure. The maximum size of coarse aggregate should be as large as possible within the specified limits but in no case be greater than one-fourth of the minimum thickness of the member and the concrete can surround all reinforcement thoroughly.

Size of coarse aggregate should be as follows :—

(a) For buildings and most reinforced concrete construction 20mm down to 10mm.

(b) For thin members, such as ribs and top slab of hollow clay-tile slabs, the largest size of aggregate be restricted 5·5 mm less than the minimum clear distance between the main bars and the size is generally 10 mm.

(c) For unreinforced concrete larger size 20mm to 25 mm, 40 mm to 50 mm upto say 75mm are permissible as in the bottom slab of two-course road construction.

(d) For unreinforced concrete in large piers of bridges, massive foundation and such similar construction 'plumbs' is permitted upto a maximum limit of 20 percent by volume of concrete.

(e) For liquid containers the largest size of 12mm to 5·5mm are generally suitable but not less than 5 percent and not more than 30 percent of the aggregate should pass through a I.S. sieve no. 30.

4-4. **Proportions of materials**—The various methods of proportioning coarse to fine aggregates are—Sieve Analysis, Minimum Voids, Arbitrary Standard and Trial Mixtures. Although the Sieve Analysis is accepted as standard, Minimum Voids method is a suitable reference for proportions and has no difficulty at site to give information regarding the mixture.

In the voids method the proportion of fiine to coarse aggregate should generally be such that the volume of fine aggregate should be 5% in excess of the voids in the coarse aggregate. Since the volume of voids may be upto 45%, a common ratio is one part of fine to two parts of coarse aggregate. The mixture of cement, fine and coarse aggregate becomes such as 1 : 2 : 4, 1 : 1½ : 3 etc. related to dry materials. The water in a damp coarse aggregate does not appreciably affect the volume, were as in a damp fine aggregate may increase the volume by 30% over the dry volume.

The ratio of 1 : 2 of dry fine to coarse aggregate should be changed if tests show that a denser concrete can be obtained by using other proportions.

4-5 Suitable proportions for concrete for various parts and types of structures under ordinary conditions :—

(a) *Proportion 1:4:8, 1:3:6 suitable for* :—plain concrete, viz, foundation piers, filling. etc.

(b) *Proportion 1:2:4 suitable for* : beams, slabs, columns, walls, foundations, bridges, roads (bottom course), retaining walls. etc.

(c) *Proportion* $1{:}1\frac{3}{8}{:}3\frac{1}{8}$ *(approx.) suitable, for* :—precast piles, impermeable constructions such as water tanks, concrete in contaminated ground, roads (single course) etc.

(d) *Proportion* $1{:}1\frac{1}{2}{:}3$ *suitable for* :—long precast piles, precast products, medium span arches, medium load column, roads (top course) etc.

(e) *Proportion 1:1:2 suitable for* :—long span arches, high load columns and such similar members.

4-6. Bulking of Sand—The increase in volume of dry sand due to absorption of moisture which forms a thin film of water around the particles of sand by frictional resistance may be called bulking of sand. A moisture content of 2 to 5 percent increases the volume from 15 to 30 percent. Finer the sand greater is the bulkage. When the moisture content is increased by adding water gradually untill the sand is completely saturated, bulking diminishes practically to nil and the sand occupies the least volume as in the dry state.

The amount of bulking can be readily determined at site by a suitable method as follows : Sufficient quantity of sand shall be put loosely into a cantainer of uniform cross section, levelled off but not pressed down and its depth is measured. The sand is then well mixed and stirred with plenty of water and allowed to settle. The top surface of the inundated sand shall be smoothed and levelled. The new depth of sand is then measured and this is practically equal to that volume which would be occupied by the same weight of sand when dry. Now the amount of loss in the volume of sand is the amount of Bulkage.

If D=depth of sand when damp

D_1=depth of sand after settling under water

then percentage of bulking$=\dfrac{D-D_1}{D_1}\times 100$, and this additional percentage of sand determining at the time of mixing shall be added for correct proportioning of a mixture.

4-7. Quantity of water :—The strength and workability of concrete depend to a great extent on the amount of water used in mixing. An increase of 10% of water than the optimum amount increases workability but may reduce the strength by 15% approximately and an increase 50% of water than the optimum amount may reduce the strength by 50% With an excess of more than 50% the concrete becomes inadhesive. Excessive amount of water in concrete mixing not only produces low strength but also increases shrinkage and decreases durability. Alternatively a smaller amount of water decreases the strength and about 10% less may be insufficient to ensure complete setting of the cement and may produce an unworkable concrete.

A rule for determining the approximate quantity of water in gallons to give a strong concrete of reasonable workability may be given by.

Water requirement of concrete = 28% by weight of cement + 4 % by total weight of aggregates.

If day aggregate has an average weight of 90lb/cft. the amount of water required in a batch of 1:2:4 concrete, mixing by volume as 1·25 cft. cement (1·25 cft. cement = 112lbs) to 2·5 cft. fine and 5 cft. coarse aggregate (practically mixed this way).

$$=0{\cdot}28\times112+0{\cdot}04\times90(2{\cdot}5+5)=5\tfrac{3}{4}\text{ gallons}$$

The above rule (following Dr. Oscar Faber) assumes that the materials are non absorbent and dry. An approximate idea of the quantity of water required = 30% by wt. of cement + 5% by wt. of aggregates.

Modern method to determine the quantity of water in a mixture **is water-cement ratio. The ratio of the volume of mixing water to the volume of cement is called the water-cement ratio.**

In practice the amount of water is actually determined at site making 'slump test' with trial mixtures. A table of water cement ratio by weight is given below for different mixtures according to the British standard specifications.

Proportion	1:2:4	1:1½:3	1:1:2
Water cement ratio (by wt.)	0·58	0·51	0·43

Quantity of water may now easily be calculated from water cement ratio as

$$\frac{\text{Weight of water}}{\text{Weight of cement}}=0{\cdot}58 \text{ for 1:2:4 mix. or, } \frac{W_w}{W_c}=\cdot58$$

∴ Weight of water per bag of cement (I bag = 50 kg.) i. e. $W_w = 50\times0{\cdot}58$ kg. = 29 litres. (Note :—one litre of water weights one kilogram)

4·8 Permissible stresses in concrete for different Grade or proportion based on I. S. recommendation.

Grade of concrete	M 150	M 200	M 250
Corresponding proportion of the grade (approx.)	1 : 2 : 4	1 : 1½ : 3	1 : 1 : 2
M. K. S. units to be adopted	kg/ sq cm	kg/ sq cm	kg./ sq cm
(a) Compressive Stresses due to Bending	50	70	85
(b) Compressive Stresses, Direct	40	50	60
(c) Shear Stresses (As inclined tension)	5·0	7·0	8·0
(d) Bond Stress (Average)	6·0	8·0	9·0

In the designation of the concrete mixture as M 150, M 200 etc., M refers to the mix and the number is the compressive strength (min works test) in kg/sq cm of 15cm cubes at 28 days after mixing.

4-9. The slump Test—Test for a required consistency of concrete is obtained by slump. Slump is the vertical settlement in centimetre obtained after filling up of a standard slump cone and turning out the contents on a flat surface. The slump cone is of 30cm height, of 20cm and 10cm diameters at bottom and top respectively, open at both ends and fitted with handles on sides and foot pieces as shown in the fig. 4-1.

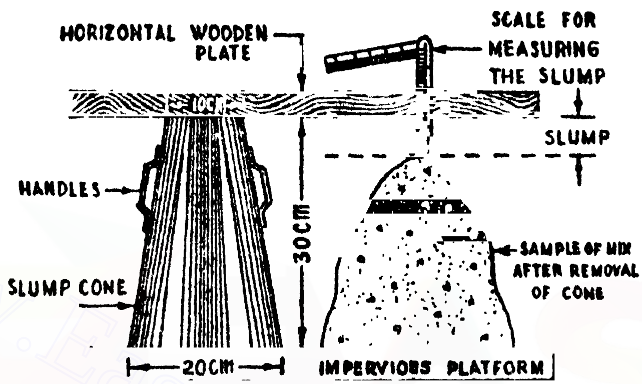


FIG. 4-1

Recommended values for slump are as below—

Type of Work	Without Vibrators	With Vibrators
Mass concrete, large sections, roads etc.	2·5 cm to 8cm	0 to 2·5 cm
Foundations, walls and other heavy sections	4 cm to 12 cm	2·5 cm to 6·5 cm
Slabs, beams, columns, and thin members with congested reinforcements.	10 cm to 18 cm	4 cm to 8 cm

4-10. Reinforcement, In cement concrete steel is embedded so that the two help each other in resisting external forces. It has great advantages over other materials due to its strength, cheapness and adaptability. The coefficient of expansion of steel is appx. equal to that of concrete and as such there is no relative movement between embaded bars and concrete due to temperature changes.

4-11. Permissible stresses in Steel Reinforcement based on I. S. Recommendations :—

Type of stress in steel	Stresses for Mild steel Grade—I KG/sq cm	Grade—II kg/sq cm
1. Tension other than helical reinforcement in column or, compression bars in a beam or slab where the compressive resistance of concrete is neglected —		
(a) Bars upto and including 40mm dia.	1,400	1,260
(b) Bars over 40mm dia.	1,300	1,170
2. Tension in shear reinforcement	1,400	1,260
3. Compression in longitudinal reinforcement in columns	1,300	1,170
4. Tension in helical reinforcement in columons	1,000	900

4.12. Length for Bond. A bar must be adequately anchored in the concrete to resist tensile forces effectively. There must be sufficient length of bar beyond any section to develop by bond between the steel and the concrete a force equal to the total tensile force in the bar at that section. The permissible bond stress between ordinary 1:2: 4 concrete and plain round bars is taken to be 6 kg/sq cm.

If the diameter of a round bar is denoted by 'D' then tensile force of the bar with a stress of f_t is $\frac{\pi D^2}{4} \times f_t$ and this will be equal to the area of perimeter of bar for a bond length, L × bond stress (f_b).

$$\frac{\pi D^2}{4} \times f_t = \pi D \times L \times f_b \quad \therefore L = \frac{f_t}{4 f_b} \times D.$$

With $f_t = 1400$kg/sq cm and f_b =6kg/sq cm $L = \frac{1400}{4 \times 6} \times D = 59D$

With grade II steel $f_t = 1,260$ kg/sq cm and f_b =6kg/sq cm$= \frac{1260}{4 \times 6} \times D = 53D$

The bond length calculated above is greater with higher tensile steels and will be lesser with richer mixes. To comply with the I. S. or D.S.I.R. Code, an anchorage is required in the case of tensile reinforcement in addition to the bond length, but the B. S. Code permits the value of anchorage is to be deducted from the bond length. Considering a worst case I. S. Code may be followed as Bond length=Calculated length+anchorage

For compression bars as in columns, beams, etc. a length of nd shall be provided.

$$\text{Where, } n = \frac{\text{Compressive stress in the bar}}{5 \times \text{permissible bond stress}}$$

In no case value of n shall be less than 12. (For unknown stresses a bond length of 24D should be considered). No hook need be provided for a bar in compression, but a bend is desirable if the end of the bar is near an outer concrete face and it shall not be accounted for anchorage purposes. In liquid containers a straight length of 30 times the diameter is recommended for compressive members.

4-13. End Anchorage or hook :—The best form of anchorage is a semi-circular hook. The radius of the semicircle must be not less than 2D as shown in the fig. (4-1a). In the absence of a hook an additional length of straight bar equal to 14D should be provided.

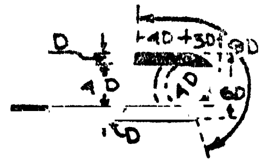


FIG. 4-1a

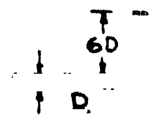
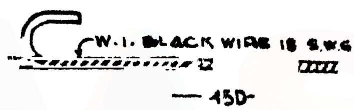


FIG. 4 1b

Length of hook = 9D.

For 90° bend (fig. 4-1b)
length of anchorage = 6D. In bothways of hooking 8cm should be their minimum value.

4-14. Laps in bar :—When a bar of required length is not available, one bar must be lapped to the other to a length of $\frac{f_t}{4f_b} \times D$ for tensile bars or 30D whichever is greater. Both ends shall be hooked and firmly wired together in the case of tensile joint. For grade II steel a length of 45D with both ends hooked (as shown in the fig. (4-2a) is considered sufficient.

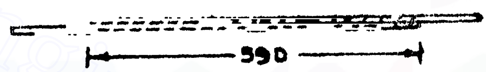


Laps For Tensils Joints with Hooks
Side View FIG. 4-2a

For bars in compression such columns

$$\text{Laps} = \frac{\text{compressive stress in the bar}}{5 \times f_b} \times D$$

or 24D whichever is greater. No hooks at its ends be provided. Generally a lapping equal to 24D without hooks at its ends is considered sufficient for compressive members. For liquid containers such as for water tank 30D for vertical bars and 40D for hooked circular rings are considered sufficient.

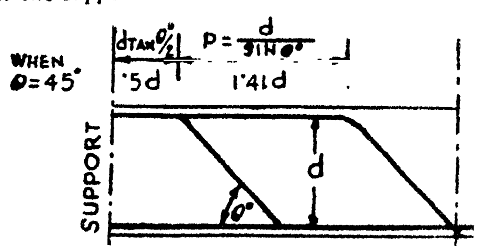


LAPS FOR TENSILE JOINTS WITHOUT HOOKS. (PLAN)

FIG. 4-2b

4-15. Bent up bars :—The usual practice of bending of a bar near a support is at an angle of 45°. The angle of bend may also be 30° in hollow beams where effective depth is less than 1·5 times its breadth. The purpose of bend near a support is two fold.— ***firstly to resist negative bending moment which occurs at the region of the support and secondly to resist shear force which is greater at the support.***

Fig. 4-3a shows the arrangement of a single system of inclined bars to satisfy the assumption that the shear resistance at any vertical section is taken as the sum of the vertical components of the inclined tension and compression forces cut by the section.



SINGLE SYSTEM

FIG. 4-3a

Bending moment which is maximum at the mid span diminishes towards the supports (except cantilevers) and the number of tensile bars required to resist bending moment may thus be reduced near the ends providing sufficient bond length. Denoting effective depth of a member by d

For 45° bends—

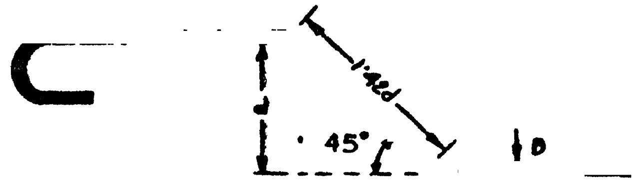


FIG (4-3)

Length of crank $= \dfrac{d}{\sin 45^\circ} = \dfrac{d}{\cdot 707} = 1{\cdot}42d$

Length covered by crank $= d$

$\therefore$ Extra length requ for one bend $= 1{\cdot}42 - d = 0{\cdot}42d$.

Thus if a bar is cranked at both ends at 45° then total length of the bar $= L + 2 \times {\cdot}42d$ where L = Span.

Thus for 30° bends—

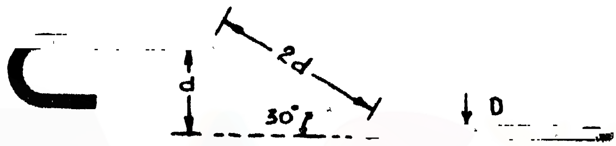


FIG (4-4)

Length of crank $= \dfrac{d}{\sin 30^\circ} = 2d$

Length covered by crank $\dfrac{d}{\tan 30^\circ} = 1{\cdot}73d$

$\therefore$ Extra length required for only one bend $= 2d - 1{\cdot}73d = 0{\cdot}27d$

Thus if a bar is cranked at both ends at 30° then total length of bar $= L + 2 \times {\cdot}27d$.

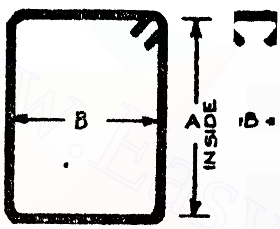
4-16. The number of bars available for bending and the position at which bars in bottom of beams can be bent up or stopped giving sufficient bond is shown below for different end conditions. This is applicable for Beams carrying uniformly distributed load only.

L = Effective span.

No. of bars at mid span.	For freely supported				End Span								Interior span (Fixed)			
					Free				Fixed							
	1st bent at	2nd bent at	3rd bent at	4th bent at	1st bent at	2nd bent at	3rd bent at	4th bent at	1st bent at	2nd bent at	3rd bent at	4th bent at	1st bent at	2nd bent at	3rd bent at	4th bent at
1	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	·15L	—	—	—	·13L	—	—	—	·11L	—	—	—	·21L	09L	—	—
3	·21L	·09L	—	—	·18L	·08L	—	—	·30L	·19L	·11L	—	·27L	·16L	·09L	—
4	·25L	15L	·07L	—	·22L	·13L	·05L	—	·33L	·24L	·17L	·11L	·30L	·21L	·15L	·09L
5	·27L	·19L	·12L	·05L	·24L	·15L	·09L	·04L	·35L	·28L	·21L	·16L	·31L	·24L	·18L	·13L
6	·30L	·21L	·15L	·09L	·25L	·18L	·13L	·08L	·36L	·30L	·24L	·19L	·33L	·27L	·21L	·16L
7	·31L	·23L	·17L	·12L	·29L	·20L	·15L	·11L	·39L	·32L	·26L	·22L	·34L	·29L	·23L	·19L

4-17. Stirrups or Binders—There are bars bent into U or rectangular shapes passing round the tensile reinforcement and the bars in the top flange. Rectangular binder and links has been shown in the Fig, 4-5. Diameter of stirrups normally varies from 5·5mm to 12 mm but 6 mm and 10 mm should be preferred. Stirrups are provided in a beam to resist shearing force and these are placed closer at the support because shearing force is greater at these places. No stirrups are generally needed in the middle third of a span, but except in simple beams as lintels they should be provided not exceeding a distance $\frac{3}{4}$ d. This does not hold good for beams used for bridges. To resist excessive shearing force double stirrups (having 4 vertical legs) can be used as shown in fig. 4-5a.

Additional bars called hangers are usually to be provided in beams for binding stirrups when there is no compressive reinforcement. Diameter of these bars may be 10 mm.



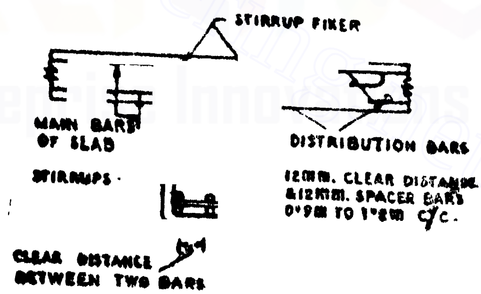
L - 2(A+B)+25cm ; L=2(A+B)+20cm
A and B are in inner diamensions.
25cm and 20cm are extra lengths.

FIG. 4-5

4 VERTICAL LEGS

FIG. 4-5a

4·18. Reinforcement in Beams.—The minimum clear distance between two bars in any one layer should not be less than the diameter of the larger bar or 2·5cm or the largest size of the aggregate plus 6 mm whichever is greater. The minimum clear distance between two layers of bars should be 12 mm and 12 mm diameter spacer bars are to be provided placing 0·9m to 1·2m apart from one other throughout the length of the beam where ever two or more layers of reinforcement occur. Main tensile reinforcement bars in beams should be not less than 6mm diameter and maximum size should not exceed 40 mm. Generally 12mm, 16mm, 20mm, 22mm, and 25mm dia. bars are in use.



4-19. Reinforcement in Slab.—In case of a slab *simply supported at its ends or at end support* (i. e. roof slab built into walls) and carrying an uniformly distributed load alternative bars are bent up from a point $\frac{1}{7}$ the effective span away from the support to resist the small negative bending moment $\left(\text{not less than } \frac{WL}{24}\right)$ that may occur in the slab due to its partial fixity in the wall (as shown in the fig. 4-7).

In case where a slab is continuous over several spans and the condition of the slab at every support is the same, somewhere between perfect fixity and perfect freedom, the bars are bent up from a point ¼th span away from the centre of support and the same bar is carried into the next span to a point ¼th span away from the centre of support. (as shown in the fig. 4-7).

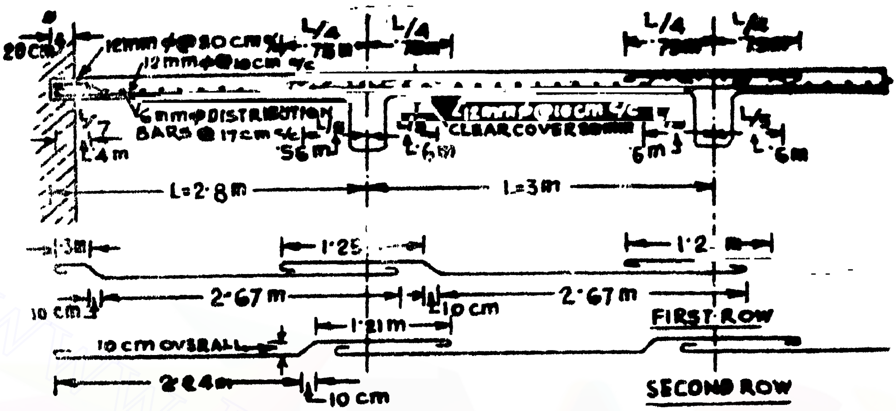
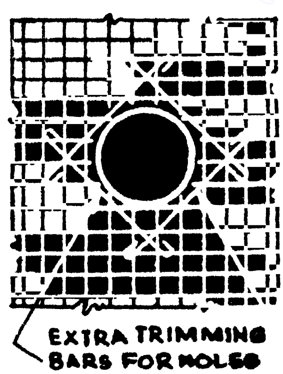


FIG. 4-7

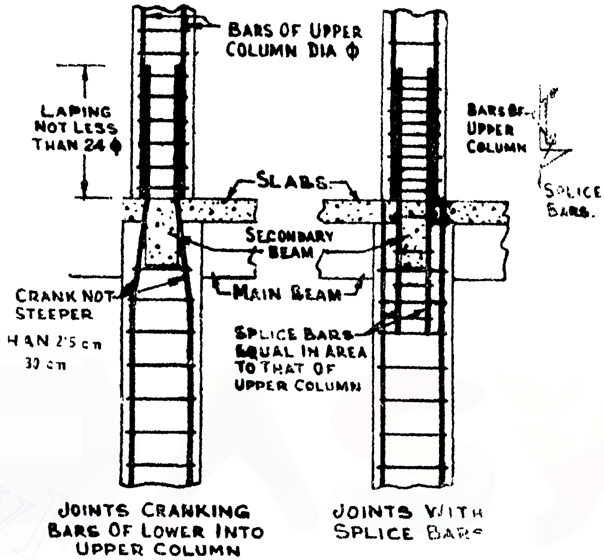
The diameter of main tensile reinforcement in slab should preferably be 6mm minimum to 16mm maximum, 10mm and 12mm are most in common use. Spacing of these bars should not exceed three times its effective depth or 30cm whichever is the lesser (600mm according to I. S.).

(*a*) *Distribution Bars*—These are also called ***Temperature Reinforcement, Transverse Reinforcement or Secondary Reinforcement***. The diameter of these bars is 5·5mm to 12mm but usually 6mm and 10mm are provided. **The object of these bars is to resist cracks caused due to temperature and shrinkage stresses, to assist in distributing local loading, to take any bending stresses that may be developed.** The I. S. code recommends that the area of distribution bar shall not be less than 0·15 percent of the gross cross sectional area of cencrete. In the slabs of bridge decks the Ministry of Transport requires 40% to 60% of the area of main reinforcement according to the spans of the slabs. For slabs spaning in one direction the spacing of transverse bars should not exceed ***four times*** (***five times according to I. S.***) ***the effective depth of the slab or*** 45cm (600mm according to **I. S.**) ***whichever is less***.

(*b*) ***Reinforcement for openings in slabs***—Due to provision of small openings in a slab such as manholes in tank roofs, openings for ventilation ducts in floors etc, main reinforcement may be disturbed and for this some extra bars, at least equal to the area of bars disturbed by the hole, should be placed parallel to the principal reinforcement. Besides this a bar should be placed diagonally across each corner of an opening.



4-20. Longitudinal reinforcement in columns—Size of longitudinal bars usually from 12mm minimum to 40mm maximum. Bars should be placed at each corner of a column (in case a circular column 6 Nos. minimum) and all bars should be placed symmetrically. For joints in the longitudinal reinforcements, the bars should be overlapped for at least 24 times the diameter of the upper bars and for liquid containing works over lapping should be 30 times the diameter of the bars. Two types of joints in the longitudinal reinforcement in a column have been shown in the figure 4-8. **The crank in the bar passing from lower column to the upper should not be more acute than 2·5cm in a length of 30cm** (see fig. 4-8). The area of longitudinal reinforcement should not be less than 0·8% of the total area of concrete or more than 8%. The diameter of binder (fig. 4-8a) should not be less than 5·5 mm or a quarter of the diameter of the largest longitudinal bars. Largest diameter of binder should be 12 mm; 16mm may also be used, but generally a smaller diameter bar is sufficient. 5·5mm, 6mm 10mm diameter bars are generally used.



DETAILS OF COLUMN JOINTS
Fig. 4-8

The principal objects of the lateral ties are.

(1) To prevent bulking of the longitudinal bars due to compression.

(2) To prevent concrete shearing on a diagonal plane (see fig. 4-8b.)

The spacing of binder (also called as transverse or lateral) should not be greater than twelve times the diameter of smallest longitudinal bar or least lateral dimension or 30 cm which ever is less.

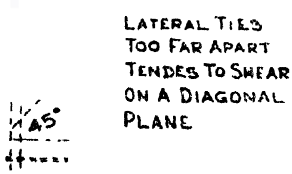


FIG. 4-8b

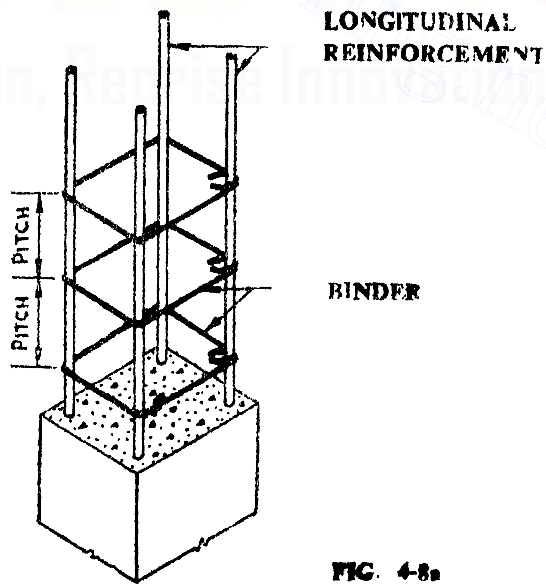


FIG. 4-8a

4-21. Measurement and classification of Reinforced Cement Concrete (R. C. C.) in situ according to the Indian Standard method of measurement of building works.

According to the recommendation of the Indian Standard Institute, R. C. C. works shall be classified and measured separately as follows :—

(i) Bases for columns, foundation footings etc. and mass concrete ;

(ii) Walls including attached plasters, string courses and buttresses etc. ;

(iii) Roofs, landings, shelves, suspended floor and balconies etc. ;

(iv) Lintels. beams and girders, etc. ;

(v) Pillars, posts columns and struts ;

(vi) Chajja up to 15 cm in thickness ;

(vii) Stairs (excluding landings) ;

(viii) For R. C. C. tee-beam construction, the roof shall be taken as runnin continuously through. and the beams as that portion below the roof.

(ix) Columns shall be measured from the floor surface to the underside of slabs or beams as the case may be. If there be any 'haunching' connecting beams and columns the later one shall be measured upto the springing of the haunchings. All other portions shall be included with the beam. If the width of the beam is less than the width of the column, the extra width at the junction shall be included with the beam.

Concrete easing to rolled steel joists or beams, steel stanchions, etc., shall be measured without giving any deduction to the volume occupied by the joist except in the case of boxed stanchions or girders, in which case the boxed portion only shall be deducted.

4-22. Length and size of bars.—As far as possible a few different size of bars should be used preferably bars of larger diameter (less than 25mm) as this reduces the number of bars to be bent and placed. Price of larger diameter bars is also lower than of smaller ones. The basic price is that of 16mm bars, all larger bars being priced at this rate while smaller bars cost more for each 3mm diameter below 16mm. But this should be remembered that for cutting and bending, bars of 25mm diameter and larger, oxy-acetylene flame or power operated machine may be used. Bars upto 8m length can be easily transported and handled. Bars upto 10mm diameter can be obtained in long lengths in coils.

4·23. Some common M.S. bars—areas and weights.

The corresponding dimensions of bars as shown in Metric System have been standardised by the Indian Standard Institute. This edition of the Abridged List gives only those metric system which are actually available in the market.

Metric System are in use			F. P. S. System		
Dia. in mm.	Sectional area in sq. mm.	Weight per metre run in	Dia. in inch	Sectional area in square inch	Weight per foot run in lbs
5·5	23·8	0·19	$\frac{3}{16}$	0·028	0·044
6·0	28·3	0·22	$\frac{1}{4}$	0·049	0·167
8·0	50·3	0·39	$\frac{5}{16}$	0·077	0·261
10·0	78·6	0·62	$\frac{3}{8}$	0·110	0·375
—	—	—	$\frac{7}{16}$	0.150	0·511
12·0	113	0·89	$\frac{1}{2}$	0·196	0·667
16·0	201	1·58	$\frac{5}{8}$	0·307	1·043
20·0	314	2·47	$\frac{3}{4}$	0·442	1·502
22·0	380	2·98	$\frac{7}{8}$	0·601	2·044
25·0	491	3·85	1	0·785	2·670
28·0	616	4·83	$1\frac{1}{8}$	0·994	3·379
32·0	804	6·31	$1\frac{1}{4}$	1·227	4·173
36·0	1018	7·99	$1\frac{3}{8}$	1·484	5·049
40·0	1257	9·86	$1\frac{1}{2}$	1·767	7·051

Weight of 1 cu m. of M.S. bar=7850 Kg. Weight of 1 cft. of M.S. bar=490 lbs.

4·24 Cover of Concrete— Exclusive of plaster or other decorative finish).

For proper protection of reinforcement against corrossive actions and to ensure that the thickness of concrete around a bar is sufficient to develop the bond resistance, it is necessary to provide requisite cover over the bars.

The minimum cover of concrete to reinforcements should be as below :—

1. At each end of reinforcing bar not less than 25mm nor twice the dia of such bar.
2. This slabs and panel wall :—12mm minimum or dia, of bar whichever is greater.

3. For longitudinal reinforcing bar in a beam 25mm minimum or dia. of the largest bar whichever is greater.
4. Columns :—For columns less than 20 cm square cover should be 25mm minimum or dia. of bar whichever is greater and for above size of 20cm square, 40mm minimum or dia. of bar whichever is greater.
5. Piles :—40mm minimum for main reinforcement and 12mm minimum for binders.
6. Liquid Containers :—32mm minimum or dia. of bar whichever is greater.
7. Foundation :—40mm minimum in case where the concrete is in direct contact with the ground.

4.25 Binding Wire—Quantity of binding wire depends upon the nature of reinforcement. For every 10 sq m slabs approximately 2·7 kg of 18 gauge soft black iron wire is required. For other works 1 kg per quintal of steel may be recommended.

4-26 Bar Bending Schedule:—In bar bending schedule the following informations are generally required—(a) Barmark :—this gives the position of the bar in the structure, (b) Diameter of bar, (c) The shape and bending dimensions of the bar, (d) Length of each bar (e) Number of the same type of bars, (f) Total length, (g) Weight, (h) Total weight. Most designers have their own form of bending schedule to suit the work in hand.

Example 1—Prepare a schedule of bars for the R.C.C. Lintel shown in the fig. 4-9 assuming bearing of the lintel be 15 cm on walls at each side. Weight of 10mm ϕ bar = 0·62 kg/rm and 6mmϕ bar = 0·22 kg/rm.

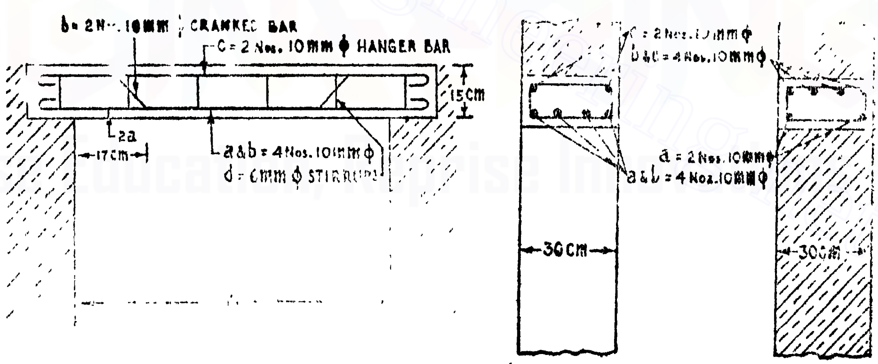


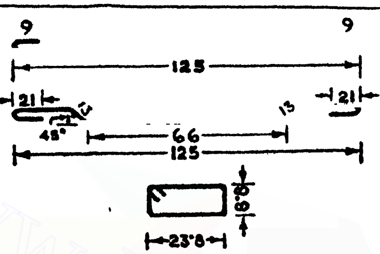
FIG. 4·9

Discussion –Cover of concrete has not been shown in the figure. In such cases standard minimum cover (in this case 25mm) may be considered. Rod mark should be carefully studied from the figure. In absence of rod mark in a figure name of the bar may be written in the barmark column. The degree of bend if not mentioned may be taken as 45°.

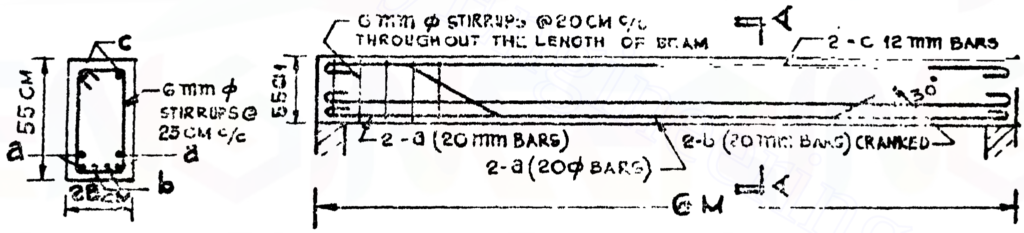
Details of calculation—

Bars a-a = 1m (clear span) + 30cm (bearings)—50mm (covers) + 2 × 9 × 10mm = 1·43m
Bars c-c = Same as a-a.
Bars b-b = 1·25 + extra length for cranks + 2 bends = 1·25m + 2 × ·42 × 10cm + 2 × 9 × 10mm = 1·52m

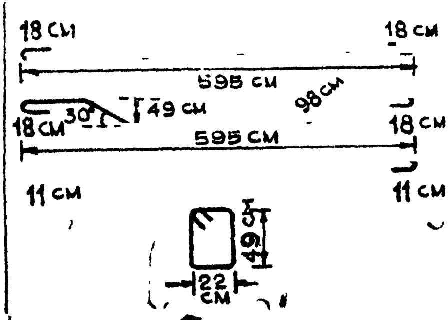
Bars d-d = 2(23·8cm + 8·8cm) + 25cm = 90cm. 23·8cm and 8·8cm are inner dimensions, 25cm is extra length. In working examples details of calculation is not required ; but all such details of measurement is to be shown in the bar bending schedule.

Bar mark	Dia. mm	Shape of bending Dimensions in cm	Length m	Nos.	Total Length m	Weight	Total Weight
a-a & c-c	10 mm		1·43	4	5·72		
b-b	10 mm		1 52	2	3·04		
					8·76	5·43 kg.	
d-d	6mm		0·90	6	5·40	1·19 kg.	
							6·62 kg. 0·066quin.

Example 2—Prepare a schedule of bars of the RC C. beam shown in the attached drawing assuming 20mm dia. bars to weight 2·47 kg/m ; 12mm dia. bars 0·89 kg/m and 6mm dia. bars 0·22 kg/m(L.C.E. 1958. Converted in metric unit).



SECTION ON A-A FIG. 4-10 LONG SECTION

Bar mark	Dia. mm	Shape of bending	Length m	Nos.	Total Length m	Weight	Total Weight
a-a	20		6·31	4	25.24		
b-b	20		6·58	2	13.16		
					38·40	94·85 kg.	
c-c	12		6·17	2	12·34	10 98 kg.	
						9·92 kg.	
Stir-rups	6		1·67	27	45·09	116 kg.	1·16 quin.

Assumptions made in the above example that bars upto 6m length are available and cover on all sides = 25mm (clear).

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Example 3.—A R. C T-beam rests on 30cm walls over a clear span of 6m. The details of reinforcement has been shown in the fig. 4·11. Prepare a schedule of bars assuming weight of 22mm, 12 mm and 10mm dia. bars are 2·98 kg./rm, ·89kg./rm and ·62kg/r m respectively.

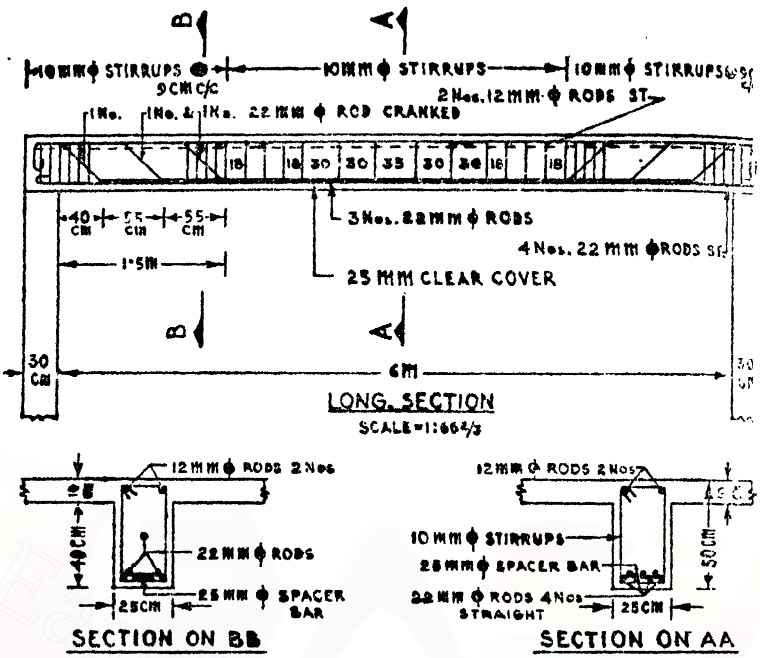
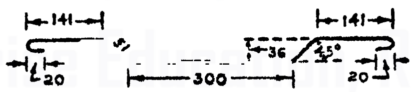
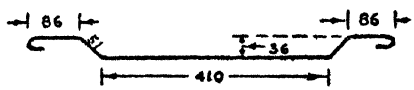
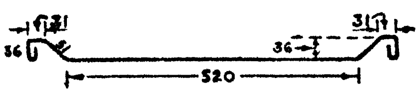
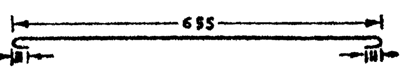
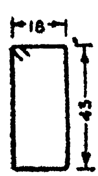


FIG. 4-11

Bar mark	Dia	Shape of bending. Dimensions in cm.	Length m	Nos.	Total Length m	Weight	Total Weight
Bottom layer St. bars	22 mm		6·95	4	27·80		
1st cranked bar	22 mm		7·24	1	7·24		
2nd cranked bar	22 mm		7·24	1	7·24		
3rd cranked bar	22 mm		7·96	1	7·96 50 24	149·7kg.	
Top bar	12 mm		6·77	2	13 54	12·1kg	
Stirrups	10 mm		1·47	62	91·14	56·5kg	218 kg. 2·18 quil

Example 4.—Fig. 4-12 shows longitudinal and cross-sections at mid-span and support of a R. C. T-beam 22cm by 40 cm overall including the slab thickness 10cm. The beam of which particulars are shown in the figure is continuous over to equal spans 4m clear and supported on 30 cm walls. Allow clear cover 25mm all round. If weight of 16mm and 10mm dia. bars are 1·58 kg and 0·62 kg per r m respectively prepare a bill for payment adopting the following market rates (a) Shuttering, Rs. 13·00 per sqm. M. S. bar Rs. 280 per quintal and concreting, Rs. 320 per cum (consider web only for concreting).

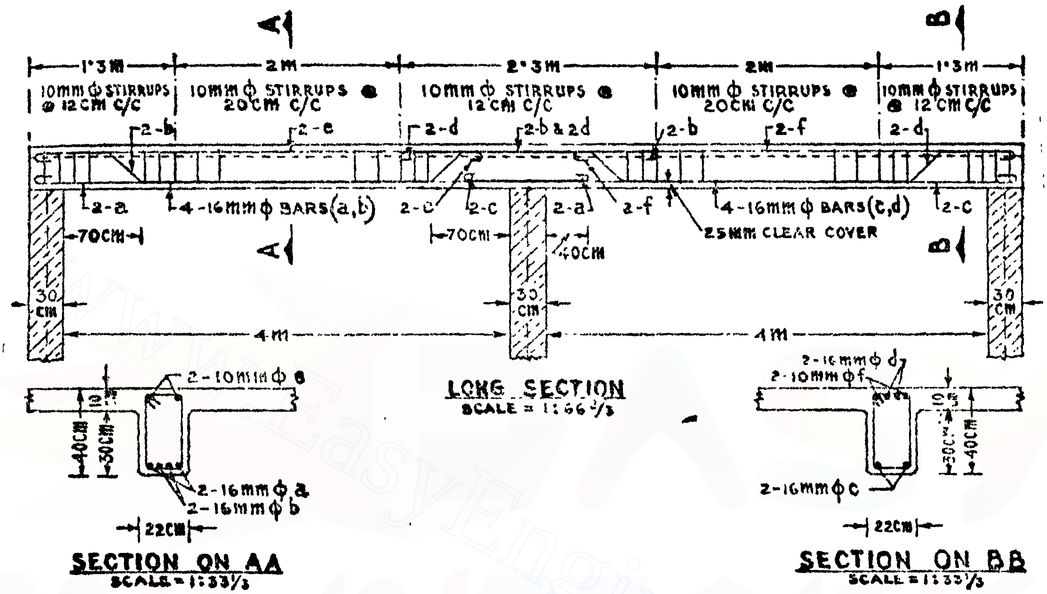


FIG. 4-12

Schedule of bars to calculate reinforcement.

Bar mark	dia mm	Shape of bending Dimensions in cm	Length m	No	Total Length m	Weight	Total weight
a—a & c—c	16	14·5, 498, 14·5	5·27	4	21·08		
b—b	16	66, 169, 31, 260	6·1 4	2	12·28		
d—d	16	169, 66, 260, 557	6·14	2	12·28 45·64	72·1 kg	
e—e & f—f	10	9, 388, 9	4 06	4	16·24		
Stirrups	10	33, 15	1·21	62	75·02 91·26	56·6 kg.	129 kg =1·29 quin.

Area of shuttering (web only) :

Both sides	$=2(8m+3\times\cdot30m)\times\cdot30m$	$=5{\cdot}34$ sq m
Bottom	$=2(4m\times\cdot22m)$	$=1{\cdot}76$ sq m
Ends	$=2(\cdot30m\times\cdot22m)$	$=0{\cdot}13$ sq m
		Total $=7{\cdot}23$ sq m

Volume of concrete $=8{\cdot}90m\times\cdot30m\times\cdot22m=0{\cdot}587$ cu m

Estimated cost :—

Shuttering 7·23 sq m @ Rs. 13·00 sq m	=Rs. 93·99
Reinforcement 1·29 qu, @ Rs. 280·00 qu.	=Rs. 361·80
Concreting 0·59 cu m. @ Rs. 320·00 cu m	=Rs. 188·80
	Total=Rs. 643·99 say Rs. 644·00

Example 5 —Fig. 4-13 shows plan and cross-section of the footing slab with a square R.C. column 20cm outside with the following particulars

Area at base of slab $=1m\times1m$

Area at base of column $=28cm\times28cm$

Depth of slab at column face $=40cm$

Depth of slab at outer edge $=15cm$

Reinforcement in the slab =16mm dia. bars both ways at 15cm c/c

Reinforcement in the column 4 nos. 16mm dia. bars with 6mm dia binders at a pitch of 18cm c/c. Clear cover for slab is 50mm and for column is 25mm. Other particulars are as per drawing. If weight of 16mm dia. and 6mm dia. bars are 1·58kg and 0·22kg per r m respectively prepare a bill for payment of the above column. Rate of the works may be taken as follows :—

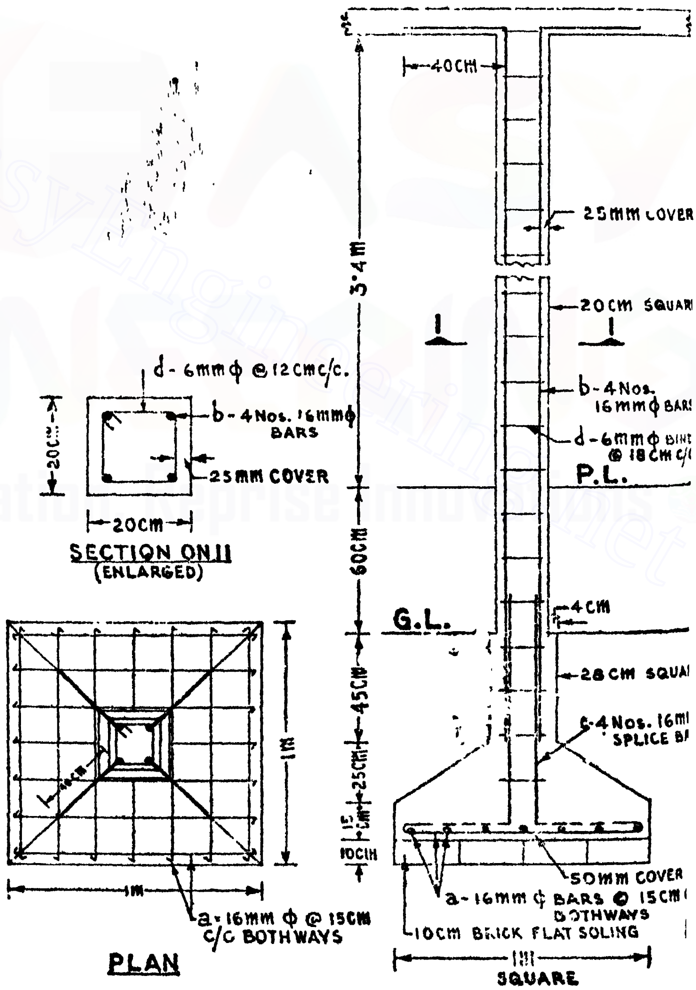
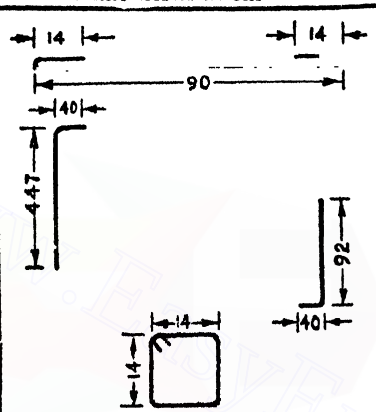


FIG. 4-13

Cement concrete (1:2:4) with stone chips (20mm down) excluding shuttering and reinforcement @ Rs. 410·0 per cu m. Shuttering including supplying, fitting, fixing an striking out the same @ Rs. 15 00 per sq m. M. S. reinforcement including, bending, binding and placing the same as per drawing @ Rs. 580 00 per quintal. Brick flat soling @ Rs. 18·00 sq m. The rates mentioned above include profit and overhead charges.

Schedule of bars to calculate reinforcement

Bar mark	dia. mm	Shape of bending Dimensions in cm	Length m	No.	Total Length m	Weight	Total Weight
a—a	16		1·18	14	16·52		
b—b	16		4·87	4	19·48		
c—c	16		1·32	4	5·28 41·28	65·2kg	
d—d	6		0·81	27	21·87	4 8kg	70 kg. =0·7 quin

Volume of concrete (1:2 4)-

Slab (bottom portion) = 1m × 1m × 15cm 0·150 cu m

Slab (upper trapezoidal portion) $= \frac{H}{6}(A_1 + A_2 + 4Am)$

Here, H = 25cm; Bottom area, A_1 = 1m × 1m = 1 sq m

Top area A_2 = 28cm × 28cm = 08 sq m

Am = area of mid section $= \left(\frac{1m + 28cm}{2}\right)^2$ = 0·41 sq m

∴ Volume $= \frac{.25}{6}(1 + 0{\cdot}08 + 4 \times 0{\cdot}41)$ ... = 0·113 cu m

Column at base = 28cm × 28cm × 45cm ... = 0·035 cu m

Column at upper part = 20cm × 20cm × 4m ... = 0·160 cu m

Total = 0·458 cu m

Shuttering :—(For column shuttering rate is generally in per rm)

Sloping trapezium portions $= 4\left(\frac{1m + 28cm}{2}\right) \times \sqrt{(.25m)^2 + (.36m)^2}$ = 0·50 sq m

Column at base = 4 × 28cm × 45cm ... ... = 1·10 sq m

Column at upper part = 4 × 20cm × 4m ... . = 3·20 sq m

Total = 4·80 sq m

Estimated cost :—

Brick flat soling = 1m × 1m = 1 sq m		@ Rs. 18·00 per sq m	= Rs. 18·00
Concreting (1:2:4)	= 0·458 cu m	@ Rs. 410·00 per cu m	= Rs. 187·78
Reinforcement ...	= 0·70 quin	@ Rs. 550·00 per quin	= Rs· 385 00
Shuttering ...	= 4·80 sq m	@ Rs. 15·00 per sqm	= Rs. 72·00

Total cost

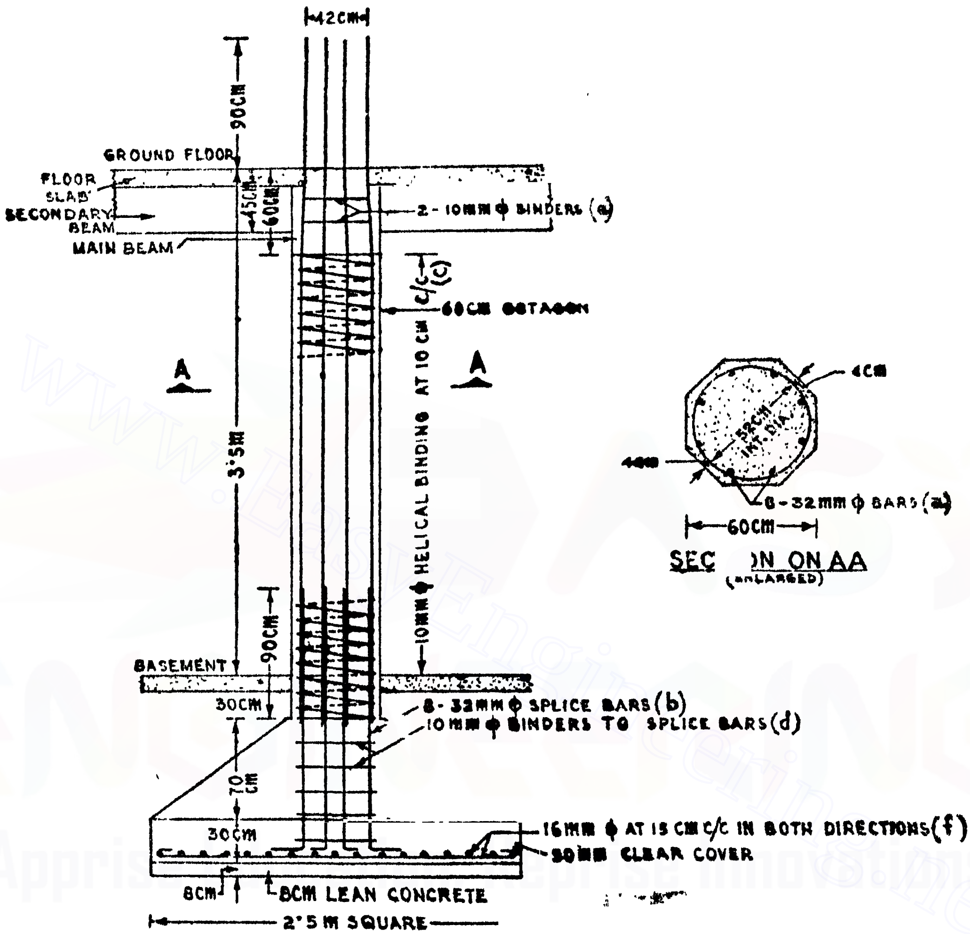
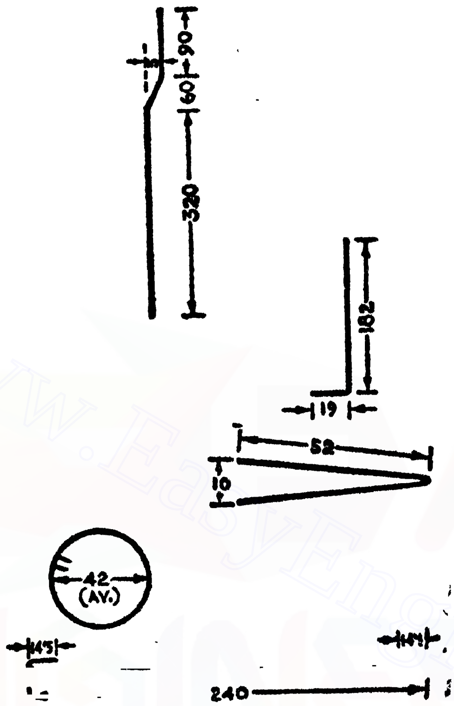


FIG. 4-14

Example 6.—An octagonal column having 52cm internal and 60cm external diameters is reinforced with 8nos. 32 mm θ longitudinal bars and 10mm θ helical binders placed at 10 cm c/c. The depth of base slab at column face is 1m and taper it down to 30 cm at the edges. The slab is 2·5m square at the base and and 66cm square at column face reinforced with 16mmθ bars at 15cm c/c. The reinforcement of longitudinal bars has been projected 90cm above roof level to from an internal dia. of 42cm at floor. Arrangements of splice bars and all other details has been shown in the drawing. Assuming wt. of 32mm. 16mm and 10mm dia. bars are 6·31 kg. 1·58 kg and 0·62 kg per rm respectively, prepare an estimate for shuttering, concreting and reinforcement assuming your own market rates.

Schedule of bars to calculate reinforcement

Bar mark	dia. mm	Shape of bending. Dimensions in cm	Length m	No.	Total Length m	Weight	Total weight
a-a	32		4·70	8	37·60		
b-b	32		2·01	8	16·08 53·68	338·7kg	
c-c	10		1·64	31	50·48		
d-d & e-e	10		1·57 (av.)	7	10·99 61·83	38·3kg.	
f-f	16		2·69	2×17	91·46	144·5kg.	522 kg 5·22 qn

Volume of concrete (1:2:4) :—Base slab, lower portion$=2·5m\times2·5m\times30cm$ ...$=1·875$cum

-do- upper trapezoidal portion$=\frac{H}{6}(A_1+A_2+4Am)$

$$=\frac{·70}{6}\left[(2·5)^2+(·66)^2+4\left(\frac{2·5+·66}{2}\right)^2\right] \quad =1·945\text{cu m}$$

Area of octagon$=·828D^2$ where D=dia. of inscribed circle.
Here $D=52+2\times4=60$cm, ∴ Sectional area$=0·828\times(·60)^2=·30$ sq m
Height is to be measured upto the underside of the main beam
$=(3·5+·30)-·60=3·2$m ∴ Volume$=0·0375\times3·2$ $=0·960$ cu m

Total volume$=4·780$ cu m

volume of lean concrete (1:4:8)$=2·5\times2·5\times·08=0·50$ cu m

Shuttering—Sloping trapezoidal portions$=4\left(\frac{2·5+·66}{2}\right)\times\sqrt{(·70)^2+(·92)^2}$ $=7·4$ sq m

Following the section on A-A, if corners are joined with the centre of the octagon the column forms 8 equal triangles having one side at face
$=2\times\frac{·60}{2}\tan 22\frac{1}{2}^\circ=25$ cm
Octagonal side of column$=8\times25\text{cm}\times3·2\text{m}$ ... ... $=6·4$ sq m

Total area$=13·8$ sq m

Estimate cost :—Cost of shuttering 13·8 sq m @ Rs. 15·00 per sq m$=$Rs. 207·00
Cost of reinforcement 5·22 quin @ Rs. 55·00 per quin$=$Rs. 2,871·00
Cost of concreting (1:2:4) 4·780 cu m @ Rs. 41·00 per cu m$=$Rs. 1,959·80
Cost of lean concrete ·50 cu m @ Rs. 300 per cu m$=$Rs. 150·00

Total cost $=$Rs. 5,187·80

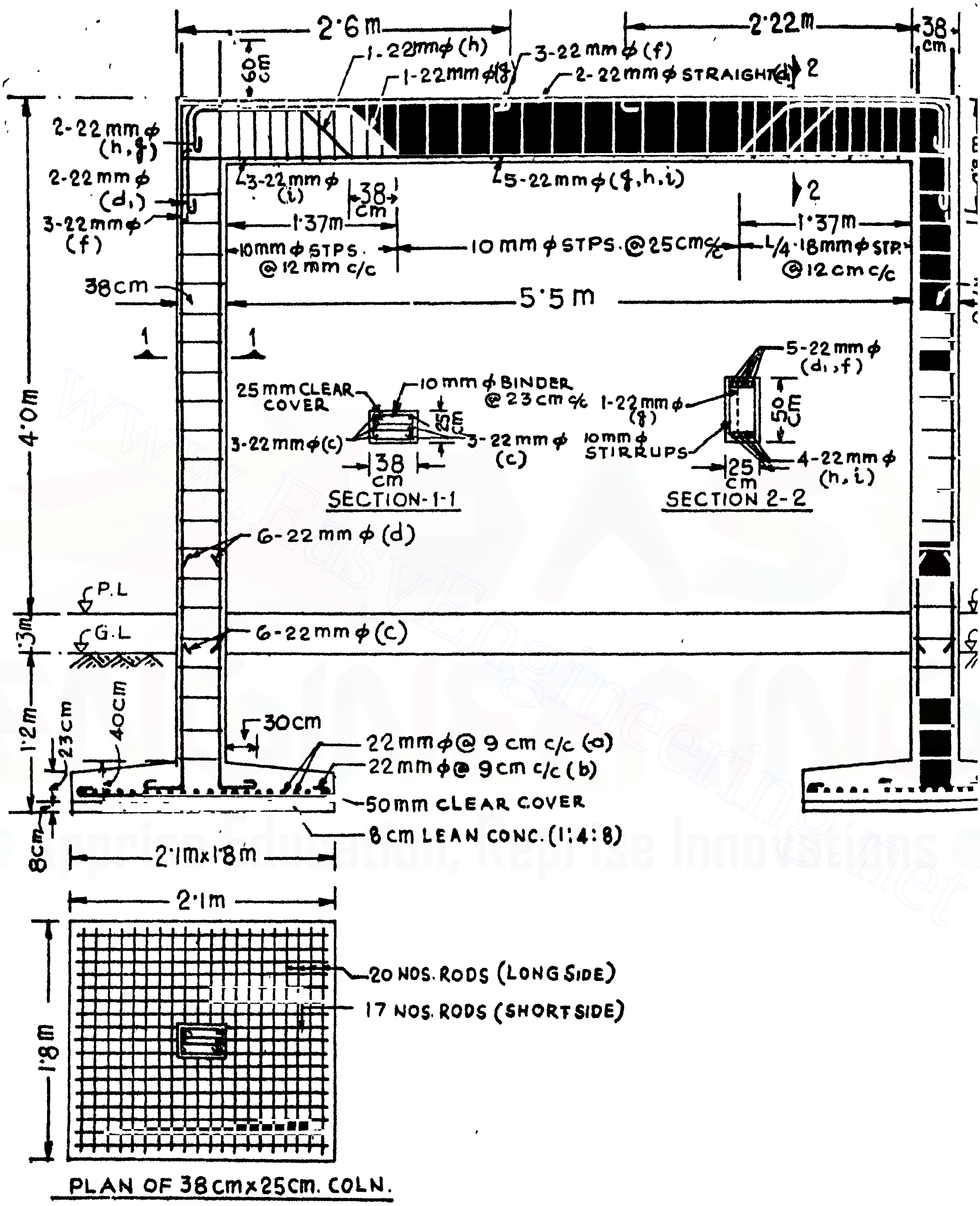
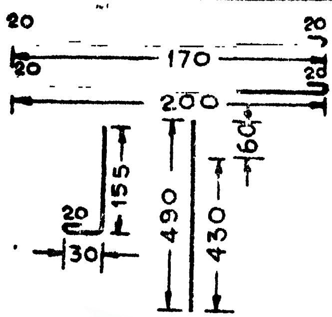


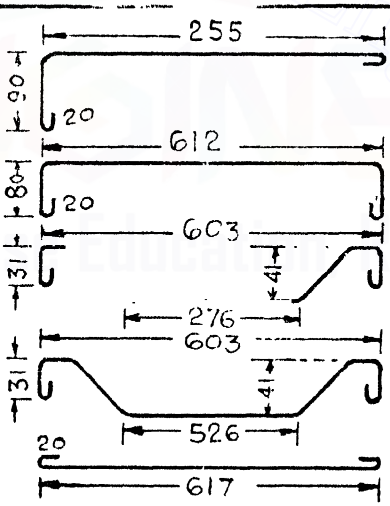
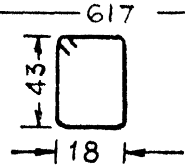
FIG. 4-15

Example 7.—Prepare a complete schedule of bars of the portal frame as shown in the Fig. 4-15. Assume weight of 22m ϕ bar=2·98 kg/rm and 10mm ϕ bar=0·62 kg/rm.

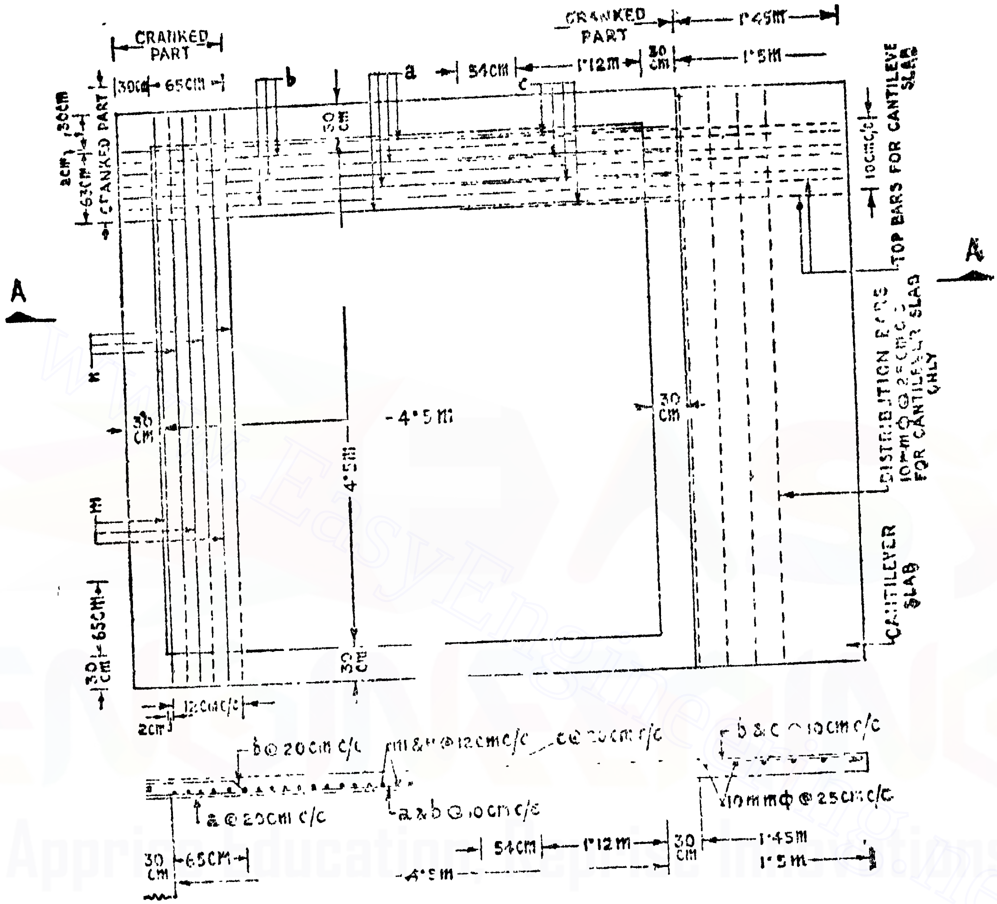
Schedule of Bars for Columns

Bar mark	dia mm	Shape of bending Dimensions in cm	Length m	Number	Total Length m	Weight	Total Weight
a-a	22		2·10	20×2	84·00		
b-b	22		2·40	17×2	81·60		
d-d	22		2·05	6×2	12·60		
c-c	22		4·90	6×2	58·80		
					237·00	706·3 kg	
Binders (for single turn)	10		·66	2×2×20	52·80	32·7 kg	739 kg

Schedule of Bars for Beam

Bar mark	dia mm	Shape of bending Dimensions in cm	Length m	Number	Total Length m	Weight	Total Weight
f-f	22		3·85	2×3	23·10		
d_1-d_1	22		8·12	2	16·24		
g-g	22		7·39	1	7·39		
h-h	22		7·39	1	7·39		
i-i	22		6·57	3	19·71		
					73·83	220·0kg	
stirrups	10		1·47	32	47·04	29·2	249·2kg

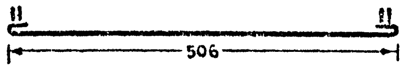
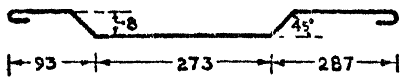
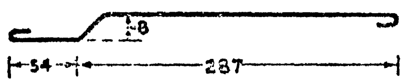
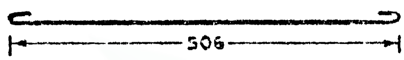
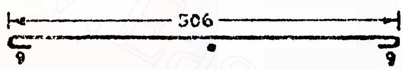
∴ Total weight of reinforcement in the portal frame = 739 kg + 249·2 kg = 988·2 kg = 9·88 quin.



SECTION ON A-A

FIG. 4-16

Example 8. FIG. 4-16 is the plan and section of a R.C. slab 13 cm thick overall, resting on 30cm walls cantilevered out on one side. The slab is reinforced bothways, a, b, c, m and n all are 12mm dia. bars. Prepare a schedule of bars for the slab assuming weight of 12mm and 10mm dia. bars are as 0·89 kg and 0·62 kg respectively. Assume 12mm clear cover.

Bar mark	Dia. mm	Shape of bending Dimensions in cm	Length m	Nos.	Total length m	Weight	Total weight
a-a	12		5·28	23	121·44		
b-b	12		6·82	22	150·04		
c-c	12		3·66	23	84·18		
m-m	12		5·28	19	100·32		
n-n	12		5·34	18	96·12 552·10	491·4 kg.	
Distribution bar canti.	10		5·24	7	36·63	22·7 kg. 514 kg.	=5·14 qu

4-27. Estimating Reinforcement in absence of bar bending schedule.

To enable reinforcement to be cut and bent accurately, bar bending schedules are prepared. Such schedules not only ensure accurate work but enable reinforcement to be used economically and avoids confusion and facilitates checking.

In case to estimate reinforcement without preparing the bar bending schedule the takeoff sheet should have columns for (1) Size of bar and position, (2) Overall length with cover, (3) Extra length for, (a) laps, (b) Cranks, (c) hooks, (4) Less cover, (5) Actual lenght. (6) Number of bars, (7) Total length and (8) Weight. Each of the above columns should properly filled up during recording measurement of works.

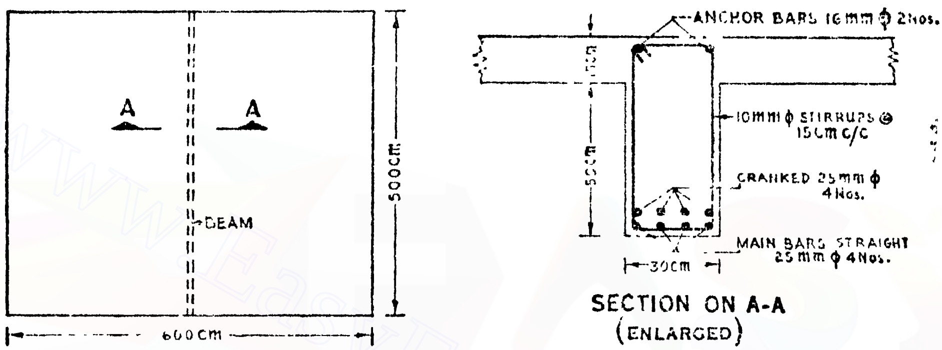
(1) Size of bar and position	(2) Overall length with cover	(3) Extra length for			(4) Less cover	(5) Actual length 2+3—4	(6) No. of bars	(7) Total length	(8) Weight
		laps	cranks	hooks					

Example 1. A room 600 cm long × 500cm wide have a flat roof. There is one **T-beam** in the centre (cross section below the slab 30 cm × 50cm) and the slab is 15cm thick. Estimate the quantity of iron bars required for reinforcement (for the T-beam only) from the data given below:—

Main bars	8 Nos. 25 mm dia. in 2 rows of 4 each (all 4 in the bottom being straight and others bent)
Stirrups	10mm dia and 15cm centre to centre throughout
Anchor bars ...	2 Nos. 16mm dia.

(**D.C.E. Maharashtra 1966**)

Ans—The estimate has been prepared assuming a clear cover of 25mm allover and bars are bent at 45°.



PLAN

SECTION ON A-A (ENLARGED)

FIG. 4-17

(1) Size of bar and position	(2) Overall length with cover cm	(3) Extra length: Lap. cm	(3) Extra length: Crank ·42d cm	(3) Extra length: Hooks 9D cm	(4) Less cover cm	(5) Actual length 2+3−4 cm	(6) No. of bars	(7) Total length m	Weight
Main bars 25mm dia. at bottom straight	500	—	—	2×9×25mm =45	5	540	4	21·60	
Main bars 25mm dia. at bottom bent [d=(50+15)−2×2·5 (cover)—2·5 (dia.)—2·5 (upto centre)= 55cm]	500	—	2×·42 ×55 =46	45	5	586	4	23·44 / 45·04 @3·85 kg	173·25
Anchor bars 16mm dia.	500	—	—	2×9×16mm =27	5	522	2	10·44 @1 58kg.	16·43
Stirrups 10mm dia. [Depth, inner=65—2×2·5—2×1·0=58 Breadth, inner=30—2×2·5—2×1·0=23]	—	—	—	—	5	2(58+23) +25(extra)=187	$\frac{500}{15}$+1 =35	65·50 @0·62kg.	40·61

Total=230 29 kg.
=2·303 quin.

Example 2. Prepare a detailed estimate of a R.C.C. cantilever retaining wall for a length of 30 metres from the fig. 4-18. Weight of 10mm dia. bars=0·62 kg/m, 12mm dia.=0·89 kg/m, 16mm dia.=1·58 kg/m and 20mm dia=2·47 kg/m. Adopt the following rates to prepare the estimate (1) R.C.C.work (1:2:4) including centering and shuttering but excluding reinforcement=Rs. 410 per cu m. (2) M. S. reinforcement including cutting, hooking etc.=Rs. 550 per quintal.

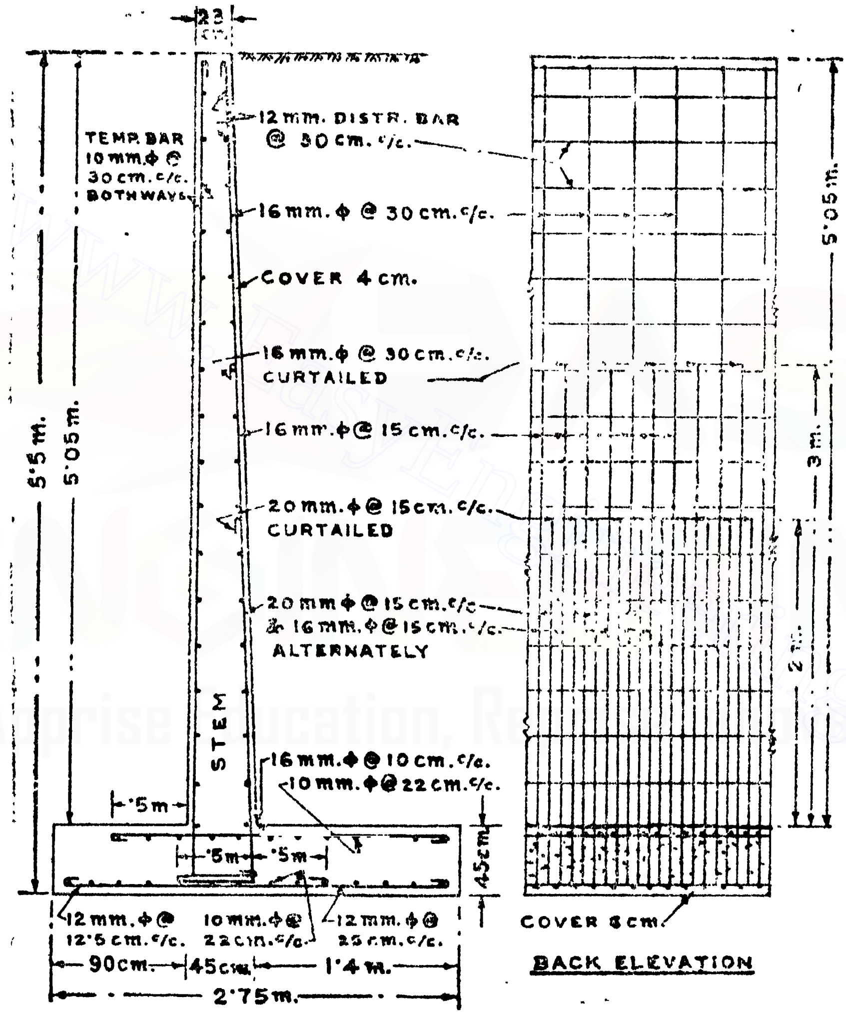


FIG. 4·18

Scale 2cm=1m (1:50)

1. R.C.C. work 1:2:4 including centering and shuttering but excluding reinforcement

(a) Stem $=30\times\frac{1}{2}(23\text{cm}+45\text{cm})\times5{\cdot}05=51{\cdot}510$ cu m

(b) Base slab$=30\text{m}\times2{\cdot}75\text{m}\times45\text{cm}$ $=37{\cdot}125$ cu m

Total=88·635 cu m

To Estimate Reinforcement :—

(1) Size of bar and position	(2) Overall length with cover	(3) Extra Length: Laps @45D	Cranks	Hooks @9D cm	(4) Less cover cm	(5) Actual length 2+3—4 m	(6) No. of bars	(7) Total length m	Weight kg
STAM **(a) Right hand side** 20mm ϕ curtailed bars @ 15 cm c/c	2m+45cm + ·5m − 22mm = 2·93m	—	—	2 nos. 36	6	3·23	(30m − 8cm)/15cm +1 = 201	649·23 @2·47kg	1603·5
16mm ϕ curtailed bars @ 30 cm c/c	3·93m	—	—	2 nos. 29	6	4·16	(30—8cm)/30cm +1 = 101	420·16	
16mm ϕ bars @ 30cm c/c full height	5 5m+ 45cm— 22mm = 5·48m	—	—	2 nos. 29	6+4 = 10	5 67	101	572·67 / 972·33 @1·58kg	1568·9
12mm ϕ distr. bars @ 30 cm c/c	30m	3 nos 1·62m	—	8 nos. 85	4+4 = 8	32·4	(5·05m—4cm)/30cm +1 = 18	583·2 @1·89kg	519·0
(b) Left hand side Temp. bars 10mm ϕ @ 30 cm c/c vertical	5 5m— 22mm = 5·48m	—	—	2 nos. 18	6+4 = 10	5·56	(30m—8cm)/30cm +1 = 101	561·56	
-do- -do- horizontal	30m	3 nos. 1·35m	—	8 nos. 72	4+4 = 8	31·99	(5·05—4cm)/30cm +1 = 18	575·82	
BASE SLAB **(a) Top portion** 10mm ϕ @ 22cm c/c	30m	3 nos 1·35m	—	8 nos. 72	6+6 = 12	31·95	(2·35m—6cm)/22cm +1 = 11	351·45 / 1488·83 @0·62kg	923·1
16mm ϕ @ 10cm c/c	1·4m+45 cm+·5m = 2·35m	—	—	2 nos. 29	6	2·58	(30m—12m)/10cm +1 = 300	774 1·58 kg	448·9
(b) Bottom portion 12mm ϕ @ 25cm c/c	2·75m	—	—	2 nos. 22	6+6 = 12	2·85	(30m—12cm)/25cm +1 = 117	333·45	
12mm ϕ @ alternate bar @ 25cm c/c	90cm+45 cm+·5m = 1·85m	—	—	2 nos. 22	6	2·01	117	235·17 / 568·62 0 89 kg	506·1
10mm ϕ @ 22cm c/c	30m	3 nos. 1 35m	—	8 nos. 72	6+6 = 12	31·95	(2·75m—12cm)/22cm +1 = 13	415·35 0 62kg	257·5

Total = 5826·7 kg.
= 58·27 quintals.

ABSTRACT OF ESTIMATED COST

Particulars	Quantity	Unit	Rate	Unit of Rate	Amount
1. R.C.C. work (1:2:4) including centering and shuttering but excluding reinforcement.	88·635	cu m	Rs. 410	cu m	Rs. 36,340·35
2. M. S. reinforcement including cutting hooking etc.	58·27	Quin.	Rs. 550	Quin.	Rs. 32,048·50

Total = Rs. 68,388·85

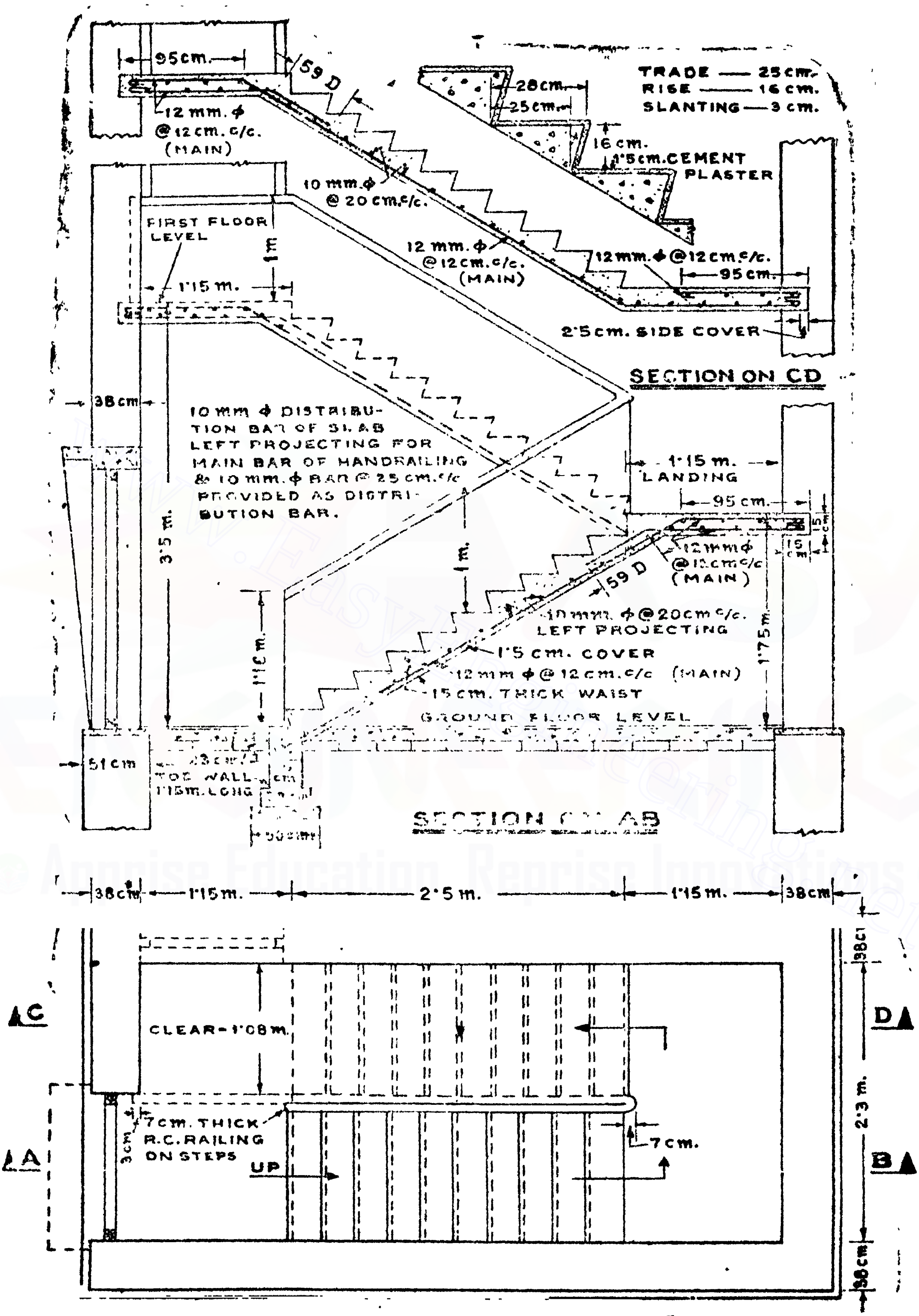
Add 5% for contingency = Rs. 3,419·44

Add 2½% for W.C. = Rs. 1,709·72

Grand Total = Rs. 73,518·01

Example 3. Prepare a detailed estimate of R.C.C. staircase from the figure 4-19. All exposed sides of concrete shall be 12mm thick cement plastered (1:4). Adopt the following rates (1) R.C.C. work (1:2:4) including centering and shuttering but excluding reinforcement Rs. 410 per cu m. (2) M. S. work including cutting, hooking etc. Rs 550 per quintal. (3) 12 mm thick cement plastering Rs. 6·25 per sq m. (4) 7 cm thick hand railing including reinforcement and plastering Rs. 80·00 per sq m. Weight of 10mm and 12mm dia. bars are 0·62 kg. and 0·89 kg. per metre run respectively. The cost of Toe wall shall not be included. *N.B. Dimensions not written shall be measured.*

Description.	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
1. R C C. work including centering and shuttering but excluding reinforcement.							
(a) Base on Toe wall ...	1	1·15	·25	·23	0·066		3·05 = $\sqrt{(17·5)^2+(2·5)^2}$
(b) Waist slab of flights	2	3·05	1·15	·15	1·052		(portion included = portion excluded)
(c) Landing (lower) ...	1	2·3	1·30	·15	0·449		
—do—(upper) ...	1	1·15	1·30	·15	0·224		1·30 = 1·15 + bearing ·03 = ·28 − ·25
(d) Steps without slanting	20	1·15	½ × ·25	·16	1·035		
-do-slanting portion	20	1·15	½ × ·03	·16	0·055		
						2·881 cu m	
2. 12mm cement plaster (1:4)							
(a) Landing (lower)	1	2·3	1·15	—	2·65		
—do—(upper)	1	1·15	1·15	—	1·32		
(b) Treads ...	20	1·08	·28	—	6·05		
(c) Rises ...	22	1·08	—	·163	3·87		·163cm = $\sqrt{(·03)^2+(·16)^2}$
(d) Below waist slab ...	2	3·05	1·30	—	7·93		1·30 = 1·15 + ·15 (edge)
(e) Below landings of 1st floor and half portion of 1st flight ...	2	·90	1·15	—	2·07		·90 measured
(f) -do- -do-for rest half of 1st flight ...	1	1·15	1·15	—	1·32		
(g) Ends of steps ...	20	½ × ·25	·16	—	0·40		
						25·61 sq m	
3. 7cm thick hand railing ...	1	6·36	1·16		7·38		6·36 = 2 × 2·5 + 2 × ·07 (on 1st landing portion) + 1·22
Less for portion covered by steps			same as (2) g.		0·40	(ve)	
						6·98 sq m	



95cm.
59 D
12 mm. φ @ 12 cm. c/c. (MAIN)
TRADE — 25 cm.
RISE — 16 cm.
SLANTING — 3 cm.
28 cm.
25 cm.
16 cm.
1·5 cm. CEMENT PLASTER
10 mm. φ @ 20 cm. c/c.
FIRST FLOOR LEVEL
12 mm. φ @ 12 cm. c/c. (MAIN)
12 mm. φ @ 12 cm. c/c.
95 cm.
1·15 m.
2·5 cm. SIDE COVER
SECTION ON CD
38 cm
10 mm φ DISTRIBUTION BAR OF SLAB LEFT PROJECTING FOR MAIN BAR OF HANDRAILING & 10 mm. φ BAR @ 25 cm. c/c PROVIDED AS DISTRIBUTION BAR.
1·15 m.
LANDING
95 cm.
3·5 m.
1 m.
59 D
12 mm φ @ 12 cm c/c (MAIN)
10 mm. φ @ 20 cm c/c. LEFT PROJECTING
1·5 cm. COVER
12 mm φ @ 12 cm. c/c (MAIN)
15 cm. THICK WAIST
1·1 m.
1·75 m.
GROUND FLOOR LEVEL
51 cm
TOE WALL 1·15 m. LONG
SECTION ON AB
38 cm
1·15 m.
2·5 m.
1·15 m.
38 cm
CLEAR - 1·08 m.
C
D
7 cm. THICK R.C. RAILING ON STEPS
3 cm
UP
7 cm.
A
B
2·3 m.
38 cm

Size of bar and its position	Overall length m	Extra length for Hooks @9 D	Cranks	Laps @ 45D	Less cover	Actual length m	No. of bars	Total length m	Weight
4. M.S. work including cutting, hooking etc., (dimensions measured)									
(A) 12mm φ main bars—									
(a) 1st flight and portion of landing for 1st flight	4·57	2 nos 22 cm	—	—	—	4·79	$\frac{1·15m}{12cm}$ i.e. 10	47·9	
(b) At bottom in portion of landing for 1st flight	1·96	1no. 11cm	—	—	—	2·07	10	20·7	
(c) In 2nd flight and landings	5·75	22cm	—	—	5cm	5·92	10	59·2	
(d) At top in portion of 1st landing for 2nd flight	9·5	22cm	—	—	2·5cm	1·14	10	11·4	
(e) At bottom of 1st floor landing (same as b)	1·96	11cm	—	—	—	2·07	10	20·7	
								159·9 @ 89kg	=142 kg
(B) 10mm φ distribution bars—									
(a) In 1st and 2nd flights	1·15	1no. 9cm	—	—	3cm	1·21	$33=2\times\frac{3·05m}{20cm}$ +1no in toe slab	39·9	
(b) In 1st landing at top	2·3	18cm	—	—	3cm	2·45	$\frac{95cm}{20cm}$ i.e. 5	12·3	
(c) In 1st Floor landing at top	1·15	18cm	—	—	3cm	1·30	5	6·5	
(d) In 1st landing at bottom	2·3	18cm	—	—	3cm	2·45	$\frac{1·30m}{20cm}$ i.e. 7	17·2	
(e) In 1st floor landing at bottom	1·15	18cm	—	—	3cm	1·30	7	9·1	
								85 @·62kg	=53 kg

Total = 195 kg
= 1·95 quin.

ABSTRACT OF ESTIMATED COST

Particulars	Quan.	Unit	Rate	Unit of Rate	Amount
1. R.C.C. work (1 2:4) including shuttering but excluding reinforcement ...	2·31	cu m	Rs. 511·50	cu m	Rs. 1,181·21
2. 12mm cement plaster (1:4)	25·61	sq m	Rs. 6·25	sq m	Rs. 160·05
3. 7cm thick hand railing including reinforcement and plastering	6·98	sq m	Rs. 80·00	sq m	Rs. 558·40
4. M.S. work including cutting, hooking etc.	1·95	quin	Rs. 550·00	quin	Rs. 1,072·5

Total = Rs. 2,972·17
Add 5% for contingency = Rs. 148·61
Add 2½% for W.C. = Rs. 74·31
Grand Total = Rs. 3,195·09

4-28. Estimating Reinforcement for R. C. C. Framed Buildings :—The load from the floor of a R.C.C. framed building transmits to the beams and from the beams to the columns. Therefore, the load from any upper floor is not carried by the floor slab and beams of another downward floor. So the reinforcement and sectional areas of slabs and beams for different floors of a multistoried building remains about the same. But due to increase or decrease of story of a R. C. C. framed building the size and reinforcement of columns, column footings or foundation changes.

An accurate estimate of reinforcement for the different R. C. C. members can be prepared from the detailed drawings. But in the absence of such drawings or in order to determine an approximate quantity any one of the following methods may be adopted.

(a) On the percentage basis of concrete.
(b) By thumb rule.

(a) On the percentage basis of concrete :—

At the time of designing a R. C. C. member the percentage of steel can be noted. With this percentage an extra which should be at least 20% shall be added for hooking, laping, cranking etc. In absence of such designed data of steel percentage the followin approximation may be made to estimate the quantity of mild steel.

(1) Foundation footing @ 0·5% to 1·0%. For ordinary buildings 0·5%.
(2) Columns @ 0·8% to 8%. For ordinary building 1·0% to 2%.
(3) Beams @ 1·0%, (4) Slabs @ 1·0%, (5) Lintel @ 0·8%, (b) Sun-shades @ 0·50 to 0·8%

(b) *By thumb Rule* :—By the thumb rule the quantity of reinforcement is determined on plinth area basis for different heights to a building as shown below. The reinforcement for columns should be calculated separately.

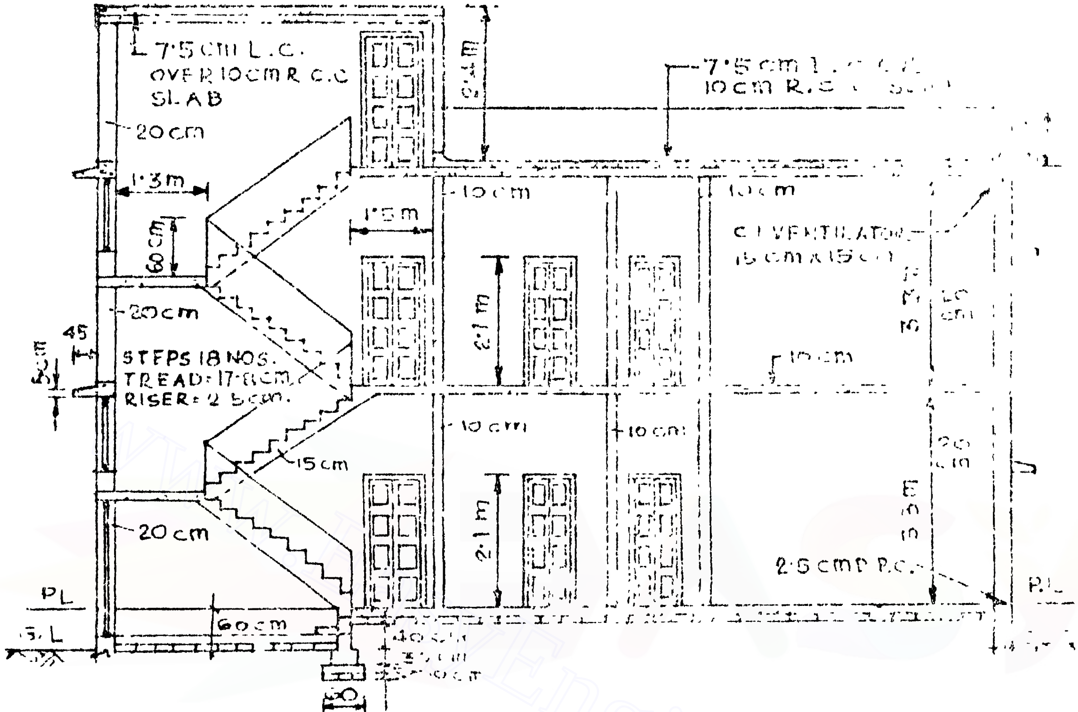
Ht. of building	Quantity of reinforcement in kg/sq m of plinth area — Foundation	Floor beams per floor	Floor slabs per floor	Remarks
9m and below 13·5m	22 to 33	18 to 20	10 to 12	—
13·5m and below 21 m	50 to 65	—do—	—do—	—
21m and below 36m	95 to 110	—do—	—do—	Foundation has to be raft slab Piling will depend on sois condition.
Above 36m	130 to 150	—do—	—do—	Concrete piling is generally required.

Example 1. Detailed Estimate of a Two storied Residential Building built up with R C. frame structure having a foundation for future extension upto three stories. *The comparison of cost between R.C. frame structure builiding and masonry load bearing wall building (whose detailed estimate has already been prepared in 3-10 page 161) has been shown.*

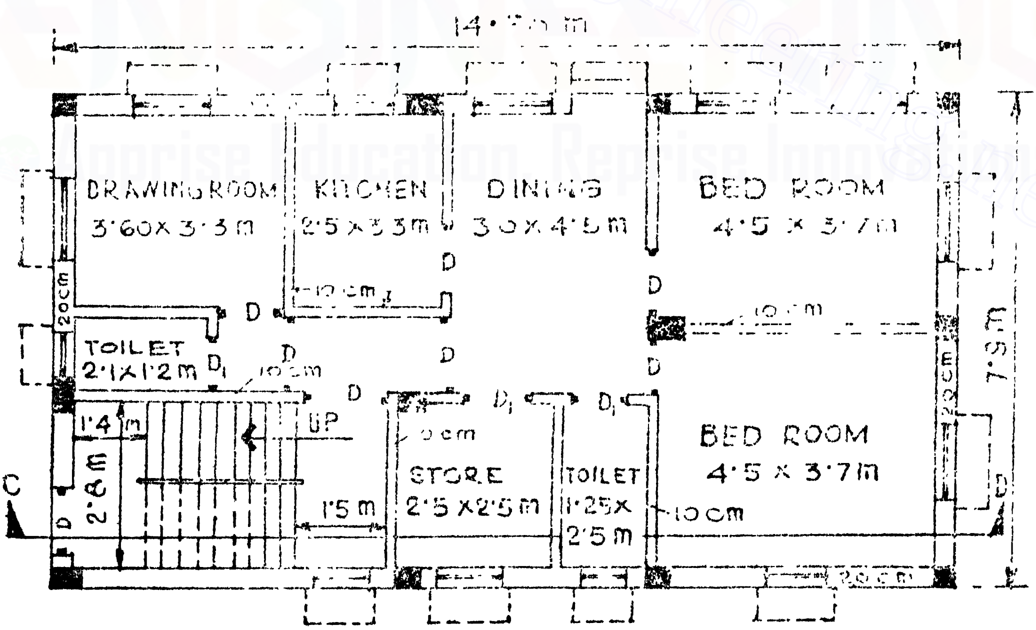
General specification other than foundation and plinth is same as that of building 3-10 page 161. Foundation for outer panel walls shall be of 1st. class brickwork in cement mortar 1:6 over cement concrete 1 : 3 : 6.

The reinforcement for different members shall be as follows :

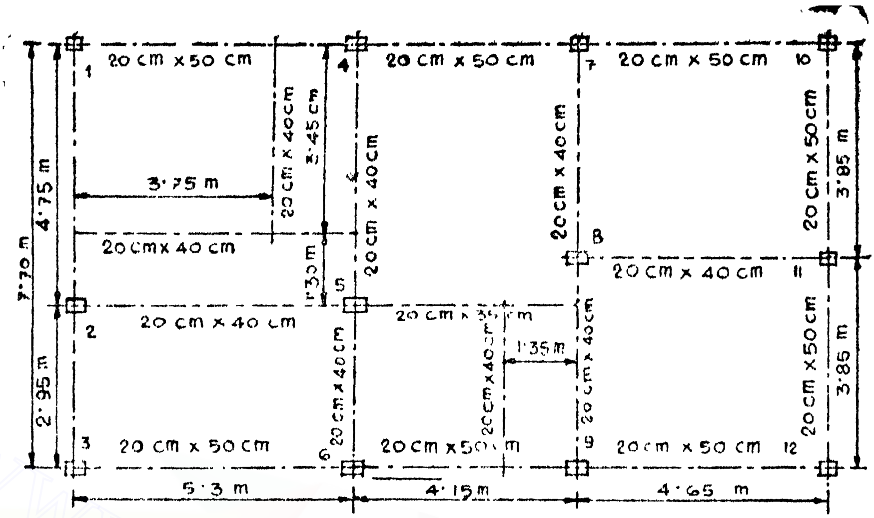
a) Column footing slab @ 0·6%, (b) Columns @ 1·5%, (c) Beams @ 1·2% d) Roof slab @ 1%, (e) Staircase @ 0·5%.



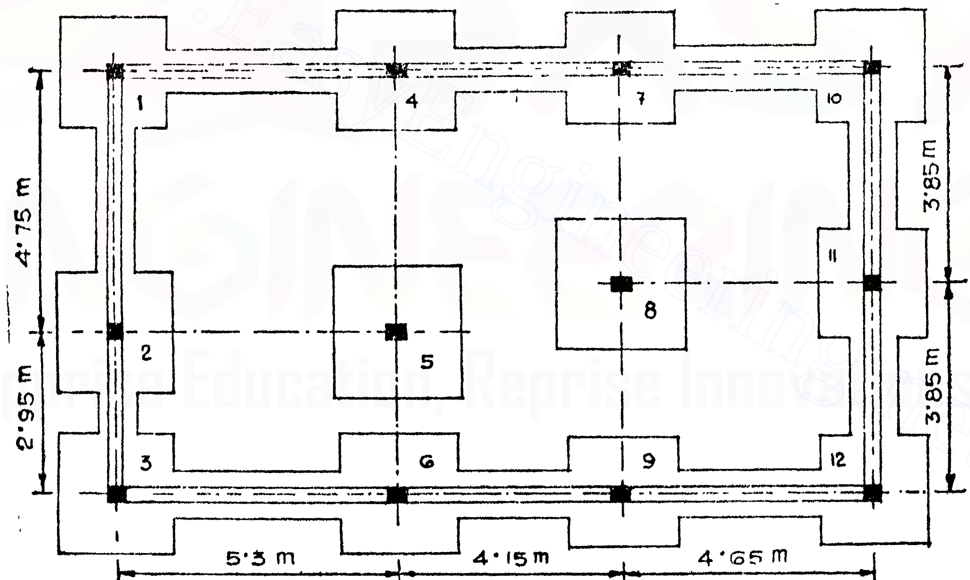
SECTION - CD



GROUND FLOOR PLAN



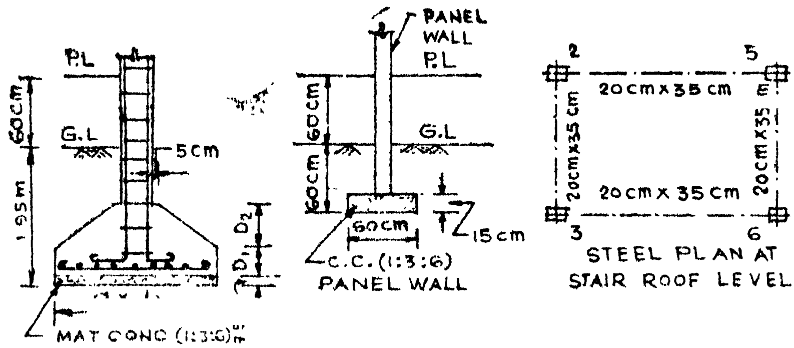
STEEL PLAN AT 1st FLOOR LEVEL
STEEL PLAN AT ROOF LEVEL IS SIMILIAR



FOUNDATION PLAN

The details of Columns are as below :—

COL. MKD	Footing size a×b	D_1	D_1	Ground floor to 1st. floor	1st.floor to 2nd floor	2nd floor to stair roof
1,7,9,10,11,12	2·0m×2·0m	15cm	30cm	20cm×25cm	20cm×20cm	—
2,3 4 & 6	2 2m×2·2m	20cm	30cm	20cm×30cm	20cm×25cm	20cm×25cm only col. MKD 2,3& 6
	2·4m×2·4m	20cm	30cm	20cm×35cm	20cm×30cm	20cm×25cm only col. MKD 7



Quantity Estimate for Ground Floor :-

Description	No.	L. m	B. m	H. m	Quantity	Total	Explanatory notes
1. Earthwork in excavation							
(a) column footings for— col. nos. 1,7,9, 10. 11 & 12		2·00	2·00	1·95	46·80		
„ „ 2,3,4 & 6 ...		2·20	2·20	1·95	37·95		
„ „ 5 and 8 ...		2 40	2·40	1·95	22·46		
(b) Panel walls (consider first as if there is no col.)							
Long sides ...		14·30	·60	·60	10·30		
short sides ...		7·50	·60	·60	5·40		
Deduct the length covered by column footings ...		2·00	·60	·60	4·32	(-ve)	
		2 20	·60	·60	3·17	(-ve)	
(c) Toe wall		2·35	·60	·50	0·71		Earthwork for steps is not counted as major length is covered by column footings.
(d) Dwarf wall under the staircase wall at inner-side upto Toe wall		2·55	·60	·50	0·77		
						116·9 cu m	
2. Earthwork in filling for foundation trench by loose earth		h of e xcavat	ion apx		23·38	23·38 cu m	Filling=earth work in excavation—vol. of work upto G. L. In this case 1/5th vol. of excavation is nearly the same as above.
3. Sand filling for plinth		13·90	7·50	·42	43·79		
Deduction for staircase portion ...		3·75	2·80	·42	4·41	(-ve)	
VOL. of col. 5 and 8		·35	·20	·42	0·06	(-ve)	
						39·32 cu m	

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4. Cement concrete (1:3:6)							
(a) For mat concrete of column footing nos.							
1, 7, 9, 10, 11 & 12...	6	2·00	2·00	·075	1·80		
2, 3, 4 & 6 ...	4	2·20	2·20	·075	1·45		
5 and 8 ...	2	2·40	2·40	·075	0·86		
(b) For foundation of panel walls (considering no pillar)							
Long sides ...	2	14·30	·60	·15	2·57		
Short sides ...	2	7·50	·60	·15	1·35		
Deduct col. lengths for col. nos. 1,7,9,10, 11 & 12	6	·25	·20	·15	0·05	-ve)	
,, 2, 3, 4 & 6 ...	4	·30	·20	·15	0·04	(-ve)	
(c) Toe wall... ...	1	2·35	·60	·10	0·14		
(d) Dwarf wall below stair case wall at inner side	1	2·55	·60	·10	0·15		
(e) Steps	1	1·20	·70	·10	0·08		
						8·31 cu m	
5. Cement concrete (1:2:4) **for R. C. C. work** excluding shuttering and reinforcemen							
(a) Column footings							
(i) Lower portion of col. nos. 1, 7, 9, 10, 11 & 12 ...	6	2·00	2·00	·15	3·60		
2, 3, 4 & 6 ...	4	2·20	2·20	·15	2·90		
5 and 8 ...	2	2·40	2·40	·15	1·73		
(ii) Trapezoidal portion—1, 7, 9, 10, 11 & 12 ...	6	$\frac{.30}{6}\left[2^2+(.30\times.35)+\frac{4(2^2+.30\times.35)}{2}\right]$			3·79		Vol. by prismoidal formula $V=\frac{L}{6}(A_1+A_2+4Am)$
1, 3, 4 & 6 ...	4	$\frac{.30}{6}\left[2{\cdot}2^2+(.30\times.40)+\frac{4(2{\cdot}2^2+.30\times.40)}{2}\right]$			2·48		
5 and 8 ...	2	$\frac{.30}{6}\left[2{\cdot}4^2+(.30\times.45)+\frac{4(2{\cdot}4^2+.30+.45)}{2}\right]$			1·77		
C. O.					16·27		

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
B. F.					16·27		According to I. S. (see art. 4-21) ht. is measured upto underside of main beam from footing.
(b) Columns—							4·25 = ·75(below G.L.) + ·60 (P.L.) + 2·90 (from P.L. upto beam)
1, 7, 9, 10, 11 & 12 ...	6	·25	·20	4·25	1·28		2·90 − (3·3 + ·1) —50 (beam depth)
2, 3, 4, & 6 ...	4	·30	·20	4·20	1·01		
5 & 8 ...	2	·35	·20	4·30	0·60		
					2·89		
(c) Beams—							
outer, back and front	2	7·70	·20	·40	1·23		
,, sides	2	14·10	·20	·40	2·26		
Inside beams MKD—							
42 & 51 (as continuous) ...	1	7·50	·20	·30	0·45		
13 & 23	2	5·10	·20	·30	0·61		
					4·55		
MKD 14	1	4·55	·20	·30	0·27		4·55 is for clear span
MKD 72 & 82 (continuous)	1	7·50	·20	·30	0·45		
,, 52 (clear span) ...	1	3·95	·20	·30	0·24		
,, 53 (—do—) ...	1	2·75	·20	·30	0·17		
,, 81 (—do—) ...	1	4·45	·20	·30	0·27		
					5·95		
(d) Slab (including staircase area first) ...	1	14·30	7·90	·10	11·30		
Less area of staircase ...	1	5·15	2·80	·10	1·44	(-ve)	
					9·86		
(e) R. C. lintel over door and windows,							
Windows, W & W_1 ...	9	1·50	·20	·10			
W & D (combined) ...	1	2·80	·20	·10			
Window, W_2 ...	3	1·20	·20	·10			
W_3 ...	2	·90	·20	·10			
	T.L.	21·70	·20	·10	0·43		
For inside walls—							
Over doors, D ...	5	1·20	·10	·10	0·06		
,, ,, D_1 ...	3	1·00	·10	·10	0·03		
					0·52		
(f) Staircase— ...	same	as p.	166 sl	10(c)=	3·60		The width of staircase slab in this case is little more
(g) Sun shades— ...	same	as p.	166	10(e)=	0·50		
						44·14 cu m	

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
6. Centering and shuttering for R. C. C works							
(a Columns—							
(i) Vertical edges of footing cols. 1, 7, 9, 10, 11 & 12	6	8·00	—	·15	7·20		8·00 is the perimeter.
,, 2, 3, 4 & 6 ...	4	8·80	—	·15	5·28		
,, 5 & 8 ...	2	9·60	—	·15	2·88		
(ii) Sloping trapezium portions—							
cols. 1, 7, 9, 10, 11 & 12	6×2	$\frac{2+\cdot30}{2}\times\sqrt{\cdot30^2+\cdot85^2}$			10·51		$\cdot85=\frac{1}{2}(2\cdot0-\cdot30)$
,, —do— —do—	6×2	$\frac{2+\cdot35}{2}\times\sqrt{\cdot35^2+\cdot82^2}$			12·63		$\cdot82=\frac{1}{2}(2\cdot0-\cdot35)$
,, 2, 3, 4, & 6 ...	4×2	$\frac{2\cdot2+\cdot30}{2}\times\sqrt{\cdot30^2+\cdot95^2}$			9 95		$\cdot95=\frac{1}{2}(2\cdot2-\cdot30)$
,, —do— —do—	4×2	$\frac{2\cdot2+\cdot40}{2}\times\sqrt{\cdot40^2+\cdot90^2}$			10 24		
,, 5 & 8 ...	2×2	$\frac{2\cdot4+\cdot45}{2}\times\sqrt{\cdot30^2+\cdot98^2}$			5·82		
,, —do— —do—	2×2	$\frac{2\cdot4+\cdot30}{2}\times\sqrt{\cdot45^2+1\cdot05^2}$			6·17		
(iii) Sides of columns 1, 7, 9, 10, 11 & 12 ...	6	·90	—	4 25	22 95		
Sides of columns 2, 3, 4 & 6 ...	4	1·00	—	4·20	16·80		
columns 5 & 8 ...	2	1·10	—	4·30	9·46		
					109·38		
(b) Beams (web only) Outer, Back and front ...	2	7·70	·80	—	12·32		$\cdot80=2\times\cdot20+\cdot40$
Sides ...	2	14·20	·80	—	22·72		
MKD 42 & 51 (as continuous) ...	1	7·50	·70	—			
,, 14 ...	1	4·55	·70	—			
,, 72 & 82 (as continuous)	1	4·50	·70	—			
,, 52 (clear span) ...	1	3·95	·70	—			
,, 53 (—do—) ...	1	2·75	·70	—			
,, 81 (—do—) ...	1	4·45	·70	—	14·14		In 11(a) P 166 deduction for wall area has been made which equalises apx. the beam area.
		27·70	·70	—	49·18		
(c) Roof slab ...	same as SL. 11(a)P. 166=				72·18		
(d) Staircase ...	—do— SL. 11(c)P. 167=				25·86		
(e) Sunshade ...	—do— SL. 11(e)P 167=				12·21		
C. O. ...					268·8		

Description	No.	Length m	Breadth m	Height m	Quantity	Total	Explanatory notes
(f) R. C. lintel over door and windows			B. F.		268·81		
Sides, windows, W & W_1	9×2	1·50	—	·10	2·70		
,, W & D (combined)	1×2	2·80	—	·10	0·56		
,, window, W_2 ...	3×2	1·20	—	·10	0·72		
,, ,, W_3 ...	2×2	·90	—	·10	0·36		
For inner walls—							
Sides of door D ...	5×2	1·20	—	·10	1·20		
,, ,, D_1 ...	3×2	1·20	—	·10	0·72		
Over openings of outer walls ...	1	22·90	·20	—	4·58		
Over openings, inner walls	1	8·40	·10	—	0·84		
					11·68	280·49 sqm	
7. **Mild steel reinforcement** (a) For footing @ 0·6%		16·27 ×	$\frac{0·6}{100}$ ×	78·5q	7·66		
(b) ,, column @ 1·5%		2·89 ×	$\frac{1·5}{100}$ ×	78·5q	3·40		
(c) ,, beams @ 1·2%		5·95 ×	$\frac{1·2}{100}$ ×	78·5q	5·60		
(d) ,, roof slab @ 1%		9·86 ×	$\frac{1}{100}$ ×	78·5q	7·74		
(e) ,, stair case & lintel @ 0·8%		4·12 ×	$\frac{0·8}{100}$ ×	78·5q	2·59		
(f) ,, Sun shades @ 0·5%		0·50 ×	$\frac{0·5}{100}$ ×	78·5q	0·20		
						27·19 quintal	
8. **1st. class brickwork in cement mortar (1:6) in foundation and plinth** (first consider as if there is no pillar)							
Outsides only Long walls	2	14·30	·20	1·05	6·01		
Short walls	2	7·50	·20	1·05	3·15		
Deduct the length covered by columns ...	6	·25	·20	1·05	0·32	(-ve)	
,, ...	4	·30	·20	1·05	0·25	(-ve)	
Steps under stair ...	1	1·40	·30	·20	0·08		
Steps ,, ,, ...	1	1·20	·45(av)	·40	0·22		
Toe wall ,, ...	1	2·35	·20	·40	0·19		
Dwarf wall below staircase wall at inner side ...	1	2·55	·20	·40	0·20		
						10·42 cu m	
9. **2·5cm thick D. P. C.(1:2:4)**							
Outer walls—							
Long sides ...	2	14·30	·20	—	5·72		
Short sides ...	2	7·50	·20	—	3·00		
Deduct the length covered by columns ...	6	·25	·20	—	0·30	(-ve)	
,, ...	4	·30	·20	—	0·24	,,	
Deduct door openings D	2	1·00	·20	—	0·40	,,	
						7·78	sq m

Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
10. 1st. class brickwork in cement mortar (1 6) in superstructure walls							
Outer side only							
Long walls ...	2	14·30	·20	3·30	18·88		
Short walls ...	2	7·50	·20	3·30	9·90		
Deduct the length covered by columns ...	6	·25	·20	3·30	0·99	(—ve)	
" " ...	4	·30	·20	3·30	0·79	"	
Deduction for openings							
Doors, D ...	2	1·00	·20	2·10	0·84	"	
Windows, W ...	3	1·20	·20	1·50	1·08	"	
" W_1 ...	7	1·20	·20	1·20	2 02	"	
" W_2 ...	3	·90	·20	1·20	0·65	"	
" W_3 ...	2	·60	·20	·70	0·17	"	21·70 is the total
Deduction for lintel ...	1	21·70	·20	·10	0·43	"	length from 3(e)
						21·81 cu m	
11. Half brickwork of 10cm thick in cement mortar (1:3) with H. B. wire netting.							
Fronts of bed rooms ...	1	7·30	—	3·30			
Partition between beds ...	1	4·15	—	3·30			
" " lav. & store	1	2·50	—	3·30			
" " kitch & passage	1	2·50	—	3·30			
Kitchen upto store ...	1	4·50	—	3·30			
Drawing room wall upto staircase	1	4·50	—	3·30			
Front of lav. & store ...	1	3·60	—	3·30			3·60=(2·5+1·25+·1)—(·35—·1)
Lav. of drawing room ...	1	2·20	—	3·30			2·20=2·1+·1
" " " ...	1	1·20	—	3·30			
Staircase inside wall ...	1	5·15	—	3·30			
	T.L.	37·60	—	3·30	124·09		
Deduction for openings							
Doors, D ...	6	1·00	—	2·10	12·60	(—ve)	
" D_1 ...	3	·80	—	2·10	3·78	"	
						107·71 sq m	
12. 7·5cm thick terraced flooring in lime concrete ($1\frac{1}{2}$:2:7) over a brick flat	1	13·90	7·50	—	104·25		13·90=14·34
Deduct the area of							2×·20.
Toe wall ...	1	2·35	·20	—	0·47	(-ve)	The inside column areas of 2
Dwarf wall ...	1	2·55	·20	—	0·51	"	cols. being
						103·27 sq m	small is neglected

Description	No.	L. m	B m.	H. m	Qu.	Total	Explanatory notes
13. 25mm thick Marbulite work with precast tiles for—							
(a) Floors, Bed rooms ...	2	4·50	3·70	—	33·30		
Dining ...	1	4·50	3·00	—	13·50		
Drawing & lav. ...	1	4·50	3·60	—	16·56		
Passage ...	1	2·50	1·10	—	2·74		
Lav. (storeside) ...	1	2·50	1·25	—	3·13		
Entrance under stair ...	1	3·45	1·40	—	4·83		
Under 2nd. landing ...	1	1·50	2·80	—	4·20		
Steps of staircase—							
Treads	18	1·40	·25	—	6·30		
Rises	18	1·40	—	·175	4·41		
Landing (lower)	1	2·80	1·40	—	3·36		
,, 1st floor	1	2·80	1·50	—	4·20		
Rises of landing	2	2·80	—	·15	0·84		
(b) Dado for—							
Bed rooms ...	2	16·40	—	·30			
Dining ...	1	15·00	—	·30			
Drawing ...	1	13·80	—	·30			
Lav. (drawing) ...	1	6·60	—	·30			
Front of Lav. ...	1	1·30	—	·30			
Passage ...	1	5·00	—	·30			
Entrance ...	1	5·05	—	·30			5·05=2×1·4+2·25
Under 2nd landing ...	1	5·80	—	·30			5·80=2×1·5+2·8
	T.L.	85·35	—	·30	25·61		
Stair flights	2	2·69	—	·30	1·61		No deduction for door openings to cover the area of jambs.
Landing (lower) ...	1	5·60	—	·30	1·68		
,, 1st. floor ...	1	5·80	—	·30	1·74		
Deduction for—							
Area of steps	18	½×·25		·175	·39	(—ve)	
						124·60 sq m	
14. 2·5cm thick grey artificial stone floor with cement concrete (1:2:4) with skinning.							
Kitchen ...	1	3·30	2·50	—	8·25		
Store ...	1	2·50	2·50	—	6·25		
Under 1st flight ...	1	3·45	1·40	—	4·83		
						19·33	sq m

Description	Same as	Qu.	Description	Same as	Qu.
15. Indian Teak wood work for frames of doors and windows	Page 167 SL. 13.	1·092 cu m	25. Dry Distempering to interior walls and ceiling ...	Page 171 SL. 26	405 sq m (apx.)
16. Indian Teak wood panelled shutters ...	Page 168 SL. 14.	17·71 sq m	26. Decorative cement based paint ...	Page 171 SL. 27	182·58 sq m
17. 3·75cm thick Fixed louver shutters ...	Page 168 SL. 15.	12·72 sq m	27. Painting two coats on timber surface	Page 171 SL. 28	115·14 sq m
18. 3·75cm thick Glazed shutters for windows ...	Page 168 SL. 16.	13·55 sq m	28. Painting two coats on metal surface.	Page 171 SL. 29	14·23 sq m
19. M. S. Ornamental Grill ...	Page 168 SL. 17.	14·05 sq. m	29. 100mm dia. asbestos cement down pipes	Page 171 SL. 30	24·00 rm
20. M. S. Clamp 37·5 cm long ...	Page 168 SL. 18.	126 nos.	30. C. I. ventilator	Page 171 SL. 31	14 nos.
21. Anodised Alluminium hand rail ...	Page 168 SL. 19	5·38 rm			
22. 12 mm thick cement plaster (1:6) to wall ...	Page 170 SL. 23	469·80 sq m (apx.)			
23. Neat cement punning	Page 170 SL. 24	46·38 sq m (apx.)			
24. 6mm thick cement plaster (1:4) ...	Page 170 to 171 SL. 25	122·39 sq m			

Quantity Estimate for First Floor :—

Description	No.	L. m	B. m.	H. m	Qu.	Total	Explanatory notes
1. Cement concrete (1:2:4) for R.C.C. work excluding shuttering and reinforcement							
(a) Columns—							
1,7,9,10,11 & 12...	6	·20	·20	2·90	0·70		2·90=(3·3+·1)—·50 (beam depth)
2,3,4, & 6	4	·25	·25	2·85	0·57		
5 and 8	2	·30	·20	2·95	0·35		
From 2nd. floor to stair roof columns— 2,3,5 & 6	4	·25	·20	2·15	0·43		2·15=2·4+·1 —·35
					2·05		
(b) Beams—							
For 2nd. floor	same	as	1st	floor	5·95		
For staircase room ...	2	5·30	·20	·35	0·74		
—do— do— ...	2	2·95	·20	·35	0·41		
					7·10		
(c) Slab of 2nd floor...	same	as	1st	floor	=9·86		5·50=5·3+·20
Slab of staircase roof...	1	5·50	3·15	·10	1·73		3·15=2·95+·20
					11·59		
(d) Lintel over openings	same	as gro	und	floor	0·52		
Lintel over openings of staircase room Door D	1	1·30	·20	·10			
Windows W_1	1	1·50	·20	·10			
„ W_2	1	1·20	·20	·10			
	T.L	4·00	·20	·10	0·08		
Sun shades	same	as gro	und	floor	0·50		
For staircase, door D	1	1·30	·20	·30			
—do—window W_1	1	1·50	·20	·30			
„ W_2	1	1·20	·20	·30			
	T.L	4·00	·20	·30	·02		
(e) Staircase	same	as gro	und	floor	3·60	25 45 cu m	
2. Centering and shuttering for R. C. works							
(a) Columns—							0·80 is t e perimeter
1,7,9,10,11 & 12 ...	6	·80	—	2·90	13·92		
2,3,4, & 6	4	·90	—	2·85	10·25		
5 and 8	2	1·00	—	2·95	5·90		
C.O.	...	...	...	...	30·07		

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
B.F. ...					30·07		
From 2nd. floor to stair roof columns— 2,3,5 & 6	4	·90	—	2·15	7·74		
(b) Beams (web only)							
For 2nd floor	same	as	first	floor	49·18		
stair case room beams...	2	5·30	—	·35	3·71		
—do— —do— ...	2	5	—	·35	2·07		
(c) Roof slab of 2nd floor	same	as	first	floor	72·18		
„ .. of stair roof	1	5 50	3 15	—	17·33		17·30=2(5·5+3·15)
Edges of stair roof	1	17·30	—	·10	1·73		
(d) Stair case ...	same	as	ground	floor	25·86		
(e) Sun shade ...			—do—	—do—	12·21		
(f) Lintel over door and window openings ...	same	as	ground	floor	11·68		
Staircase room door D	1×2	1·30	—	·10	0·26		
„ „ window W_1	1×2	1·50	—	·10	0 30		
„ „ „ W_2	1×2	1·30	—	·10	0·24		
Over openings of door and windows ...	1	3·10	·20	—	0·62	235·18 sq. m	3·10=1·0+1·2+·9 i.e. total width of door & windows
3. Mild steel reinforcement							
(a) Columns @ 1·5%		2·05 ×	$\frac{1.5}{100}\times$	78·5q	2·41		
(b) beams @ 1·2%		7·10 ×	$\frac{1.2}{100}\times$	78·5q	6·69		
(c) roof slab @ 1%		11·59	$\times\frac{1}{100}$	78·5q	9·10		
(d) Staircase and lintel @ 0·8%		4·20 ×	$\frac{0.8}{100}\times$	78·5q	2·64		
(e) Sunshades @ 0·5%		0·52 ×	$\frac{0.5}{100}\times$	78·5q	0·20	21·04 quintal	
4. 1st class brickwork in superstructure walls							
Outside only	same	as	ground	floor	21·81		
staircase walls (three sides) ...	1	12·85	·20	2·40	6·50		12·85=2×5·05+2·75 5·05=5·30—·25
Deduction for stair room W_1	1	1·20	·20	1·2	0·22	-(ve)	
W_2	1	·90	·20	1·20	0·52	„	
D	1	1·00	·20	2·10	0 42	„	
						27 38 cu m	

Quantity for items 5 & 6 are same as that of ground floor and other items are same as building 3-10.

ABSTRACT OF ESTIMATED COST FOR GROUND FLOOR

(Note. The rates are same as for building 3-10)

Description.	Qu.	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
Earthwork in excavation for foundation trenches	116·90	cu m	320·00	%cu m	374·08
Earthwork in filling in foundation trenches	23·38	cu m	260·00	%cu m	60·79
Sand filling in plinth in layers	39·32	cu m	40·00	cu m	1,572·80
Cement concrete (1:3:6) with graded brick ballast (3cm down)	8·31	cu m	325·00	cu m	2,700·75
Cement concrete (1:2:4) with graded stone chips excluding shuttering and reinforcement	44·14	cu m	410·00	cu m	18,094·40
Hire and labour charges for centering and shuttering	280·49	sq m	16·00	sq m	4,487·84
M. S. reinforcement including cutting etc.	27·19	qu	600·00	qu.	16,314·00
1st. class brickwork in cement mortar (1:6) in foundation and plinth	10·42	cu m	245·00	cu m	2,552·90
2·5cm thick Damp-Proof course (1:2.4)	7·78	sq m	13·00	sq m	101·14
1st class brickwork in cement mortar (1:6) in superstructure	21·81	cu m	250·00	cu m	5,452·50
Half brickwork of 10cm thick in cement mortar (1:3) with H. B. netting in every third layer	107·71	sq m	38·00	sq m	4,092·90
7·5 cm thick Terraced flooring of lime concrete with stone lime surki and overburnt-brick ballast ($1\frac{1}{2}$:2:7)	103·27	sq m	32·00	sq m	3,304·68
25mm thick Marbulite work with precast tiles	124·60	sq m	75·00	sq m	9,345·00
2·5cm thick grey artificial stone in floor dado etc.	19·33	sq m	23·00	sq m	444·59
Indian Teak wood work in door and window frames including protective coat of painting at the contact surfaces of the frames	1·092	cu m	6000·00	cu m	6,552·00
3·75cm thi 1st class Indian Teak wood panel shutters with 19mm thick panel	17·71	sq m	200·00	sq m	3,542·00
3·75cm thick fixed louver shutters	12·72	sq m	195·00	sq m	2,480·40
C. O.					81,472·77

Sl. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
	B. F.	...	...		...	81,472·77
18.	3·75cm thick Glazed shutters of windows	13·55	sq m	140·00	sq m	1,897·00
19.	M. S. Ornamental Grill ...	14·05	sq m	110·00	sq m	1,545·50
20.	M. S. clamp 37·5cm long and fixing in walls	126	nos.	2·65	Each	333·90
21.	Anodised Alluminium hand rail ...	5 38	rm	80·00	rm	430·40
22.	12mm thick cement plaster (1:6) ...	469·80	sq m	6·75	sq m	3,171·15
23.	Neat cement punning about 1·5mm thick	46·38	sq m	2·50	sq m	115·95
24.	6mm thick cement plaster (1:4) ...	117·78	sq m	5·45	sq m	641·90
25.	Dry Distempering	405	sq m	2·35	sq m	951·75
26.	Decorative cement based paint ...	182·58	sq m	2·75	sq m	502·10
27.	Painting two coats on timber surface	115·14	sq m	7·00	sq m	805·98
28.	Painting two coats on metal surface	14·23	sq m	5·50	sq m	78·26
29.	100mm dia. asbestos cement down pipes.	24·00	Metre	18·00	Metre	432·00
30.	C. I. Ventilator with two coats of painting	14	nos.	3·00	Each	42·00
					Total=	92,420·66
	Add 10% cost of building for water supply and sanitation=					9,242·07
	Add 9% „ „ „ „ „ =					8,317·80
					Total=	1,09,970·53
	Add 5% for contingency					5,498·52
	Add $2\frac{1}{2}$% for Workcharged Establishment					2,749·26
					Grand Total=	1,18,218·31
					Say Rs.	1,18,218·00

Plinth area (same as building 3-10) = 14·3m × 7·9m = 112·97 sqm

∴ Plinth Area Rate including the cost of water supply and sanitation and electrification works $= \frac{\text{Rs. } 1,18,218}{112{\cdot}97 \text{ sqm}} =$ Rs. 1046·45 per sqm

ABSTRACT OF ESTIMATED COST FOR FIRST FLOOR

Note :—Star mark by the side of Sl. No. indicates higher rates for additional Storey.

Item No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
*1.	Cement concrete (1:2:4) with graded stone chips excluding shuttering and reinforcement.	25·46	cu m	416·00	cu m	10,591·36
*2.	Centering and shuttering for R. C. C. works. ...	235·18	sq m	17·50	sq m	4,115·65
*3.	M.S. reinforcement including cutting etc....	21·04	qu	603·50	qu.	12,697·64
*4.	1st. class brickwork in cement mortar (1:6)	27·38	cu m	256·00	cu m	7,009·28
*5.	Half brickwork of 10 cm thick in cement mortar (1:3) with H. B. netting in every third layer.	107·71	sq m	40·80	sq m	4,394·57
*6.	25mm thick Marbulite work with precast tiles.	124·60	sq m	76·00	sq m	9,469 60
*7.	25 mm thick grey artificial stone in floor etc.	26 97	sq m	23 50	sq m	633·79
8.	7·5 cm thick lime terracing on roof (2:2:7).	106·40	sq m	32·50	sq m	3.458·00
9.	1st. class Indian Teak wood for frames	1·130	cu m	6,000·00	cu m	6,780 00
10.	3 75 cm thick 1st. class Indian Teak wood panel shutters with 19mm thick panel.	15·99	sq m	200 00	sq m	3 198 00
11.	3·75 cm thick Fixed-Louver shutters.	13·56	sq m	195·00	sq m	2,644·20
12.	3·75 cm thick Glazed shutters.	15·51	sq m	140·00	sq m	2,171·40
13.	M. S. Ornamental Grill with 30mm × 6mm flats.	15·86	sq m	110·00	sq m	1,744·60
14.	M. S. clamp for fixing frames 37 5cm long.	128	nos	2 65	each	339 20
15.	Anodised Alluminium hand rail.	6·96	rm	80·00	rm	556·80
16.	12mm thick cement plaster (1:6) to wall.	601·00	sq m	6·90	sq m	4,146·90
17.	Neat cement punning about 1·5mm thick.	17·10	sq m	2·50	sq m	42·75
18.	6mm thick plaster with (1:4) cement mortar.	122·39	sq m	5·55	sq m	679·26
	C.O.					74,673·00

Item No.	Description	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	B. F.	...	...		...	74,673·90
*19.	Decorative cement based paint two coats	261·88	sq m	2·80	sq m	733·26
20.	Dry Distempering to interior walls ceiling with a coat of priming.	436·16	sq m	2·35	sq m	1024·97
21.	Painting two coats on timber surface.	122·66	sq m	7·00	sq m	858·60
22.	Painting two coats on metal surface.	15·86	sq m	5 50	sq m	87·23
23.	100mm dia. Down pipe of asbestos cement	21·00	metre	18·00	metre	378 00
24.	C. I. Ventilator.	14	nos.	3·00	Each	42·00
					Total	77,797·06

Add 10% cost of building for water supply and sanitation ... =7,779·71
And 9% " " for Electrification works ... =7,001·73

Total=92,578·50

Add 5% for Contingency ... ... =4,628·92
Add 2½% for work charged Establishment ... ... =2,314·46

Grand Total=99,521·88

Plinth area=112·97 sqm ∴ Plinth area Rate including the cost of water supply and sanitation and Electrification = Rs. $\frac{99522{\cdot}00}{112{\cdot}97 \text{ sqm}}$=Rs. 880·95 per sq m.

(A) *Comparative cost of different storey on percentage basis* :—

$\frac{\text{Cost of second storey}}{\text{Cost of first storey}}=\frac{\text{Rs. } 99{,}522}{\text{Rs. } 1{,}18{,}218}=0{\cdot}84$ ∴ Cost of second storey=84% of Ist. storey.

(B) *Comparative cost between Masonry load bearing wall and R.C.C. framed structure building* :—Total estimated cost of the two storied R.C.C. framed structure building =Rs. 1,18,218+99,522=Rs. 2,17,740·00

Total estimated cost of the two storied Masonary load bearing wall building as worked out for building 3-10 page 183= Rs. 2,05,277·00

∴ **Percentage increase in cost** for R.C.C. framed structure building having the same specification= $\frac{\text{Rs. } 2{,}17{,}740-\text{Rs. } 2{,}05{,}277}{\text{Rs. } 2{,}05{,}277}\times 100=6{\cdot}07\%$

Total floor or rentable area of R.C.C. framed structure building=2×82·89=165·78 sq m

Total floor or rentabale area of the building with load bearing walls=68·29+76·23=144·52sqm

∴ Increased floor or rentable area due to adoption of R.C.C. framed structure=21·26sqm

Percentage increase of floor area for framed structure building over load bearing walled building=$\frac{21{\cdot}26 \text{ sqm}}{144{\cdot}52 \text{ sqm}}\times 100=14{\cdot}71\%$

Although the cost for the framed structure building is 6·07 percent more than the load bearing walled building but the floor area of the framed structure building is 14·71% more than the load bearing walled building. **Therefore a framed structure building is more economical even for a two storey. Moreover the cost of upper storey is 84% to that as ground floor.**

4-29. Advantages of R. C. C. Framed Structure Buildings.

Since brick is weak in compressive strength in comparison with 1:2:4 cement concrete the width of load bearing walls for buildings having more than four stories becomes abnormally high and for such cases frame structures are adopted. In case of tall buildings there is no other alternative but to adopt framed structure which may be of steel frame or R. C. C. frame. The modern trend is that for R. C. C. framed buildings.

As load bearing wall building can not be provided in case of multistories, the question of comparison of cost between R. C. C. framed and load bearing wall buildings does not arise at all. But now-a-days R. C. C. framed structures are adopted in many cases even to construct two or three storied buildings. For such cases it is necessary to (a) compair the cost of construction between load bearing walled and R. C. C. framed structure buildings and (b) the advantages of R. C. C. framed building over the load bearing walled building.

(a) *Comparative cost* :—Detailed estimate of a particular building providing with load bearing walls first and then with R. C. C. framed structure has been prepared separately adopting same rates as in the pervious example. The cost of R. C. C. framed structure building becomes 6 to 7 percent more than that of load bearing wall building. For different plan and design the difference of cost may vary say even upto 8%. But the floor area of a R. C. C. framed structure building is 12 to 15 percent more than that of a load bearing walled building (as worked out in the previous example). Therefore there is actual economy in the case of R. C. C. framed structure buildings, specially where the cost of land is high.

(b) ***Further advantages of R. C. C. framed buildings are*** :—

(1) The inside planning of room, bathrooms, W. C. etc. can be changed by changing the position of partition walls. Thus greater freedom in planning can be availed.

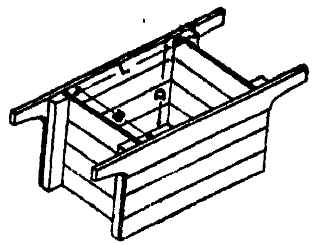
(2) Monolithic construction is possible in the ease of R. C. C. framed structure and thus can resist vibrations and shocks more effectively than that of a load bearing walled building. Further, R. C. C. framed structure can be designed to withstand normal earthquake.

(3) The speed of construction is more.

(4) R. C. C. framed structure building can be constructed on any kind of soil specially for soft ground.

(5) Subsequent maintenance charges are less.

4-30 Viva Voce Questions with answers :—

Questions	Answers
(1) To mix the ingredients of concrete in batches how these are to be measured ?	(1) The ingredients are measured by a batch box as shown below.  L=75cm B=45cm D=40cm Volume=0 135cu m
(2) How water is measured for mixing concrete in batches ?	2) By a 5 litres Kerosine tin the depth of which may be easily divided into five equal parts by scratch marks to measure 1 litre of water.
(3) What allowance may be recommended for the net quantities of materials to mix concrete ?	(3) To the net quantities of aggregate 10 percent must be added for tolerance on measurement and for waste, and 5 percent to the net quantities of cement for waste and for making grout.
(4) What type of aggregate you wil recommend, smooth and rounded or sharp angular ?	(4) Smooth and rounded aggregate is to be recommended, because this will produce a more workable concrete where as the latter produces unworkable concrete for the same water cemen. ratio as for rounded aggregate.
(5) Due to incomplete compaction if there be 5% and 10 % air voids what will be the effects ?	(5) Presence of 5% air voids may reduce the strength of concrete by 30% and 10% airvoids the strength may be reduced as much as 50%.
(6) If concrete be over compacted have you any objection ?	(6) Due to over compaction segregation (i. e. separation of coarse aggregate from the rest) may result.
(7) In one stack how many bags of cement you may recommend ?	(7) Maximum 10 bags, but preferably 8 bags. Any further amount may cause bursting and hardening of the bags in bottom layers.
(8) What amount of floor space may be considered to occupy by one bag of cement ?	(8) $3\frac{1}{2}$ sft.
(9) How you will maintain clear cover of concrete to reinforcement ?	(9) By placing cover blocks or packing pieces between reinforcement and shuttering.
(10) In order to hasten the time of trowling if neat cement or a dry mixture of cement and sand is spread thinly over a wet concrete surface to absorb excess water what are the harms ?	(10) If cement be spread, the thin layer of neat cement formed on the superficial surface crazes and cracks. If a dry mixture of cement and sand be spread this may absorb too much water locally which effects curing and ultimately a dusty surface is formed when it is subjected to wear.
(11) During floor finishing if an ordinary oil paint is applied before the concrete is fully dry what are the harms ?	(11) The moisture escaping from the concrete will tend to lift the paint, which may result in peel off in patches. Moreover, rapaid deterioration of the paint will result if the moisture contains alkali and free lime.

4-31. [4] **Designed T-beams for domestic purposes :—**

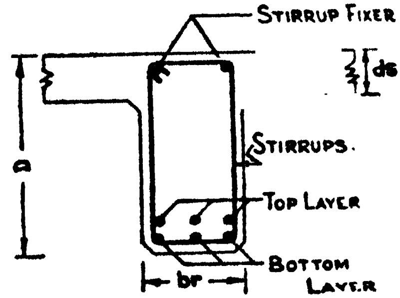
ributed live load=290kg per square metre

slab one way reinforced

fc=50kg./sq cm.

fs=1260kg./sq cm

m=15



Clear Span	3·65m			4·25m			4·85m				5·50m			
pacing of beams c/c. (in metre)	1·6	1·67	1·75	1·67	1·83	2·0	1·83	2·0	2·15	2·30	1·83	2·15	2·45	2·6
. (cm)	7·5	7·5	9	9	9	9	9	9	10	10	10	10	10	11
(cm)	22	22	23	23	23	25	28	28	30	33	30	34	38	41
r (cm)	15	15	15	15	15	15	18	18	18	18	18	1 8	18	18
Bottom reinforcement: Top layer (nos) dia in mm	2 16	2 16	2 16	2 20	2 20	2 20	2 20	3 20	2 22	2 22	3 20	3 20	3 20	3 20
Bottom layer nos. dia. in mm	2 16	2 20	2 20	2 .22	2 22	2 22	3 20	3 20	2 22	2 22	3 20	3 20	3 20	3 20
Dist. of bend for top layer (from support) in cm	25 32	25 32	30 45	25 32	25 32	27 45	30 48	32 56	32 66	40 68	35 60 78	40 68 96	45 75 106	50 78 108
irrup fixer dia in mm	10	10	10	10	10	10	10	10	10	10	12	12	12	12
10mm ϕ Stirrups: Spacing near at support (cm)...	15	15	15	15	15	17	17	20	19	19	19	19	21	21
Distance from support. (cm)...	90	90	120	210	210	210	105	244	105	120	135	135	150	165
Spacing for rest portion ... (cm)	15	15	15	—	—	—	20	20	21	23	21	25	28	30
uantity of main bar kg. ...	30	30	37	59	59	59	69	84	77	78	92	92	69	97
uantity of stirrups nd fixer in kg. ...	10	10	11	14	14	19	20	21	22	23	25	26	28	28

EXERCISE IV

Fig. 4·21 shows the roof plan (omitting the directions of roof slopes and rain water pipes) for two rooms with back verandah and kitchen. The slab is two-way reinforced and the cranked bars are shown as if cranked upwords on the plan instead of dotted lines.

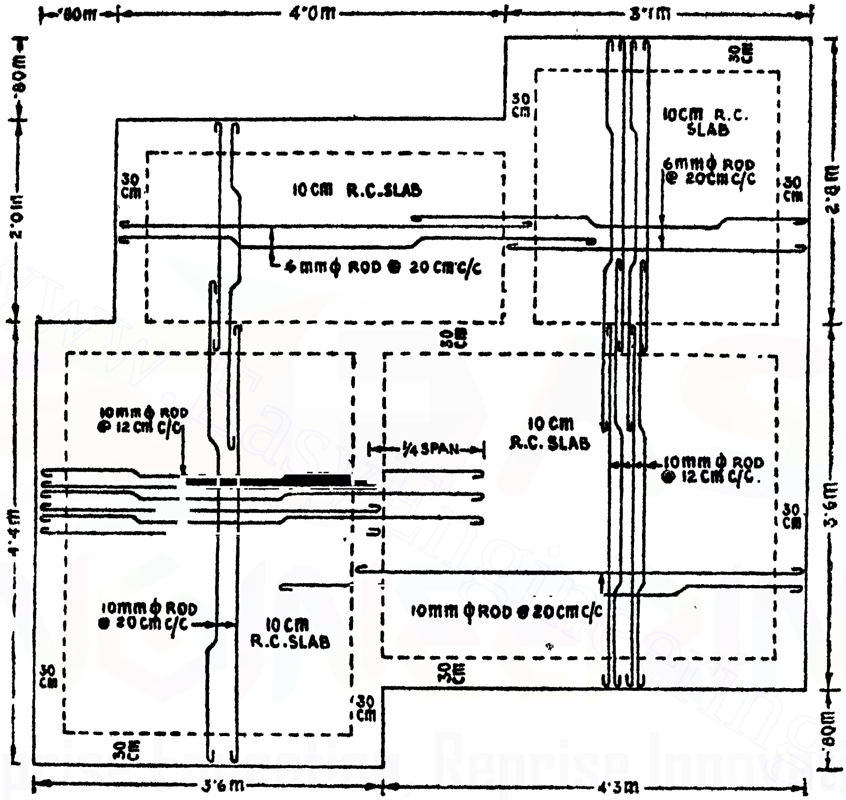


FIG. 4·21

The arrangement of bars at mid spans are as follows :

For rooms :—Main bars 10mm ϕ @ 12 cm c/c along short spans and secondary bars 10mm ϕ @ 20cm c/c along long spans.

For kitchen (roof measuring outer 2·8m × 3·1m) :—Main bars 10mm ϕ @ 12cm c/c and secondary bars 6mm ϕ @ 20cm c/c.

Verandah :—Main bars 10mm ϕ @ 20cm c/c and secondary bars 6mm ϕ @ 20cm c/c. Alternate bars are cranked near and support for both ways of reinforcement and in case of adjacent spans the same is carried upto one-fourth of the next span.

Prepare an estimated cost to construct the roof if weight of 10mm and 6mm dia. bars are 0·62 kg and 0·22 kg per rm and the slab thickness be 10cm all over. Assume any reasonable rate of your locality and make an indent of bars.

CHAPTER V

WOOD WORK FOR DOORS AND WINDOWS

5-1. Door and window frames—Frame works for doors and windows are fixed to masonry wall by providing 'Horns' 15cm length as shown in fig. 5-1 or by M. S. clamps of flat iron about 30cm × 5cm × 6mm as shown in fig. 5-3 or by wooden block built into the masonry as shown in fig. 5-2. The latter methods are mostly followed and specially for 3 piece frames without sill. When 'Horns' are not specified it is usual to provide door window frames without them.

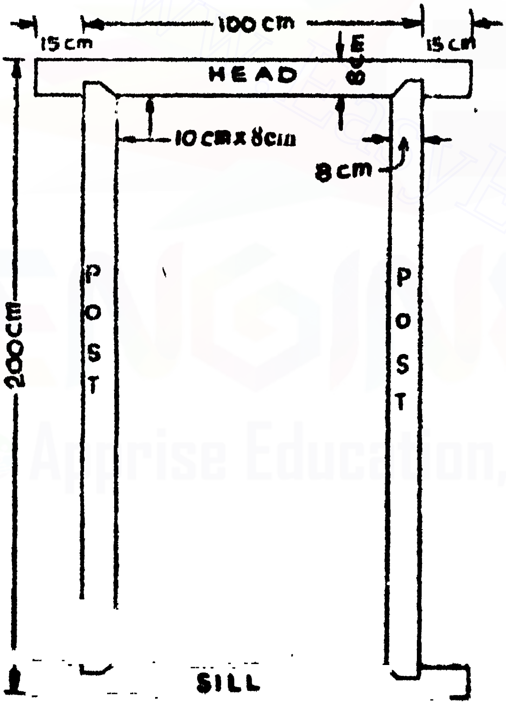


FIG. 5-1

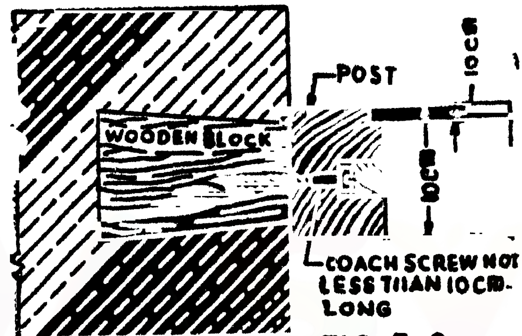


FIG. 5-2

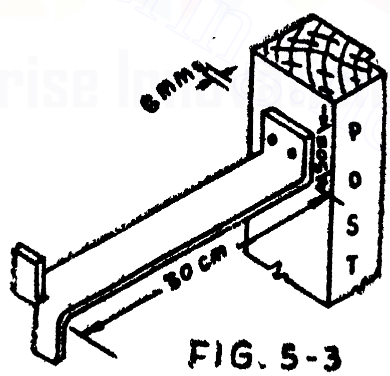


FIG. 5-3

Example - Estimate the quantity of wood work of door frame as shown in fig. 5-1.

Ans :—Total length of frame = 2 [200 + (100 + 2 × 15)] = 660cm

∴ Quantity of wood work = 660cm × 10cm × 8cm = 0·0528 cu m.

5-2. Estimate of a Battened ledged door leaf—Estimate the quantity of timber required to construct a Battend-ledged door leaf 80cm × 1·9m as shown in fig. 5-4 and also prepare an analysis of rate. All timber works shall be of C. P. teak wood. Assume reasonable rate of materials and labour of your locality. Length of each ledge is 70cm.

(For analysis of rate read Chapter X).

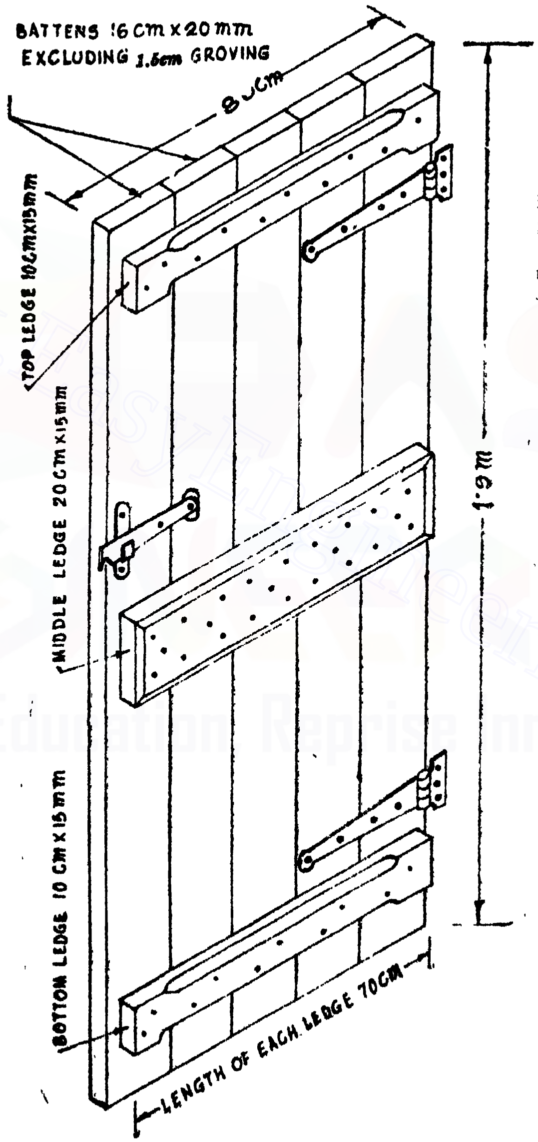


FIG 5-4

BATTENED-LEDGED DOOR LEAF

Particulars	No.	Length cm	B. cm	Thickness cu m	Quantity, cu m	Rate Rs. P.	Unit of Rate	Amount Rs. P.
(a) Materials—								
(i) Timber (1st. class Indian Teak)								
Batten (left edge) ...	1	190	16	20	0·006			
Battens remaining portion with groving	4	190	17·5	20	0·027			
Top ledge ...	1	70	10	15	0·001			
Middle ledge ...	1	70	20	15	0·002			
Bottom ledge ...	1	70	10	15	0·001			
			Total	=	0·037			
*Add 10% for wastage ...	—	—	—	—	0·004			
		Grand Total		=	0·041 cu m	3,800	cu m	155·80
(ii) Fitting—								
Garnet or Tee hinges 10 cm long	...			...	2 Nos.	3·00	Each	6·00
Tower bolt 15 cm	...			...	1 No.	2·80	Each	2·80
Aluminium handle 10 cm	...			...	1 No.	4·00	Each	4·00
Iron socket bolt 15 cm long	...			...	1 No.	2·60	Each	2·60
Wooden cleat	...			...	1 No.	0·80	Each	0·80
Hinges for cleat 2·5 cm	...			...	1 No.	1·50	Each	1·50
Screws 25 mm	...			...	50 Nos.	1·00	Doz.	4·16
Screws 20mm	...			...	10 Nos.	0·80	Doz.	0·63
(b) Labour—								
Carpenter	...			...	2	18·00	Each	36·00
Helper	...			...	1	14·00	Each	14·00
							Total =	228·29
(c) Sundries or contingency and T. & P. etc.							@ 1% of the total =	2·28
							Total =	230·57
(d) Profit and Overhead							@ 10% of the total =	23·06
							Grand Total =	253·63

$\therefore$ Rate $= \dfrac{\text{Rs. } 253{\cdot}63}{1{\cdot}9 \times {\cdot}80} =$ **Rs. 166·86 per sq m.**

* **10 percent wastage has been allowed following the practice of C.P.W.D.**

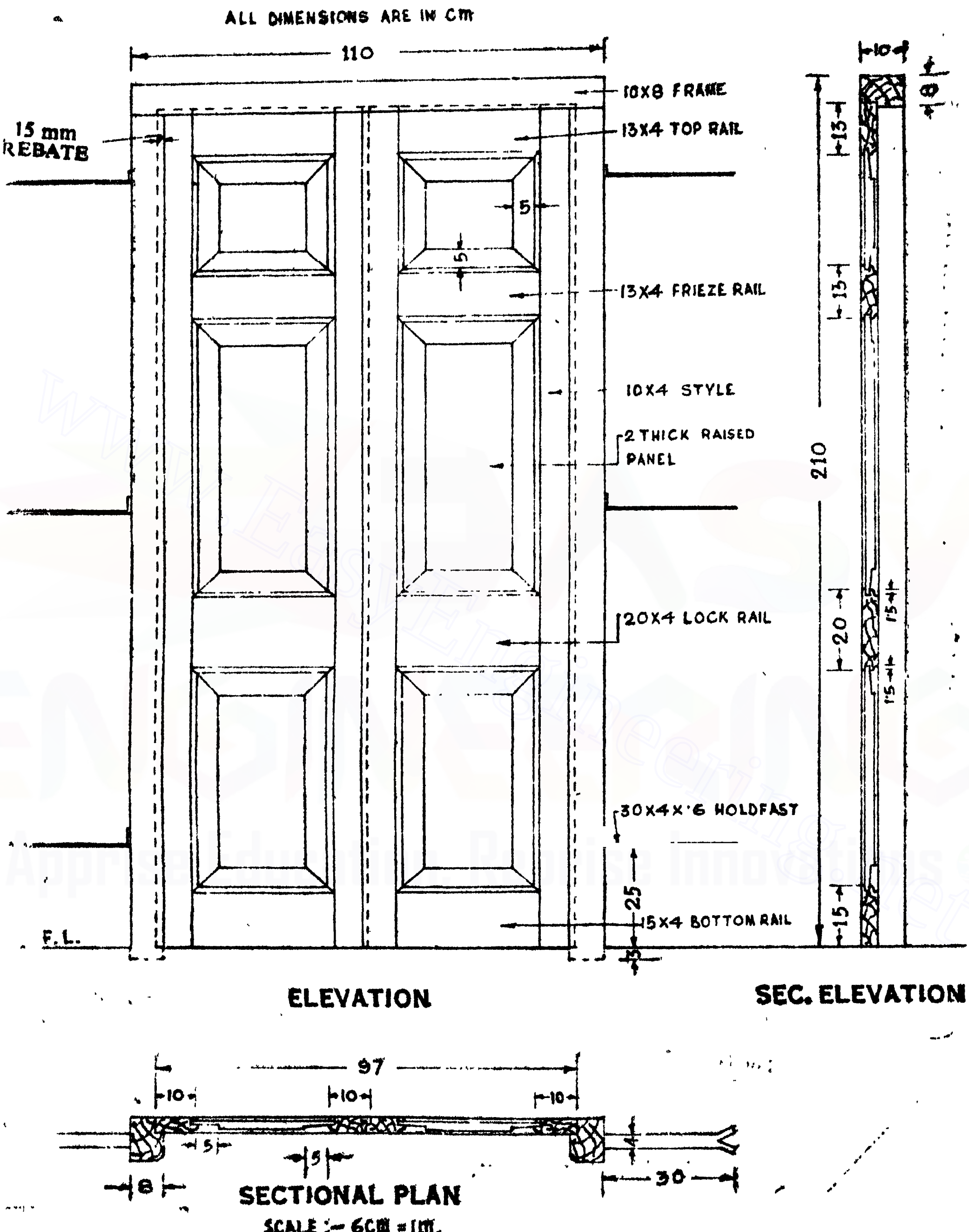


FIG. 5-5

PANELLED DOOR SHUTTER WITH FRAME

5-3. Estimate of a panelled door-shutter—Estimate the quantity of timber required to construct a panelled door shutter as shown in fig. 5-5 including frame and also prepare an analysis of rate for the shutter only. All timber works shall be of 1st. class Indian teak wood.* Assume reasonable market rate of your locality.

Particulars	No.	L. cm.	B. c	Thickness mm	Quantity cu m	Rate Rs. P	Unit of rate	Amount Rs. P.
(a) Materials—								
(i) Timber (1st class Indian Teak)								
Styles (203·5=210—8+1·5)	4	203·5	10	40	·0326			
Top rail (97=110—2×8+2×1·5) ...	1	97	13	40	·0050			
Frieze rail ...	1	97	13	40	·0050			
Lock rail ...	1	97	20	40	·0078			
Bottom rail ...	1	97	15	40	·0058			
Panels (sum total length with 1·5cm insertion)= 203·5—2×13—20—15+6×1·5)	2	151·5	32·25	20	·0195			
B=½[(97+1·5)—4×10+4×1·5]			Total	=	·0757			
1·5cm=central overlap								
*Add 10% for wastage ...	...	...	...	—	·0076			
		Total			·0833	3800	cu m	316·54
(2a) Frame		530	10	80	·0429			
Total quantity of timber ...				...	0·1262	cu m		
(ii) Fittings—								
Tower bolt 30cm (at top) ...				...	1 No.	5·00	Each	5·00
—do— 15cm (at bottom) ...				...	1 ,,	2·80	,,	2·80
Aluminium handle 10cm ...				...	1 ,,	4·00	,,	4·00
Aldrop (for locking) ...				...	1 ,,	7·50	,,	7·50
Hinges 10cm				...	6Nos	2·50	,,	15·00
Wooden cleat ...				...	2 ,,	0·75	,,	1·50
Hings 2·5cm (for wooden cleat) ...				...	2 ,,	1·50	,,	3·00
Screws 40mm				...	50 ,,	1·00	Doz	4·16
Screws 20mm				...	75 ,,	0·80	Doz	5·00
(b) Labour—								
Carpenter				...	4 ,,	18·00	Each	72·00
Helper				...	2 ,,	14·00	,,	28·00

Total=464·45

(c) Sundries or contingency and T. & P. etc. @ 1% of the total = 4·64

Total=469·09

(d) Profit and Overhead ... @ 10% of the total = 46·90

Grand total =514·99

$$\therefore \quad \text{Rate} = \frac{\text{Rs. } 514{\cdot}99}{{\cdot}97 \times 2{\cdot}035} = \text{Rs. } 215{\cdot}00 \text{ per sq m}$$

* 10 percent wastage has been allowed following the practice of the C. P. W. D.

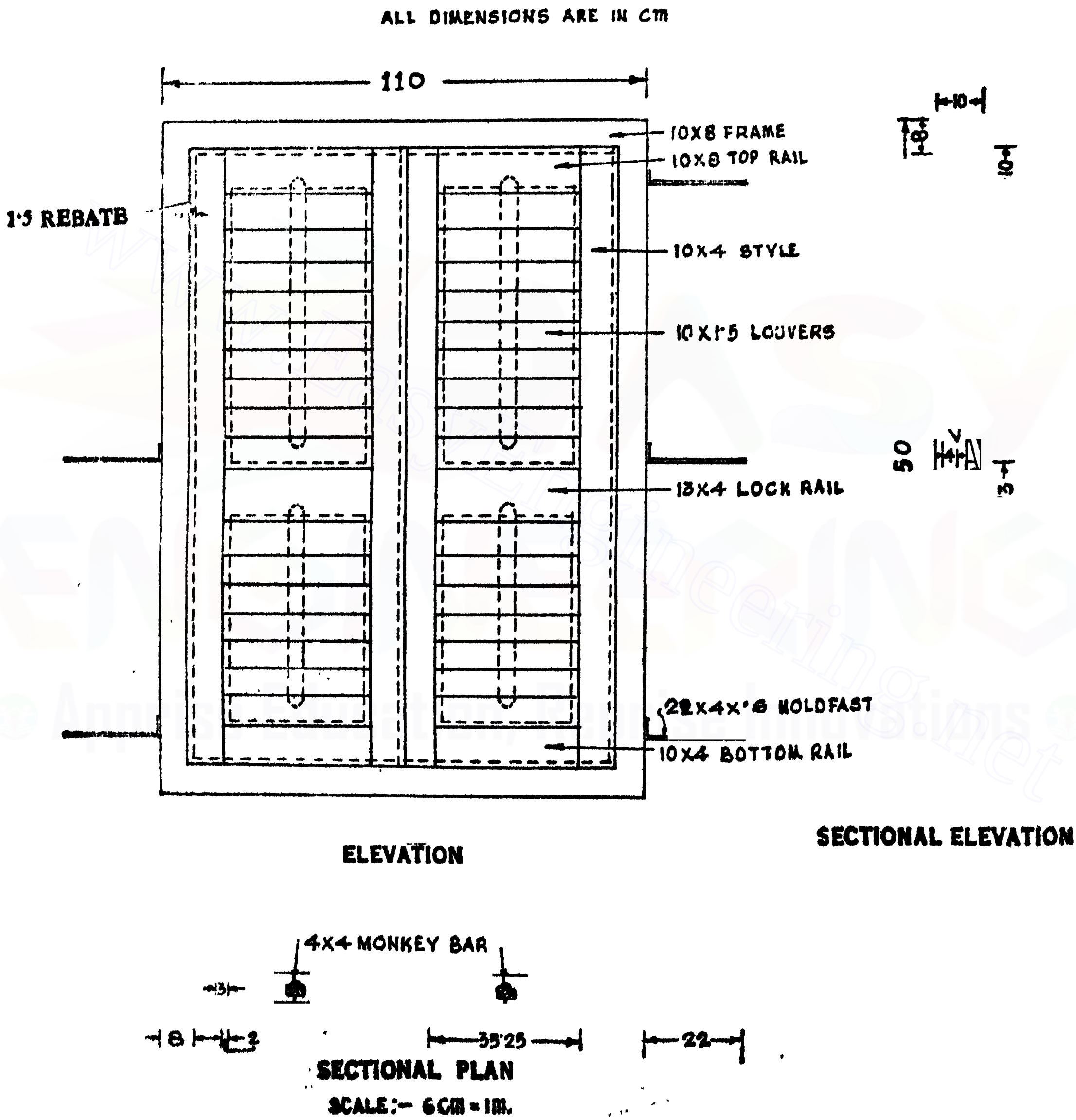


FIG. 5-6

VENETIONED WINDOW SHUTTER WITH FRAME

5-4. **Estimate of a venetioned Window Shutter.**—Estimate the quantity of timber required to construct 40mm thick venetioned window shutter only as shown in fig 5-6 and also pre-[illegible] All timber works shall be of 1st. class Indian teak wood.

Particulars	No.	L cm	B. cm	Thickness mm	Quantity cu m	Rate Rs. P.	Unit of rate	Amount Rs. P.
(a) **Materials**								
(i) *Wood work* (1st. class Indian Teak)								
Styles ...	4	137	10	40	·0219			
Top rail ...	1	97	10	40	·0039			
Lock rail ...	1	97	13	40	·0050			
Bottom rail ...	1	97	10	40	·0039			
Lovers ...	2×16	35·25	10	15	·0169			
$35·25 = \frac{1}{2}[97-(20+18·5)+(4\times3)]$								
Monkey Bar (upper and lower) ...	2	120	4	40	·0038			
			Total	=	·0554			
Add 10% for wastage ...	...	...	...	=	·0055			
		Grand Total=			0·0609	3,800	cum	231·42
(ii) *Fittings*—								
Screw type monkey hook ...		...			32 Nos.	1·00	each	32·00
Parliamentary hinges 10cm×10cm ...		...			4 Nos.	4·00	each	56·00
Tower bolt 22·5cm×10mm ...		...			1 No.	4·00	each	4·00
Butt hinges for cleat 2·5cm ...		...			1 No.	3·50	each	3·50
					2 Nos.	0·80	each	1·60
Screws 40mm ...		...			36 ,,	1·00	Doz	3·00
Screws 12mm ...		...			150 ,,	0·60	Doz	7·50
(b) **Labour**—								
Carpenter ...		...			5 Nos.	18·00	each	90·00
Helper ...		...			3 Nos.	14·00	each	42·00

Total = Rs. 471·02

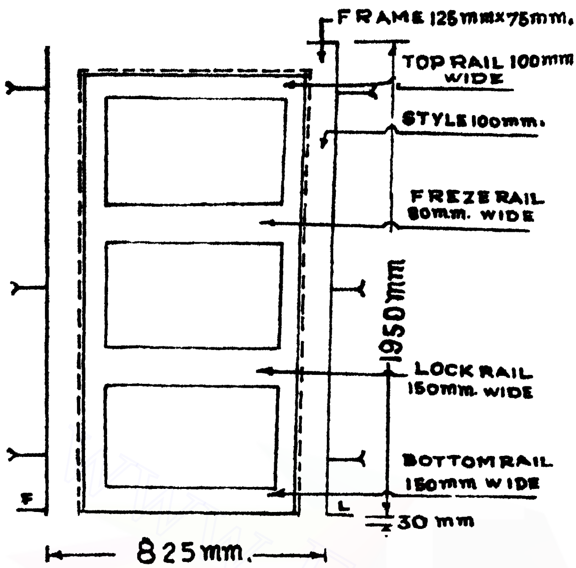
(c) **Sundries or contingency and T. & P. etc.** @ 1% of the Total = Rs. 4·71

Total = Rs. 475·73

(c) **Profit and Overhead** @ 10% of the Total = Rs. 7·57

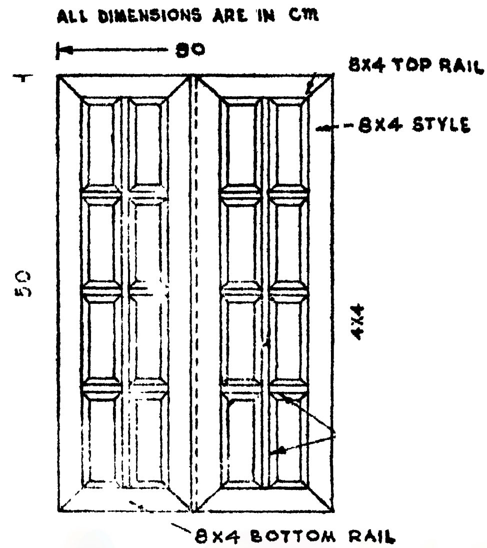
Grand Total = Rs. 483·30

$$\therefore \text{Rate} = \frac{\text{Rs. } 483·30}{0·97\times1·37} = \text{Rs. } 363·38 \text{ per sq m}$$



SINGLE LEAF PANELLED SHUTTER

FIG. 5-7



SCALE:-4CM=1M.

GLAZED WINDOW SHUTTER WITHOUT FRAME

FIG. 5-8

5-5. **Estimate of a single leaf wooden panelled door with frame** :—Draw a proportioned and dimensioned sketch of a single leaf teak wood panelled door, size of the wall opening being 1950mm height × 825mm width and estimate the total quantity of timber required in cubic metres for each door including frames and shutters. Also make a list of fittings you suggest for this door.

Details of the sketch as adopted :—The frame size is 125mm × 75mm. Shutter is 37mm thick. Top rail is 100mm × 37mm. Bottom rail is 150mm × 37mm. Frieze rail is 80mm × 37mm. Lock rail is 150mm × 37mm. Styles are 100mm × 37mm. Insertion of panel into rail or style is 20mm. Rebate in frame is 12mm. Panel thickness is 12mm.

[**Note** :—Single leaf door may have 4 nos intermediate rails instead of freize and Lock rails with a smaller width].

Estimate :—

Particulars	No.	L. m	B. m	Th. m	Quantity cu. m
(i) Teak wood work for shutters : —					
Styles L=1950−75+12 (rebate)=1887mm	2	1·887	0·100	0·037	0·0140
Top rail L=825−2×75+2×12=699mm	1	0·699	0·100	0·037	0·0025
Frieze rail	1	0·699	0·080	0·037	0·0021
Lock rail	1	0·699	0·150	0·037	0·0039
Bottom rail	1	0·699	0·150	0·037	0·0039
Panels (sum total length with 20mm insertion) L=1887−100−80−2×150+6×20=1627mm B=699−2×100+2×20=539 mm ...	1	1·627	0·539	0·012	0·0152
(ii) Frame :—Posts (with 30mm insertion)...	2	1·980	0·125	0·075	0·0371
Head	1	0·825	0·125	0·075	0·0077

∴ **Total quantity of timber required for each door including frame=0·0864 cum**

List of fittings :—Tower bolt 30cm long 1 No., Aluminium handle 2 Nos., Lever handle (for locking) 1 No., Hinges 10cm 4nos., Wooden cleat 1 No., Hinge for cleat 1 No.

5-6. Estimate of a Glazed Window Shutter—Estimate the quantity of timber required to construct 40mm thick glazed window shutter only as shown in fig. 5-8 and also prepare an analysis of rate. All timber works shall be of 1st class Indian Teak wood.

Particulars	No.	L. cm	B. cm.	Thickness mm	Quantity cu m	Rate Rs. P.	Unit of rate	Amount Rs. P.
(a) Materials—								
(i) ***Timber—***								
Styles ...	4	150	8	40	·0192			
Top and bottom rails ...	2	90	8	40	·0058			
Sash bars horizontal with 2·5cm insertion ...	6	34	4	40	·0033			
Sash bars vertical with 2·5cm insertion ...	2	139	4	40	·0044			
			Total	=	·0327			
Add. 10% for wastage ...	...	...	...	=	·0033			
		Grand Total		=	0·0360	3,800	cu	136·80
(ii) ***Fittings—***								
Tower bolt 30cm ...		...		...	1 No.	4·50	Each	4 50
Tower bolt 15cm ...		...		...	1 No.	3·00	Each	3 00
Hinges 10cm ...		...		...	4 Nos.	2·50	Each	10·00
Aluminium handle 10 cm		...		...	1 No.	4·00	Each	4 00
Wooden cleat ...		...		...	2 Nos.	0 75	Each	1·50
Hinges for wooden cleat 2 5cm		...		...	2 ,,	1·50	Each	3·00
Screws 40mm ...		...		...	36 ,,	1·00	Doz.	3·00
Screws 20mm ...		...		...	50 ,,	0·80	Doz.	3·22
Glass panes 16 Nos each 32·5cm × 14·5cm (with 1cm insertion) ...		...		...	0 752sqm	28·00	sq m	21·06
(b) Labour—								
Carpenter... ...		...		...	3 Nos.	18·00	Each	54 00
Helper ...		...		...	1 No.	14·00	Each	14·00

Total Rs. 258 08

(c) Sundries or contingency and T. & P. etc. @1%... of the total Rs. 2·58

Total = Rs. 260·66

(d) Profit and overhead ... ... 10% of the total = Rs. 26·07

Grand Total = Rs. 286·73

$$\therefore \text{ Rate} = \frac{\text{Rs. } 286\cdot73}{0\cdot90 \times 1\cdot50} = \text{Rs. } 212\cdot39 \text{ per sq m.}$$

5·7. Some door and Window Fittings :—

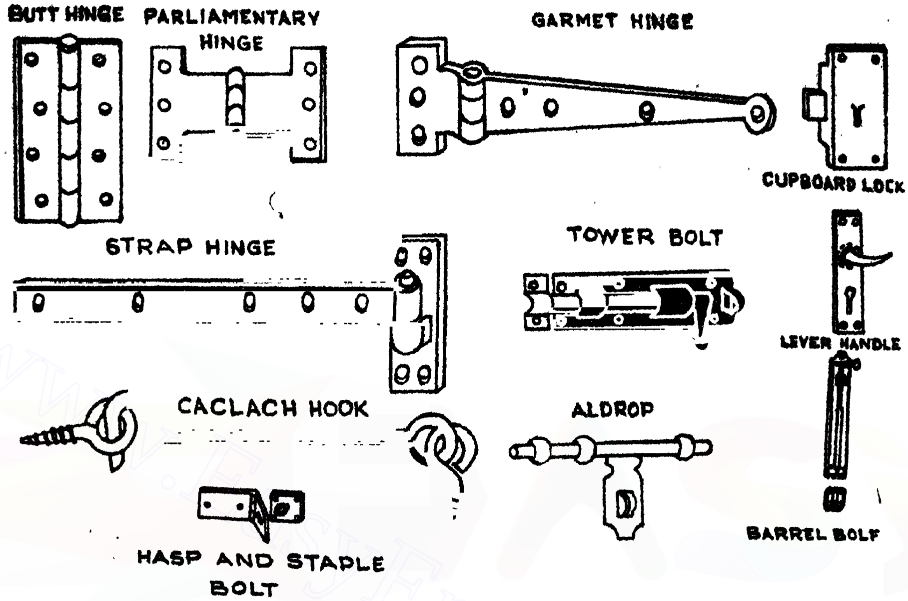


FIG. 5·9

EXERCISE

Fig. 5·10 shows the details of a Fanlight. Prepare a detailed estimate of the same using C.P. teak wood and adopting your local market rates.

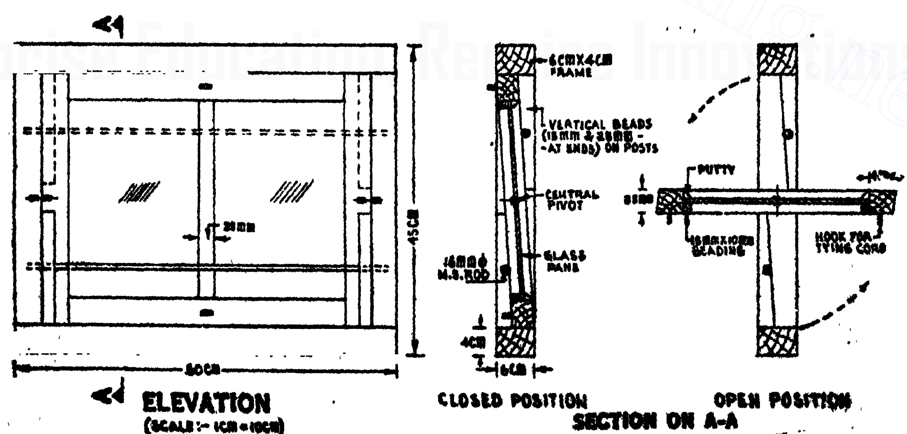


FIG. 5·10

CHAPTER VI

WATER SUPPLY AND SANITARY WORKS

6·1. Method of Measurement of Water supply and Sanitary works based on IS 1200.

(*a*) *General* :—The description of each item shall include all labour for finishing to required shape and size, setting, fitting and fixing in position, straight cutting and waste, handling, fabrication, hoisting, conveyance and delivery etc. All works shall be measured net as fixed in its place. All pipes and fittings shall be classified according to their diameters, method of joining and fixing. The diameter shall be the nominal diameter of the internal bore. In the case of fittings of two unequal bores, the largest bore shall be accounted.

All pipes shall be measured net, in running metres along the centre line of the pipes and fittings. Length as laid or fixed shall be measured over all fittings like bends, junctions etc, which shall not be measured separately. The method of laying and joining pipes and fittings shall be fully described. Testing of pipe line and sanitary works shall be described in the description of the item. Lead caulked joints shall be enumerated separately.

(*b*) *Water supply* :— Pipes laid in trenches and pipes fixed to wall, ceiling shall be measured separately. In the description for laying pipe line shall include all cutting and waste. standard fittings and cutting threads where necessary and also the method of joining and fixing. Pipes shall be classified according to their sizes and quality. Cutting through walls, floors etc. and making good the damage shall be included with the item excepting concealed pipe work.

(*c*) *Plumbing* :—Bib cocks, pillar cocks, stop cocks, ball valves, cisterns, ferruls, gratings, waste washers etc. shall be described stating the size, capacity and materials. The joints and the fixing shall also be described and included in the item.

Bends, branches, inspection doors, enlarged sockets etc. for Soil waste and Vent pipes shall be enumerated as extra over.

Ventilation cowls, and wire guards shall be described and measured separately according to the bore of the pipe over tops of which these shall be fixed.

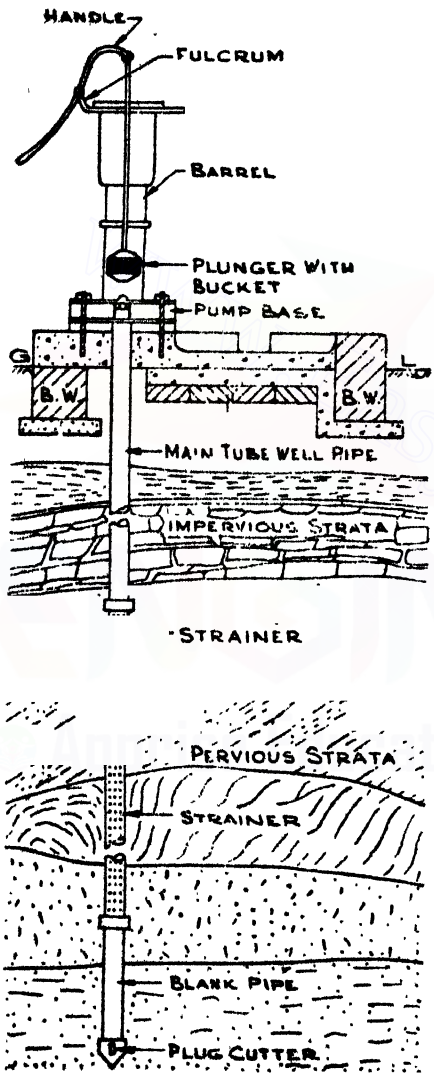
Lead pipes shall be classified according to their size and weight per running metre and shall be measured in running metres.

(*d*) *Effluent Drains and sanitary fittings* :—Effluent Drains shall be fully described and measured in running metres.

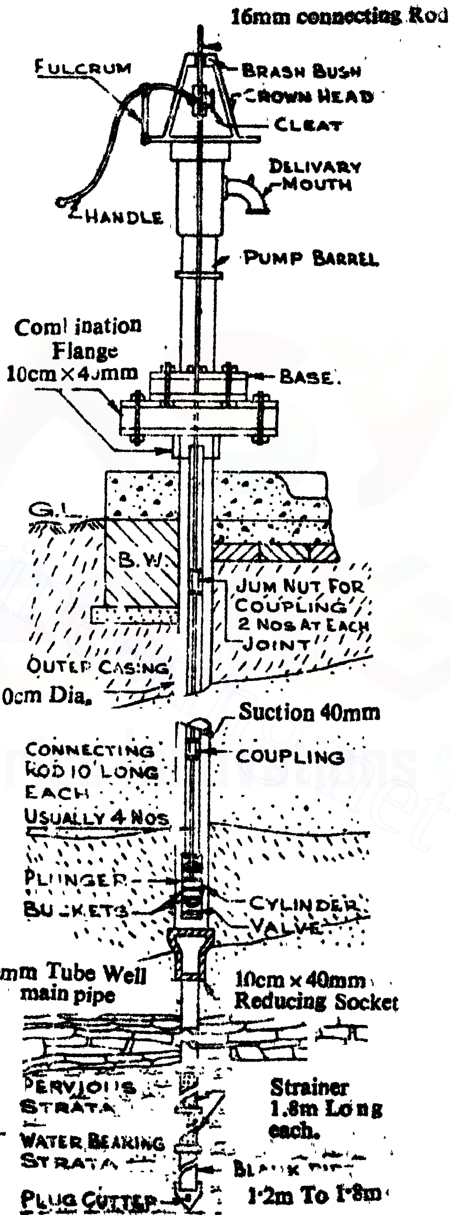
Gullies, syphons, intercepting traps etc. shall include setting, concrete bedding and connecting to drains, and shall be enumerated.

Sanitary fittings such as closet pans, urinal, flushing pipes, brackets, lavatory basins, shower roses, sinks and their fittings together with the fixing of the same shall be enumerated and fully described.

6-2. Estimate for sinking one 40mm dia. Tube-well.—Fig. 6·1 shows the elevation of a tube-well 40mm dia. fitted with an ordinary hand pump after removal of earth etc. Prepare an estimated cost with schedule of items to construct a tube-well for a total depth of 90m. Assume any reasonable rate of your locality. Length of strainer is 3·6m and surface drain is 2m.



(FIG. 6-1)
For water level upto 7·3m from G.L.



(FIG. 6-2)—
For water level beyond 7·3m from G. L.

Item No.	Description of Items	Quantity	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	(a) Materials—				
1	40mm dia. Galvanised Iron (G.I.) pipe I. T. C. (Medium)	86·4 rm	33·00	rm	2851·20
2	40mm dia. Strainers (1·8m long each) (P. T. I.)	2 Nos.	145·00	each	290·00
3	Hand Pump No. 6	1 No.	130·00	each	130·00
4	40mm dia. C.I. plug cutter ...	1 No.	9·50	each	9·50
5	40mm dia. steel plug cutter ...	1 No.	13·00	each	13·00
	(b) Labour—				
	(1) Sinking in any soil 40mm dia. pipes by water jet system and withdrawing the same from—				
	G.L. to 60m ...	60 rm	12·00	rm	720·00
	60m to 90m ...	30 rm	16·00	rm	480·00
2	Fitting, fixing, jointing and lowering 40mm dia. pipes with strainers and plug cutter in the bore hole from G.L. to 90m ...	90 rm	3·00	rm	270·00
3	Fitting, fixing, and erecting the hand pump including supplying necessary H.D. bolts ...	1 No.	20·00	each	20·00
4	Pumping out water till sand free water is obtained ...	1 T.W.	18·00	per T.W.	18·00
5	Construction of 1·2m × 1·2m masonry platform of cement concrete (1:2:4) base and foundation over a brick flat soling including 12mm cement plaster (1:3) and surface finished with neat cement as per drawing ...	1 No.	215·00	each	215·00
6	Brick masonry surface drain 15cm wide 10cm deep on 8cm cement concrete (1:3:6) foundation including 12mm cement plaster (1:3) surface finished with neat cement etc. complete ...	2 m	20·00	rm	40·00
				Total =	5056·70
				Add 5% for contingency =	252·84
				Add 2½% for W.C. =	126·42
				Grand Total =	5435·96

6·3. Estimate for sinking one 40mm dia. Tubewell fitted with deep well hand pump—Fig. 6-2 shows the elevation of a tubewell 40mm dia. fitted with deep well hand pump after removal of earth etc. Prepare an estimated cost with schedule of items to construct such a tube well for a depth of 90m below G.L. The length of casing pipe is 12m below G.L. Assume any reasonable rate of your locality. Lengths of strainer and surface drain are 3·6m and 2m respectively.

Item No.	Description of Items	Qu.	Rate Rs. P.	Unit of Rate	Amount Rs. P.
	(a) Materials—				
1.	40mm dia. Galvanised Iron (G.I.) pipe I.T.C. (Medium) ...	74·40	33·00	rm	2,455·20
2.	40mm dia. strainers (1·8m long each) ...	2 Nos.	145·00	Each	290·00
3.	Deep well hand pump ...	1 No.	175·00	Each	175·00
4.	40mm dia. steel plug cutter ...	1 No.	13·00	Each	13·00
5.	40mm dia. C.I. plug cutter ...	1 No.	9·75	Each	9·75
6.	10cm × 40mm reducing socket ...	1 No.	18·00	Each	18·00
7.	10cm dia. casing pipe (30cm extra above G.L.) ...	12·3m	163·00	rm	2009·90
8.	10cm × 40mm combination flange L.T.C. (Medium) ...	1 No.	34·00	Each	34·00
9.	12mm dia. connecting rod ...	12·3m	16·00	rm	196·80
10.	Jam nut ...	8 Nos.	1·50	Each	12·00
11.	12mm coupling ...	4 Nos.	2·50	Each	10·00
12.	7·5cm all brass cylinder (Bisco) ...	1 No.	285·00	Each	285·00
	(b) Labour—				
1.	Making necessary bore by water jet system for lowering 10cm dia. housing pipe for deep well pump set and withdrawing the boring pipes from G.L. to 12m. ...	12m	35·00	rm	420·00
2.	Sinking 40mm dia. pipes by water jet system and withdrawing the same from—				
	(a) Below the 10cm dia. bore to 60m from G.L.	48m	12·00	rm	576·00
	(b) From 60m to 90m. ...	30m.	16·00	rm	480·00
3.	Fitting, fixing, jointing and lowering 10cm dia. housing pipe. ...	12m	3·00	rm	36·00
4.	Fitting, fixing jointing, and lowering 40mm pipe, strainers with plug cutter including making necessary joint with 10cm dia. housing pipe. ...	78m	0·85	rm	66·30
5.	Fitting, fixing deep well pump cylinder, Head-stock, connecting rod & jointing flanges around 10cm dia. well pipe and 40mm dia. delivery pipe. ...	1 No.	100·00	Each	100·00
6.	Pumping out water till sand free water is obtained ...	1 No.	18·00	Each	18·00
7.	Constructing 1·2m × 1·2m masonry platform cement concrete (1:2:4) base and foundation over a brick flat soling 12mm cement plaster (1:3) including surface finished with neat cement ...	1 No.	215·00	Each	215·00
8.	Brick masonry surface drain 15cm wide 10cm deep on cement concrete (1:3:6) foundation including 12mm cement plaster (1:3) surface finished with neat cement complete ...	2m	20·00	rm	40·00
				Total = Rs.	7,436·9
				Add 5% for contingency = Rs.	371·8
				Add 2½% for W. C. = Rs.	185·9
				Grand Total = Rs.	7,994·7
				Say Rs.	7,995·(

6·3. How length of a strainer of a tube-well may be determined :—

From Dupuit's principles, steady radial flow in an extensive confined aquifer of uniform thickness and permeability is given by

$$Q=\frac{2{\cdot}73\,Kt\,(H-h)}{\log\frac{D}{d}}$$

Where, K = Coefficient of permeability at unit Hydraulic gradient.
t = The thickness of aquifer
H—h = Drawdown
D = Diameter of cone of influence.
d = Diameter of strainer pipe.

From tabulations of Casagrande giving different values of coefficient of permeability for different types of soil, K has been assumed as 4×10^{-2} centimeter per second, which will satisfactorily apply to the type of soil condition.

Limiting the drawdown to a maximum of 15ft. and using 100ft of 8″ dia strainer pipe and assuming the dia. of cone of influence as 500ft. the yield of the tube-well works out to :

$$K=4\times10^{-2}\text{cm/sec}=1{\cdot}31\times10^{-3}\text{f.p.s.}$$
$$t=100' \qquad H-h=15'$$
$$D=500' \qquad d=8''=0{\cdot}67'$$

$$\therefore\quad Q=\frac{2{\cdot}73\times(1{\cdot}31\times10^{-3})\times100\times15}{\log.\frac{500}{0{\cdot}67}}\text{ cu sec}$$

$$=\frac{2{\cdot}73\times(1{\cdot}31\times10^{-3}\times100\times15}{\log.\frac{500}{0{\cdot}67}}\times22{,}500\text{ g.p.h.}\left[22{,}500=60\times60\times\frac{62{\cdot}5}{10}\right]=42{,}000\text{ g.p.h}$$

Assuming that the infiltration rate is 200 g.p.h. per sq. ft. of the strainer area as may be observed from practical experience yield comes to

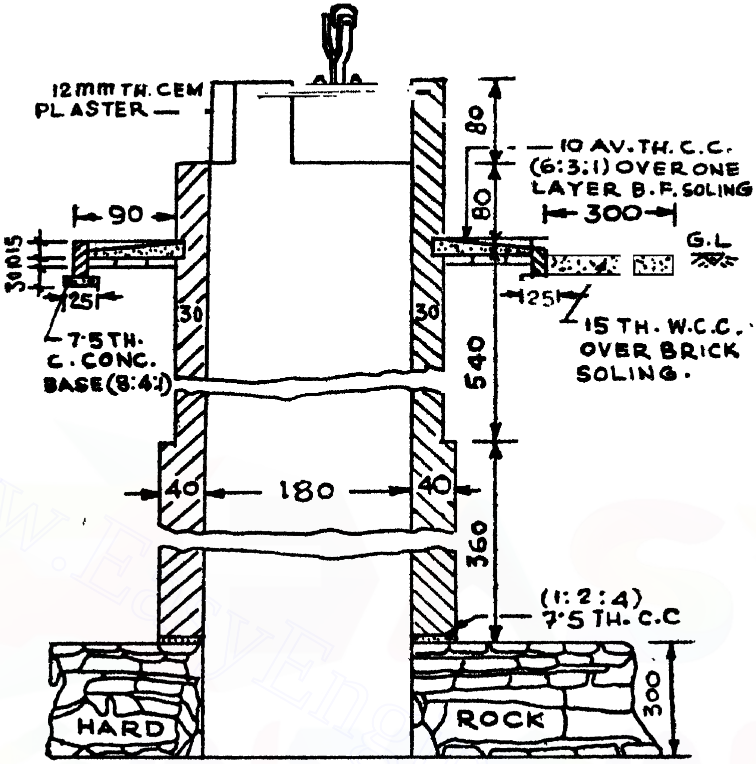
$$Q=\pi d\times L\times q$$

Where, Q = Discharge in g.p.h.
d = dia. of strainer pipe = 8″ = 0·67′
L = Length of strainer pipe = 100′
q = infiltration rate = 200 g/sft./hr.

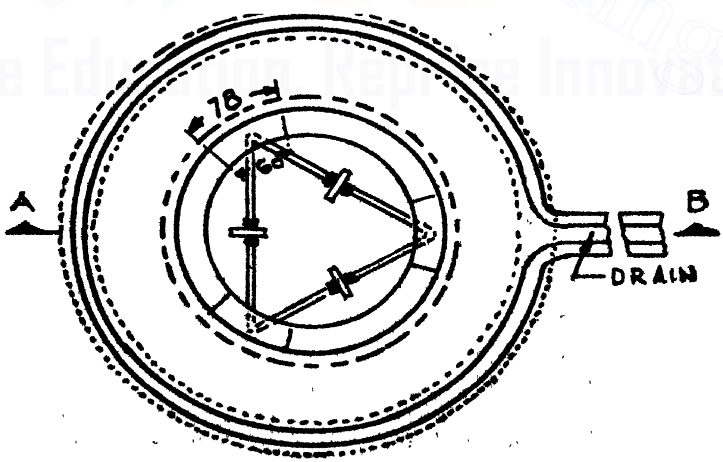
$$\therefore\quad Q=3{\cdot}14\times0{\cdot}67\times100\times200=42{,}000\text{ g.p.h.}$$

It is thus seen that yield computed on observational data compares very favourably with the theoretical yield of the tube well shown above.

Considering a factor of safety of 1·25 from practical observation, 8″ dia. and 100′ long strainer pipe may be proposed for an yield of $\frac{42\,000}{1{\cdot}15}$ =33,608 say 33,000 g.p. h.



12 mm TH. CEM PLASTER
80
10 AV. TH. C.C. (6:3:1) OVER ONE LAYER B.F. SOLING
80
90
300
G.L
30
15
25
25
7·5 TH. C. CONC. BASE (8:4:1)
30
30
15 TH. W.C.C. OVER BRICK SOLING.
540
40
180
40
360
(1:2:4) 7·5 TH. C.C
HARD
ROCK
300
SECTION ON-AB



A
B
78
DRAIN
PLAN

FIG. 6-3

6·4. Estimate of a Masonry well—Fig. 6-3 shows the plan and sectional elevation of a masonry well 180 cm dia. Prepare an estimated cost to construct such a well assuming reasonable prevalent rates of your locality. General specification of the work are as follows :—Brickwork in steining wall of well, pillars and parapet and platform shall be of 1st. class in cement mortar (1:4), inside of steining wall and all round to that of pillars parapet and platform shall be 12mm thick cement plastered (1:3). Other particulars shall be followed as per drawing.

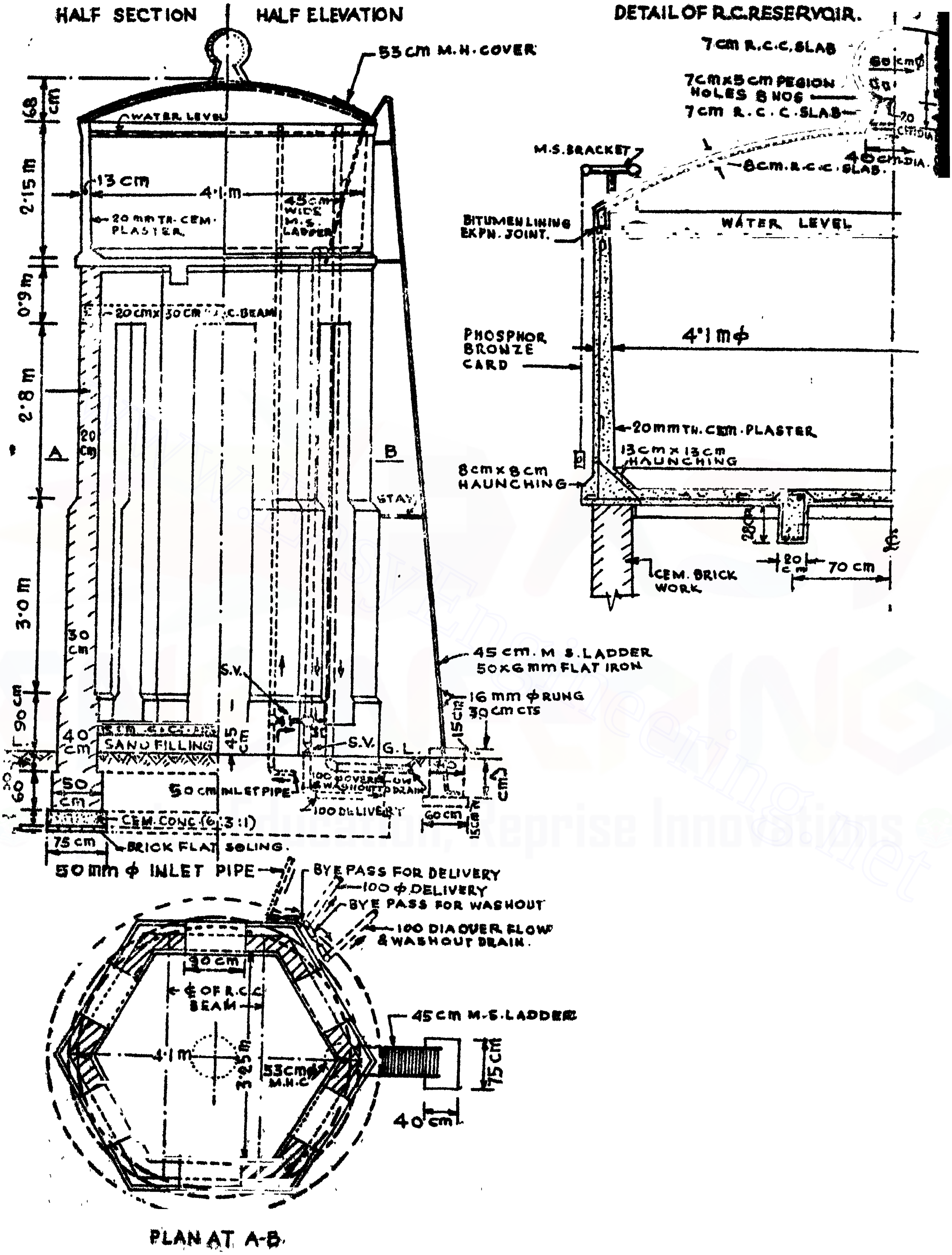
Item No.	Description	No.	L. m	B. m.	H. m	Qu.	Total	Explanatory notes
	Earthwork in excavation in any soil upto 1·5m below G.L. (a) along the depth of the well ...		$\pi(2{\cdot}60^2)$	× 1·5		7·97		260=180+2×40
	(b) retaining wall of platform ...		2π × 2·0	× ·25	× ·30	0 97	8·94 cu m	205 = radius = 90 + 30 + 80 + 5
	Digging 260 cm external dia. for 180cm internal dia. masonry through any soil including blasting if necessary from							
	(a) 1·5m to 5·4m ...		3·90			3·9	3·9 rm	
	(b) 5·4m to 9m ...		3 60			3·6	3·6 rm	
	Digging 18 0cm dia. and dressing the vertical faces with plumb to that of its upper steining wall in any soil including blasting	1	3·00			3 0	3·0m	
	Earthwork in filling up the gaps on the back of 30cm well steining layer by layer ...		5·40			5·4	5·4 rm	
	7·5cm thick cement concrete (1:2:4) for bed of the well steining ...		π × 2·20	× ·40	× 075	·21	21 cu m	2·2 m is mean dia. =180 cm+40 cm
	Cement concrete (1:4:8) in foundation of retaining walls		π(2·05)	× ·25	× 075	·24	·24 cu m	
	1st. class brickwork for steining wall of well in cement mortar (1:4) below G.L.							
	(a) 40cm thick portion...		× 2·20	·40	× 3·60	·95		
	(b) 30cm thick portion...		× 2·10	·30	× 5·40	1·20		
							21·15 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
8.	**1st. class brickwork in cement mortar** (1:4) above G.L.							
	(a) Parapet ...	1	$\pi\times2{\cdot}10$	$\times{\cdot}30\times$	·84	1·66		$84=\frac{1}{2}(80+88)$ 8cm slope considered.
	(b) Pillars ...	3	$\frac{1}{2}({\cdot}60+{\cdot}78)\times{\cdot}30\times$		·76	·47		$76=\frac{1}{2}(72+80)$.
							2·13 cum	
9.	**10 cm thick brickwork** for retaining wall ...	1	$2\pi\times2{\cdot}05$	$\times{\cdot}30$	—	2·06	2·06 sqm	15 cm ht. with platform (Total ht. of 10cm brick work =45 cm)
10.	**Constructing 10cm av. thick W.C.C. (1:8:6) platform** over a brick flat soling including 12mm cement plaster (1:4) and neat cement finish complete ...	1	$\frac{\pi}{4}[(4{\cdot}20)^2$	$-(2{\cdot}40)]^2$	—	37·33 sqm	37·33sqm	$420=180+2\times30+2\times90$
11.	**12mm thick cement plaster** (1:3) finished with neat cement							
	(a) Inside of steining wall including parapet	1	$\pi\times1{\cdot}80$	$\times9{\cdot}90$	—	56·00		
	(b) Outside of parapet wall ...	1	$\pi\times2{\cdot}40$	$\times{\cdot}68$	—	5·13		·68=·80—·12, ·12 is the depth of conc. at parapet
	(c) Top of parapet and pillars ...	1	$\pi\times2{\cdot}10$	$\times{\cdot}30$	—	1·98		
	(d) Inside of pillars ...	3	·60	—	·72	1·30		
	(e) Outside of pillars...	3	·78	—	·80	1·87		
							66·28sqm	
12.	**15cm×10cm spill water surface drain** having 10cm B.W. in cement mortar (1:4) on two sides as per drawing ...	1	3·00	—	—	3·00	3 rm	
13.	**Supplying and fitting, fixing in pillars** 65mm×65mm×6mm iron painting complete ...	3	2·0m	—	—	6·0	6·0 rm	
14.	**Supplying and fitting, fixing 150 mm dia. C.I. pulley** with L-iron pulley bar ...	3	—	—	—	3	3 Nos	
15.	**Dewatering, silt cleaning** and site dressing ...	1	—	—	—	—	1 item	

Abstract of Estimated Cost

Item No.	Description	Quantity	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Earthwork in excavation in any soil upto 1·5m below G L.	8·94	cum	320·00	%cu m	28 61
2.	Digging 260 cm outer dia. for 180 cm internal dia. masonry well through any soil including blasting if necessary					
	(a) 1·5m to 5·4m below G.L. ...	3·9	rm	120·00	rm	468 00
	(b) 5·4m to 9m below G.L. ...	3·6	rm	175 00	rm	630·00
3.	Digging 180cm dia. and dressing the vertical faces with plumb to that of its upper steining wall in any soil including blasting ...	3	rm	165·00	rm	495·00
4.	Earthwork in filling up the gaps on the back of 30cm well steining layer by layer ...	5·4	rm	10·00	rm	54·00
5.	Cement concrete (1:2:4) with stone chips.	0·21	cum	425·00	cum	89·25
6.	Cement concrete (1:3:6) with stone chips	0·24	cum	335·00	cum	80·40
7.	1st class brickwork for steining wall of well in cement mortar (1:4) below G.L.	21·15	cum	300·00	cum	6,345·00
8.	1st class brickwork in cement mortar (1:4) above G L.	2·13	cum	295·00	cum	628·35
9.	10cm thick brickwork for retaining wall ...	2·06	sqm	40·00	sqm	82·40
10.	Constructing platform with 10 cm av. thick W.C.C. (1:3:6) over a brick flat soling including neat cement and 12mm cement plaster (1:4)	37·33	sqm	33 00	sqm	1231·89
11.	12mm thick cement plaster (1:3) finished with neat cement	66·28	sqm	6·80	sqm	450·70
12.	15cm × 10cm spill water surface drain having 10 cm B.W. in cement mortar (1:4) on two sides as per drawing	3	rm	27·00	rm	81·00
13.	Supplying and fitting, fixing in pillars 65mm × 65mm × 6mm L-iron painting complete ...	6	rm	22·00	rm	132·00
14.	Supplying and fitting, fixing 150mm dia. C.I. pulley with L-iron pulley bar... ...	3	Nos.	32·00	each	96·00
15.	Dewatering, silt cleaning and site dressing.	1	item	100·00	per item	100·00

Total = Rs. 10,992·60
Add 5% for contingency = Rs. 549 63
Add $2\frac{1}{2}$% for W. C. = Rs. 274·82
Grand Total = Rs. 11,817·00



HALF SECTION
HALF ELEVATION
DETAIL OF R.C.RESERVOIR.
53 cm M.H. COVER
WATER LEVEL
13 cm
4·1 m
45 cm WIDE M.S. LADDER
20 mm TH. CEM. PLASTER
20 cm x 30 cm R.C.C. BEAM
68 cm
2·15 m
0·9 m
2·8 m
3·0 m
90 cm
20 cm
30 cm
A
B
STAY
S.V.
SAND FILLING
45 cm
40 cm
50 cm
50 cm INLET PIPE
CEM. CONC. (6:3:1)
75 cm
BRICK FLAT SOLING
50 mm ϕ INLET PIPE
100 DELIVERY
G.L.
60 cm
15 cm
45 cm. M.S. LADDER 50x6 mm FLAT IRON
16 mm ϕ RUNG 30 cm CTS
7 cm R.C.C. SLAB
7 cm x 5 cm PEGION HOLES 8 NOS
7 cm R.C.C. SLAB
M.S. BRACKET
8 cm R.C.C. SLAB
40 cm DIA.
BITUMEN LINING EXPN. JOINT.
WATER LEVEL
PHOSPHOR BRONZE CARD
4·1 m ϕ
20 mm TH. CEM. PLASTER
13 cm x 13 cm HAUNCHING
8 cm x 8 cm HAUNCHING
CEM. BRICK WORK
20 cm
70 cm
BYE PASS FOR DELIVERY
100 ϕ DELIVERY
BYE PASS FOR WASHOUT
100 DIA OVER FLOW & WASHOUT DRAIN.
30 cm
℄ OF R.C.C. BEAM
4·1 m
3·25 m
53 cm M.H.C.
45 cm M.S. LADDER
75 cm
40 cm
PLAN AT A-B.

FIG. 6·5

6·6. Estimate of a brick—cum R.C. Reservoir 22.800 litres capacity :—Fig. 6-5 shows 22,800 litres capacity brick-cum R.C. reservoir. The staging height of the tank is 7·6m above ground level and constructed with brickwork. Prepare a quantity estimate including pipe connections but excluding cement pointing to brickwork.

General specifications :—Earthwork in filling shall be of sand, staging shall be Rule pointed with cement mortar (1:3). Brickwork shall be of 1st class in cement mortar (1:4). Floor and vertical inner sides of the tank shall be of 20mm thick cement plastered with water proofing compound. Outside of the tank and roof shall be 12mm thick cement plastered. Pigeon holes are to be wire netted with mosquito proof wire netting. Tank shall be colour washed two coats over two coats of white washing.

Item No.	Description	No.	L. m	B. m	H m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation** depth upto 1·85m below G.L.							
	(a) For reservoir foundation ...	1	12 32	·75	1·23	11·36		12·32=(6×2)×1·78m tan 30°
	(b) For ladder foundation ...	1	·75	·60	·75	0·34		$1·78 = \frac{3·25}{2} + \frac{·30}{2}$
							11·70 cu m	
2.	**Sand filling to foundation trenches &** floor							
	(a) Foundation trenches ...	1	$\frac{1}{5}$th of excavation		=	2·92		Area of hexagon = 0·866 d²
	(b) Flooring ...	1	0·866 ×	(3·25 - ·10)²	·30	2 58		
							5·50 cu m	
3	**Brick flat soling** ...	1	12·32	·75	—	9·24	9·24 sq m	
4	**Cement concrete** (1:3:6) in foundation and flooring							
	(a) For staging ...	1	12·32	·75	·23	2·12		
	(b) For ladder ...	1	·75	·60	·15	0·07		
	(c) For flooring ...	1	0·866 ×	(3·25--·10)²	·15	1·29	3·48 cu m	
5.	**Brickwork in foundation** in cement mortar (1:4)							
	(a) For reservoir							
	50cm layer ...	1	12·32	·50	·60	3·70		Chamfer has been considered as if square
	40 cm layer ...	1	12·32	·40	·30	1·48		
	(b) For ladder ...	1	·75	·40	·60	0·18	5·36 cu m	
6.	**Brickwork in superstructure** in cement mortar (1:4)							
	(a) For reservoir							
	40cm layer ...	1	12 32	·40	90	4·44		11·98m=(6×2)×1·73m tan 30°
	30cm layer ...	1	12 32	·30	3·00	11·09		
	20cm layer ...	1	11·98	·20	3·70	8 87		$1·73 = \frac{3·25}{2} + \frac{·20}{2}$
	(b) For ladder ...	1	·75	40	·15	0·04		
	B.F.					24·44		

Item no.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	C.O.					24·44		
	Deductions for openings in 40cm layer ...	6	·90	·40	·45	·97(-ve)		
	in 30cm layer ...	6	·90	·30	3·00	4·86(,,)		
	in 20cm layer ...	6	·90	·20	2·80	3·02(,,)		
	For R. C. band lintel	1	11·98	·20	·30	0·72(,,)	14·87 cu m	
7.	**R.C.C.** work excluding reinforcement but including shuttering **band lintel** (1:2:4) ...	1	11·98	·20	·30	0·72	0·72 cu m	
8.	**cement concrete** (1:1½:3) including shuttering but excluding reinforcement							
	(a) For overhead tank							4·23=4·1+·13
	Vertical sides ...	π×	4·23	·13	2·15	3·71		13cm is av.thickness
	Haunchings at inner base ...	π×	3·97	½×·13	·13	0·11		3·97m=4·10—·13
	-do-at outer edge ...	π×	4·44	½×·08	·08	0·09		4·44m=4·10+2×·13+·08
	Base slab ...	1	π×	$\frac{(4·52)^2}{4}$	·13	2·09		
	Roof ...	π	$[\frac{(4·36)^2}{4}$	$+(·64)^2]$	×·08	1·30		Area of spherical segment= $\pi\left(\frac{c^2}{4}+h^2\right)$
	Dome lower slanting part ...	π/2	(·27+	·47)·20	·07	0·02		·27m=·20+·07 ·47=·40+·07
	-do upper circular part (considering whole)	1	π ×	·(53)²	·07	0·06		
	(b) Beams (web only)	2	3·66	·20	·28	0·41		surface area of a sphere= πr^2 3.66=3·26+2×·20
	Deduction for Manhole	1	π ×	$\frac{(·53)^2}{4}$	·08	0·02(-ve)		
	Bottom portion of top circular dome ...	1	$\pi\times(\frac{·20}{4})^2$	apx.	·07	·01(-ve)		
	Top portion of roof...	1	$\pi/4\times(·40)^2$		·08		7·76 cu m	
9.	**12mm Cement plaster** (1:4)							4·36=4.10+2×·13
	Vertical sides of tank		π×(4·36)	—	2·28	31·23		
	Bottom of tank ...	1	π ×	$\frac{(3·96)^2}{4}$	—	12·32		3·96=4·10+2×·13—2×·40
	Top of roof slab ...	1	$\frac{\pi}{4}\times$ (4·36	)² 4+	(·68)²	16·38		Roof is a spherical segment
	Dome lower slanting	1	π×	·44	×·20	0·28		·44=½(·40+·20)+2×·07
	Dome upper circular	1	π/4×(·60	)² —	—	0·28		
	Sides of beams ...	2×2	3·25	—	·28	3·64		
	Deduction for Manhole	1	π/ 4 ×	(·53)²	—	0·22	(-ve)	Deduction of bottom portion of top circular dome is negligible
	-do-top portion of roof	1	$\frac{\pi}{4}\times$	(·40)²	—	0·13	(-ve)	
							63·78 sq m	

Item No.	Description	No	L.	B. m.m.	H.	Qu.	Total	Explanatory notes
10.	**20mm thick cement plastering (1:2)** with water proofing compound :–							3·84=4·1–2×·13
	Floor of slab (excluding haunchings) ...	1	$\pi\times$	$\frac{(384)^2}{4}$	—	11·58		small inclination neglected
	Vertical sides ...	1	$\pi\times$	410×215	—	27·70		
	Haunchings ...	1	$\pi\times$	$397\times\sqrt{(13)^2+(13)^2}$		2·29	41·57 sq m	397=410–13
11.	**45cm wide M. S. ladder** consisting of 2 nos. of 40mm×12mm thick flat bar straigers and 20mm dia. rungs and angle iron stays including painting inside and outside ...	1	14	—	—	14	14 rm	
12.	**Copper floot, brass guide pulleys** with deep groove etc. painting complete...	1	—	—	—	1	1 set	
13.	**53 cm dia. C. I. M. H cover** with frame ...	1	—	—	—	—	1 no.	
14.	**7 cm×5 cm pigeon holes** covered with mosquito proof wire netting ...	8	—	—	—	—	8 nos.	
15.	(a) **100mm dia. C. I. pipes** with valves & specials for delivery ...	1		—	—	8	8m	
	(b) 50 mm dia. C. I. pipes with valves & specials for inlet ...	1		—	—	8	8m	
	(c) 50mm C. I. pipes with valves & specials for bye-pass ...	1	60 cm	—	—	60 cm	60cm	
	(d) 100 mm dia. C. I. pipes with valves & specials for bye-pass ...	1		—	—	60 cm	60 cm	
16.	**Colour washing two coats** over two coats of white washing ...	1	same	as item no.	9=	63·78	63·78	sq m

6-8. Estimates of surface drains—Fig. 6·6 to 6-9 are the cross sections of different types of surface drains. Estimate the cost of construction for such drains for a length of 3 metres each and findout the rates per metre. Weak cement concrete (8:4:1) shall be with overburnt brick ballast and cement concrete (4:2:1) shall be of stone chips. Assume your own rates

FIG. 6-6

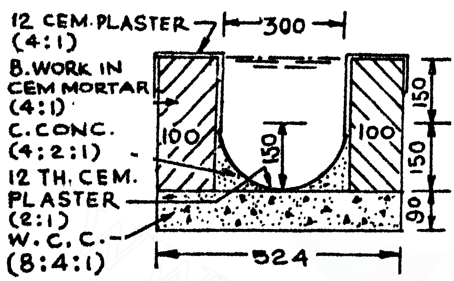
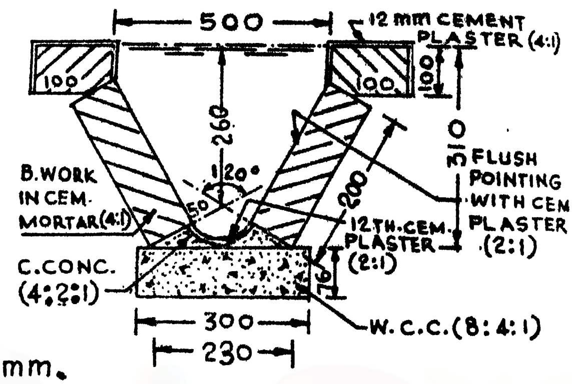
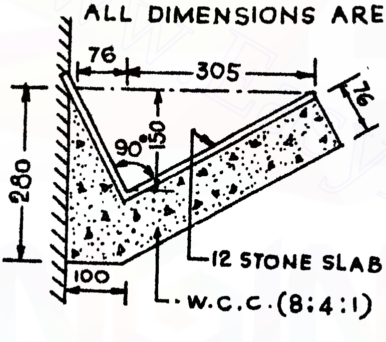


FIG. 6-7



ALL DIMENSIONS ARE IN mm.



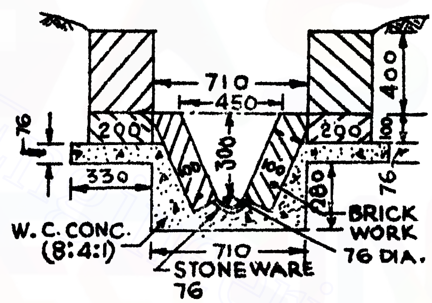


FIG. 6-8

FIG. 6-9

Item No	Description	L m	B. mm	H. mm	Qu.	Total	Rate Rs. P.	Amount Rs. P
	Type-1 Fig. (6-6)							
1.	Earthwork in excavation. ...	3 00	524	390	·38	·38 cu m	320%cu m	1·22
2.	Cement concrete (8:4:1) ...	3·00	524	90	·14	·14 cu m	300 cu m	42·00
3.	Cement concrete (4:2:1) ...	3·00	324	150	·15			
	Less ...	3·00	$\frac{\pi}{8}$ (156)²	—	·03	(-ve)		
						0·12cu m	425 cu m	51 00
4.	10cm thick brickwork in cement mortar (4:1) ...	2×3	—	300	1·80	1·80sq m	32 sq m	57·60
5.	12mm thick cement plaster (2:1) circular ...	3·00	$\frac{2\pi\times150}{2}$	—	1·41	1·41sq m	9·00 sq m	12 69
6.	12mm thick cement plaster (4:1) remaining portion ...	2×3	350	—	2·10	2·10sq m	6·80 sq m	14·28

$\therefore$ Cost per metre = Rs. $\frac{178\cdot79}{3}$ = Rs. 59·60 For 3m Total = 178·79

Item No.	Description	L. m	B. mm	H. mm	Qu.	Total	Rate Rs. P.	Amount Rs. P
	Type—2 (Fig. 6-7)							
1.	Earthwork in excavation ...	3·00	$\frac{1}{2}$(700 +230)	386	·54	·54cu m	320%cum	1·73
2.	Cement concrete (8:4:1) ...	3 00	230	76	·05	·05cu m	300 cum	15·00
3.	Cement concrete (4:2:1) ...	3·00	$\frac{1}{2}\times230$	62	·02			
	Less the portion of sector ...	3·00	$\pi\times(56)^2\times$	$\frac{120°}{360°}$	·01	(-ve) ·01cu m	425 cum	4·25
4.	10cm thick brickwork in cement mortar (4:1) ...	2×3 00	—	200	1·2	1·2sq m	32 sqm	38·40
5.	12mm thick cement plaster (2:1) ...	3·00	$2\pi\times50\times$	$\frac{120°}{360°}$	·31	·31sq m	9·00 sqm	2·79
6.	12mm thick cement plaster (4:1)	2×3·00	300	—	1·80	1·8 sq m	6·80 sqm	12·24
7.	Flush pointing with cement mortar (2:1) ...	2×23·00	200	—	1·20	1·20sqm	3·80sqm	4·56

For 3m Total = Rs. 78·97

∴ Cost per metre = 58·96/3 = Rs. 26·32

Item No.	Description	L. m	B. mm	H. mm	Qu.	Total	Rate Rs. P.	Amount Rs. P
	Type—3 (Fig. 6-8)							
1.	Earthwork in excavation ...	3·00	1/2(100 +481)	280	·23	·84 cum	320% cu m	2·69
2	Cement concrete (8:4:1) (considering whole 1st) ...	3·00	$\frac{1}{2}$(100 + 481)	280	·94			
	Less ...	3·00	$\times\frac{1}{2}381\times$	150	·09	(-ve)		
	,, ...	3·00	$\frac{1}{2}\times76\times$	76	·01	·23 cum	300cum	69·00
3.	Stone slab set in cement mortar (2:1) ...	3·00	$\sqrt{162)^2 -}$ $\sqrt{150)^2}\times$	$\frac{305)^2}{100\ ^2}$	58	1·58sqm	15 sqm	23·70

For 3m Total = Rs. 95·39

∴ Cost per Metre = Rs. 31·80

Item No.	Description	L. m	B. mm	H. mm	Qu.	Total	Rate Rs. P.	Amount Rs. P
	Type—4 (Fig. 6-9)							
1.	Earthwork in excavation top portion	3·00	1370	576	2·37			
	—do— —do—bottom	3·00	710	280	·60	2 97 cu m	320%cum	9·50
2.	Cement concrete (8:4:1) (considering portion included is equal to the portion excluded)							
	(a) bottom portion ...	3·00	710	80	·17			
	(b) sides ...	2×3 00	130	280	·11			
	(c) below brick walls ...	2×3 00	330	76	15	·43cum	300cum	129·00
3.	10cm thick brickwork in cement mortar (4:1) ...	2×3·00	332	—	1·99	1·99sqm	32sqm	63·68
4.	20cm thick brickwork in cement mortar (4:1) ...	23×·00	200	500	26·4	·60	280cum	168·00
5.	Flush pointing with cement (2:1) inclind.	2×3·00	332	—	1 99	1 99sqm	3 00 sqm	7 56
6.	12mm thick cement plaster (4:1) remaining.	2×3 00	300	—	1·8	1·8sqm	6·80sqm	12·24

For 3m Total = Rs. 389·98

Cost /rm = Rs. 129 99 Say Rs. 130·00

6-9. **Estimate of septic tank**—Fig. 6-10 shows the plan and sectional elevation of a house hold septic tank for 20 users. Prepare an estimated cost to construct such a tank adopting any local rate. (The sewer line, latrine are not to be included)

Traditional size for House hold Septic Tanks

No. of users	Size of Tank L m	B m	H m	Cubical content cu m
10	1·08	0·60	0·95	1·03
20	2·30	0·60	1·30	1·79
30	2·80	0·60	1·40	2·35
50	3·40	0·70	1·60	3·81
100	4·30	0·75	1·95	6·29

H Liquid depth.

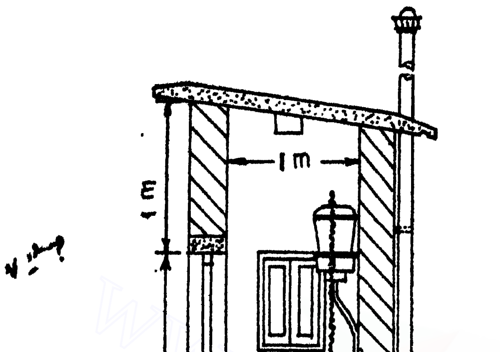
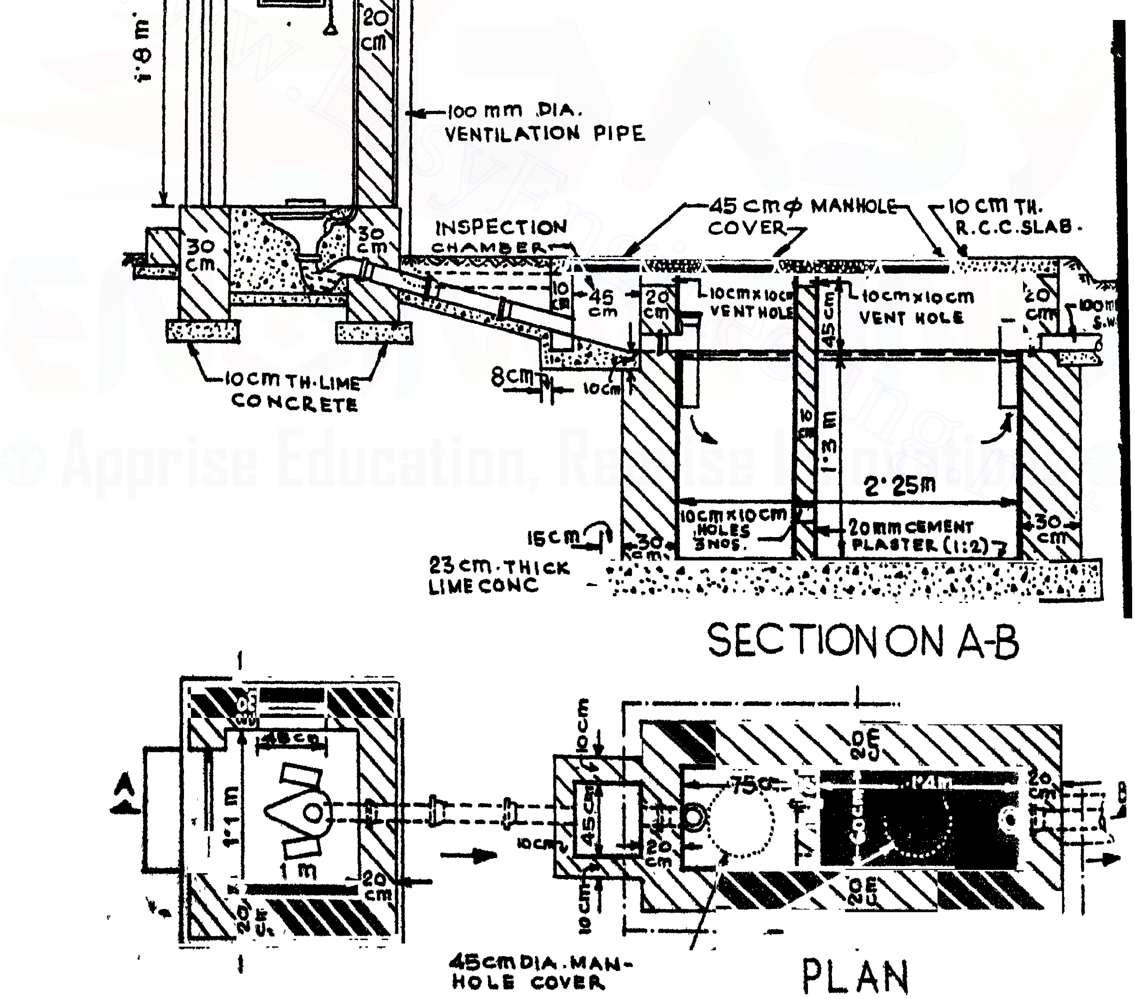


FIG. 6-10



Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							
	(a) Septic tank ...	1	3·15	1·50	1·98	9·36		1·98 = ·45+1·3+·23
	(b) Inspection pit ...	1	0·38	0·80	0·55	0·18		0·38=·45+·10+·8—·10—·15
							9·54 cum	
2.	**W.C.C. (1:3:6) in foundtion**							
	(a) Septic tank ...	1	3·15	1·50	0 23	1·09		
	(b) Inspection pit ...	1	0·63	0·80	0·10	0·05		63=·45+·10+·08
							1·14 cum	
3.	**First class brickwork in** cement mortar (1:4)							
	(a) for 30cm walls –							2·65 outer to outer.
	Long walls ...	2	2·65	·30	1·2	1·91		
	Short walls ...	2	·60	·30	1·2	0·43		1·2=1·3—·10
	(b) for 20cm walls—							
	Long walls ...	2	2·45	·20	·55	0·54		2·45=2·25+2×·10
	Short walls ...	2	·60	·20	·55	0·13		
							3·01 cum	
4.	**20mm thick cement plaster** (1:2) on floor and walls (inside only)							
	(a) floors ...	1	1·40	·60		·84		
		1	·75	·60		·45		
	(b) Walls ...	2	1·40	—	1·75	4·90		
		2	·75	—	1·75	2·63		
		4	·60	—	1·75	4·20		
	Inspection pit							
	(a) floor ...	1	·46	·45	—	·20		
	(b) walls ...	4	·45	—	·45	·81		
							14·03sqm	
5.	**10cm thick brickwork in cement mortar (1:4)**							
	(a) partition walls ...	1	·60	—	1·75	1·05		
	(b) Inspection pit ...	2	·55	—	·45	0·50		
		1	·45	—	·45	0·20		
							1·75 sqm	
6.	**10cm thick R.C C. slab (1:2:4**							
	(a) Inspection pit ...	1	·55	·65	·10	0·036		
	(b) Septic tank ...	1	2·65	1·00	·10	0·265		
	Less Manhole covers ...	3	$\pi \times$	$\left(\frac{45}{4}\right)^2$	·10	0·048	(—ve)	The area occupied by a single M.H. is more than 0·1 sqm
							0·25 cum	

Item No.	Description	No	L.	B.	H.	Qu.	Total	Explanatory notes
7.	**45cm dia. C. I M. H. cover** with frame. ...	3	@56	kg	each	168kg	168kg	
8.	**Step iron** built in wall ...	2×5	@2·5	kg	each	25kg	25kg	
9.	**Leaving 10cm×10 cm vent hole in** wall. ...	1	—	—	—	1No.	1No.	
10.	**Leaving 10cm×10cm holes** in partition wall plaster complete ..	4	—	—	—	4Nos.	4Nos.	
11.	**Supplying and building 10cm×10cm ×60cm S.W. Junction** ...	2	—	—	—	2Nos.	2Nos.	
12.	**Charging septic tank** with water full. ...	—	—	—	—	1 Item	1 Item	

Abstract of Estimated cost

Item No.	Items	Quantity	Unit.	Rate Rs. p	Unit of Rate	Amount Rs. p.
1.	Earthwork in excavation ..	9 51	cu m	32·0	% cu m	30·43
2.	W.C.C.(1:3:6)with brick ballast in foundation	1·14	cu m	325·00	cu m	370·50
3.	First class brickwork in cement mortar(1:4)	3·01	cu m	290·00	cu m	872·90
4.	20mm thick cement plaster(1:2)finished with neat cement including rounding corners ...	14·03	sq m	10·00	sq m	140·30
5.	10cm thick brickwork (1:4)in partition wall...	1·75	sq m	32·00	sq m	56·00
6.	R.C.C.work (1:2:4 with stone chips including 1% reinforcement & shuttering...	0·25	cum	600	cu m	150·00
7.	Supplying 45cm dia. (Hole) C I.M H. cover with frame weight 56 kg. each ...	168	kg	3·50	kg	588·00
8.	C.I. step iron built in wall each wt. 2·5kg...	25	kg	5·20	kg	130·00
9.	Leaving 10cm×10cm vent whole in wall ...	1	No	1·00	Each	1·00
10.	Leaving 10cm×10cm holes in partition wall...	4	Nos	1·00	Each	4·00
11.	Supplying and building 10cm×10cm×60cm S.W. junction	2	Nos	30·00	Each	60·00
12.	Charging septic tank with water full ...	1	Item	30·00	Each	30·00

Total = Rs. 2433·13
Add 5% for contingency = Rs. 121·66
Add 2½%for W.C. = Rs. 60·83
Grand Total = Rs. 2,615·62

6-9. How to design a house hold septic tank—The following procedure should be followed to design a house-hold septic tank.

(1) Multiply the designed population by the supply of water per head per day.

(2) Find out the average flow per hour $= \frac{\text{flow per day}}{24}$ litres/hour $= \frac{\text{flow per day}}{24 \times 1000}$ cu m/hour. (Note : 1000 litres = 1 cu m for practical purposes)

(3) Assuming the peak rate being 3 times the average flow per hour, peak vol. = 3 × av. hourly flow. When water consumption is not known then according to the Indian Standard Institute allow the flow of liquid wastes from buildings at the rate of one cft. or $0{\cdot}03\text{m}^3$ per minute for 100 persons based on a water cousumption of 30 gallons or 140 litres per head per day. This is the peak rate and not to be multiplied by 3.

(4) Considering the size of particles to be removed from the liquid waste consider the detention period of $2\frac{1}{2}$ hours and find the volume for this period.

(5) The design of a septic tank now-a-days based on the following facts—(a) The top part of the liquid depth in a tank acts as a sedimentation tank and is usually considered 30cm, (b) The middle portion of the liquid depth acts as a digesting tank (c) The bottom portion acts as for storage of digested sludge, (d) at top of the liquid in the tank an air space of 30cm depth is to be provided.

(6) The following assumptions may be adopted considering the amount of total solid in the sludge—(a) Vol. of liquid sludge = 0·831 cu m per 1000 persons per day, and (b) Vol. of digested sludge = 0·205 cu m per 1000 persons per day.

$\therefore$ Capacity of digesting tank $= \frac{0{\cdot}831 + 0{\cdot}205}{2} \times \frac{\text{persons}}{1000} \times 60.$

60 days being digesting period. The average of fresh and digested sludge has been taken due to the fact that the digesting portion of a tank is a combination of the two.

(7) For sludge storage volume, multiply $\left(\frac{0{\cdot}205}{1000} \times \text{persons}\right)$ by the days after which the tank is to be cleaned.

(8) Considering that a part of water consumption per capita will be excluded from the tank and that the installation may be partly used the capacity of liquid and sludge should be taken as half of the total volume obtained from the smmation of columns no. (4), (6) and (7) and thus find the vol. of the tank excluding the air-space. For 10 user septic tank 75% of the total vol. should be taken considering its minimum capacity.

(9) The depth of liquid and sludge should be taken as 90 cm minimum and 2·1 m maximum. 90cm should be taken for 10 users and this depth may be increased by 8cm to 10 cm for an increment of 10 persons. The width of a septic tank should be taken as 60 cm upto 30-users. A maximum width upto 1·8m should be restricted to increase the length of travel of the sewage. Length of a septic tank should be 3 to 6 times the width. For more than 200 users it is preferable to make more than one tank in parallel units.

(10) As a precaution against possible disturbance of the scum a vertical portion wall (also called a "baffle) should be provided at a distance 80cm from the inlet pipe. In long tank a second baffle wall is sometimes provided at a distance 60 cm from the outlet end and within few centimetres below the surface of liquid in the tank.

To design a septic tank according to the main assumptions of Indian Standard (IS 2470-1963) the following modificatians should be made in the design :

(1) Peak discharge in litres per minute per capita should be as follows :—

(a) *Domestic purposes* :— 1·8 for 5 or 10 users and 1·20 for 15 or 50 users and 1·35 for 20 users.

Residential Housing Colonies :—2·16 for any number of users.

Hostels and Boarding Schools :— 1·3 for 100, 200 or 300 users and 1·7 for 150 users.

(2) Detention period may be considered as 30 minutes.

(3) Capacity required for sludge digestion=3·3 cu m per 100 persons at 25°C.

(4) Capacity required for storage of digested sludge = 7·76 cu m per 100 persons per year.

(5) Minimum width of tank = 75 cm.

Capacities and Sizes of Septic Tanks according to the I. S. Recommendations :—

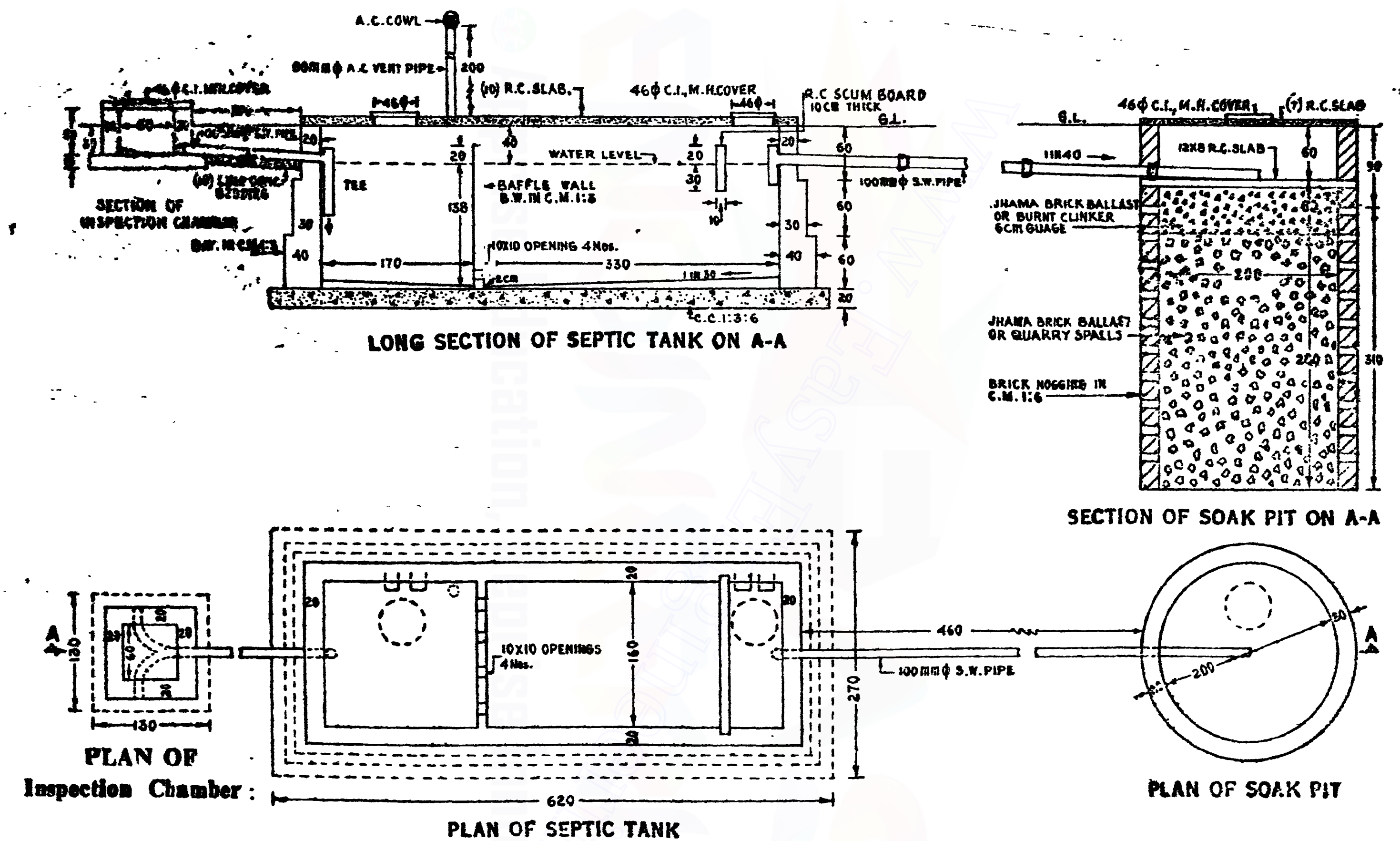
(a) For Domestic purposes :—

No. of users	Length m	Breadth m	Liquid Depth 'D' for sludge removal interval of 1 year m	Liquid Depth 'D' for sludge removal interval of 2 years m	Liquid capacity for sludge removal interval of 1 year cu m	Liquid capacity for sludge removal interval of 2 years cu m
5	1·50	0·75	1·00	1·05	1·12	1·18
10	2·00	0·90	1·00	1·40	1·80	2·52
15	2·00	0·90	1·30	2·00	2·34	3·60
20	2·30	1·10	1·30	1·80	3·30	4·55
50	4·00	1·40	1·30	2·00	7·28	11·20
(b) For Housing Colonies :—						
100	8·00	2·60	1·00	1·04	22·40	23·32
150	10 60	2·70	1·00	1·15	28·60	32·90
200	12·40	3·70	1·00	1·15	33·40	44·20
300	14·60	3·90	1·00	1·15	56·90	64·90
(c) For Hostel and Boarding Schools :—						
50	5 00	1·60	1·30	1·40	10·40	11·20
100	5·70	2·10	1·40	1·70	16·80	20·40
150	7·70	2·40	1·40	1·70	25·80	31·90
200	8·90	2·70	1·40	1·70	33·60	41·00
300	10·70	3·30	1·40	1·70	49·50	50·00

6-10. Estimate of a 50 users Septic tank for Hostels and Boarding Schools accompanying with an Inspection Chamber and a Soak pit.

(The length, breadth and depth of the tank are same according to the recommendation of I.S.I.)

Prepare a detailed estimate of a Septic tank accompanying with an inspection chamber and a soak pit from the given plan, section and general specification or works as given below.



ALL DIMENSIONS ARE IN CM FIG. 6-11 SCALE 1 : 75

General Specification :—(1) Cement concrete in foundation 1:3:6; (2) Brickwork in cement mortar for (a) Septic tank and chamber 1:4 (b) Soak pit top solid portion and honey comb work of 2nd class brick in cement mortar 1:6, (3) Cement plaster for inside of Inspection chamber and septic tank 20mm thick 1:3 mixed with water proofing compound, (4) R.C.C. works 1:2:4 with stone chips.

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Item No.	Description	No.	L. m.	B. m.	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation for**							
	(a) Spetic tank ...	1	6·20	2·70	2·00	33·48		
	(b) Inspection chamber ...	1	1·30	1·30	·30	0·51		
	(c) Soak pit ...	1	$\pi/4(2\cdot$	$40)^2\times$	4·00	18·10		
							52 09 cu m	
2.	**Cement concrete in foundation** (1:3:6)							
	(a) Septic tank—							
	Foundation floor ...	1	6·20	2·70	·20	3·35		075 $=\frac{1}{2}$(·02+ 13)
	Inside sloping floor D/S ...	1	3·40	1·60	·075av	0·41		
	,, ,,U/S...	1	1·70	1·60	·05av.	0·14		
	(b) Inspection chamber ...	1	1·30	1·30	·15	0·25		
							4·15 cu m	
3.	**First class brickwork in** cement mortar (1:4)							
	(a) Septic tank							
	Long walls—							
	1st footing40cm ...	2	5·90	·40	·60	2·83		5·90=6·20—2×·15 5·70=5·90—2×·10
	2nd footing 30cm ...	2	5·70	·30	·60	2·05		
	3rd footing 20cm ...	2	5·50	·20	·60	1·32		
	Short walls—							
	1st footing 40cm ...	2	1·60	·40	·60	0·77		
	2nd footing 30cm ...	2	1·60	·30	·60	0·58		
	3rd footing 20cm ...	2	1·60	·20	·60	0·38		
	(b) Inspection chamber ...	4	·80	·20	·50	0 ·3· [illegible]	8·25 cu m	·80=·60+2×·20/2
4.	**2nd class brickwork in** cement mortar (1:6)							
	Soak pit solid top part ...	1	π×2·20	·20	·90	4·42	4 42 cu m	2·20 is the mean dia.
5.	**20cm thick honey comb brickwork** in cement mortar (1:6) Soak pit ...	1	π×2·20	—	3·10	21·43	21·43 sq m	Honey comb portion is not to be deducted
6.	**10cm thick brickwork in** Baffle wall in cement mortar (1:3) ...	1	1·60	—	1 40	2·24	2.24 sq m	1·40=1·38+·02
7.	**R.C.C. work** (1:2:4) including reinforcement and shuttering							
	(a) Septic tank—							
	Roof slab ...	1	5·50	2·00	·10	1·100		
	Baffle wall ...	1	1·60	·10	·50	0·080		
	(b) Inspection chamber ...	1	1·00	1·00	·10	0·100		
						C.O.	1·280 cu m	

Item No.	Description	No.	L m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ..					1·280		
	(c) Soak pit—							
	Roof slab ..		$\pi/4(2{\cdot}4)^2$ ×		·10	0·452		10cm bearing considered
	Supporting slab ..		2·20	·12	·08	0·021		
	Deduction for Manhole covers		$\pi/4(\cdot 46)^2$×		·10	0·066	(-ive) 1·687 cu m	Area per opening is more than 0·1 sqm each, therefore these are to be deducted
8.	**20mm thick cement plaster** (1:2) with water proofing							
	(a) Septic tank inside—							
	Long walls ...		5·00		1·80	18 00		
	Short walls ...		1·60		1·80	5·76		
	Sides of baffle wall ...		1·60		1·58	5·06		
	Top of „ „ ...		1 60		·10	0·16		
	(b) Inspection chamber ...		·60		50	1·20	30·18 sq m	No plastering on 2nd baffle wall of R.C is considered
9.	**Laying 100mm dia. S.W.** pipe embedded in cement concrete (1:4:8) with a slope of 1:40 from—							
	I. chamber to S. tank ...		2·30			2·30		
	S. tank to soak pit ...		5·60			5·60		
							7·90 rm	
10.	**Supplying, fitting and fixing 46cm dia. C I. M.H. cover** with frame each 56kg	@	56	kg	each	224	224kg	
11.	**100mm × 100mm × 60cm dia.** S. W. Tee supplied and fixed						2 nos.	
12.	**Brick ballast** or burnt clinker 6mm gauge		$\pi/4(2{\cdot}0)^2$		·60	1·89	1·89 cu m	
13.	Brick bats or Quarry spalls		$\pi/4(2{\cdot}0)^2$×		2·80	8·80	8·80 cu m	
14.	Supplying and fitting fixing 80mm dia. A.C. ventilation pipe		2·00			2·00	2·00 r m.	
15.	Supplying fitting, fixing A. C. ventilating cowl over 80mm dia. A. C. pipe ...						1 No.	
16.	Step iron of 16mm dia. bar built in wall ...	2×4				8	8 Nos.	

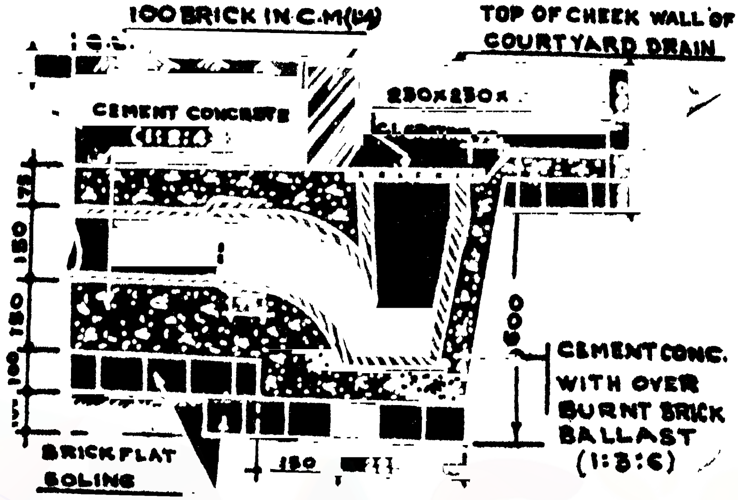
ABSTRACT OF ESTIMATED COST.

Item No.	Description of item	Quan.	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Earthwork in excavation ...	52·09	cu m	320·00	%cu m	166·69
2.	Cement concrete (1:3:6) in foundation with brick ballast ...	4·15	cu m	325·00	cu m	1,348·75
3.	First class brickwork in cement mortar (1:4)	8·25	cu m	290·00	cu m	2,392·50
4.	Second class brickwork in cement mortar (1:6) ...	4·42	cu m	260·00	cu m	1,149·20
5.	20cm thick honeycomb brickwork in cement mortar (1:6) ...	21·43	sq m	32·00	sq m	685·76
6.	10cm thick brickwork in cement mortar (1:3) ...	2·24	sq m	35·00	sq m	78·40
7.	R.C.C. work (1:2:4) with stone chips including reinforcement and shuttering ...	1·687	cu m	600·00	cu m	1,012·20
8.	20mm thick cement plaster (1:3) with water proofing compound ...	30·18	sq m	9·25	sq m	279·17
9.	Supplying and laying 100mm dia S. W. pipe in cement joint (1:3) embedded in cement concrete (1:4:8) including excavation of earth upto 1·50 metre depth ...	7·90	rm	28·00	rm	221·20
10.	Supplying and fitting fixing weight 56kg each C.I.M.H. cover with frame ...	224	kg	3·50	kg	854·00
11.	100mm × 100mm × 60cm S. W. Tee supplied and fixed ...	2	nos.	30·00	Each	60 00
12.	Brick ballast or burnt clinker 6mm gauge...	1·89	cu m	42·00	cu m	79·38
13.	Brick bats or Quarry spalls ...	8·80	cu m	38·00	cu m	334·40
14.	Supplying fitting, fixing 80mm dia. A.C. ventilation pipe ...	2·00	rm	50·00	rm	100·00
15.	Supplying, fitting, fixing A.C. cowl ...	1	no.	6·25	Each	6·25
16.	Step iron 16mm dia. bars built in wall ...	8	nos.	6·00	Each	48 00

Total = Rs. 7,803·70
Add 5% for contingency = Rs. 390·19
Add 2½% for W. C. = Rs. 195·10

Grand Total = Rs. 8,388·99

6-11. Yard Gully :— This is a chamber built of masonry round a gully trap for housing the same and is provided with a cast iron grating on top of it (shown in fig. 6-12) as a cover and to prevent the entry of solid matter. Yard Gully is provided in a house drainage system with a water seal 6 to 7·5 cm and fixed in a suitable position of the Yard of a house to collect waste water from the scullery, kitchen, sink, wash basins, rain water pipes, surface water from paved yards etc. The primary object of a yeard gully is to disconnect the sullage drain from the main drainage system and is an essential part of a house drainage. The size of the gully trap is generally 23 cm × 15 cm with C. I. grating 23 cm square mouthed entry side. The smaller size being 15cm × 15cm with 15cm grating.

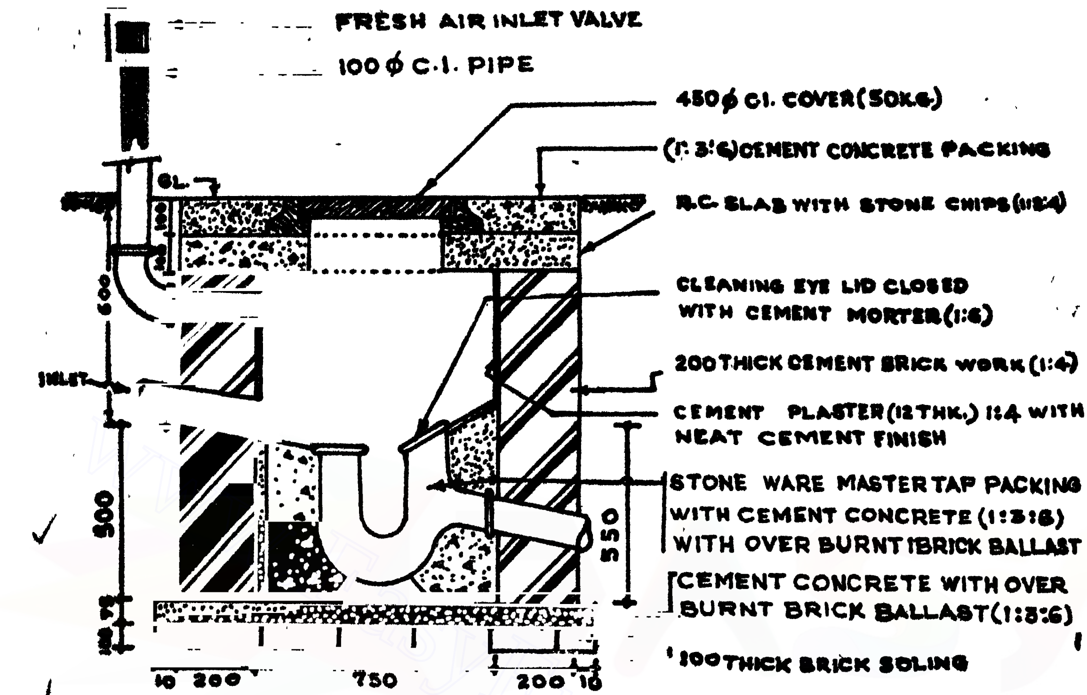


SECTIONAL ELEVATION
Fig. 6-12

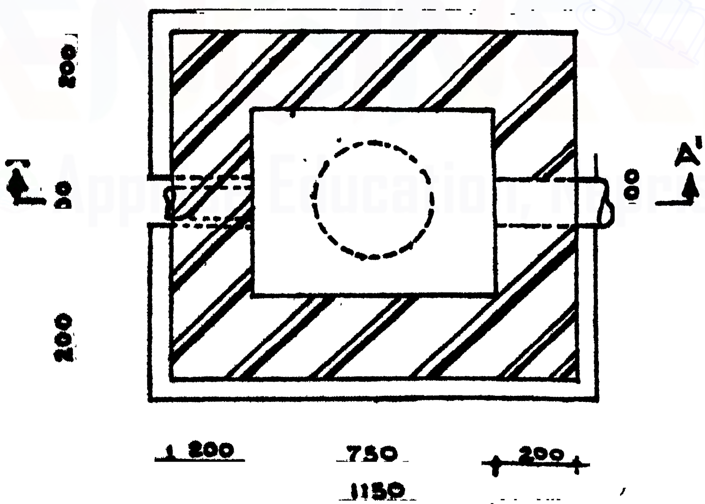
Schedule of item :—Supplying, fitting and fixing 23cm × 15cm yard gully with approved H. C. I. gratting complete as per drawing and direction.

Analysis for the cost of construction of yard gully portion only.

Sl. no.	Description of item	Quantity	Unit	Rate Rs. P.	Amount Rs. P.
1.	Earthwork in excavation	·475 × ·475 × ·800 = 0·18	cu m	3·20	0·57
2.	Single brick flat soling ...	·475 × ·475 = 0·23	sq m	20·00	4·60
3.	Cement concrete with overburnt brick ballast (1 : 3 : 6)	(·475 × ·475 × ·475) − (·225 × ·225 × ·375) − {π/4 × (·150)²} × ·150 = 0·08	cu m	350·00	28·00
4.	Cost of yard gully 23cm × 15cm with H. C. I. grating ...	1	No.	30·00	30·00
			Total	— Rs.	63·17



SECTION-A.A



PLAN

Fig. 6-13
PLAN AND SECTION OF
A MASTER TRAP

6-12. Master Trap or Intercepting Trap or Interceptor Manhole or Interceptor Chamber : This is a square manhole incorporating an intercepting trap, and providing means of access thereto and equiped with a fresh air inlet on the upstream side of the trap.

The trap disconnects the house drain from the street sewer and is installed in a chamber with Manhole cover at top in between the lower end of the house drain and the street sewer. It has a deeper seal about 10cm than an ordinary trap with an opening at the top of the trap known as cleaning eye as shown in fig. 6-13. Fresh air inlet pipe of 100mm diameter is connected with this chamber and about 3m high above the ground level fixed vertically with a wall. A mica flap valve which opens inwards only is fitted at the top of the inlet pipe with an enlarged square head. Fig. 6-13 shows the details of plan and section of a master trap.

Schedule of item :—*Supplying, fitting and fixing and joining 15cm S. W. Master Trap including construction of Chamber 60cm × 75cm inside and 50kg C. I. cover as per drawing upto 1·5 metre depth.*

Analysis of cost

Sl. no.	Description of item	Quantity	Unit	Rate Rs. P.	Amount Rs. P.
1.	Earthwork in excavation in foundation trenches	1·17 × 1·02 × 1·275 = 1·52	cu m	3·20	4·36
2.	Single brick flal soling with overburnt brick	1·17 × 1·02 = 1·19	sq m	20 00	23 80
3.	Cement concrete with over-burnt brick ballast (1 : 3 : 6)	1·17 × 1·02 × ·075 (Base) + ·750 × ·600 × ½(470 + ·560) (i.e. packing neglecting vol. of trap) + (1·15 × 1·00) × ·10 (neglect M. H. cover) = 0·44	cu m	350·00	154·00
4.	1st class brickwork with cement mortar (1 : 4)	2 × 1·15 × ·20 × ·90 + 2 × ·60 × ·20 × ·90 = 0·63	cu m	300·00	189·00
5.	R. C. C. slab (1 : 2 : 4) with stone chips	1·15 × 1·00 × ·10 (neglect M. H. cover) = 0·12	cu m	425·00	51·00
6.	M. S. reinforcement with 1% vol. of conc.)	(0 12 × 0·01) × 75·5 = 0 094 quin	quin	550·00	51·70
7.	Hire and labour charges for shuttering	1·15 × 1 00 + 2(1·15 + 1·0) × ·01 = 1·58	sq m	16·00	25·28
8.	12 mm thick cement plaster (1:4) with neat cement finishing	2(0·600 + 0·750) × 0·400 = 1·08	sq m	7·00	7·56
9.	Supplying, fitting and fixing 15 cm Master trap	1	No.	80·00	80·00
10.	Fitting and fixing 10 cm dia. C. I. Soil pipe including supplying bend and necessary fixing arrangement	3	m	10·00	30·00
11.	Supplying, fitting and fixing a fresh air inlet valve	1	No.	15·00	15·00
12.	Supplying, fitting and fixing 45 cm dia. C. I. Manhole cover with ring	50	Kg.	5·50	275·00
			Total—		Rs. 907·20

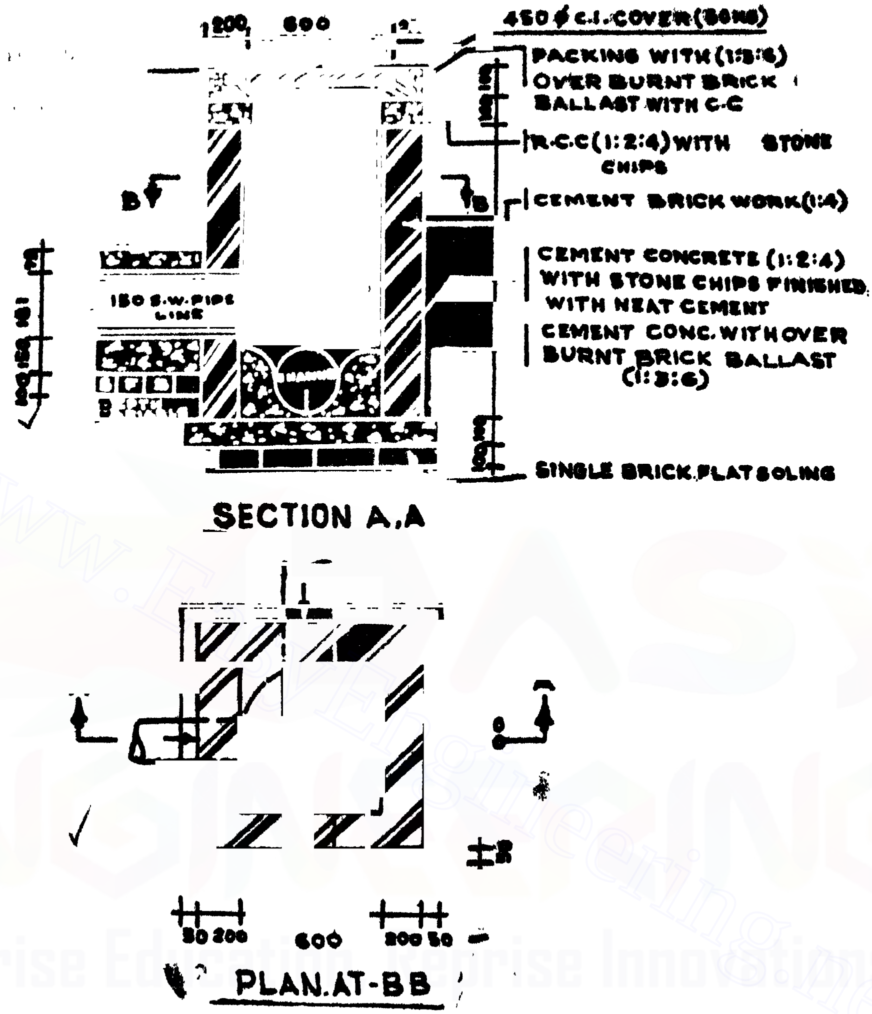


Fig. 6-14

6-13. Inspection pit or Chamber :—This is a miniature form of manhole provided in a house drainage system in order to open out the house drainge pipes and to inspect the condition of flow, cleaning obstructions in the drain, and for providing branch connections with the main line of the house drain. This is also provided at every change of direction or gradient or every 30 metres intervals or at the point where the vertical soil pipe joins the house drain.

The underground depth of the house drain and the number of branch connections are the deciding factors for the size of a chamber. Generally the inside dimensions of the chamber is 60cm wide × 75cm length × 75cm depth. The length of the chamber is usually increased by 22½ cm for every additional connection.

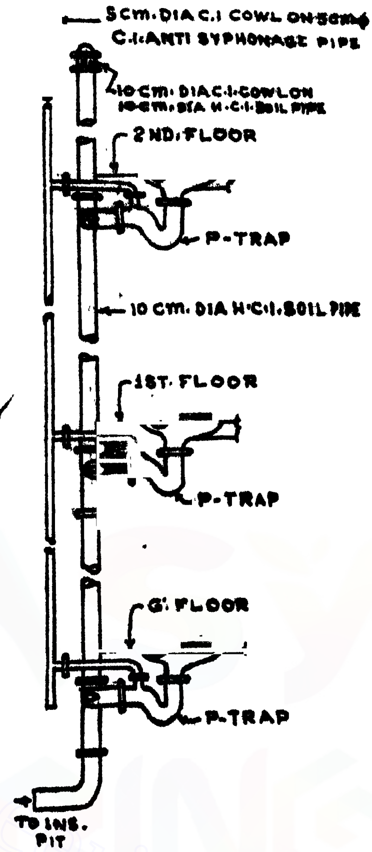


Fig 6-15

In the top slab of the chamber an air-tight light weight (50kg) cast iron cover is provided to open out the underground drain. The plan and section of an inspection pit or Chamber has been shown in the fig. 6-14 to describe the details of the construction.

6-14. Anti-Syphonage pipe :—Anti-Syphonage is the device to preseve the water seal in traps by providing ventilation. In multi-storeyed building water-closets or other sanitary appliances fitted with traps for water seal are generally connected with the same soil pipe by a short branch drain pipe. A sudden flush of water from an appliance on the upper storey, causes the air in the short branch connecting pipe in the lower storey to be sucked out creating a partial vocuum at the down stream side of the water seal. That atmospheric pressure acting on the upstream side of the water seal, being greater naturally forces the water up the trap and siphons it out into the branch. Thus the seal remains broken and foul gas from the outside drain can entire into the house.

To stop the syphonic action of water from the trap an antisyphonage pipe of not less than 50mm diameter and made with cast iron are provided which connects the short branch pipe at the down stream side of the water seal to the atmosphere. Thus due to ventilation the partial vacuum at the down-stream side of the trap becomes stoped. The anti- syphonage or vent pipe shall be carried up as high as the top of the soil pipe and provided with a C. I. cowl at top.

6-15 Different types of traps used for a Water Closet and their use :—

There are two types of traps used for a water closet either a 'P' or a 'S' outlet as given n fig 6-16. In all cases a pan shall be provided with 100 mm dia. Sand Cast Iron (S.C.I.) trap "P" or "S" with approximately 50 mm water seal and 50 mm diameter vent horn on the outlet side. For P-traps the slope of outlet shall be 14 degrees below the horizontal.

The water seal shall be 50 mm, minimum in order to prevent the entry of foul gass from the sewer line. The inside surface of the trap shall be glazed, reqular and smooth in order to ensure an efficient flush. The exterior surface of outlet and the interior surface of the inlet socket shall not be glazed and these surfaces shall sufficiently rough or scored or grooved for perfect joining.

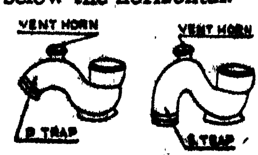


Fig. 6-16

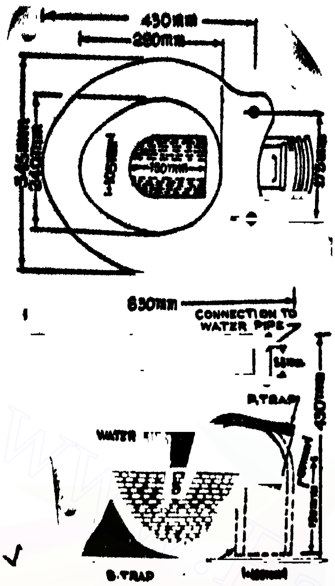


Fig. 6-20
PLAN AND SECTION
OF PADESTAL TYPE W.C

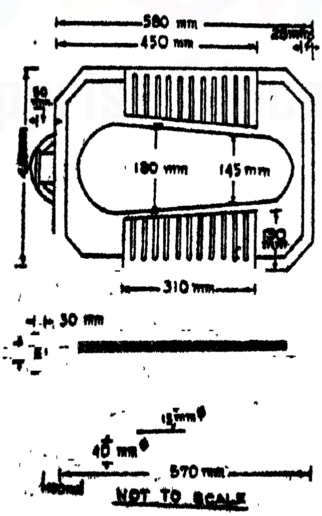


Fig. 6-19
ORISSA TYPE

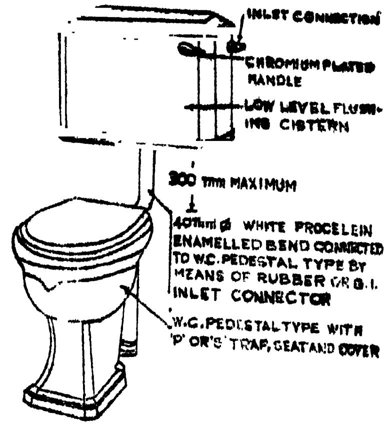


Fig. 6-17

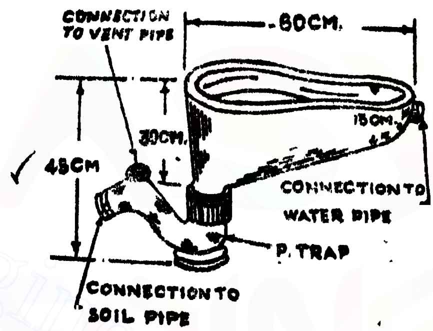


Fig. 6-18
INDIAN TYPE W. C.

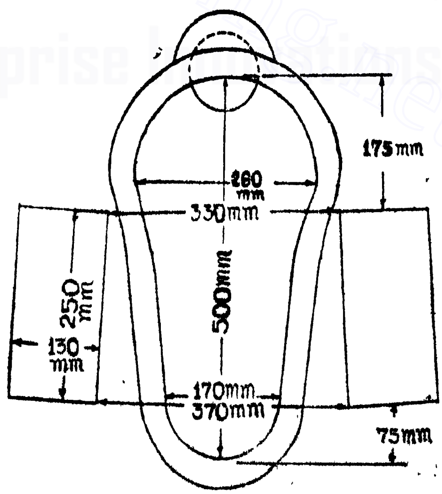


Fig. 6-21
POSITION OF FOOT REST WITH RESPECT TO W.C. PAN

6-16 Water-closet :—This is a sanitary fitting to receive the human excreta directly and is fitted with a "S" or "P" trap for water seal to prevent the entry of foul gasses from the soil pipe with which connection is made to discharge the excreata. The washing of water closets are done by two ways either as ordinary or wash down system and the syphonic system. The ordinary type water closet is flushed with high level cistern kept 2m above the closet. Syphonic system can washdown well with the low level suit as shown in fig. 6-17.

Generally two types of water closet are in use and these are—

(1) Squatting type or Indian type, (2) Padestal or European type.

(1) Squatting type or Indian type water closet may be of the following patterns :—

(i) Long pan pattern (length 450, 580, 680 mm), (ii) Orissa pattern (length 580, 630, 680 mm) with glazed foot-rest (iii) Rural pattern (length 425 mm)

Fig. 6-18 shows an Indian type water closet. Fig. 6-19 shows the Orissa pattern water closet & fig. 6-20 shows the plan and section through an pedestal or European Type water closet.

Squatting pan shall be either of white glazed earthenware, white vitreous china or white glazed fire clay as specified. Pan of (i) and (ii) shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flushpipe as shown in the figure.

The pans intended to be fixed in superior class of buildings bungalows shall be of vitreous china or of white glazed fire clay. Fig 6-20 shows the plan and section of a padestal or European closet. The closets shall be of one piece construction, i. e. each water closet shall have an integral trap with either "S" or "P" outlet with at least 50mm water seal. Each water closet shall have 4 holes for fixing to floor and shall have an integral flushing rim. It shall also have on inlet or supply horn for connecting the flush pipe.

6-17. Wash Basins :—Wash basins shall be of white glazed earthenware, white vitreous china or white glazed fire clay as specified and be of one piece construction. Pressed steel and plastic basins are also made. They are manufactured in different shapes and sizes. Basins ate provided with single or double square tap holes. Each basine is provided with 32 mm waste fitting and has an integral soap holder recess The basin is provided with one or two 15 mm. C.P. brass pillar taps.

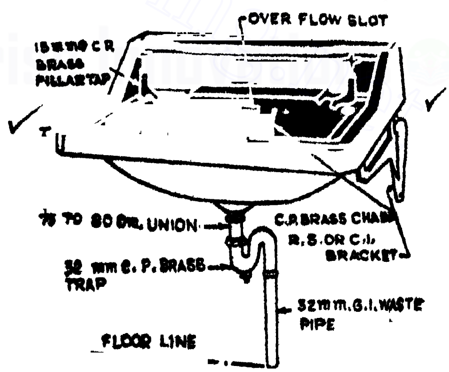


Fig. 6-22
BRACKET TYPE BASINE

These basins are generally of either pedestal type or bracket type. Fig. 6-22 shows a bracket type wash basin. Where pedestal are provided it is completely recessed at the back for the reception of supply and waste pipes and fittings. The pedestal is capable to support the basin rigidly and adequately and is so designed as to make the height from the floor to top of the rim of basin 75 to 80 cm. Alternatively basins may be supported on a pair of R. S. or C. I. cantilever brackets in cement mortar (1 : 3) fixed in position by means of wooden plugs and screws.

For lavatory basin C.P. brass trap (as in fig. 6-22) and union is required for connection with waste pipe in case where connection be made direct with gully trap or a waste pipe. The C. P. trap is not required where the surface drain or a floor trap is placed directly under the basin and the waste is discharged into in vertically.

6-18. Gradients and pipe size for sewer lines according to IS : 1742 :—Since the discharge of water through a domestic drain is intermittent and limited in quantity, gradients of sewer lines shall be sufficient to prevent temporary accumulations of solid matter and blocking the drains. Normally, the sewer shall be designed for discharging three times the dry-weather flow flowing half-full with a minimum self cleaning velocity of 0·75 m/s. The approximate gradients which give this velocity for the sizes of pipes likely to be used in building drainage and the corresponding discharges when flowing half-full are as follows (according to Mannings formula n = 0·015).

			For cast iron pipe with velocity 2·4 m/s	
Diameter	Gradients	Discharge cum min	Gradients	Discharge cum/min
100	1 in 57	0·18	1 in 5·6	0·59
150	1 in 100	0·42	1 in 9·7	1·32
200	1 in 145	0·73	1 in 14	2·4
230	1 in 175	0·93	1 in 17	2·98
250	1 in 195	1·70	1 in 19	3·60
300	1 in 250	1·10	1 in 24·5	5·30

Salt Glazed Stoneware pipes for all sewers and drains shall be used for diameter upto 300 mm. as for as possible where acid effluents or acid subsoil conditions are likely to be encountered.

6-19. Jointing of Glazed Stoneware pipe :—Tarred gasket or hemp yarn soaked in thick cement slurry shall 1st be placed round the spigot of each pipe and the spigot shall be sliped home well into the socket of the pipe previously laid (as in fig. 6-23). The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly home so as to fill more than ¼th of the total depth of the socket. The remaing depth of the socket shall be thoroughly filled with a stiff mixture of cement mortar in the proportion of 1:1. When the socket is filled, a fillet shall be formed round the joint with a trowel, forming an angle of 45° with the barrel of the pipe. After a day's work any extraneous material shall be removed from the inside of the pipe. The newly made joints shall be cured for at least three days.

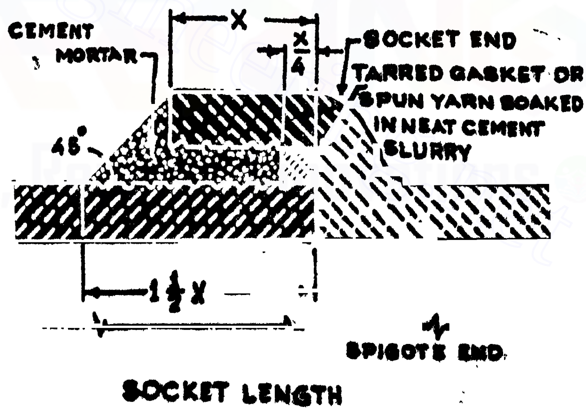


Fig. 6-23

6-20. Rain Water Pipe for Drainage of Roofs according to IS : 1742 :—Sufficient number of cast iron, asbestor cement or galvanized sheet rain-water pipes of adequate size shall be arranged to permit effectual drainage from the roofs of a building and to ensure that the rain-water is carried away without causing dampness in any part of the building. Rain water pipes shall be normally sized on the basis of roof areas according to Table given below. Spacing of pipes at 6m apart is a convenient distance.

Dia of pipe	Average Rate of Rainfall in mm/h					
mm	50 mm.	75 mm.	100 mm.	125 mm.	150 mm	200 mm.
	Roof Area, square metres					
50	13·4	8·9	6·6	5·3	4·4	3·3
65	24·1	16·0	12·0	9·6	8·0	6·0
75	40·8	27·0	20·4	16·3	13·6	10·2
100	85·4	57·0	42·7	34·2	28·5	21·3
125	—	—	80·5	64·3	53·5	40·0

6-21 Manhole according to IS-411 :—Manholes are used for inspection, cleaning, repairing of sewerline, connection of Gully pits and other maintenance operations. Manhole may be (a) *Shallow Manhole* of depth less than 2m and (b) *Deep Manhole* of depth greater than 2m.

Spacing of Manholes in any pipe line should be as follows :—

Pipe diameter upto 300mm ...Spacing 45m
„ „ 301 mm to 500mm...Spacing 75m
„ „ 501 mm to 900mm... „ 90m
„ „ Beyond 900mm...Spacing at any interval depending on local condition and as approved by the administrative authority.

Beside the above regulation manholes should be provided at every (a) change of allignment, (b) junction of sewers, (c) change in size of sewers. Manholes should also be provided at the head and at end of all sewers.

The spacing of manholes on very large sewer is governed by :—(a) the distance which silt may have to be carried along the sewer to the nearest manhole for removal. (b) The distance which repairing materials may be conveyed through the sewer. (c) Ventilation requirement for men working in the sewer.

In case of very large sewers where a man can stand properly an access shaft only may be constructed.

Sizes of Manholes :—The minimum size of a rectangular shallow manhole in which a man can work efficiently is 1·2m in length on the line of the sewer and 75cm width across the sewer. The benching on each side of the invert should be at least 15cm. In case of one benching, at least 35cm wide should be provided for manholes on sewer of 400mm diameter or more. The benching should have a fall towards the invert of about 1 in 12 and for sewers up to 450mm in diameter, should rise vertically from the springing to at least the height of the soffit of the sewer. For junction Manholes, the soffit of the smaller sewer at a junction should be not lower than that of the larger, in order to avoid the surcharging of the former when the latter is running full.

The manhole frame should not be embedded in the R.C.C. slab to facilitate replacement and adjustment where necessary. **Rungs (step iron)** should be provided in all manholes over 0·8m in depth. These step irons may be staggered in two vertical runs which may be 38cm apart horizontally. The top step iron shall be 45cm below the manhole cover and the lowest not more than 30cm above the benching. Vertical distance between successive rungs shall be 38cm.

6-22. Detailed Estimate of a Manhole :—Prepare a detailed estimate of a Manhole from the drawing shown in fig. 6-24. Specifications have written in the drawing.

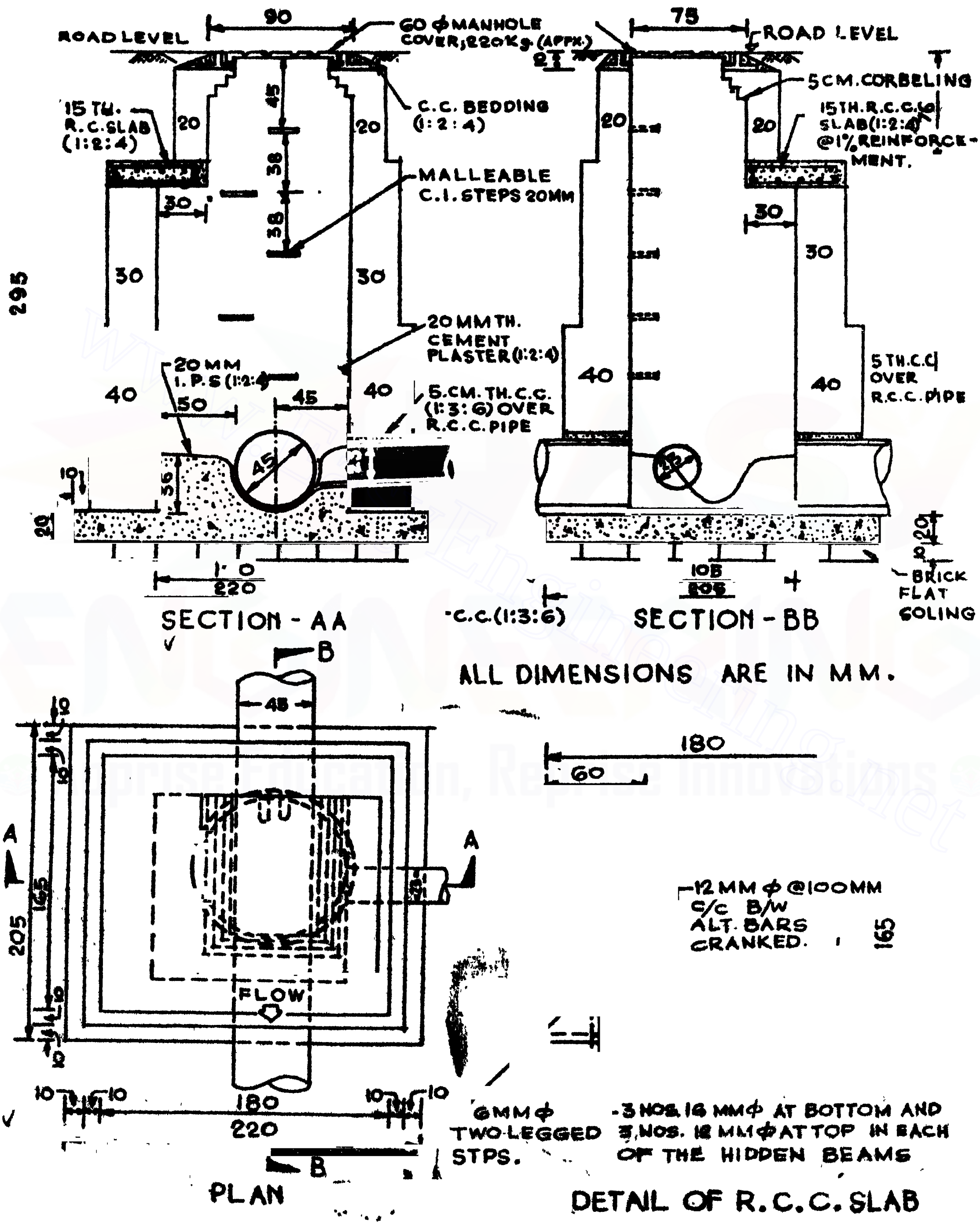


FIG. 6-24

Item No.	Description	No.	Length m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation including dewatering normal seepage and cutting road material**							
	(a) From 0m to 1·5m below G.L.	1	2·20	2·05	1·50	6·77	6·77 cu m.	The quantity of earthwork in filling being small is omitted.
	(b) beyond 1·5m to 3m below G.L.	1	2·20	2·05	1·50	6·77	6·77 cu m	
	(c) beyond 3·0m to 4·5m below G.L.	1	2·20	2·05	0·25	1·13	1·13 cu m	
2.	**Hire & labour charges for 5cm thick timber shoring**							
	(a) from 0m to 3m below G.L.							
	Main sewer sides ...	2	1·68	—	3·00	10·08		1·68=2·20–·52
	Branch sewer side ...	1	1·77	—	3·00	5·31		·52 is the outer dia. considered
	Opposite of branch line	1	2·05	—	3·00	6·15		for main line.
							21·54 sq m	Branch pipe outer dia. is 28cm
	(b) beyond 3m to 4·5m below G.L.							
	Main sewer sides. ...	2	1·68	—	0·25	0·84		
	Branch sewer side ...	1	1·77	—	0·25	0·44		
	Opposite of branch line	1	2·05	—	0·25	0·51		
							1·79	sq. m.
3.	**Brick flat soling** ...	1	2·20	2·05	—	4·51	4·51 sq m	
4.	**Cement concrete (1:3:6)**							
	In foundation ...	1	2·20	2·05	·20	0·90		Portion of benching included equalises portion excluded under ·45m dia. pipe
	Benching, bigger side ...	1	1·05	·05	·36	0·19		
	Smaller side ...	1	1·05	·22	·36	0·08		
	Deduction for branch sewer	1	$\cdot 8\times\pi\times$	$(28)^2/4$	$\times\cdot 22$	0·01	-(ve)	
	Over main pipe ...	2	0·52	·40	·05			
	„ branch pipe ...	1	0·28	·40	·05			
		T.L.	1·32	·40	·05	0·03		
							1·19 cu m	
5.	**First class brickwork in cement mortar (1:3)**							
	Bottom part							
	Long walls (outer to outer) ...	2	2·00	·40	1·20	1·92		
	Short walls (inner to inner) ...	2	1·05	·40	1·20	1·01		
	Middle part							
	Long walls (outer to outer) ...	2	1·80	·30	0·90	0·97		
	Short walls (inner to inner) ...	2	1·05	·30	0·90	0·27		
	Top part							
	Long walls ...	2	1·30	·20	·60	0·31		
	Short walls ...	2	·75	·20	·60	0·18		
	C.O.					4·66		

6-22. Detailed Estimate of a Manhole :—Prepare a detailed estimate of a Manhole from the drawing shown in fig. 6-24. Specifications have written in the drawing.

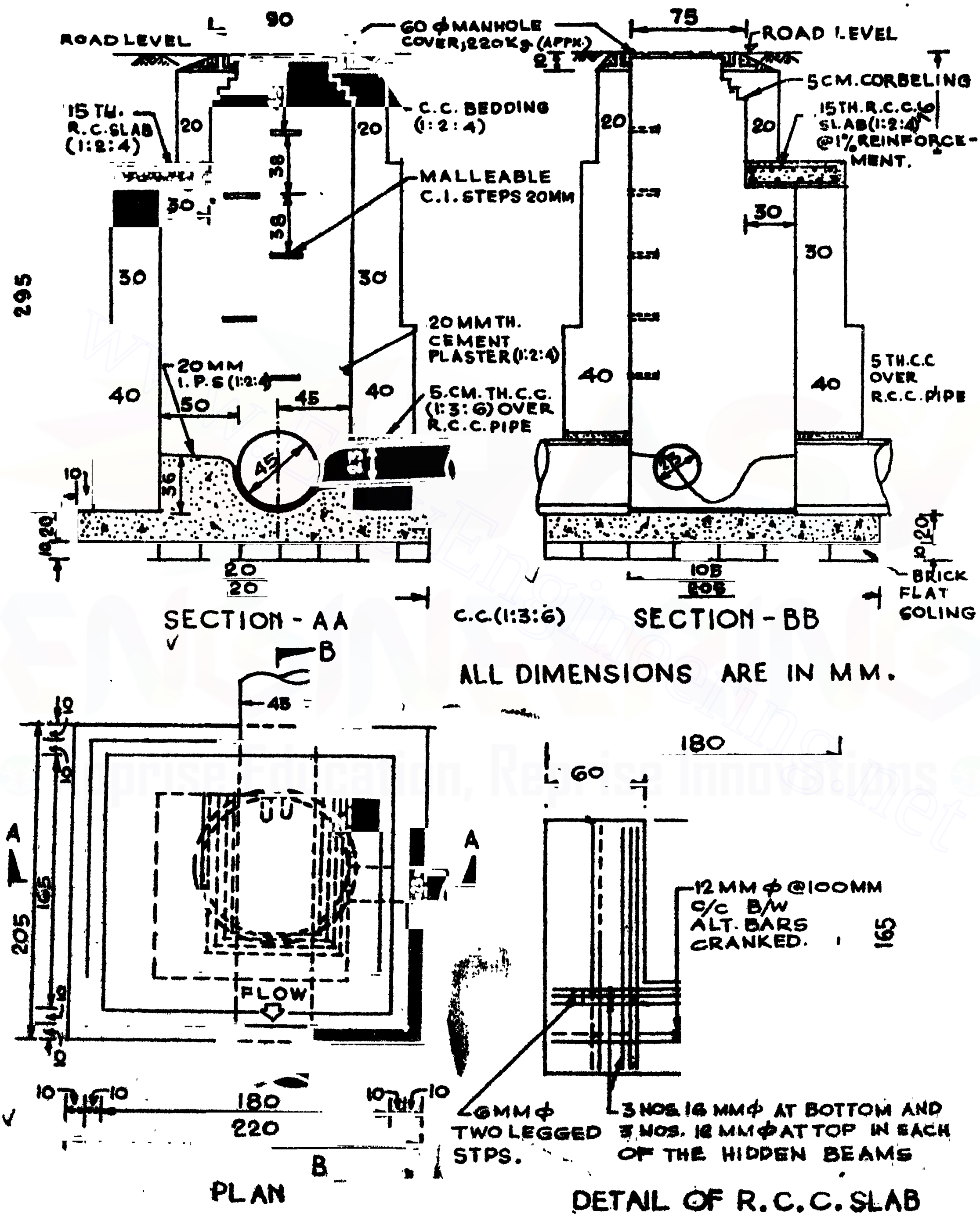


FIG. 6-24

Item No.	Description	No.	Length m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation including dewatering normal seepage and cutting road material**							
	(a) From 0m to 1·5m below G.L.	1	2·20	2·05	1·50	6·77	6·77 cu m	The quantity of earthwork in filling being small is omitted.
	(b) beyond 1·5m to 3m below G.L.	1	2·20	2·05	1·50	6·77	6·77 cu m	
	(c) beyond 3·0m to 4·5m below G.L.	1	2·20	2·05	0·25	1·13	1·13 cu m	
2.	**Hire & labour charges for 5cm thick timber shoring**							
	(a) from 0m to 3m below G.L.							
	Main sewer sides ...	2	1·68	—	3·00	10·08		1·68=2·20–·52
	Branch sewer side ...	1	1·77	—	3·00	5·31		·52 is the outer
	Opposite of branch line	1	2·05	—	3·00	6·15		dia. considered
							21·54 sq m	for main line. Branch pipe outer dia. is 28cm
	(b) beyond 3m to 4·5m below G.L.							
	Main sewer sides. ...	2	1·68	—	0·25	0·84		
	Branch sewer side ...	1	1·77	—	0·25	0·44		
	Opposite of branch line	1	2·05	—	0·25	0·51		
							1·79	sq. m.
3.	**Brick flat soling** ...	1	2·20	2·05	—	4·51	4·51 sq m	
4.	**Cement concrete** (1:3:6)							
	In foundation ...	1	2·20	2·05	·20	0·90		Portion of
	Benching, bigger side ...	1	1·05	·05	·36	0·19		benching inclu-
	Smaller side ...	1	1·05	·22	·36	0·08		ded equalises
	Deduction for branch sewer	1	·8 × π ×	(28)²/4	× ·22	0·01	-(ve)	portion exclu-
	Over main pipe ...	2	0·52	·40	·05			ded under
	„ branch pipe ...	1	0·28	·40	·05			·45m dia. pipe
		T.L.	1·32	·40	·05	0·03		
							1·19 cu m	
5.	**First class brickwork** in cement mortar (1:3)							
	Bottom part							
	Long walls (outer to outer) ...	2	2·00	·40	1·20	1·92		
	Short walls (inner to inner) ...	2	1·05	·40	1·20	1·01		
	Middle part							
	Long walls (outer to outer) ...	2	1·80	·30	0·90	0·97		
	Short walls (inner to inner) ...	2	1·05	·30	0·90	0·27		
	Top part							
	Long walls ...	2	1·30	·20	·60	0·31		
	Short walls ...	2	·75	·20	·60	0·18		
	C.O.					4·66		

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
	B. F.	.	...	...	...	4·66		
	Corbellings— Along main line ...	2	·63 (av.)	·10 (av)	·15	0·02		$\cdot63 = \frac{1}{2}(\cdot60+\cdot75)$ $\cdot10 = \frac{1}{2}(\cdot05+\cdot15)$
	Across main line ...	1	·75 (av.)	·10 (av)	·15	0·01		
							4·69 cu m	
6.	**Cement concrete** (1:2:4) excluding reinforcement & shuttering for slab—							
	Across main sewer ...	1	1·80	·60	·15	0·16		1·05 = 1·65 − ·60
	Along—do— ...	1	1·05	·60	·15	0·09		
							0·25 cum	
7.	**M.S. reinforcement** @ 1% vol. of concrete		0·25	$\times\frac{1}{100}$	×78·5	0·20	0·20 qu.	
8.	**Centering & shuttering** under unsupported portion ..	1	2·55	·30	—	0·76		2·55 = (1·80 − ·30) + (1·65 − ·60) 3·45 = 1·80 + 1·65 2·25 = (1·80 − ·60) + (1·65 − ·60)
	Outer edges ...	1	3·45	—	·15	0·52		
	Inner edges ...	1	2·25	—	·15	0·34		
	Invert ...	1	1·05	—	·36	0·38		
							2·00 sq m	
9.	**20mm thick cement plaster** (1:4) including neat cement finishing							
	Wall upto R.C. slab—							
	Long sides ...	2	1·20	—	·80	1·92		
	Short sides ...	2	1·05	—	·80	1·68		
	For shaft ...	1	3·30	—	·60	1·98		3·30 = 2(·90 + ·75)
							5·58 sq m	
10.	**20mm thick Indian patent stone** (1:2:4)							
	Benching ...	1	1·05	·50	—	0·53		
	" ..	1	1·05	·22	—	0·23		
	Invert ...	1	·8×(π	×·45)	×1·05	1·19		
							1·95 sq m	
11.	**Malleable C.I. step iron** (wt. 3·50 kg. apx each)	6	@3·50	kg.	each =	21	21 kg	
12.	**Heavy duty Manhole cover and frame including fitting and fixing in cement concrete** (1:2:4) 60cm dia. (wt. 220 kg each apx.)	1	@220	kg.	each =	220	220 kg	

Abstract of Estimated Cost :—

Item No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation, in any sort of soil including cutting road materials and stacking or removing the excavated materials upto a distance 75 m including dewatering normal seepage etc.					
	(a) from 0m to 1·5m below G. L.	6·77	cu m	455	%cu m	30·80
	(b) beyond 1·5m to 3m below G. L.	6·77	cu m	880	%cu m	59·58
	(c) beyond 3·0m to 4·5m below G. L.	2·20	cu m	1150	%cu m	25·30
2.	Hire & labour charges for 5cm thick timbering with planks, runners, struts etc. complete including removing them etc. upto 4m trench width.					
	(a) from 0 m to 3m below G. L.	21·54	sq m	22·00	sq m	473·88
	(b) beyond 3m to 4·5m below G. L.	1·79	sq m	24·00	sq m	42·72
3.	Single brick flat soling of overburnt bricks including ramming and dressing bed to level	4·51	sq. m	18·00	sq m	81·18
4.	Cement concrete (1 : 3 : 6) with over burnt brick ballast (3cm down)	1·19	cu m	325·00	cu m	386·75
5.	1st class brickwork in cement mortar (1:3) in any depth and shape as per drawing including curing.	4·66	cu m	290·00	cu m	1,351·40
6.	Cement concrete (1 : 2 : 4) with 20cm down graded stone chips excluding shuttering and reinforcement.	0·25	cu m	425·00	cu m	106·25
7.	M. S. reinforcement including cutting requisite length, hooking, bending & binding with 16 gauge black anneale wire.	0·20	qu	500·00	quin	100·00
8.	Hire and labour charges for providing timber shuttering for concrete works including invert and removing the same	2·00	sq m	18·00	sq m	36·00
9.	20mm thick cement plaster (1:4) including neat cement finishing at top	5·58	sq m	10·00	sq m	58·80
10.	20mm thick Indian patent stone in invert with cement concrete (1:2:4) with graded stone chips and smooth finishing at top	1·95	sq m	20·00	sq m	39·00
11.	Supplying, fitting and fixing malleable C.I. steps	21·00	kg	5·20	kg	109·20
12.	Supplying fitting and fixing with cement concrete (1:2:4) with stone chips 60cm dia. C. I. Manhole cover and frame	220	kg	3·50	kg	770·00

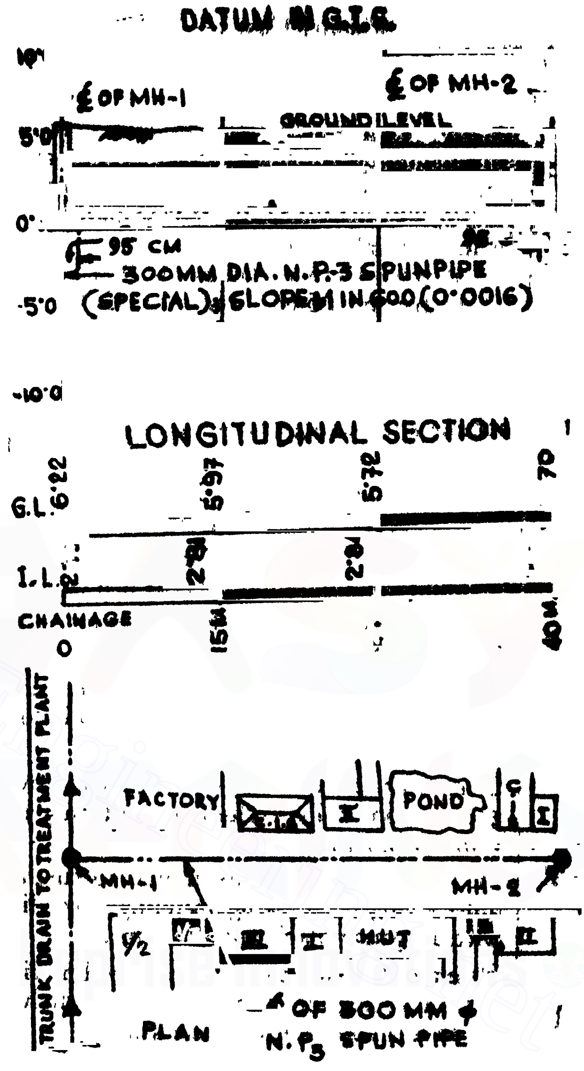
Total = 3,670·86

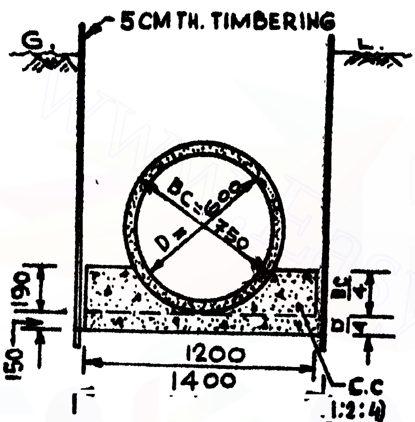
Add 5% for contingency = 183·54

,, $2\frac{1}{2}$% for W. C. = 91·77

Grand total = 3,946·17

6-22. Estimate of a sewer line : Prepare a detailed estimate to construct a branch sewer line between two Manholes as shown in fig. 6-25 assuming reasonable rates of your locality. The timbering shall be penetrated below the trench for a depth of 15cm as shown in drawing. (The estimate of Manhole and road restoration work is not required).





ALL DIMENSIONS ARE IN MM

FIG. 6-25

SCALE; HOR. 1:600 VER. 1:1200

Item No.	Description	No.	L. m	B.	H. m	Qu.	Total	Explanatory notes
1.	Earthwork in trenches							38·10=40·00−2×95 i.e. the portion covers due to earthwork of Manholes.
	(a) from 0 m to 1·5 m below G. L.		38·10	1·40	1·50	80·01	80·01 cu m	
	(b) beyond 1·5m to 3·0m below G. L. ..		38·10	1·40	1·50	80·01	80·01 cu m	
	(c) beyond 3·0m to 4·5m below G. L.							0·52=½[(6·22−2·79)+(5·97−2·81)]+0·075 (thickness of pipe+0·15 (conc. under pipe.)−3·0
	(i) between 0m to 15m ..		14·05	1·40	0·52	10·23		
	(ii) -do- 15m to 30m ...		15·00	1·40	0·25	5·25		
	(iii) -do- 30m to 40m ...		9·05	·40	0·09	1·14	16·62	cu m

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
2.	Hire and labour charges for 5cm thick timbering							
	(a) from 0m to 3m below G. L. ...	1×2	38·10	—	3·00	288·60	288·60 sq m	
	(b) from 3m to 4·5m below G. L.							
	(i) between 0m to 15m ...	1×2	14·05	—	0·67	18·83		0·67=0·52
	(ii) -do- 15m to 30m ..	1×2	15·00	—	0·40	12·00		(as earthwork)
	(iii) -do- 30m to 40m ..	1×2	9·05	—	0·24	4·30		+0·15 (insertion)
							35·13 sq m	
3.	Cement concrete with stonechips (1:2:4)							Area of segment $\frac{2}{3}\times 2a\times h$
	For bedding of pipe ...	1	38·10	1·20	0·34	15·50		
	Deduct for pipe segment	38·10 × $\frac{2}{3}$		× 2 × 0·326 × ·19		3·15	(-ve)	(approx.)
							12·35 cu m	a=half chord= $\sqrt{375^2-(375-190)^2}$ =326mm
4.	Providing timber shuttering for concrete work	1×2	38·10	—	0·34	5·91	25·91 sq m	
5.	Supplying and laying 300mm dia. NP-3 (special) pipe with coller	1	39·10	—	—	39·10	39·10 rm	
6.	Back filling of the trench ...	=vol. of earth work—vol. of conc.—space of pipe $=178{\cdot}11-12{\cdot}35-\frac{\pi}{4}(\cdot 75)^2\times 38{\cdot}1$					148·92	cu m

Abstract of Estimate cost :—

				Rs. P.		Rs. P.
1.	Earthwork in trenches including supplying, fitting, fixing of site rails, bonning rods and stacking excavated earth upto a distance of 75m					
	(a) from 0m to 1·5m below G.L.	80·01	cu m	670·00	%cu m	536·08
	(b) beyond 1·5m to 3·0m below G.L. ..	80·01	cu m	850·00	%cu m	600·85
	(c) beyond 3·0m to 4·5m below G.L. ...	16·62	cu m	930·00	%cu m	168·24
2.	Hire and labour charges for 5cm thick timbering with planks, battens, runners, struts etc.					
	(a) from 0m to 3m below G. L. ..	288·60	sq m	24·00	sq m	6,926·40
	(b) from 3m to 4·5mm -do-	37·74	sq m	27·00	sq m	1,018·98
3.	Cement concrete with stone chips (1 : 2 : 4)	12·35	cu m	425·00	cu m	5,243·75
4.	Providing timber shuttering for concrete work	25·91	sq m	14·00	sq m	362·74
5.	Supplying and laying 300mm dia. NP-3 R.C.C. (special) pipe with collar, lowering the same into the trench and jointing with cement mortar (1 : 2)	39·10	rm	265·00	rm	10,361 50
6.	Back filling of the trenches including consolidation.	148·92	cu m	255·00	%cu m	379·75

Total=25,603·29
Contingency 5%= 1,280·16
W.C. 2½%= 640·08
Total=Rs. 27,523·53

6·23. Schedule of items should be taken into consideration in estimating for sanitary fittings and drainage of a Toilet of a single storeyed dwelling house has a shower, a wash-hand basin, and a European Pattern water closet situated in a sewered area.

(a) **G. I. pipe works & its fittings for water connections :—**

1. Supplying, fitting and fixing galvanised iron pipes with necessary G. I. specials, fittings including cost of joining materials, cutting pipes, making threads, for works above ground in structures fitting, fixing with holder bat clamps etc.

2. Inserting pipes by cutting chase including mending good damages in cement concrete (1:2:4) with stone chips and cement plaster(1:6) 12mm thick to match with including centering complete.

(b) **For shower Rose :—**

3. Supplying, fitting and fixing vitreous china octagonal shower rose of 15 cm dia.

4. Supplying, fitting and fixing cromium plated piller taps (Emco brand).

5. Spplying, fitting and fixing C. P. Bib cock (Heavy type) tested 21 kg sq cm (Esso brand J. Tosh brand).

(c) **For wash Basin :—**

6. Wash Basin vitreous china (white without fittings) supplied, fitted and fixed on Pedestal.

7. Supplying, fitting and fixing Pedestal with the same colour as that of wash basin including supplying all fixing materials to support the basin rigidly and adequately.

8. Supplying, fitting and fixing approved P. V. C. connector white flexible with both ends coupling with heavy alluminium or brass 12mm size (a) 45cm long (b) 60cm long (as the case may be).

9. Supplying, fitting and fixing approved brand P.V.C. waste pipe for basin waste with coupling at one end fitted with brass/alluminium nut 3cm dia (a) 75cm long (b) 90cm long (as the case may be).

10. Supplying, fitting and fixing 32mm dia. nonferrous, chromium plated waste fitting.

11. Supplying, fitting and fixing C. P. chain or stay for wash Basin.

12. Supplying, fitting and fixing 3cm dia. rubber plug only.

13. Supplying, fitting and fixing C. P. stop cock (heavy duty) tested 21kg per sq cm (Esso brand, J. Tosh brand) 12mm size.

14. Supplying, fitting and fixing C.P. Bib cock (heavy duty) tested 21kg per sq cm (Esso brand, J. Tosh brand)

(d) **For European pattern W. C. : –**

15. European pattern W.C. vitreous china with P trap vent supplied, fitted and fixed in position complete.

16. Teak wood closet seat with C.P. hinge, rubber buffer and brass screws, single piece.

17. Supplying, fitting and fixing Norton's 12·5 litre (I. S. I. marked) C. I. plain painted low level flushing cistern complete with polythene syphon, C.P. cap, Handle Ring washer, I. R. adaptus joint, M. S. bend, Brass ball cock, polythene ball, polythene overflow, C. I. Bracket and painted two coats complete.

6·25. Estimate of service connection between street and consumer's pipe.

Prepare an estimated cost for service connection from the fig. 6-26. A meter Box is placed within the communication pipe to check the supply. The ferrules, stop cock and other fittings must be strong and made of best brass metal. Assume any suitable rate during preparation of the estimate.

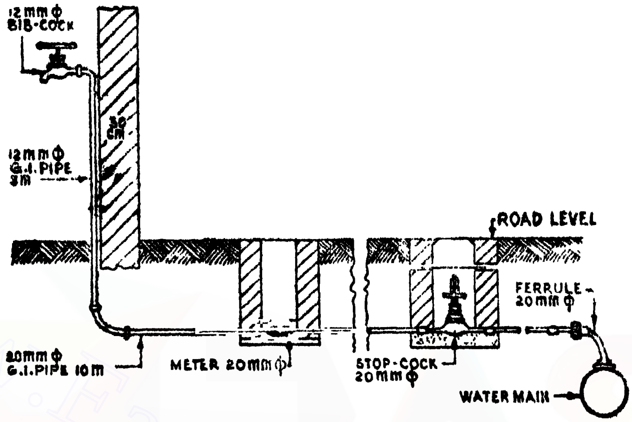


FIG. 6-26

Item No.	Description	Quan.	Unit of Rate Rs. P.	Amount Rs. P.
1.	Excavating the existing road for laying20mm dia.pipe connecting with the main water pipe and restoring the road to its original condition.	1 item	125·00 L. S.	125·00
2.	Drilling the watermain pipe and supplying, fitting, fixing Ferrule 20mm dia.	1 item	70·00 L. S.	70·00
3.	Supplying, fitting, fixing 20mm dia. G.I. pipe including necessary bends and laying the same 45cm below G.L.	10 m	24·00 rm	240·00
4.	Supplying, fitting, fixing 12mm dia. G. I. pipe including supplying necessary bends, clamps etc. as per drawing. ...	3 m	20·00 rm	60·00
5.	Supplying 12mm dia. Bib cock, including fitting, fixing the same in position. ...	1 No.	28·00 Ea.	28·00
6.	Supplying 20mm dia. Meter valve, fitting, fixing the same and constructing a meter chamber as per drawing. ...	1 No.	230·00 Ea.	230·00
7.	Supplying 20mm dia. Stop-cock fitting, fixing the same and constructing a stop-cock chamber as per drawing. ...	1 No.	130·00 Ea.	130·00
8.	Making hole in the existing brickwork and mending good the same after pipe connection. ...	1 No.	10·00 L. S.	10·00

Total = Rs. 893·00
Add 5% for contingency = Rs. 44·65
2½% for W.C. = Rs. 22·33

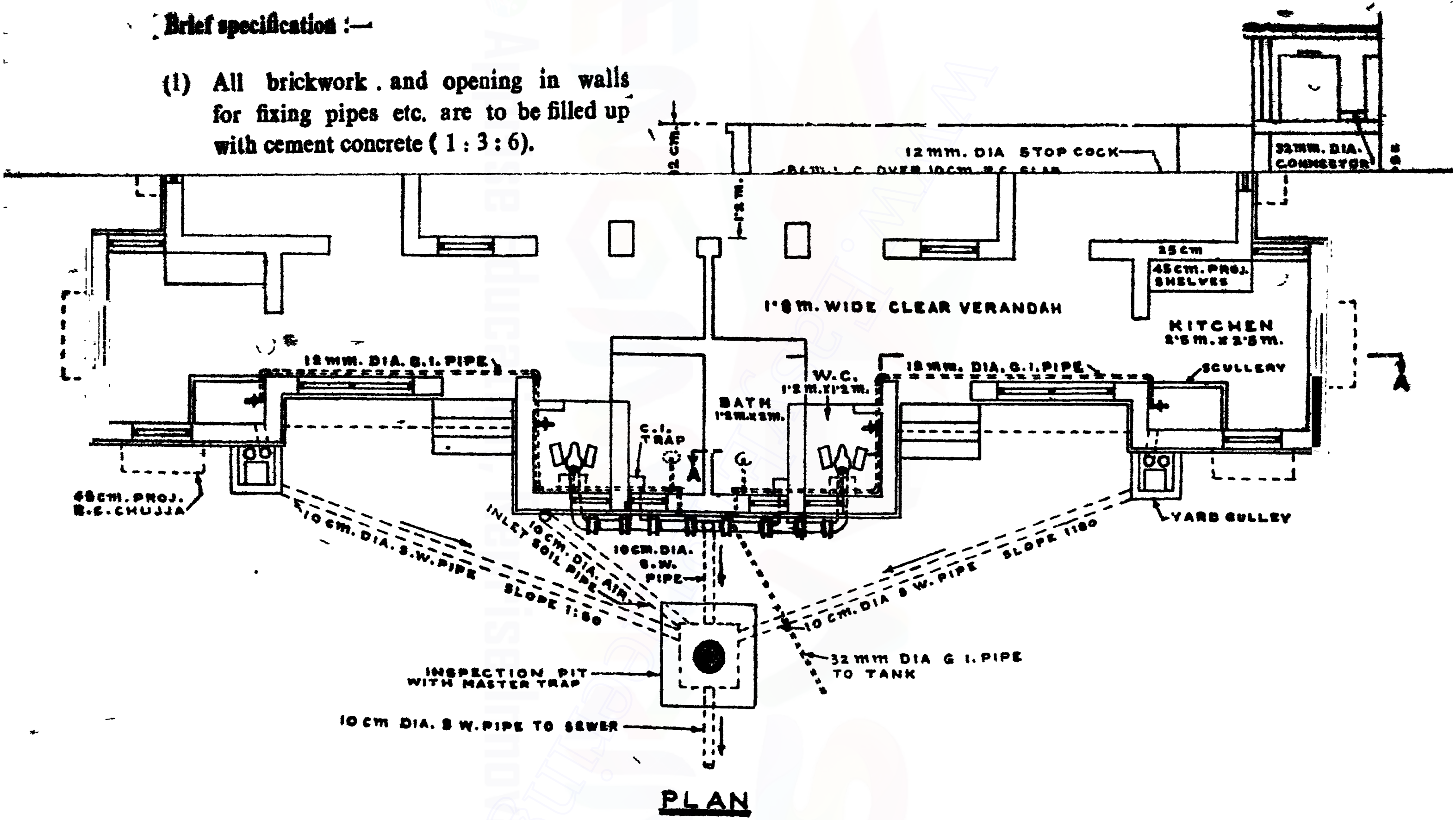
∴ Grand Total = Rs. 959·98

6-26. Internal plumbing and Water Supply Estimate :— The attached drawing plate shows the internal plumbing and water supply arrangement with details of different parts for a two storied building. Prepare a detailed estimate for internal plumbing and water supply arrangement assuming reasonable rate of your locality. (The portion of S. W. pipe from inspection pit to sewer line and building works such as plastering and flooring to latrins or bath rooms etc. are not required in the estimate. Supporting arrangements of G. I. roof tanks may also be excluded).

Item No.	particulars of works	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount
	For W. C.					
1.	Supplying, fitting, fixing 46cm long porcelain pan with Siphon P-trap in ground and Ist floor with cement mortar (1:4) finished with neat cement on top.		Nos.	180·00	Each	720·00
2.	Cutting existing R. C. slab with reinforcement if any for setting of pan in Ist. floor. ..		Nos.	10·00	Each	20·00
3.	Supplying fitting, fixing precast concrete (1:2:4) foot-rest 25cm × 15cm with cement mortar (1:4) finished smooth with neat cement as per drawing.		Pairs	8·00	Each Pairs	32·00
4.	Supplying, fitting, fixing 15 litres capacity flushing cistern on a pair of bracket. The bracket is to be supplied, painted and fixed in walls by cutting existing brickwork and mending the damage by cement concrete (1:3:6).		Sets	180·00	Each set	720·00
5.	Supplying, fitting, fixing 32mm dia. flush pipe for porcelain pan including painting two coats of white zinc paint over a coat of priming.		Sets	20·00	Each set	80·00
6.	Making 12 mm dia. wipe joint with 12mm dia lead pipe supplied, fitted, fixed at one end with 12mm dia. G. I. pipe and at other end with cistern as per drawing. 4 × 0·5 each =			20·00	r.m.	40·00
	For Kitchen					
7.	Construction of washing chamber with 10cm brickwork and finished smooth with cement plaster (1:4) and neat cement, complete as detailed in drawing.		Nos.	40·00	Each	160·00
8.	Supplying, fitting, fixing C.I. Gratings in the outlet bell mouth including cutting walls for pipe connection and making the bell-mouth with cement motar (1:4) finished smooth with neat cement.		Nos.	8·00	Each	32·00
						1,804·00

Brief specification :—

(1) All brickwork and opening in walls for fixing pipes etc. are to be filled up with cement concrete (1 : 3 : 6).



PLAN

Amount Rs. P.
1,804·00
120·00
90·00
84·00
098·00

Item No.	Particulars of works	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
					B. F.	1,804·00
9.	Supplying, fitting, fixing 100 mm dia. H.C.I. Yard Gully 15 cm × 10 cm with 95 cm C. I grating including construction of brick chamber on cement concrete (1:2:4) bed, earth work etc. complete & making connection with 100 mm dia. S. W. pipe as detailed in drawing. ...	2	Nos.	60·00	Each	120·00
	For Bath room					
10.	Supplying, fitting, fixing 100 mm dia. bell-mouth C. I. P-trap with C. I. grating including cutting concrete of 1st floor and walls and making the bell-mouth with cement mortar (1:4) finished smooth with neat cement. ...	2	Nos.	45·00	Each	90·00
11.	Supplying, fitting, fixing 100mm. dia. bell-mouth C. I. P-trap with C. I. grating including cutting lime concrete of ground floor and wall and making the bell-mouth with cement mortar (1:4) finished with neat cement. ...	2	Nos.	42·00	Each	84·00
	H. C. I. Soil Pipe					
12.	Supplying, fitting, fixing 100 mm dia. H.C.I. soil pipe in walls and in ground including lead joint with jute yarns, supplying all specials and painting two coats of steel coat paint over a coat of priming complete as detailed in drawing : — (a) *Kitchen at ground floor 2 Nos.* : From Yard Gully to P. L. = 2 × 60 cm − 1·20m For bend i.e. outside of pipe to wall = 2 × 10cm = 0·20m For insertion in 25 cm wall = 2 × 25cm = 0·50m Total = 1·90m (b) *Kitchen at first floor* :—*2 Nos.* From Yard Gully to P. L. = 2 × 60 cm = 1·20m From P. L. to 1st floor = 2 × 3·4 m = 6·8m For bend i.e. outside of pipe to wall = 2 × 10 cm = 0·20m For insertion in 25cm wall = 2 × 25cm = 0·50m Total = 8·70m (c) *Latrine connection 4 Nos.* (length measured) From main vertical pipe to bend = 4 × 2m = 8·00m For bend connecting P-trap = 4 × 0·3m = 1·20m Total = 9·20m					
					C. O.	[illegible]

Item No.	Particulars of works	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
					B. F.	2098·00
	(d) *Bath room connections—4 Nos.* For portion of T-in wall = 4 × 0·2m 0·80m					
	(e) *Vertical down pipe* Below G. L. ... ... = 0·45m Above G. L. ... ... = 9·62m Total = 10·07m					
	Grand Total = 30·67m	30·67	m	52·00	rm.	1594·84
13.	Supplying, fitting, fixing 100mm dia. cowl in vent pipe including painting two coats of steel coat paint over a coat of priming ...	1	No.	25·00	Each	25·00
14.	Supplying, fitting, fixing 50 mm dia. antisyphonage pipe including cutting walls and making all connections as detailed in drawing.					
	(a) *Latrine connections—4 Nos.* Same as 12 (c) + 4 × 0·2m for bends in wall = 9·2m + 0·8m = 10m					
	(b) *For bath room connections—4 Nos.* 4 × 25cm + 4 × 0·2m ... ... = 1·8m					
	(c) *Vertical down portion* ... ... = 8·9m					
	Grand Total = 20·7m	2·7	m	38·00	rm.	786·60
15.	Supplying, fitting, fixing 50mm dia. cowl in vent pipe including painting two coats of steel coat paints over a coat of priming ...	1	No.	12·00	Each	12·00
16.	Supplying, fitting, fixing 100mm dia. H.C.I. soil pipe with all specials for air inlet including the cost of earthwork, laying and fitting, fixing with walls complete Above ground level = 2m In ground = 2·6m Total = 4·6m	4·6	m	52·00	rm.	239·20
17.	Supplying, fitting, fixing mica value with flap for air inlet including painting two coats of steel coat paint over a coat of priming ...	1	No.	18·00	Each	18·00
					C. O.	4773·64

Item No.	Particulars of works	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
					B F.	4,773·64
18.	Supplying, laying 100 mm dia. S.W. pipe in prescribed gradient to inspection chamber including earth work and embedding the S. W. pipe with mass concrete complete as detailed in the drawing. From Yard Gully = 2 × 6·7m = 13·4m From W. C. and Bath = 1·5m Total = 14·9m	14·9	m	30 00	Each	447·00
19.	Construction of inspection chamber 92cm × 92cm × 1m to 1·4m average depth with brick masonry (1:6) over one layer of soling and base concrete (1:3:6) complete as detailed in drawing.		No.	380·00	Each	380·00
20.	Labour charge for making connections of 100mm dia. soil and 50mm dia. antisyphonage pipe with syphon trap in W. C. and Bath rooms. W. C. = 4 Nos. Bath = 4 Nos. Total = 8 Nos.		Nos.	12·00	Each	96·00
21.	Making connection with the 100mm dia. soil pipe of air inlet with inspection chamber and finished smooth with cement plaster (1:4) and neat cement		No.	8·00	Each	8·00
22.	Making connection with the 100mm dia. S.W. pipe and inspection chamber and finished smooth with cement plaster (1:4) and net cement.		Nos.	10·00	Each	30·00
23.	Supplying, fitting, fixing 32mm dia. G. I. pipe including supply of all specials complete as per drawing (portion of pipe in ground is to be laid upto 75 cm below G. L.) Vertical = 9·1m + 75cm = 9·85m Horizontal in G. L. = 3·00m Connector between tanks = 0·40m Total = 13·25m	13·25	m	38·00	r m.	503·50
24.	Supplying, fitting, fixing G. I. pipe including supply of all specials complete as per drawing medium quality.					
	a) 25mm dia. distribution = 2 × 5·1m = 10·20m Overflow pipe = 1·00m Total = 11·20m	11·20		24·00	r m.	268·80
					C. O.	6,506·94

Item No.	Particulars of works	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs P.
					B. F.	6,506·94
	(*b*) *12mm. dia. pipe* (horizontal and vertical lengths measured from the plan and elevation respectively)					
	Horizontal for two sides in two flats =4×9·15=36·60m					
	Vertical -do- -do- =4×8·30=33·20m					
	Total=69·80m	69·8	m	20·00	rm.	1,396·00
25.	Supplying, fitting, fixing brass wheel valve of approved quality					
	(a) 32 mm dia. in the inlet pipe ...	1	No.	120 00	Each	120·00
	(b) 25 mm dia in the distribution lines ...	2	Nos.	72·00	Each	144·00
26.	Supplying, fitting, fixing 12 mm dia. brass stop cock with all specials					
	Kitchens =4×1=4 Nos.					
	Baths =4×1=4 Nos.					
	Latrins =4×1=4 Nos.					
	Total=12 Nos.	12	Nos	28·00	Each	336·00
27.	Supplying, fitting, fixing 12 mm dia. brass bib cock with all specials					
	Indents are same as Item No. (26)	12	Nos.	28·00	Each	336·00
28.	Supplying, fitting, fixing 15cm dia chromium plated shower rose with all specials of approvd quality as per drawing. ...	4	Nos.	20·00	Each	80·00
29.	Supplying, fitting, fixing, and hoisting in position 1800 litres capacity each 14 gauge G. I. tanks including C. I. manhole cover, ball valve and making connections of all 32mm dia. and 25mm dia. pipes complete as per drawing.	2	Nos.	1675	Each	3,350·00

Total=Rs. 12,268·94

Add 5% for contingency=Rs. 613·45

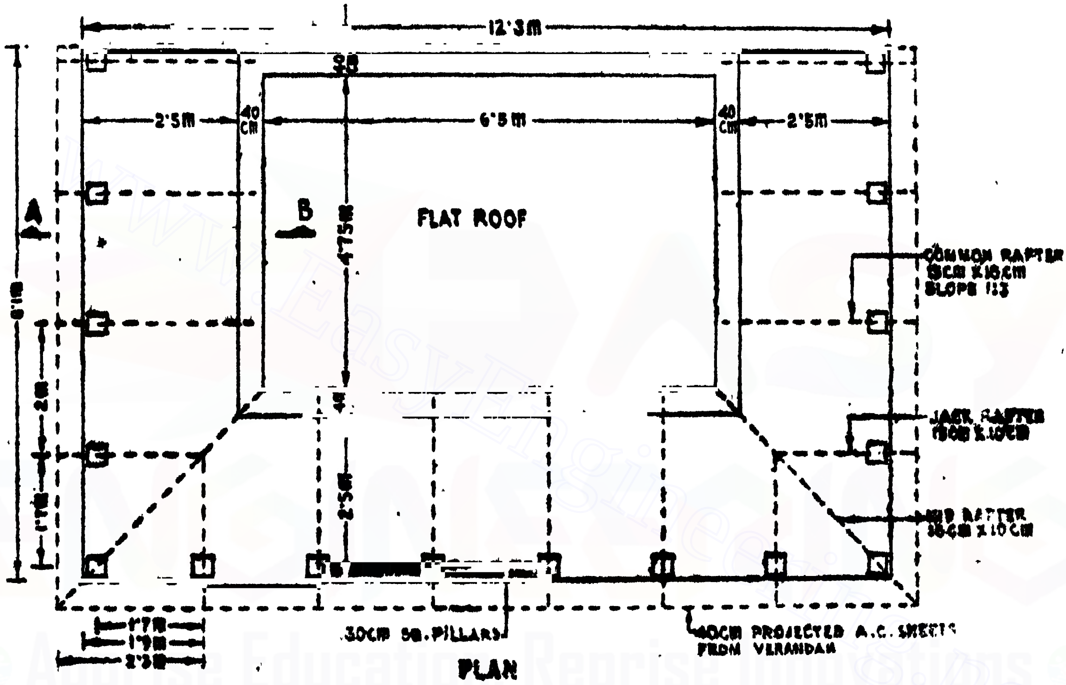
Add 2½% for work charge=Rs. 306·73

Grand Total=Rs. 13,189·12

CHAPTER VII

SLOPED ROOF, ROOF-TRUSS AND STEEL STRUCTURE

7-1. Estimate of a sloped roof with Asbestos Cement sheet roof covering—Prepare a detailed estimate for the verandah roof consisting of Asbestos of Corrugated sheet over sal wood rafter and purlins as shown in the Fig. 7-1. All woodwork shall be painted two coats of approved paint. Assume reasonable market rates of your locality. The slope of the roof shall be of 1:3.



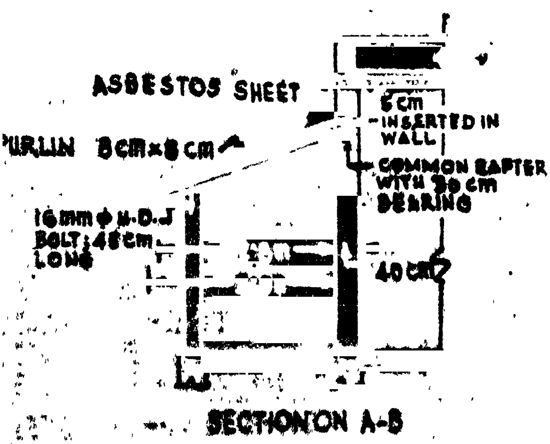


FIG. 7-1

Item No.	Description	No.	L. m	T.L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**A. C. Sheet**								
	Front ...	1	(13·1+7·2)/2	10·15	3·11	—			13·1=12·3+2×·40; 7·2=12·3−2×2·5 −2×·05 (5cm is bearing in wall)
	Sides ...	2	(8·5+5·55)/2	14·05	3·11	—			
				24·20	3·11	—	75·26	75·26 sq m	For 3·11 see note(a)
2.	**Sal wood work**								
	Common rafter ...	10	3·26	32·6	·10	·15	·489		For 3·26 see note(b)
	Hip rafter ...	2	4·37	8·74	·10	·18	·157		For 4·37 see note(c)
	Jack rafter ...	4	2·33	9·32	·10	·15	·140		For 2·33 see note(d)
	Purlins front ...	3	(13.1+7·2)/2	30·45	·08	·08	·195		
	Purlins sides ...	2×2	(8·5+5·55)/2	42·15	·08	·08	·270		
								1·251 cu m	
3.	**A. C. Ridge**	2	4·22	8·44	—	—	8·44	8·44 r m	4·22=4·37(Hiprafter) +·10 (projection) —·30 (less bearing) +·05 (insertion)
4.	**16mm dia. H. D. Bolts** 45cm long ...	16	—	—	—	—	16	16nos	
5.	**Painting to wood work** (two coats)								
	Common rafter ...	10	3·26	32·6	·50	—	16·80		·50=2(·10+·15) i.e. perimeter.
	Hip rafter ...	2	4·37	8·74	·56	—	4·89		
	Jack rafter ...	4	2·33	9·32	·50	—	4·66		
	Purlins front ...	3	(13·1+7·2)/2	30·45	·32	—	9·74		
	Purlins sides ...	2×3	(8·5+5·55)/2	42·15	·32	—	13·49		
								49·08 sqm	

ABSTRACT OF ESTIMATED COST

	Description	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount
1.	**A. C. Sheet roof** ...	75·26	sq m	60·00	sq m	4,515·60
2.	**Sal wood work** ...	1·251	cu m	2200·00	cu m	2,752·20
3.	**A. C. Ridge** ...	8·44	r m	55·00	r m	464·20
4.	**16mm dia. H. D. bolts** ...	16	Nos.	4·50	each	72·00
5.	**Painting to wood two coats** ...	49·08	sq m	7·00	sq m	343·56

Total=Rs. 8,147·56

Add 5% contingency=Rs. 407·38

Add 2 % for W.C.=Rs. 203·69

Grand Total=Rs. 8,758·63

Explanatory notes for

(*a*) ***A. C. Sheets 3·11 m*:—**

Width of Verandah = 2·50m
Projection of sheets = 0·40m
Insertion of sheets = 0·05m
Total = 2·95m

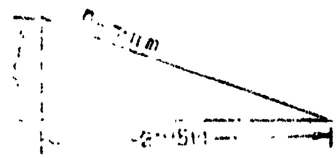


FIG. 7-2

Referring to the fig. 7-2, for a slope of 1:3

Rise $= 2{\cdot}95 \times \frac{1}{3} = 0{\cdot}98$m

$\therefore$ Length of sheets $= \sqrt{(2{\cdot}95)^2 + ({\cdot}98)^2} = 3{\cdot}11$m

(*b*) *Length of Common rafter* = 3·26m = 3·11m (as A. C.) + 30cm (bearing) − 5cm (bearing of A. C. sheets as already considered with A. C. in *a*) − 10 cm (i.e. length less than sheets)

(*c*) *Hip rafter 4·37m*

Referring to the fig. 7-3

Length of Hip rafter $= \sqrt{(2{\cdot}8\text{m})^2 + (2{\cdot}96\text{m})^2}$
$= 4{\cdot}07$m

Add ·30cm for bearing = 4·07 + ·30 = 4·37m

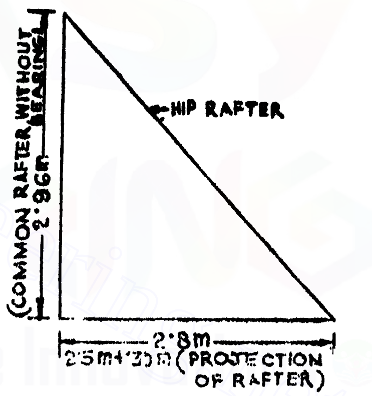


FIG. 7-3

(*d*) *Jack rafter 2·33m*

Referring to the fig. 7-4

Length of Jack rafter = L

$\therefore \dfrac{L}{2{\cdot}2\text{m}} = \dfrac{2{\cdot}96\text{m}}{2{\cdot}8\text{m}}$

$\therefore$ L = 2·33m

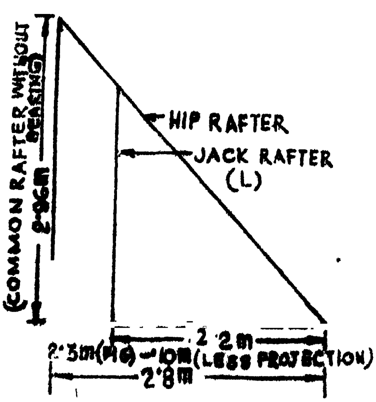
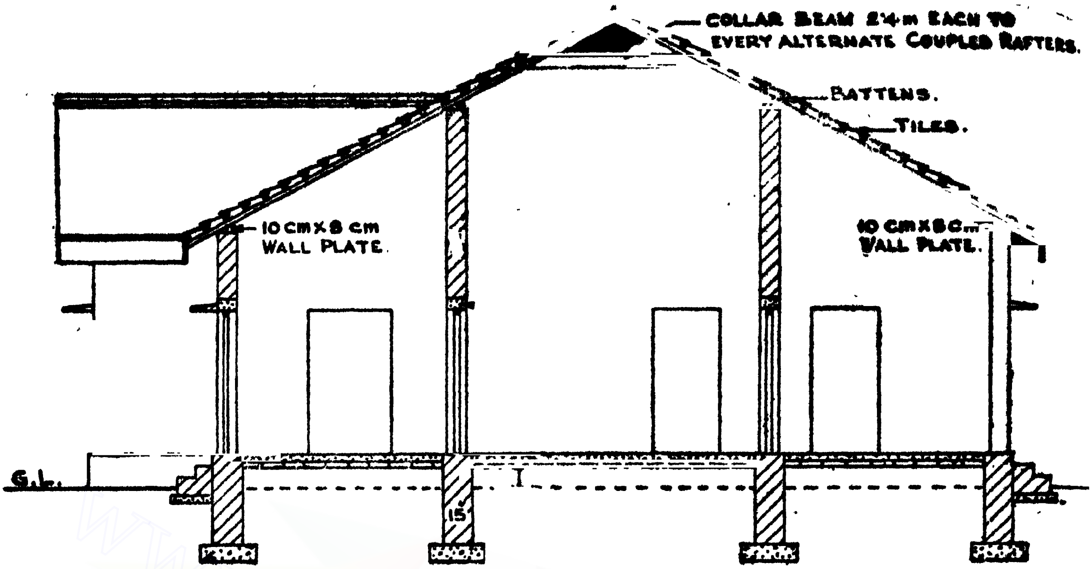
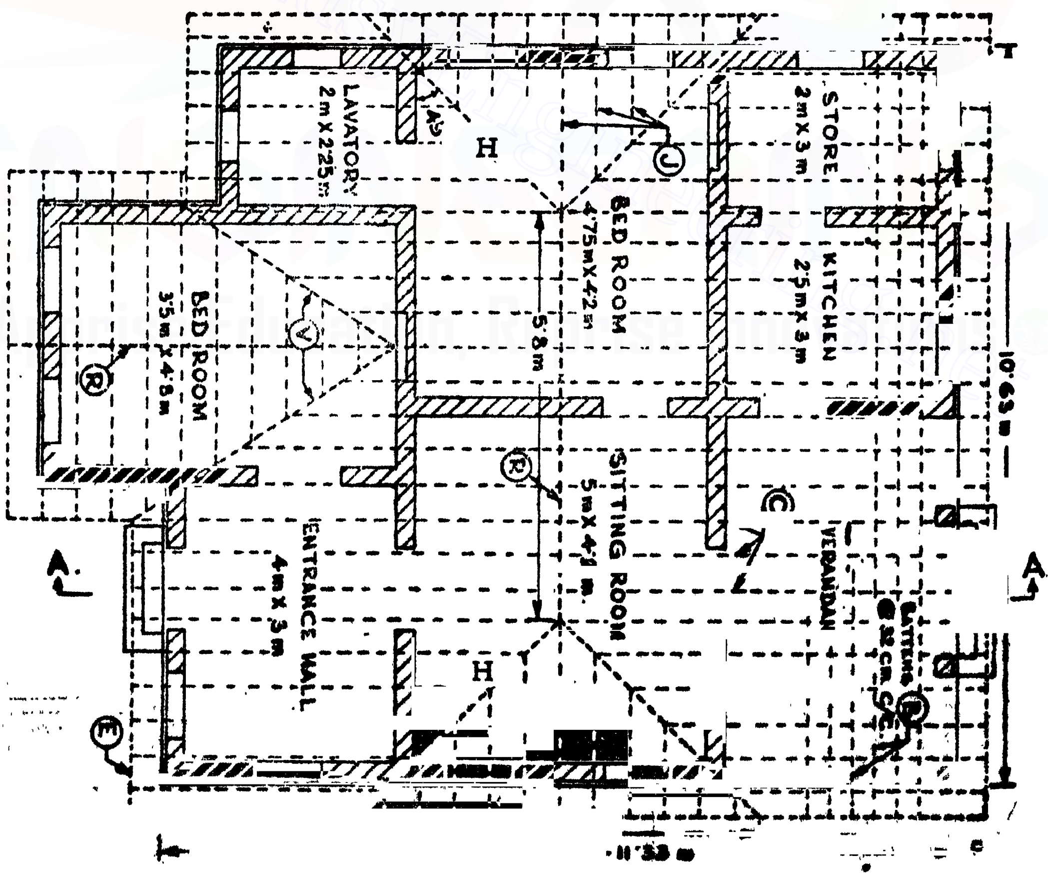


FIG. 7-4



SECTION ON A-A



PLAN
SCALE–1 Cm = 1 m.

7-2. Estimate of a Sloped roof with Mangalore tiles roof covering :—Prepare a detailed estimate of the roof of a building consisting of Mangalore tiles 40cm × 24cm supported over sal wood rafters and purlines etc. as shown in fig. 7-5. All wood works shall be painted two coats. The slope of the roof shall be 1 : 2·5 and the roof shall have a projection of 0·5m from superstructure walls. Other particulars are as per drawing. Assume any reasonable rate for your locality.

Details of roofing :— (C and J) Common and Jack rafters 15 cm × 8 cm @ ·5 cm c/c ; (H and V) Hip and Valley rafters 18cm × 10cm ; (R) Ride pieces 15 cm × 5 cm; (B) Battens 5 cm × 2·5 cm @ 32 cm c/c; (E) Eave board 18 cm × 5 cm ; Main collar beam 18 cm × 10cm 2·4m long ; Gabelt Collar beam 18 cm × 10cm, 2m long.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	Sal wood work							
(i)	(a) *Main ridge* ..	1	5·80	·05	·15			
	(b) Ridge at gable ..	1	5·55	·05	·15			5·55=4·8+·25 +·50
			11·35	·05	·15	0·085		
(ii)	*Common rafters*—							
	(a) Back side— middle portion ..	13	6·24					·24 See note 1.
	left and right portions	2×6	4·77(av.)					
	(b) Front— Extreme right hand side	6	4·77(av.)					4·77 See note 2
	Right hand side	4	6·24					
	(c) On front bed room	2×4	4·53(av.)					4·53 See note 3
	(d) Along front ridge rafter	1	2·53					3·96 See note 4.
	(e) -do- left hand side ..	6	3·96(av.)					
			254·47	·08	·15	3·054		
(iii)	*Hip rafters*	2×2	4·34	·10	·18	·313		
(iv)	*Valley rafters at*							
	(a) Gable right hand side	1	4·78					
	Left hand side	1	4·21					
			8·99	·10	·18	1·62		
(v)	*Jack rafters at*							(b) 4 Nos. excluding eaves board. One side of one rafter is neglected.
	(a) Hipped ends (both sides) ..	2×13	$\frac{0+3·07}{2}$					
	(b) Gable Front most portion	2×4	2·69					(c) Although actual No. is 6 but counted as 7 for zero length of one rafter.
	Right hand remaining	7	$\frac{0+2·15}{2}$					
	Left hand remaining		$\frac{0+2·69}{2}$					
			49·87	·08	·18	0·598 C.O.	4·212	cu m.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B. F. ...					4·212		
	(vi) Collar beam for							
	(a) Main ridge ...	6	2·4					
	(b) Gable ridge ...	5	2·0					
			24·4	·10	·8	0·439		
	(vii) Eaves board							
	(a) Back (entire) ...	1	11·50					4·25 =
	(b) Front right hand side	1	4·25					4+·25+·4−·5
	(c) Front left hand side ..	1	2·25					1·8=(4·8+·25+
	(d) Right hand to gable ..	1	1·80					·5)−(3·0+·25+·5)
	(e) Left hand to gable ...	1	2·55					
	(f) Hipped sides ...	2	5·70					
			33·75	·05	·18	0·304		
	(viii) Battens 5cm × 2·5cm @ 31·5 cm c/c							
	(a) Extreme back rectangular portion ...	10	11·5					10 nos. for 3·24
	(b) Trapezium portion of back side ...	8	$\frac{11·5+5·8}{2}$					8 nos. for 2·90
	(c) Trapezium portion attached to ridge at front ...	6	$\frac{10+5·8}{2}$					
	(d) Trapezium portion (approximately) left hand side ...	10	$\frac{4·57+2·25}{2}$					
	right hand side ...	12	$\frac{6·75+4·25}{2}$					
	(e) Hipped ends ...	2×8	$\frac{5·7}{2}$					
	(f) Gable end left hand portion ...	7	2·55					
	-do- -do- triangular	8	$\frac{2·55}{2}$					2·55=(4·8+·25+
	(g) Gable left hand front portion ...	5	2·55					·5)−(2·25+·25+ ·5)
	-do-right hand triangular ...	11	$\frac{2·55}{2}$					
			432·13	·025	·05	·0540		
	(ix) 10cm × 8cm wall plate with fixing							
	(a) Sides (entire) ...	2×1	13·55					
	(b) Back ...	2×1	10·00					
			47·10	·08	·10	0·377		
							5·872	cu m

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	*Explanatory notes
2.	**Painting to wood work**							
	(a) Ridges 15 cm × 5 cm ...	1	11·35	·40	—	4·54		·40=2(·15+·05)
	(b) Common and Jack rafter 15cm × 8cm ...	1	304·34	·46	—	140·00		304·34 is the total length
	(c) Hip, Valley refters and Coller beams 18cm × 10cm ...	1	50·75	·56	—	28·41		
	(d) Eaves board 18 cm × 15 cm ..	1	33·75	·46	—	15·52		50·75 is the total length
	(e) Battens 5cm × 2·5m ..	1	432·13	·15	—	64·82		
	(f) Wall plates 10cm × 8cm ..	1	47·10	·36	—	16·95		
							270·24 sq m	
3.	**Mangalore tiled roofing**							
	(a) Extreme back rectangular portion ..	1	11·50	3·24	—	37·26		Following the procedure as in 1
	(b) Trapezium portion back side ...	1	$\frac{11·5+5·8}{2}$	2·90	—	25·08		
	(c) Trapezium portion attached to ridge at front side ..	1	$\frac{10+5·8}{2}$	2·02	—	15·96		$2·02=\sqrt{(2·1)^2+\left(\frac{2·1}{2·5}\right)^2}$
	(d) Trape. portion (appx.)							
	left hand side ...	1	$\frac{4·57+2·25}{2}$	3·5	—	24·50		$3·5=\sqrt{(3·25)^2+\left(\frac{3·25}{2·5}\right)^2}$
	right hand side ...	1	$\frac{6·75+4·25}{2}$	4·31	—	23·71		$4·31=\sqrt{4^2+\left(\frac{4}{2·5}\right)^2}$
	(e) Hipped ends ...	2	3·07	$\frac{5·7}{2}$	—	15·50		
	(f) Gable and left hand front portion ...	1	2·55	2·55	—	6·3		
	-do- left hand triangular portion ...	1	2·25	$\frac{2·25}{2}$	—	3·18		
	-do- right hand front portion ...	1	2·55	1·8	—	4·59		
	-do- right hand triangular portion ...	1	3·75	$\frac{2·25}{2}$	—	4·22		
							160·15 sq m	
4.	**Mangalore tiled ridges and valley.**		Add total 1(iii)+1(iv)	lengths +1(v)	of —	76·22	76·22 rm	

Details of Explanatory notes for :—

1. $6{\cdot}24 = \sqrt{(6{\cdot}1)^2 + (2{\cdot}44)^2}$

   Now, horizontal length $6{\cdot}1 = 2{\cdot}1$ (half room) $+ {\cdot}25$ (wall) $+ 3$ (veran) $+ {\cdot}25$ (pillar) $+ {\cdot}5$ (projec.) this may also be obtained by measurement.

2. $4{\cdot}77 = \frac{1}{2}(6{\cdot}03 + 3{\cdot}50)$; $6{\cdot}03 = \sqrt{(5{\cdot}6)^2 + (2{\cdot}24)^2}$; Horizontal length 5·6 measured ;
   $3{\cdot}50 = \sqrt{(3{\cdot}25)^2 + (1{\cdot}3)^2}$; Horizontal length 3·25 measured.

3. $4{\cdot}53 = \frac{1}{2}(5{\cdot}67 + 3{\cdot}39)$; $5{\cdot}67 = \sqrt{(5{\cdot}3)^2 + (2{\cdot}04)^2}$; 5·3 measured.
   $3{\cdot}39 = \sqrt{(3{\cdot}15)^2 + (1{\cdot}26)^2}$; Horizontal length 3·15 measured.
   $2{\cdot}53 = \sqrt{(2{\cdot}35)^2 + ({\cdot}94)^2}$; Horizontal dist. $2{\cdot}35 = 2{\cdot}1 + {\cdot}25$.

4. $3{\cdot}96 = \frac{1}{2}(5{\cdot}22 + 2{\cdot}62)$; $5{\cdot}22 = \sqrt{(4{\cdot}85)^2 + (1{\cdot}94)^2}$
   Horizontal length 4·85 measured ; $2{\cdot}69 = \sqrt{(2{\cdot}5)^2 + 1^2}$

ABSTRACT OF ESTIMATED COST

Item No.	Description	Quantity	Unit	Rate	Unit of rate	Amount
1.	Sal wood work including fitting, fixing ...	5·872	cu m	Rs. 2200·00	cu m	Rs. 12,918·40
2.	Painting wood work two coats ...	270·24	sq m	Rs. 7·00	sq m	Rs. 1,891·68
3.	Mangalore tiled roofing ...	160·15	sq m	Rs. 16·00	sq m	Rs. 2,562·40
4.	Mangalore tiled ridges and valley	76·22	r m	Rs. 16·00	r m	Rs. 12,19·52

Total = Rs. 18,592·00
Add 5% for contingency = Rs. 926·60
Add 2½% for work charged = Rs. 464·80

Grand Total = Rs. 19,983·40

7-3. Trussed Roofs.—For greater spans rafters require intermediate support in the form of struts and ties to increase their rigidity and to decrease their size. A frame work of timber or steel or any other metal which may be built up satisfying the above conditions may be called a truss. The advantages of a roof truss is that (a) it transmits roof loads in a vertical direction upon the walls, provided purlins are placed on load points. (b) each member is either under direct tension or compression without any addition of bending stresses. The spacing between timber trusses are usully kept between 2·5m to 3m (8ft to 10ft.) apart and that of steel trusses between 3m to 4·5m (10 ft. to 15 ft.). Over the trusses purlins are first laid and over purlins common rafters are fixed. The roof battens are then placed over the common rafters with the roof covering (tiles, slates, G. I. or A. C. sheets) on top of these battens as shown in fig. 7-8. In cases of G. I. or A. C. sheet roofing, roof battens are also sometimes placed directly over the trusses without using purlins and common rafters.

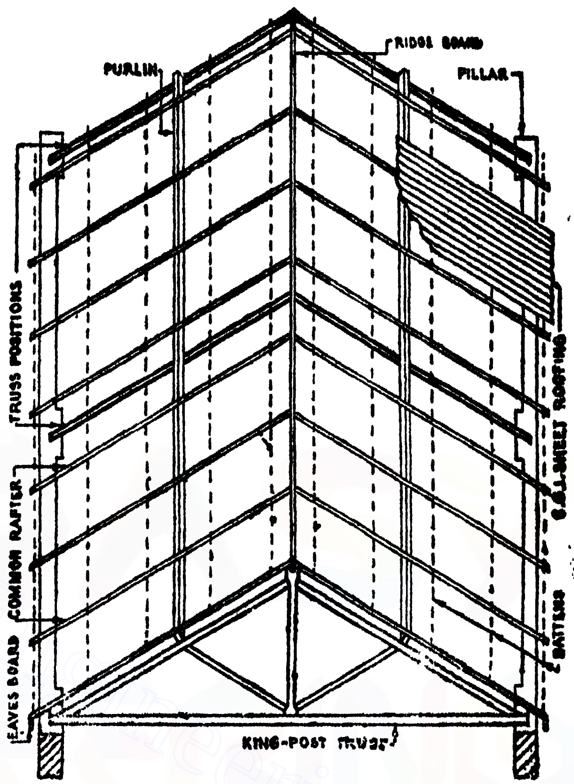


FIG. 7-8

To estimate the quantity of wood work in trusses, first calculate the quantity for one truss from the dimensions shown in the drawing or if not shown measure the same from the drawing. In case of steel trusses the weight of different members are taken from the steel table.

7-4. Roof cover of G. I. Sheets—Roof cover of galvanised corrugated iron sheets are four classes and for each class the rate of zinc (spelter) coating on both sides inclusive has been mentioned below based on I. S. 277-1962 :—

Class 1—Extra heavy coating @ 750 g/sq m ; Class 2—Heavy coating @ 600 g/sq m.
Class 3—Medium coating @ 450g/sq m ; Class 4—Light coating @ 375 g/sq m.

Each class of G. I. sheets has the following thickness and these may correspond to the respective Berminghum Gauze (B. G.) as indicated within brackets 1·60mm (12 B. G.), 1·25mm (18 B. G.), 1·00mm (20 B. G.), 0·80mm (22 B. G.) and 0·63 mm (24 B. G.). Class 4 type is normally used as roof covers for domestic houses details of which have been given in the appendix (steel table).

The G. I. sheets are manufactured in lengths of 1·8m, 2·2m, 2·5m, 2·8m and 3·2m with standard width of 0·90m or 0·75m. The pitch, P i.e. centre to centre distance is 75 mm and depth of corrugation, d is 18 mm. The number of corrugations is 8 nos. per sheet.

In the lengthwise direction an end lap of 15 cm and breadthwise direction side laps of two corrugations are usually provided. In ridges and hips where plain sheets are used a lap of 23 cm should be provided. In estimates the roof is considered on area basis as per sq m but the G. I. sheets are commercially sold per bundle ; each bundle weighs a little above 100 kg. (or one quintal),

7-5. Roof Cover of A. C. Sheets—Asbestos Cement (A. C.) corrugated and semi-corrugated unreinforced sheets are manufactured in the length of 1·5m, 1·75m, 2m, 2·25m, 2·5m, 2·75m and 3m and their standard width (overall) is 1·10m. The other details are shown in the table as below.

Type of sheet	Pitch of corrugation	Depth of corrugation	Width of each sheet	Thickness of sheet (Nominal)	Number of pitch	Spacing of purlins c/c
Corrugated	146 mm	48 mm	105 cm	6mm & 7mm	6 Nos.	1·4m for 6mm and 1·6m for 7mm thick sheets
Semi-corrugated	338 mm	45 mm	110 cm	—do—	3 Nos.	

A lengthwise lap or end lap of not less than 15cm and side lap of one corrugation 14·6cm (or 146 mm) are usually provided.

7-6. Estimate of roof covers—Measurement of roof covers are taken for finished work only in sq. m. including screws, bolts, nuts, washers, spikes etc. Ridges, hips and valleys are measured in running metres stating the laps.

7-7. Weight of straps, bolts, nuts and Washers etc.—Weight may be taken $\frac{1}{4}$ quintal (25 kg.) per truss for spans of 6m and above. For spans under 6m consider the weight of $\frac{3}{16}$ qu. per truss.

7-8. Estimate of a timber roof truss.—Prepare a detailed estimate to build up a roof of Corrugated Galvanised iron sheet supported over wooden king-post truss, purlines, and rafter etc. as shown in fig. 7-9 for a Godown 14m × 6m clear. The spacing of trusses are 2·8m c/c and the ends will be provided with gable walls. Corrugated Galvanised iron sheet will be of 0·63mm (24 gauge) and all timber works shall be of sal wood with two coats of painting over a coat of priming.

Ans.—Number of trusses $= \frac{14}{2 \cdot 8} + 1 = 6$ Nos.

Due to two gable walls at ends the actual number of trusses $= 6 - 2 = 4$ Nos.

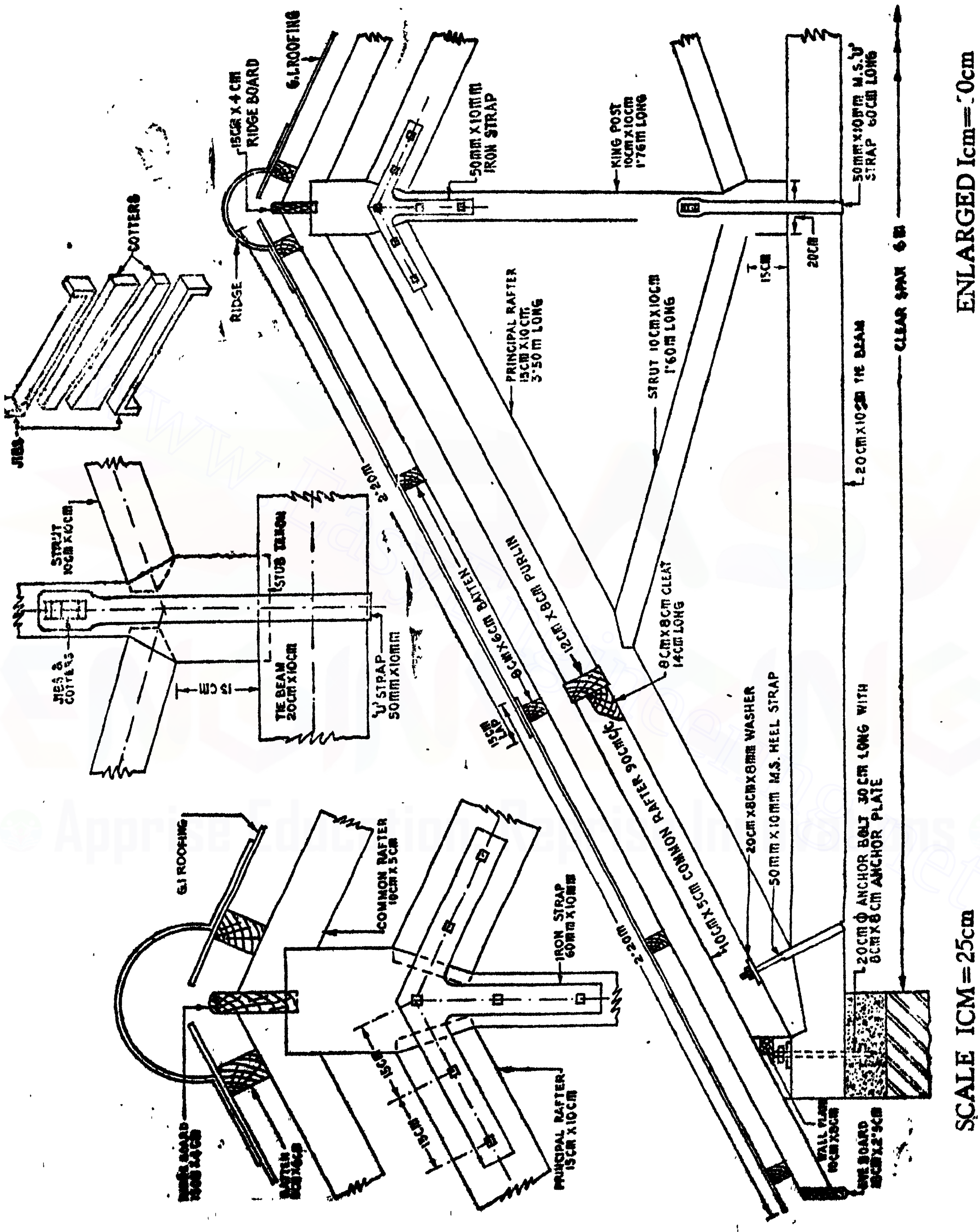

G.I.ROOFING
15Cm X 4 Cm RIDGE BOARD
RIDGE
COTTERS
JIBS
50mm X 10mm IRON STRAP
KING POST 10cm X 10cm 1'76m LONG
50mm X 10mm M.S.'U' STRAP 60Cm LONG
PRINCIPAL RAFTER 15Cm X 10Cm 3'50 m LONG
STRUT 10Cm X 10cm 1'60m LONG
20Cm
15Cm
CLEAR SPAN 6 m
20Cm X 10Cm TIE BEAM
2'20m
8Cm X 6Cm BATTEN
12Cm X 8Cm PURLIN
8Cm X 8Cm CLEAT 14Cm LONG
10Cm X 5Cm COMMON RAFTER 90Cm C/C
20Cm X 8Cm X 8mm WASHER
50mm X 10mm M.S. HEEL STRAP
20Cm Φ ANCHOR BOLT 30Cm LONG WITH 8Cm X 8 Cm ANCHOR PLATE
STRUT 10Cm X 10Cm
STUB TENON
JIBS & COTTERS
TIE BEAM 20Cm X 10Cm
'U' STRAP 50mm X 10mm
G.I ROOFING
COMMON RAFTER 10Cm X 5Cm
IRON STRAP 60mm X 10mm
PRINCIPAL RAFTER 15Cm X 10Cm
ENLARGED
SCALE ICM = 25cm

FIG. 7-9

Item No.	Description	No.	L. m	B. m	H m	Qu.	Total	Explanatory notes
1.	**Sal wood work** in one truss (wrought framed							
	Principal rafters ...	2	35·0	·10	·15	0·1050		Section of 'K' post
	King post ..	1	1·76	·20	·10	0·0352		at ends 10cm ×
	Struts ...	1	1·60	·10	·10	0·0320		20cm has been
	Tie beam ...	1	6·80	·10	·20	0·1360		considered. This
	Wooden cleats for purlin	2	·14	·08	·08	0·0018		is required to form the shape
			Total	for 1 truss	=	0·3100		
		∴	Total	for 4 trusses	=	1·2400		
	Purlins ...	2	14·30	08	·12	0·2746		15cm bearing into
	Ridge board ...	1	14·30	·04	·15	0·0858		gable walls has been considered.
	Common rafters @ 90cm c/c. ...	2×16	4·25	·05	·10	0·6800		16 Nos $=\frac{14}{\cdot 9}+1$
	Eaves boards ...	2	14·30	0·25	·18	0·1287		with a clear dist.
	Battens .	2×5	14·30	·06	·08	0·6864		of 25cm from
	Wall plates ...	2	14·30	·10	·08	0·2288		gable walls to 1st rafter.
						3·6343	3·6343	
2	**Iron work** in one truss							
	(a) Straps (50mm × 10mm)-							
	Three way strap at ridge	2	·90	—	—	1·80		
	U-strap at central bottom	1	1·30	—	—	1·30		1·30=2 × ·60+·10
	U-straps at heal ...	2	·70	—	—	1·40		·70=2 × ·30+·10
						4 50m @3·9kg	17·60	
	b) Anchor bolts 20mm dia	2	·30	—	—	·60m @2·47 kg	1·48	
	(c) 8mm thick flats as washer							
	For U heal straps ...	2	·20	·08	—	0·032		
	For anchor bolts .	2	·08	·08	—	0·013		
						·045sqm @62·8 kg	2·83	
	(d) Head and nuts—							
	For heal straps ...	2 × 4	—	—	—	8		Note :—*Wt. of straps, bolts etc*
	For anchor bolts ...	1 × 2	—	—	—	2		*may be taken as* $\frac{1}{4}$.
						10 Nos @·25 kg.	2·50	*quintal per truss (see note 7-7).*
	(e) Gibs and cotters for fixing and tightening central strap ...		—	—	–	L. S.	1·00	
		∴	Total	for one	truss	=	25·41	kg.
			Total	for 4	trusses	=	101·64	kg.
						=	1·02	quin.

Item No.	Description	No.	L. m.	B. m	H. m	Qu.	Total	Explanatory notes
3.	**Corrugated Galvanised Iron sheet work** fitted, fixed with 8mm dia. 'J' or 'L' hook, bolts and nuts, sheet bolts, limpet and bitumen, washers and putty complete ·63mm (24 Gauge) sheets	2	14·30	—	4·25	—	121·5 sq m	4·25=2×2 2−·15
4.	**Galvanised Iron sheet ridging** with 23cm lap each way, fitted with necessary fittings etc. complete ·63mm (24 Gauge) sheets	1	14·30	—	—	—	14·30 r m	
5.	**Painting two-coats** over a coat of priming							
	In one truss—							
	Principal rafters ..	2	3·50	·50	—	3·50		·50=2(·10+·15) i. e. perimeter
	King post ...	1	1·76	·40	—	0·70		
	Struts ..	2	1·60	·40	—	1·28		
	Tie beam ..	1	6·80	·60	—	4·08		
	Cleats ...	2	0·14	·24	—	0·67		
			Total for 1 truss			=10·23		
		∴	Total for 4 trusses			=40·92		
	Purlins ...	2	14·30	·40	—	11·44		
	Ridge board ...	1	14·30	·38	—	5·43		
	Common rafters ...	2×16	4·25	·30	—	40·80		
	Eaves boards ...	2	14·30	·41	—	11·73		
	Wall plates ...	2	14·30	·36	—	10·30		
	Battens ...	2×5	14·30	·28	—	40·04		
						160·66	160·66 sq m	

ABSTRACT OF ESTIMATED COST

Item No.	Particulars	Quan.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Sal wood work wrought framed and fixed ..	3·6343	cu m	2200·00	cu m	7,995·46
2.	Iron work including fitting, fixing ..	1·02	quin.	450·00	quin	459·00
3.	Corrugated Galvanised iron sheet work including fitting, fixing etc. ·63mm thick (24 Gauge)	121·5	sq m	55·00	sq m	6,682·50
4.	Galvanised iron sheet ridging with 22 cm lap each way ·63 mm thick (24 Gauge) ..	14·30	r m	38·00	r m	543·40
5.	Painting two coats over a coat of priming on timber surface.	160·66	sq m	6·25	sq m	1,004·12

Total = Rs. 16,684·48
Add 5% for contingency = Rs. 834·22
Add $2\frac{1}{2}$% for work charge = Rs. 417·11
Grand Total = Rs. 17,935·81

7-9. A godown measures 18m by 9m and is provided with a pitched roofing consisting of queen-post trusses at 3m centres, purlins and common rafters with battens and Mangalore tiles. The various details of the roof are shown in figure (7-10). The walls are 50 cm thick and ends of the roof project beyond the outside face of the wall by 45cm on all sides. The short walls of the godown are provided with gables. The ends of the trusses rest on cement concrete bed blocks of 50cm × 60cm × 15cm size.

(a) Takeout the quantities of the following trades of work for the complete roof.

(i) Quantity of wood work in each truss.

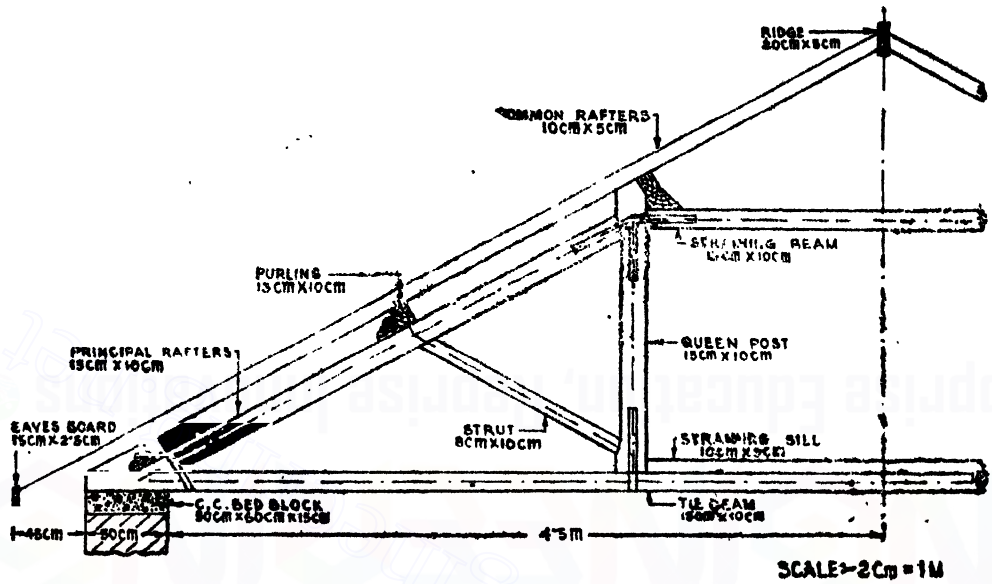
(ii) Quantity of wood work in purlins, common rafters, eaves and barge boards and ridge.

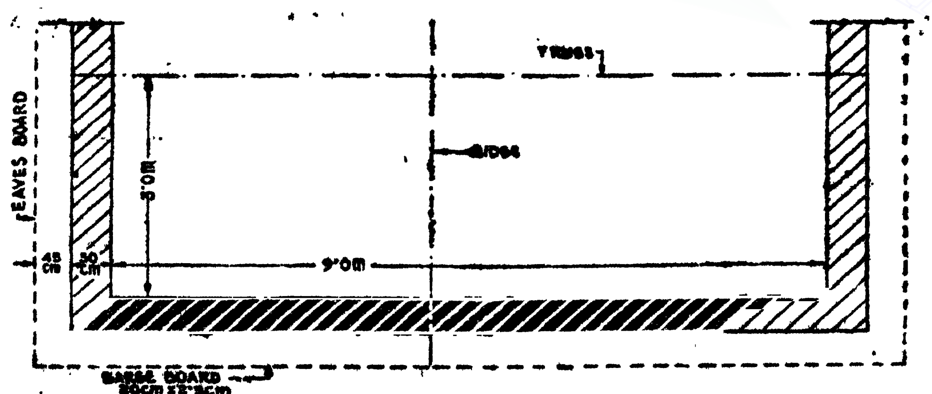
(iii) The area of the tiled roof.

(iv) Concrete bed-blocks.

(b) Prepare a bill of quantities for the above mentioned items and state the cost of each item, assuming your own rates (D.C.E. Gujrat, M.K.S. units only taken).

Ans.– Number of trusses $= \frac{18}{3} + 1 = 7$ Nos. But due to Gable walls at ends actual number $= 7 - 2 = 5$ Nos. The lengths of members have been measured from the figure by the given scale.


RIDGE
20cm x 5cm
COMMON RAFTERS
10cm x 5cm
PURLINS
13cm x 10cm
QUEEN POST
15cm x 10cm
PRINCIPAL RAFTERS
15cm x 10cm
EAVES BOARD
15cm x 2·5cm
STRUT
8cm x 10cm
C.C. BED BLOCK
30cm x 60cm x 15cm
45cm
30cm
4·5m
SCALE:- 2Cm = 1M


TRUSS
RIDGE
EAVES BOARD
3·0m
45 cm
30 cm
9·0m
SCALE:- 1Cm = 1M

PLAN FIG. 7·10

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	
(a)	**(i) Quantity of wood-work in each truss—**							
	Principal rafters ...	2	3·45	·10	·13	·0897		
	Queen posts ..	2	2·00	·10	·15	·0600		
	Struts ...	2	1·45	·03	·10	·0232		
	Tie beam ...	1	5·50	·10	·13	·0715		
	Straining beam ...	1	3·20	·10	·13	·0416		
	Straining sill ...	1	3·20	·10	·13	·0416		
	Seatings ..	2	·15	·08	·10	·0024		
	Cleats for purlins ...	4	·15	·08	·08	·0038		
			Total	for 1	truss=	·3338		
		∴	Total	for 5 tr	usses=	1·6690	1·6990 cu m	
	(ii) Quantity of wood work in purlins common rafters, eaves and barge boards and ridge.							
	Purlins ...	6	19·90	·10	·13	1·5522		19·90=18+2×·50 +2×·45(projection)
	Common rafters ...	2×81	6·10	·05	·10	4·9410		$81=\frac{19·90}{·25}+1$
	Eaves boards ...	2	19·90	·025	·15	0·0995		Barge boards are inclined pieces used
	Barge boards ...	2×2	6·10	·025	·20	·1220		to stop the ends of battens and purlins
	Ridge ...	1	19·90	·05	·20	·1990		at the Gable ends (shown in the plan)
						6·9137	6·9137 cu m	
	(iii) The area of the tiled roof ...	1	19·90	6·10	—	121 39	121·39 sq m	
	(iv) Concrete bed blocks ..	6×2	·60	·50	·15	·045	·045 cu m	

(b) Bill of Quantities and cost of each item :—

(i) Wood work (sal) in 5 trusses=1·6990 cu m @ Rs. 2200·00 per cu m=Rs. 3,737·80

(ii) Wood work (sal) in purlins
common rafters eaves and
barge boards and ridge ... =6·9137 cu m @ Rs. 2200·00 per cu m=Rs. 15,210·14

(iii) Mangalore tiled roofing ... =121·39 sq m @ Rs. 16 per sq m=Rs. 1,942·24

(iv) Concrete bed blocks 1:2:4... =0·045 cu m @ Rs. 450 per cu m=Rs. 20·25

7-10. Estimate of gusset plates and rivets—In estimating a steel truss the length and size of all main members and details may be obtained from the drawing. Number of rivets may be counted from the detail.

Some estimating departments have their tabular material form to estimate the percentage of weight of details to the weight of the main members. The percentage of details (gusset plates) is generally 16 to 20 percent of the main members and the percentage of rivets is 6 percent. A considerable difference in the percentage for gusset paltes is found due to various truss designs, but it will be found that the percentage of rivets remains at 4 to 6 percent and accordingly a figure of 5 percent should be taken to practically estimate a riveted truss. But there is no reason for not using an actual count of rivets when this can be obtained from detailed drawing.

However, the percentage weight system for gusset plates and rivets should preferably be considered in case when only the outline of the members has been shown in the drawing. In case of rivets the percentage weight system may be followed in all cases.

7-11. Approximate estimates for a steel frame Truss—The approximate weight of a steel frame truss may be calculated from the sq m of floor area, or the cubical contents of the building, the latter method being more accurate. The weight of the frame work of steel frame will vary from 50 to 80 kg per sq m while the weight of the covering will vary from 12 to 18 kg per sq m of floor area. For cubic rate estimate the weight of the frame work will vary from 6 kg 11 kg per cu m, while the weight of the covering will vary from 1·5 kg to 3·5 kg per cu m.

7-12. Estimate of cost of different types of framed steel structures—The cost of framed steel structures may be divided into the following Sub heads, (a) Cost of material, (b) Cost of fabrication, (c) Cost of erection, (d) Cost of transportation. Estimate of the crane Girder in fig. 7-15 has been prepared following the sub-heads. But in many cases all the sub-heads are included in one item only.

7-13. Estimate of a Steel Truss Prepare a correct take off of an Industrial Shade of C. G. I. sheet supported over purlins and steel trusses placed at 3m centres from the fig. 7-11. The effective span of the truss is 9m. All steel and wood work shall be painted with 2 coats of paint over a coat of priming. All Gusset plates are 10 mm thick weight @ 78 5 kg per sq m Particulars of members are shown in the table.

Section of Member mm		Length m	Section of Member mm		Length m
P. rafter	80 × 80 × 8T	5·60	Tie (horizontal)	50 × 6 I	1·84
Strut	50 × 50 × 6L	0·70	Tie (with joint 4)	50 × 6 I	2·10
Strut	60 × 60 × 6L	1·40	Tie (with joint 2)	50 × 6 I	1·85
Tie	63 × 10 I	3·60			

Note : Weight of members may be taken from steel table.

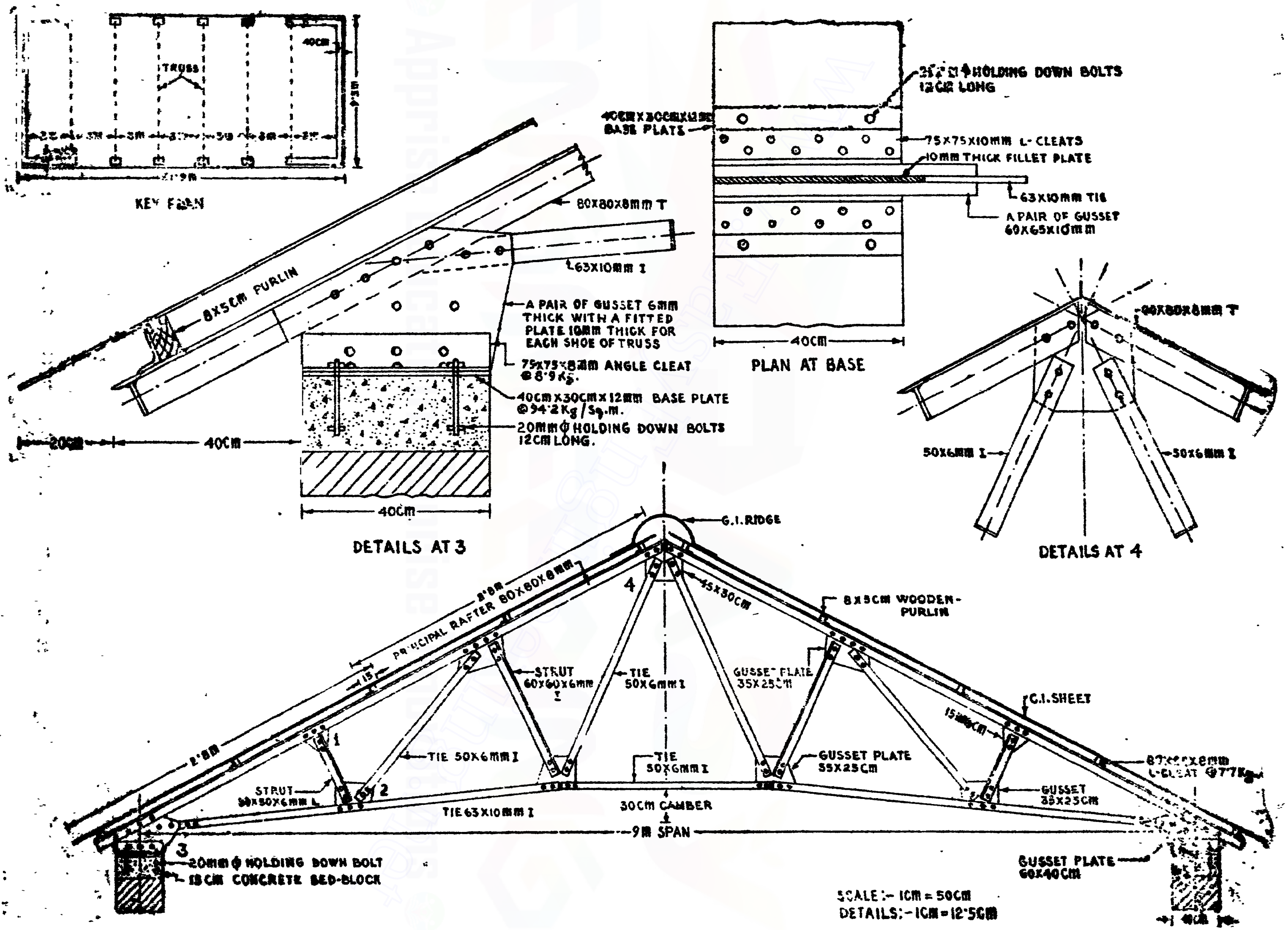

TRUSS
40cm
KEY PLAN
8x5cm PURLIN
80x80x8mm T
63x10mm I
A PAIR OF GUSSET 6mm THICK WITH A FITTED PLATE 10mm THICK FOR EACH SHOE OF TRUSS
75x75x8mm ANGLE CLEAT @8·9Kg.
40cm x 30cm x 12mm BASE PLATE @94·2Kg/Sq.m.
20mm φ HOLDING DOWN BOLTS 12cm LONG.
20cm
40cm
DETAILS AT 3
HOLDING DOWN BOLTS
12cm LONG
BASE PLATE
75x75x10mm L-CLEATS
10mm THICK FILLET PLATE
63x10mm TIE
A PAIR OF GUSSET 60x65x10mm
PLAN AT BASE
50x6mm I
DETAILS AT 4
G.I.RIDGE
PRINCIPAL RAFTER 80x80x8mm
45x30cm
8x5cm WOODEN-PURLIN
STRUT 60x60x6mm
TIE 50x6mm I
GUSSET PLATE 35x25cm
C.I.SHEET
TIE 50x6mm I
GUSSET PLATE 35x25cm
L-CLEAT
GUSSET 35x25cm
STRUT 50x50x6mm L
TIE 63x10mm I
30cm CAMBER
9m SPAN
20mm φ HOLDING DOWN BOLT
15cm CONCRETE BED-BLOCK
GUSSET PLATE 60x40cm
SCALE:- 1cm = 50cm
DETAILS:- 1cm = 12·5cm

FIG. V-11

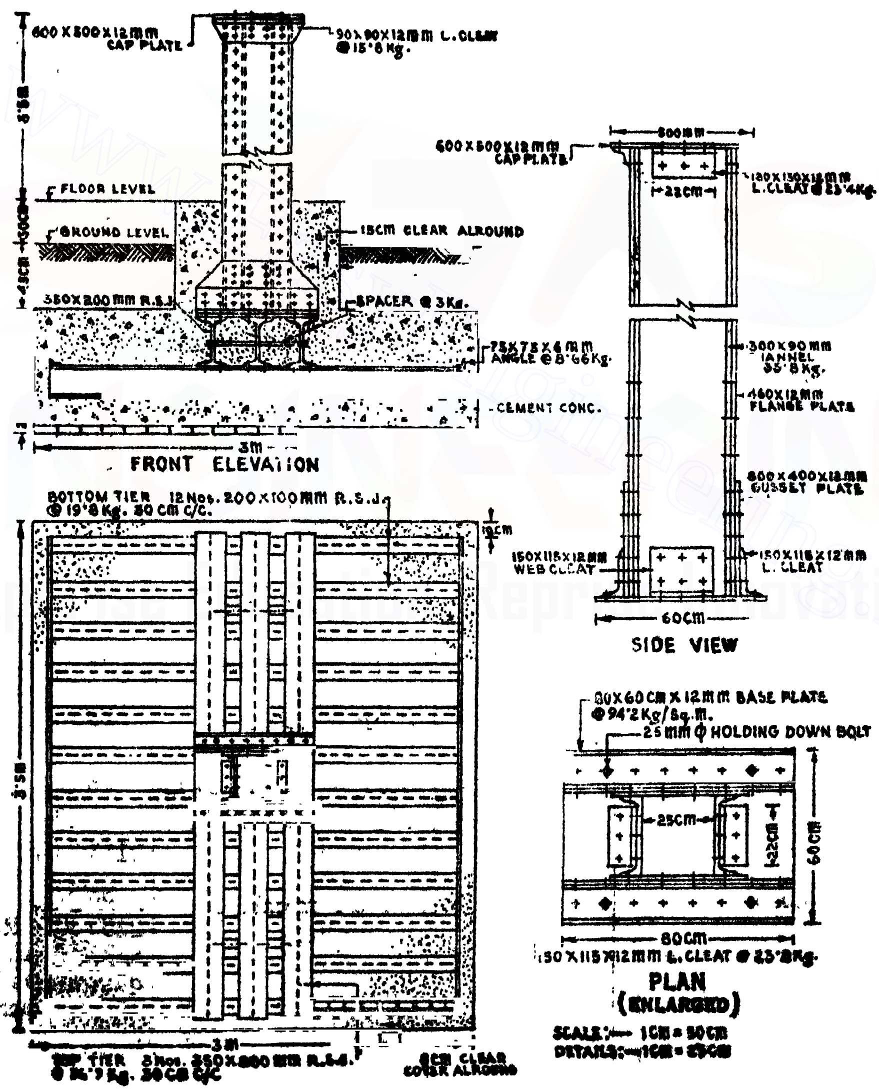
Item No.	Description	No.	L m	B. m	Quantity or content	Weight per unit	Total kg.	Explanatory notes
1.	**Steel work**							
	in one truss—							
	(a) Main members :—							
	Principal rafters 80×80×80mm T. ...	1×2	5·6	—	11·20m	9·6 kg/m	107·52	
	Struts 60×60×6mm L	1×2	1·40	—	2·80m	5·4 kg/m	15·12	
	Struts 50×50×6mm L	1×2	0·70	—	1·40m	4·5 kg/m	6·30	
	Tie 50×6mm I (hor.)	1	1·80	—	1·80m	2·4 kg m	4·32	
	Ties 63×10mm I ...	1×2	3·60		7·20m	4·9 kg/m	35·28	
	Ties 50×6mm I (at 2)	1×2	1·85	—	3·70m	2·4 kg/m	8·88	
	Ties 50×6mm I (at 4)	1×2	2·10	—	4·20m	4·20 kg/m	10·08	
							187·50	
	(b) Gusset plates 6mm thick :—							
	At apex ...	1	·45	·30	0·135sq m			
	At bases of struts ...	2×2	·35	·25	0·350 „			
	At head of struts	1×2	·15	·18	0·054 „			
	„ „ „	1×2	·35	·25	0·175 „			
	At shoe of truss ...	2×2	·60	·40	0·960 „			
					1·674 q m	47·1kg/sqm	78·85	
	(c) Rivets in truss ...		5% of	main	members ie of (a)=		9·38	
	(d) Cleats for purlins 80×50×8mmL-cleats	5×2	·08	—	0·80 m	7·7 kg/m	6·16	
	(e) Rivets for purlin cleats ...		1% of	(a)+(b)	...	... =	2·66	
	(f) Angle cleats at bases 75×75×8mm ...	2×2	·40	—	1·60 m	8·9 kg/m	14·24	
	(g) Fillet plates at bases 10mm thick	1×2	·60	·40	0·480sq m	78·5kg/sqm	37·68	
	(h) Base plates 12mm thick	1×2	·40	·30	0·120 „	94·2kg/sqm	11·30	Dimensions of fillet plate are same to that of gusset plate at shoe of the truss.
	(i) Holding Down (H.D.) bolts 20mm dia. ...	4×2	—	—	8 nos.	·50kg	4·00	
			Total	for one	truss	... =	351·77	
			Total	for six	trusses	.. =	2110·6	
						=	21·11	quintals.

Item No.	Description	No.	L. m	B. m	Quantity or content	Weight per unit	Total wt. or Qu.	Explanatory notes
2.	**Wood work in purlins**	5×2	21·30	×·05	×·80	—	·0852 cu m	15 cm bearing in end walls
3.	**Painting steel work** two coats over a coat of priming							
	In one truss :—							
	(a) Principal rafters							
	80×80×80mm T	1×2	5·60	·32	3·58			·32=2(·08+·08) i.e. per meter
	Struts 60×60×6mmL	1×2	1·40	·24	0·67			
	Struts 50×50×6mmL	1×2	0·70	·20	0·28			
	Tie 50×6mm I (hor)	1	1·80	·11	0·20			·11=2(·05+·006)
	Ties 63×10mm I	1×2	3·60	·15	1·08			
	Ties 50×6mm I (at 2)	1×2	1·85	·11	0·41			
	Ties 50×6mm I (at 4)	1×2	2·10	·11	0·46			
	(b) Gusset plates at—							
	Apex	1×2	·45	·30	0·27			
	Bases of struts	4×2	·35	·20	0·70			
	Head of struts	2×2	·15	·18	0·11			
	" "	2×2	·35	·25	0·35			
	Bases	4×2	·60	·40	1·92			
	(c) Cleats for purlins	10	·08	·26	0·21			·26=2(·08+·05)
	(d) Angle cleats at bases	4	·40	·30	0·48			30=2(·075+·075)
	(e) Fillate plates at bases	2×2	·60	·40	0·96			
	(f) Base plates	2×2	·40	·30	0·48			
		Total for one truss=12·16						
		Total for six trusses					72·96 sq m	
4.	**Painting wood work** Purlins	5×2	21·30	·26	55·38	—	55·38 sq m	
5.	**C. G. I. (corrugated Galvanized Iron) roofing** including all fittings, nuts, bolts, washers etc. complete.	2	23·00	5·45	232·17	—	232·17 sq m	5·45=2·8+2·8 −·15 (see fig.)
6	**G. I. ridging** with necessary lap and nuts, bolts, washers etc. complete.	1	21·30	—	21·30	—	21·30m	

7-14. Estimate of a Grillage Foundation—Prepare a take off sheet for construction of a Grillage foundation from the fig. 7-12. Weight of steel has been shown by the side of each member. The arrangement of the grillage is as follows :

Foundation :—Consists of two tiers of R. S. J. Bottom tier 12 Nos. 200 × 100 mm @ 30cm c/c and fixed by 2 Nos. L-cleats 75 × 75 × 6mm. Top tier 3 Nos. 350 × 200 mm @ 30cm c/c and fixed with 2 Nos. spacer tubes.

Base and head :—2 Nos. 300 × 90mm and 4·25m heigh channels placed on a base plate 80cm × 60cm × 12mm. Distance of channel is 25cm back to back. Flange plates—2 Nos. 460 × 12mm. Gusset plates—2 Nos. 800 × 400 × 12mm and 40cm heigh. Web cleats at base 2 Nos. 150 × 115 × 12mm and 22cm long ; web cleat at head 130 × 130 × 12mm—2Nos. Flange cleat at base 150 × 115 × 12mm—2Nos. and at head 90 × 90 × 12mm. Cap plate 600 × 500 × 12mm. Cover of concrete allround of tiers is 8cm.

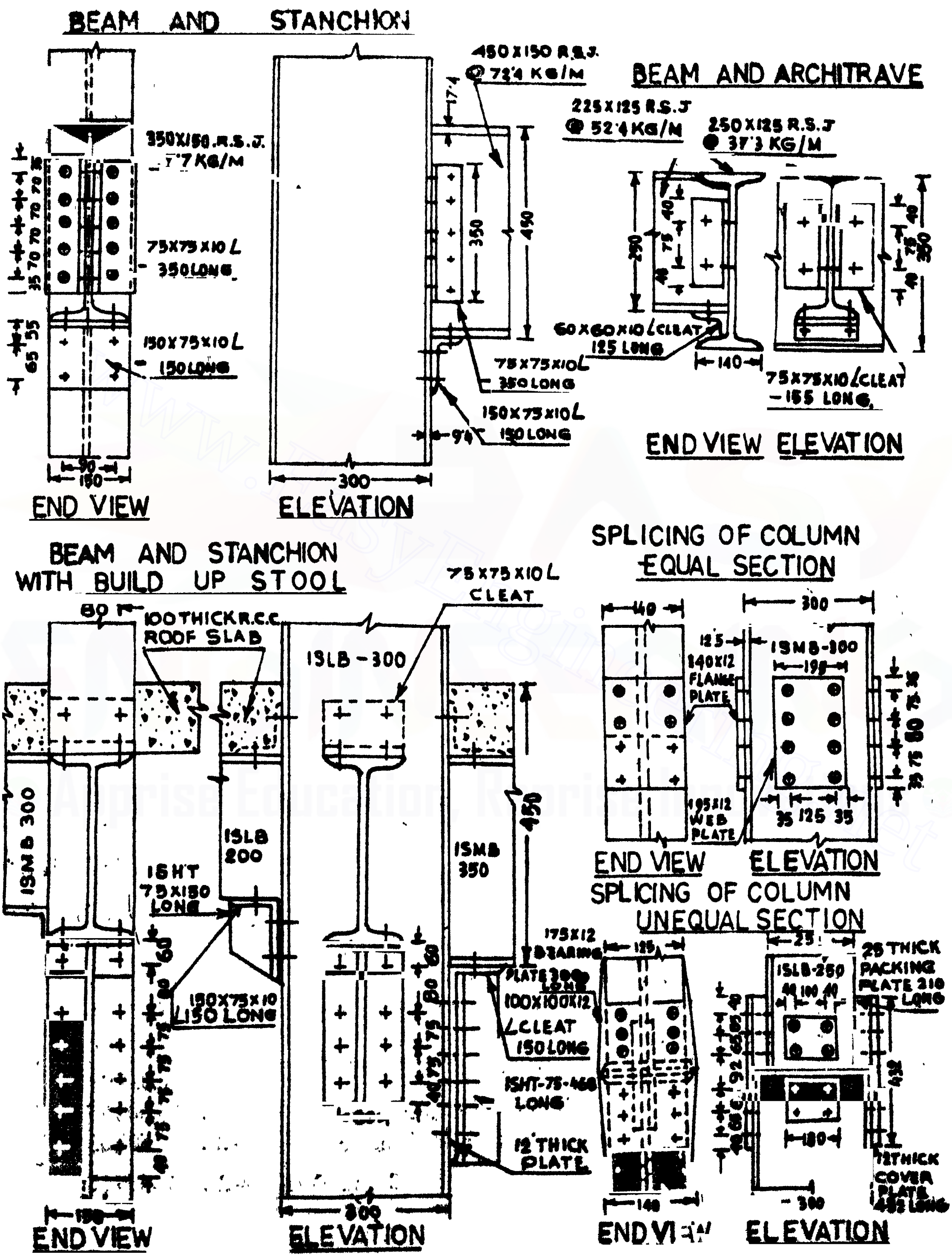


PLAN FIG. 7-12

Take of Sheet

Item No.	Description	No.	L. m	B. m	Quantity or Content	Weight per Unit	Total weight or quantity	Explanatory notes
1.	**Earthwork in excavation**	1	3·5	3·0	×1·33	(height)=	13·65 cu m	
2.	**Brick flat soling**	1	3·5	3·0	—	—	10·50 sq m	
3.	**Cement concrete in foundation (1:2:4)**							
	Lower portion	1	3·5	3·0	×·75	(height)	7·88	1·10=
	Upper portion ...	1	1·10	·90	×·75	(")	0·74	·80+2×·15
							8·62 cu m	
4.	**Steel work for—**							
	Bottom-tier 200×100mm	12	2·84	—	34·08m	18·9 kg/m	644·11	
	Bottom tier L-cleat 75×75×6mm ...	2	3·30	—	6·60m	8·66 kg/m	57·16	
	Top tier 350×200mm ..	3	3·34	—	10·02m	56·9 kg/m	570·14	
	Top tier spacer tube ...	2	·80	—	1·60m	3 kg/m	4·80	
	Base plate 12mm thick ...	1	·80	·60	·48sq m	94·2 kg/sq m	45·22	
	L-cleats 150×115×12mm thick with Gusset plates	2	·80	—	1·60m	23·8 kg/m	38·08	
	Gusset plates 12mm thick	2	·80	·40	·64sq m	94·2 kg/sq m	60·29	
	Flange plates 12mm thick ...	2	4·25	·46	3·91sq m	94·2 kg/sq m	368·32	4·25=
	300×90mm channels ...	2	4·25	—	8·5m	35·8 kg/m	304·30	·45+·30+3·50
	L-web cleats 150×115×12mm with channel at base ...	2	·22	—	·44m	23·8 kg/m	10·47	
	L-web cleats 130×130×12mm at head ...	2	·22	—	·44m	23·4 kg/m	10·47	
	L-cleats 90×90×12mm at head ...	2	·60	—	1·20m	15·8 kg/m	18·96	
	Cap plate at head 12mm thick ...	1	·60	·50	·30sq m	94·2 kg/sq m	28·26	
	Holding down bolts ...	4	—	—	4 Nos.	0·8 kg/Each	3·20	
							2163·78	
	Rivets 20 mm dia. ...	4% of the wt. of all members=					86·52	
							2250·30 =22·50 quintals	Rivets may also be taken as 30 Nos. per ton.

7-15. Some steel connections :



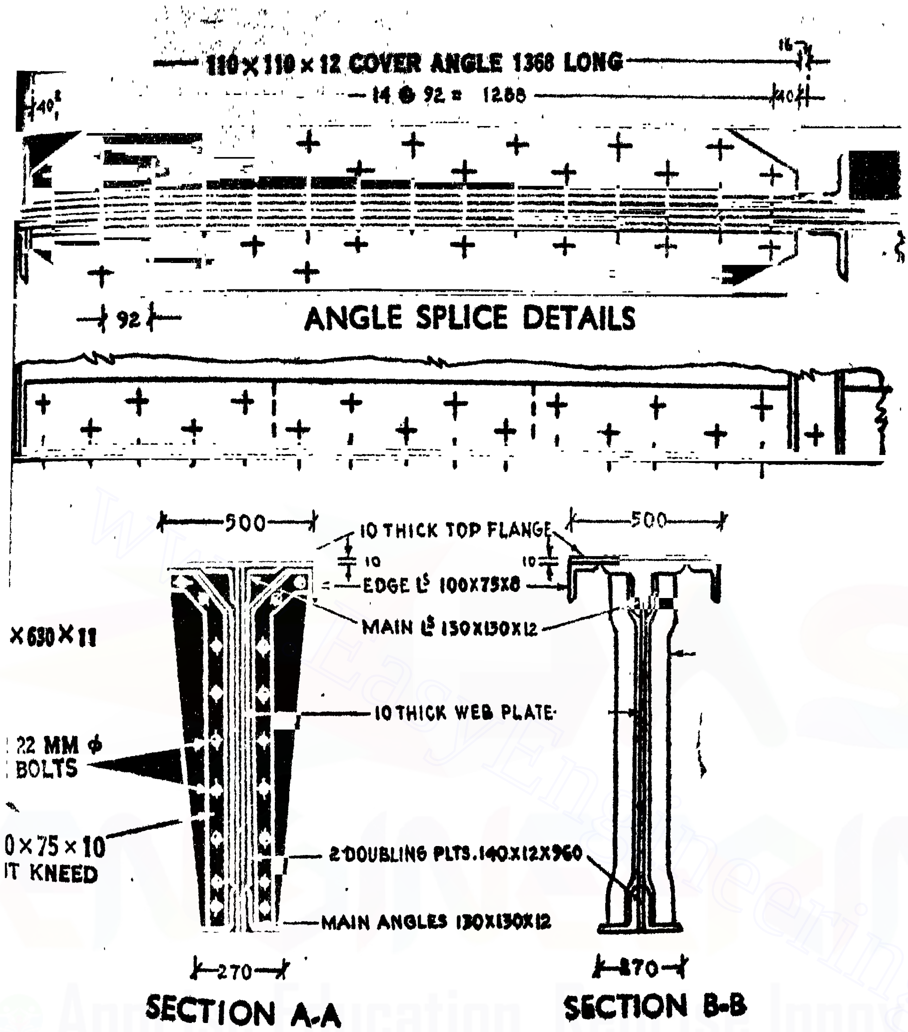
7-16. Estimate of a Spliced Girder :—*Prepare a detailed estimate of a typical crane* girder of 12m span as shown in fig. 7·15. The details of the section are as follows :

The top flange consists of two main angles of 130 × 130 × 12mm thick and a plate of size 500 × 10mm run throughout the span. The bottom flange consists of two main angles of 130 × 130 × 12mm with a plate of size 355 × 10mm which is curtailed at 4220mm from the centre of the girder. The web plate is of size 1220 × 10mm which is spliced at the centre of the girder where the shear is minimum. The top flange angles are spliced with 2L^s of 110 × 110 × 12mm, the position of which is shown in the drawing. Two edge angles of 100 × 75 × 8mm are provided on both sides of the top flange.

Item No.	Description	No.	Shape	Section mm	Length mm	Weight per m in kg	Weight in kg: Main members	Weight in kg: Details	Total weight
1.	Flange angles ..	1	L^{le}	130 × 130 × 12	3490	23·4	81·66	—	
	„ „ ..	1	L^{le}	130 × 130 × 12	8500	23·4	198·90	—	
	„ „ ..	1	L^{le}	130 × 130 × 12	3935	23·4	92·08	—	
	„ „ ...	1	L^{le}	130 × 130 × 12	8055	23·4	188·49	—	
2.	Flange splicing angles ...	2	L^s	110 × 110 × 12	1368	19·6	—	53·62	
3.	End stiffeners ..	4	L^s	100 × 75 × 10	1384	13·0	—	71·97	
4.	Intermediate stiffeners ..	18	L^s	100 × 75 × 10	1208	13·0	—	282·67	
5.	Edge angles ...	2	Pl	100 × 75 × 8	11990	10·5	—	125·98	
6.	Top flang ..	1	Pl	508 × 10	11990	39·2	470·26		
7.	Bottom flange ..	1	Pl	355 × 10	8440	27·9	235·47		
8.	Web plates ...	2	Pl	1220 × 10	5995	98·1	1176·22		
9.	Web Splicing ...	2	Pl	630 × 11	948	54·4	103·13		
10.	Stiffener plates ...	4	Pl	140 × 12	960	16·8	—	64·52	
11.	Edge plate ...	1	Pl	500 × 10	1230	39·2	—	48·22	
			2052 Nos. Rivet heads @7·27 kg pe				100—	149·20	
							2546·31	796·18	3342·50 kg
								=3·34	25 tons

ABSTRACT OF ESTIMATED COST

1.	Cost of materials 3·3425 tons @ Rs. 3,100 per ton	=Rs.	10,361·75
2.	Cost of fabrication 3·3425 tons @ Rs. 1700 per ton	=Rs.	5,682·25
3.	Cost of erection 3·3425 tons @ Rs. 1200 per ton ..	=Rs.	4,011·00
	Total	Rs.	
	Add 5% for contingency	=Rs.	1,002·75
	Add 2½% for workcharge	=Rs.	501·38



CRANE GIRDER 12M SPAN

WENTY FOURTH FULL SIZE
DIMENSIONS ARE IN MM.
CRANE RAIL IS NOT SHOWN IN THE DRAWING.

necessarily the route actually taken. For the purpose of measurements of lead,"

CHAPTER VIII

ROADS

A - EARTHWORK

8-1 Mode of measurement based on IS-1200 :—

Earthwork shall be measured in cubic metres without any allowance for increase in bulk. The volume of earthwork shall be calculated by multiplying the length, breadth and depth or height measured from the ground from which soil has been taken out.

Earthwork for different kinds of soil viz, soft or loose soil, hard or dense soil, muddy soil contains water, soft or decomposed rock, hard rock requiring blasting but excavation has to be carried out by chiselling, hard rock requiring blasting shall be classified separately.

No separate measurement shall be taken for cleaning of grass or vegetation, setting out profiles, leaving 'Dead men' or 'tell-tals' in borrow pits to check up the average depth of excavation forming steps or benching in sides of deep excavation removal of slips or falls in excavation, dewatering in excavation from rains or from sub-soils, supporting water pipe or gas pipe or electric cables, or telephone cables etc. met during excavation.

Measurement for earthwork in excavation in fairly uniform ground shall be made directly from the dimensions on the soil which has been taken out. In order to check up the average depth of excavation 'Dead men' or 'tell-tals' may be left out at a regular intervals preferably at the mid widths of borrow pits or trenches

Measurement of earthwork in excavation from undulating or uneven ground shall be calculated from the difference of levels taken by levelling instrument before and after excavation of the ground.

Wherever it is not possible or convenient to adopt any one of above two methods of measurement, the volume of earthwork shall be worked out from the corresponding volume of filling or banking after giving specific deduction for voids.

Dressing or Trimming and levelling or grading shall be described and included in the item for earthwork in excavation.

The item for earthwork in excavation to form the road embankment or filling shall include the formation of correct profile and depositing the soil in layers. The thickness of layers shall be described in the item. The method of consolidation shall also be specified.

Lead :—Lead shall be average horizontal straight practicable distance through which the earth can be carried from the sources to the place of spreading and not necessarily the route actually taken. For the purpose of measurements of lead, the area excavated shall be divided into a number of blocks and for each block the lead shall be measured from the centre of the block to the centre of the soil heaped. The unit of lead is 50m for a distance upto 500m and shall be measured as a separate item for (a) 0m to a distance not exceeding 250m, (b) distance exceeding 250m but not exceeding 500m.

The unit of lead is 500m for a distance exceeding 500m up to 5 km and shall be measured as a separate item with the following stages :—(a) lead exceeding 500m and not exceeding 1000m, (b) lead exceeding 1000m to 1500m, (c) lead exceeding 1500m to 2,000m. Such separate stages shall be provided for a distance up to 5 km.

The unit of lead is 1 km where the lead exceeds 5 km. Half or more than half km shall be deemed as one km and less than half km shall be ignored.

Lift :—Lift shall mean the average height through which the earth has to be lifted from the sources to the place of spreading. The tnit of lift is 1·5m measured from ground level in successive stages viz, (a) 0m to 1·5m (b) 1·5m to 3m and so on.

In case where excavated earth shall have to be carried over a bank and dumped on the top of bank lift shall be measured as the difference in level between the centre of gravity of the excavated earth and the formation level of the bank in successive stages of 1·5m stating commencing level.

Materials for Roadwork :—The type, quality and size of materials shall be described and their source of supply shall be stated. Measurement shall be taken in bottomless boxes or measuring boxes or in closely packed stacks prepared on level ground and measured in cubic metres. Allowance for sinkage and/or shrinkage shall be made as indicated in the article 2-5 item No. 70. The net quantity shall be arrived at after deducting this allowance from the measurement of fresh stacks and payment for supply or carriage shall be made on the net quantity thus derived.

Roadwork shall be measured in square metres except where otherwise stated. The thicknes shall be the minimum thickness after compaction. In case of soling, sub-bases etc. the measurement shall be done in square or cubic metres.

Edging shall be measured in running metres with description of material and the method of placing. Soling or bottoming of boulders shall be described stating the thickness. The description shall include filling of interstrices with spalls.

Tar or bitumen named as binder shall be described and the type grade and penetration shall be stated. Priming surfaces of water-bound macadam prior to surface dressing shall be measured separately stating the type and quantity of primer per square metre.

For cement concrete ases and Roads the strength of cement concrete to be used shall be described. Formwork for pavings shall be measured separately. Special surface finishes shall be described and measured in square metres and may be included in the main item itself. Expansion joints shall be described and measured separately and given in running metres stating the thickness and depth of the joint.

8-2. Ground cross-section for a highway—Cross sections of a highway are taken at right angles to the centre line of a project at every 30m station and at intermediate points wherever the ground changes abruptly. These are also taken at the starting points and at the ends of curves.

8-3. Cross-Sectional area having no transverse slope—Where the ground surface has no transverse slope, cross section at any place either in banking (filling) or cutting of a highway will form a trapezium. Fig. 8-1 and 8-2 represents cross sections of a high-way in banking (i e. filling) and cutting respectively.

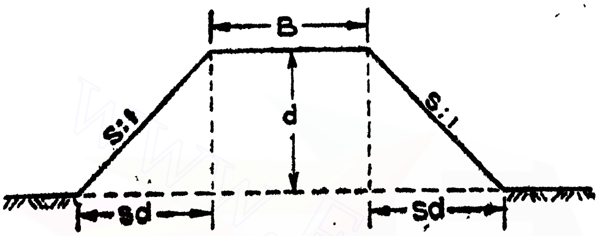


FIG. 8-1

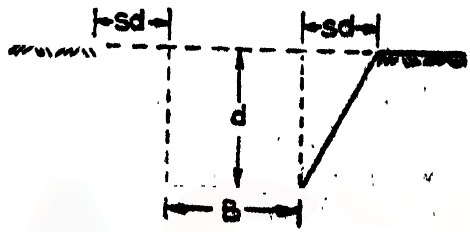


FIG. 8-2

Sectional area for Banking or Cutting

$=$ Central area, rectangular in shape $+ 2 \times$ area of sides, triangular in shape.

$= B \times d + 2(\frac{1}{2}\, s\, d \times d)$

$= Bd + s\, d^2$

where, B = crest width of road.

d = depth of banking or cutting.

s : 1 = ratio of side slope as horizontal : vertical.

8-4. Volumes of earthwork—(a) When the ground is levelled and the formation level of the road (after Banking or Cutting) has no gradient,

Volume of earthwork = Sectional area $\times$ length.

i.e $V = (Bd + sd^2) \times L$.

(b) When the ground is in a longitudinal slope or the formation level has an uniform gradient for a length 'L' quantities of earthwork may be calculated by any one of the following methods—

(i) By Mid-Section formula.

(ii) By Trapezoidal formula also known *as average end area formula.*

(iii) By Prismoidal formula.

Procedure of each of the above formula has been illustrated as hereafter.

(1) **Mid-section formula**—In this formula the mean depth is to be calculated first by averaging the depths of two consecutive sections. From the mean-depth the area of mid-section is to be worked out and volume of earthwork to be computed by multiplying the area of mid-section by the distance between the two original sections,

Referring fig. 8-3. Volume of earthwork $= A_m \times D$

Where, A_m = area of mid-section

D = distance between two consecutive sections.

To calculated A_m calculate first d_m.

$\therefore A_m = Bd_m + Sd_m^2$

$\therefore V = (Bd_m + Sd_m^2) \times D.$

To estimate the quantity of earthwork for a road whose level sections have been taken at a common distance, 'D' or one chain interval, a tabular form should be followed as shown below.

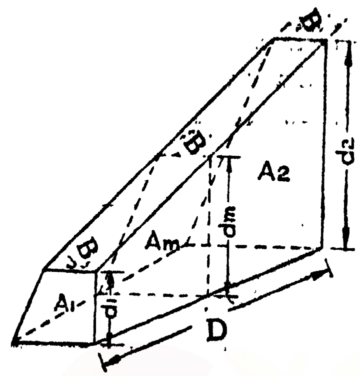


FIG.8-3

Table No.—1. For Mid Section formula

Station or chainage	Depth or height at station	Mean depth or height d_m	Area of central portion Bd_m	Area of sides Sd_m^2	Total area $Bd_m + Sd_m^2$ (A_m)	Distance between stations D	Quantity: Embankment $A_m \times D$	Quantity: Cutting $A_m \times D$

Example 1. Estimate the quantity of earthwork for an embankment, 120m long 8m wide at crest and whose side slopes is 2 to 1. The central heights at every 30m intervals are 0·60m, 1·1m, 1·6m and 1·3m.

Station or chainage	Depth or height at station	Mean depth or height d_m	Area of central portion Bd_m	Area of sides Sd_m^2	Total area $Bd_m + Sd_m^2$ (A_m)	Distance between stations D	Quantity: Embankment $A_m \times D$	Quantity: Cutting $A_m \times D$
	m	m	sq m	sq m	sq m	m	cu m	cu m
0	·60							
1	1·20	0·90	7·20	1·62	8·82	30	264·6	
2	1·60	1·40	11·20	3·92	15·12	30	453·6	
3	2·00	1·80	14·40	6·48	20·88	30	626·4	
4	1·30	1·65	13·20	5·45	18·65	30	559·5	

Total quantity of earthwork = 1904·1 cu m

(II) Trapezoidal formula or Average End area formula –

This method is based on the assumption that the mid-area of a pyramid is half the average area of the ends and the end sections are in parallel planes. If A_1 and A_2 are areas of the ends (Fig. 8-3) the volume of the prismoid is given by—

$$V = D\left(\frac{A_1 + A_2}{2}\right)$$

The mid area of a prismoid is half the average area of the ends, but, the prismoid is composed of prisms and wedges only and not of pyramids, therefore the volume of the prismoid is over estimated. But since the earth solid is not in general exactly represented by a prismoid, this method may be accepted as sufficiently accurate for most practical purposes For more accuracy prismoidal correction is applied which is equal to the difference between the volume as calculated and that which could be obtained by the use of prismoidal formula.

Quantity of earthwork may be calculated in a tabular form as shown below.

Table No.—2 For Trapezoidal formula :

Station or chainage	Depth of central portion d	Area of central portion Bd	Area of sides Sd^2	Total sectional area $BD+Sd^2$	Total mean sectional area	Distance D	Quantity L×T. M. area: Embank-ment	Quantity L×T. M. area: Cutting

Let us now calculate the volume of earthwork between a number of sections having areas A_0, A_1, A_2 A_{n-1}, A_n spaced at a common distance D.

Volume between first two sections $= \frac{D}{2}\left(A_0 + A_1\right)$

" " 2nd " " $= \frac{D}{2}\left(A_1 + A_2\right)$

" " n–1 " " $= \frac{D}{2}\left(A^2 + A_{n-1}\right)$

" " last or nth " " $= \frac{D}{2}\left(A_{n-1} + A_n\right)$

$$\therefore \text{ Total volume} = \frac{D}{2}\left(A_0 + A_1 + A_1 + A_2 + A_2 + A_{n-1} + A_{n-1} + A_n\right)$$

$$= \frac{D}{2}\left(A_0 + 2A_1 + 2A_2 + \cdots + 2A_{n-1} + A_n\right)$$

To find out the difference between the mid-section and Trapezoidal formula example-1 has also been worked out as follows :—

The cross-sectional area from 8-3, $A = Bd + Sd^2 = (B + Sd)d$ In this example B = 8m and S = 2

$\therefore A_0 = (8 + 2 \times \cdot 6) \times \cdot 6 = 5{\cdot}52$ sq m $\quad A_1 = (8 + 2 \times 1{\cdot}1) \times 1{\cdot}1 = 11{\cdot}22$ sq m

$A_2 = (8 + 2 \times 1{\cdot}6) \times 1{\cdot}6 = 17{\cdot}92$ sq m $\quad A_3 = (8 + 2 \times 2{\cdot}0) \times 2{\cdot}0 = 24{\cdot}00$ sq m

$A_4 = (8 + 2 \times 1{\cdot}3) \times 1{\cdot}3 = 13{\cdot}78$ sq m

Applying Trapezoidal formula

$$\text{Volume, } V = \frac{30}{2}\left\{5{\cdot}52 + 2(11{\cdot}22 + 17{\cdot}92 + 24{\cdot}00) + 13{\cdot}78\right\} = 15 \times 125{\cdot}18 = 1883{\cdot}7 \text{ cu m.}$$

(III) Prismoidal formula—This formula is based on the assumption that end sections are in parallel planes. Following the notations as stated in (ii)

$$V=\frac{D}{3}\left\{\text{First Area}+\text{last Area}+4\Sigma\text{ even Areas}+2\Sigma\text{ odd Areas}\right\}$$

i.e. $$V=\frac{D}{3}\left\{A_0+A_n+4(A_1+A_3+\ldots\ldots\ \ldots+A_{n-1})+2\Big(A_2+A_4+\ldots\ldots+A_{n-2}\Big)\right\}$$

If the value of D i.e. the distance between two consecutive sections can not be kept constant throughout, the volume must be calculated in separate stages over which the value of D is constant for a stage and the results are added.

Note that the number of sections, must be odd to apply the prismoidal formula. In case of even number of sections, the end strip must be treated separately and the volume of the remaining strips should be calculated by the prismoidal formula.

The volume of the last strip may be calculated either by trapezoidal or by prismoidal formula. If prismoidal formula is used the mid-section of the last strip should be calculated by averaging the corresponding linear dimensions of the end strip as worked out in example 7.

To calulate the quantity of earthwork for only one strip prismoidal formula is also expressed as $V=\frac{L}{6}(A_1+A_2+4Am)$

Where, L=Length of the entire strip, A_1 and A_2 =sectional areas at ends,
Am=area of mid section.

The above form has also been based on the same formation of prismoidal formula as described before. For only three sections in number, the total length of the strip has been taken instead of the distance between two consecutive sections, D i.e. $L/_2$.

Thus $$V=\frac{L/_2}{3}\Big(\text{1st. Area}+\text{last Area}+4\Sigma\text{ even Areas}+2\Sigma\text{ odd Areas}\Big)$$

Here, 4Σ even Areas=4 Am. 2Σ odd Areas=O

$$\therefore\ V=\frac{L}{6}\Big(A_1+A_2+4Am\Big)$$

Deriving further—

$$=\frac{L}{6}\left[\Big(Bd_1+sd_1^2\Big)+\Big(Bd_2+sd_2^2\Big)+4\left\{B\frac{d_1+d_2}{2}+s\Big(\frac{d_1+d_2}{2}\Big)^2\right\}\right]$$

$$=\frac{L}{6}\left[\Big(Bd_1+Bd_2+4\frac{Bd_1}{2}+4\frac{Bd_2}{2}\Big)+\Big(sd_1^2+sd_2^2+4s\times\frac{d_1^2+2d_1d_2+d_2^2}{4}\Big)\right]$$

$$=\frac{L}{6}\left[\Big(3Bd_1+3Bd_2\Big)+\Big(2sd_1^2+2sd_2^2+2sd_1d_2\Big)\right]$$

$$=\frac{L}{6}\left[3B\Big(d_1+d_2\Big)+2s\Big(d_1^2+d_2^2+d_1d_2\Big)\right]$$

$$=\frac{LB}{2}(d_1+d_2)+\frac{Ls}{3}(d_1^2+d_2^2+d_1d_2)$$

$$=L\left\{B\left(\frac{d_1+d_2}{2}\right)+s\left(\frac{d_1^2+d_2^2+d_1d_2}{3}\right)\right\}$$

=Length × [Area of central portion + Area of side slopes]

=Volume of earth work of central portion + Volume of earth work for sides

=Total volume of earthwork.

Quantity of earthwork for a number of sections may be calculated forming a table as set in example II.

Applying prismoidal formula on example—I, we have the number of sections as five i.e. odd

$$\therefore V=\frac{D}{3}\left\{\text{1st. Area}+\text{last Area}+4\Sigma\text{ even Areas}+2\Sigma\text{ odd Areas}\right\}$$

Putting the values of areas as already calculated in the trapezoidal formula.

$$V=\tfrac{30}{3}\{5{\cdot}52+13{\cdot}78+4\ (11{\cdot}22+24{\cdot}00)+2\times17{\cdot}92\}=\tfrac{30}{3}\times196{\cdot}02=1960{\cdot}2\text{ cu m.}$$

Prismoidal formula should be adopted to obtain more accurate result although Mid-Section formula is generally used when great accuracy is not wanted considering the rate of earthwork.

8.5 Area of turfing or pitching on sloping surface—

First of all calculate mean depth, dm,

Width of turfing $=\sqrt{dm^2+(s\ dm)^2}$

$=dm\sqrt{1+s^2}$

$\therefore$ Area of side slopes at both faces

$=2L\ dm\ \sqrt{1+s^2}$

where, L=Length of the road turfed.

To calculate the area of turfing along with earthwork an additional column as shown in Example-3 may be provided. But to calculate this separately a tabular form may be used as below—

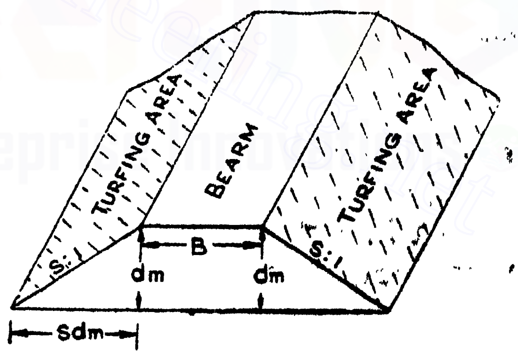


FIG. 8-4

Station or chainage	Depth or height	Mean depth or height dm	Width of turfing $dm\sqrt{1+s^2}$	Distance between stations D	Total area both sides $2D\times dm\sqrt{1+s^2}$

Example—2. Earthwork of a tank :—

Find the volume of earthwork of a tank which is excavated in level ground to a depth of 4m. The top of the tank is rectangular in shape has an area of $50m \times 40m$ and side slope of the tank is 2 : 1.

Ans :—For a side slope of 2 : 1, Length at bottom $= 50 - 2\,s\,d = 50 - 2 \times 2 \times 4 = 34m$

Breadth at bottom $= 40 - 2\,s\,d = 40 - 2 \times 2 \times 4 = 24m$

(a) Applying Prismoidal formula for a single strip $V = \frac{L}{6}(A_1 + A_2 + 4Am)$

$L = 4$ m

$A_1 = 50 \times 40 = 2000$ sq m, $A_2 = 34 \times 24 = 816$ sq m

Am = Area of mid section from the mean linear dimensions

$= \frac{1}{2}(50+34) \times \frac{1}{2}(40+24) = 42 \times 32 = 1344$ sq m

$\therefore\ V = \frac{4}{6}(2000 + 816 + 4 \times 1344) = 5461{\cdot}33$ cu m

(b) Applying Trapezoidal or Average end area formula—The mean of the linear dimensions of the tank $= 42 \times 32 = 1344$ sq m. $\therefore$ Volume $= 1344 \times 4 = 5376$ cu m.

An incorrect result has been obtained by the method (b) The discrepancy between the results would have been much less had the areas of top and bottom of the tank been more nearly equal.

So in order to compute the volume of cutting or embankment, cross sections are taken at sufficiently close intervals.

Example—3. The longitudinal section of a road has been shown in the fig. 8-5. Estimate the quantities of (a) earthwork in embankment having a side slope of 2 : 1, (b) earthwork in cutting having a side slope $1\frac{1}{2}$: 1 and (c) turfing to the sides of banking only. Formation width of the road is to be 12m and the ground has no transverse slope.

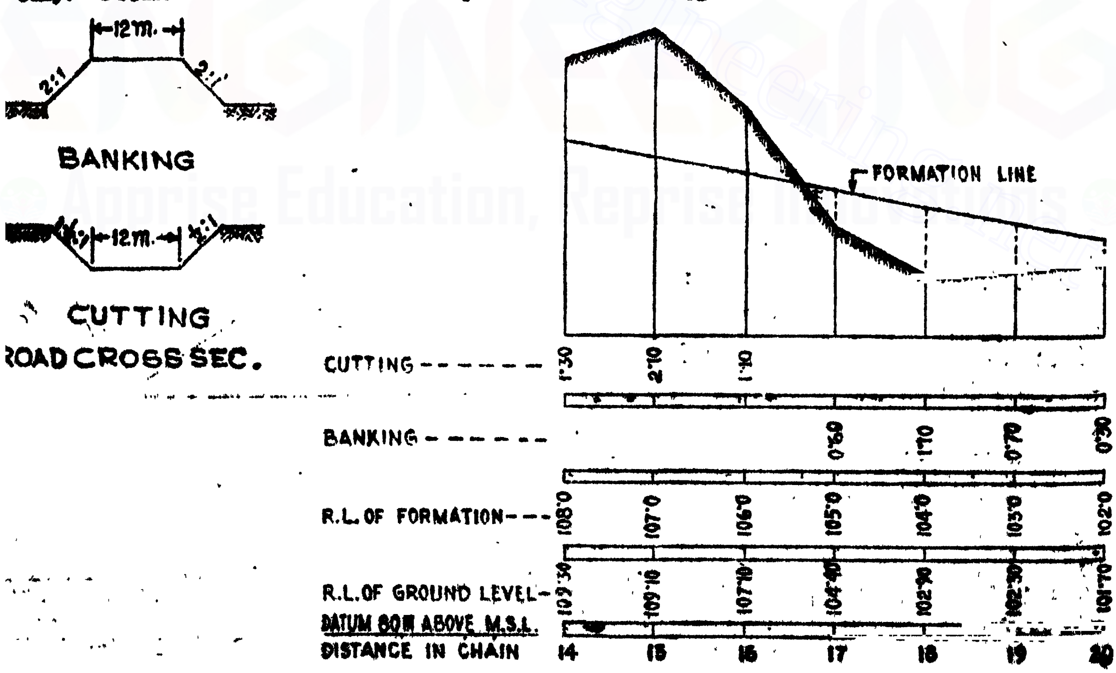


FIG. 8-5

Following the mid-section farmula quantities have been calculated in a tabular form. Depth of cutting and banking has been indicated by $-$ve and $+$ve signs respectively. The portion of cutting and banking between 16th and 17th chainage has been found from similar Δs. (Fig. 8-6). B=12 ; S=2 for embankment and 1·5 for cutting.

Section at chainage	Depth at Station m	Mean depth dm m	Area of central portion B dm m	Area of side slopes S dm² sqm	Total area Bdm+Sdm² sqm	Distance D m	Quantity D(Bdm+Sdm²) Embankment cum	Quantity D(Bdm+Sdm²) Cutting cum	Turfing: Length of side slopes $dm\sqrt{1+S^2}$	Turfing: Total area $=2D\times dm\sqrt{1+S^2}$
14	1·30	—								
15	2·10	1·70	20·4	4·34	24·74	30	—	742·2		
16	1·10	1·60	19·2	3·84	23·04	30	—	691·2		
	0	0·55	6·6	0·45	7·05	20	—	141·0		
17	0·60	0·30	3·6	0·18	3·78	10	37·8	—	0·67	13·40
18	1·10	0·85	10·2	1·45	11·65	30	349·5	—	1·90	114·00
19	0·70	0·90	10·8	1·62	12·42	30	372·6	—	2·01	120·60
20	0·30	0·50	6·0	0·50	6·50	30	195·0	—	1·12	67·20
							954·9 cu m	1574·4 cu m		315·20 sq m

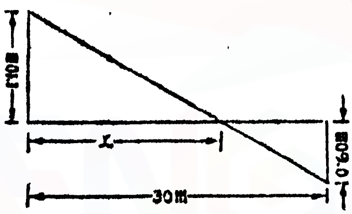


FIG. 8-6

$$\frac{x}{1 \cdot 1}=\frac{30-x}{0 \cdot 6} \text{ or } \cdot 6x=33-1 \cdot 1x$$

$$\therefore\ x=\frac{33}{1 \cdot 7}=20\text{m (say)}$$

Example 4.—Estimate the quantity and cost of earthwork for a road between two stations A to B with the following datas—

Width of road is 10m at formation surface and side slope 2 : 1. Rate for earthwork in banking and cutting may be taken as Rs. 2·00 per cubic metre including a lead upto 150m. with a condition that portion of earthwork available from cutting is to be utilised for banking within the same lead of 150m. The datas of field book for the portion of road are as below—

Chainage	0	1	2	3	4	5	6
Reduced level	123·90	125·00	124·60	122·90	121·60	121·00	120·40
Formation level	123·20	123·60	124·00	123·60	123·20	122·80	122·40

[*One chain=30m*]

Ans.—Calculating the quantity of earthwork through mid-section formula and denoting the depths of cutting and banking by—ve and+ve sings respectively a table has been framed below :—

The portions of cutting and banking between 2nd and 3rd chainage have been found from similar triangles. Let the dist. from 2nd chainage upto the portion of cutting be x

$$\therefore \frac{x}{\cdot 60} = \frac{30-x}{\cdot 70} \quad \therefore x = 14 \text{ m}$$

B=10m, S=2

Chainage	Depth m	Mean depth dm m	Area of central portion Bdm	Area of sides Sdm^2	Total area $Bdm+Sdm^2$	Distance D	Quantity=D(Bdm+Sdm^2) Cutting	Embankment
			sq m	sq m	sq m		cu m	cu m
0	—0·70	—						
1	—1·40	—1·05	10·50	2·21	12·71	30	381·3	—
2	—0·60	—1·00	10·00	2·00	12·00	30	360·0	—
	— 0	—0·30	3·00	0·18	3·18	14	44·5	—
3	0·70	0·35	3·50	0·25	3·75	16	—	60·0
4	1·60	1·15	11·50	2·65	14·15	30	—	424·5
5	1·80	1·70	17·00	5·78	22·78	30	—	683·4
6	2·00	1·90	19·00	7·22	26·22	30	—	786·6
						Total=	785·8 cu m	1954·5 cu m

Since quantity of earthwork in cutting from 0 to 2·14 chainage may be utilized in banking within a range of 150 m (or 5 chains) lead, balance quantity of earthwork required for banking=1954·5−785·8=1168·7 cu m.

∴ Total quantity of earthwork is to be paid=785·8+1168·7=1954·5 cu m.

∴ Cost of earthwork @ Rs. 2·00 per cu m=1954·5×2=Rs. 3,909·00.

Example-5. The ground levels of a proposed longitudinal road section of the consecutive points 30m apart are as below :—

Distance	0	30	60	90	120	150	180	210
Ground level	110·40	111·40	114·10	113·30	112·70	112·90	114·40	113·90

The formation level at 0 chainage be 0·60m below the ground level and thence rises uniformly on a gradient 1 in 60. If the crest width be 10m and side slopes 2 : 1 estimate the volume of earthwork by the standard Trapezoidal formula.

Ans :—

Considering the formation level, as 0·60m below G.L. at 0 chainage and thence an uniform rise of 1 in 60, formation levels and depths of cutting and banking for all stations have been calculated below.

Distance	0	30	60	90	120	150	180	210
Ground level	111·40	112·40	114·10	113·30	112·70	112·90	114·40	113·90
Formation level	110·80	111·40	112·00	112·60	113·20	113·80	114·40	115·00
Depth of cutting	0·60	1·00	2·10	0·70				
Depth of banking					0·50	0·90	0	1·10

Studying the table as framed above it is noticed that cutting occurs from distance 0 upto a point between 90m and 120m. Let the dist. from 90m upto the portion of cutting be x.

$$\therefore \frac{x}{\cdot 70}=\frac{30-x}{\cdot 50} \quad \therefore x=17{\cdot}5 \text{ m} \quad \therefore \text{Cutting occurs upto } 107{\cdot}5\text{m}$$

Cross sectional area, A=(B+sd) d

For cutting :—

$A_0=(10+2\times\cdot60)\cdot60 \quad =11{\cdot}2\times\cdot60 \quad =6{\cdot}72$ sq m

$A_1=(10+2\times1)\times1 \quad =12{\cdot}0\times1 \quad =12{\cdot}00$ „

$A_2=(10+2\times2{\cdot}1)2{\cdot}1 \quad =14{\cdot}2\times2{\cdot}1 \quad =29{\cdot}82$ „

$A_3=(10+2\times\cdot70)\cdot70 \quad =11{\cdot}40\times\cdot70=7{\cdot}98$ „

$\therefore$ Volume of earthwork in cutting upto 90m $+\frac{30}{2}\{6{\cdot}72+2\ 12{\cdot}00+29{\cdot}22)+7{\cdot}98\}$

$=15\times98{\cdot}34=1{,}475{\cdot}1$ cu m

Volume of earthwork in cutting from 90m upto 107·5m$=\frac{17{\cdot}5}{2}(7{\cdot}98+0)=69{\cdot}8$ cum

$\therefore$ Total volume in cutting$=1{,}475{\cdot}1+69{\cdot}8=1{,}544{\cdot}90$ cu m

For banking :—

$A_4=(10+2\times\cdot5)\cdot5 \quad =11\times\cdot5=5{\cdot}50$ sq m

$A_5=(10+2\times\cdot9)\cdot9 \quad =11{\cdot}8\times\cdot9=10{\cdot}62$ sq m

$A_6=(10+2\times0)0 \quad =0$

$A_7=(10+2\times1{\cdot}1)1{\cdot}1 \quad =12{\cdot}2\times1{\cdot}1=13{\cdot}42$ sq m

Volume of earthwork in banking from 120m to 210m $=\frac{30}{2}\left\{5{\cdot}5+2(10{\cdot}62+0)+13{\cdot}42\right\}$

$=602{\cdot}4$ cu m

Volume of earthwork in banking from 107·5m to 120m$=\frac{12{\cdot}5}{2}\left(0+5{\cdot}5\right)=34{\cdot}40$ cu m

$\therefore$ Total volume in banking$=602{\cdot}4+34{\cdot}4=636{\cdot}8$ cu m

$\therefore$ Grand total volume of earthwork in cutting and banking$=1544{\cdot}9+636{\cdot}8=2{,}181{\cdot}7$ cu m.

Example—6. Estimate the quantities of earthwork in part of an embankment 60m long (of uniform gradient) when the height of bank is 3m at one end and 1·8m at the other. The width of embankment at top is 6m and its side slopes are 1½ : 1. The longitudinal and transverse gradient of the ground is nil.

Ans :—

Applying prismoidal formula, Quantity$=\frac{L}{6}\left\{A_1+A_2+4A_m\right\}$

Where, A_1=Sec. area at one end$=(B+Sd_1)d_1=(6+1{\cdot}5\times3)3=31{\cdot}5$ sq m

A_2=Sec. area at other end$=(B+Sd_2)d_2=(6+1{\cdot}5\times1{\cdot}8)1{\cdot}8=15{\cdot}66$ sq m

A_m=area of mid. section, Mean depth $d_m=\frac{3+1{\cdot}8}{2}=2{\cdot}4$ m

$\therefore$ $A_m=(B+Sd_m)d_m=(6+1{\cdot}5\times2{\cdot}4)2{\cdot}4=23{\cdot}04$ sqm

L=Total length of embankment 60m

$\therefore$ Quantity$=\frac{60}{6}\left\{31{\cdot}5+15{\cdot}66+4\times23{\cdot}04\right\}=1393{\cdot}2$ cu m.

Example—7 Estimate the quantity of earthwork to be required according to standard prismoidal formula in a road embankment having 10m formation width with 2 : 1 side slope in a length of 7 chains (30m). The central difference of formation and ground level is 0·70m, 1·20m, 2m, 1m, 1·5m, 2·1m, 1·8m and 1·5m at 0 to 7th chain respectively. Assume the ground is level in a direction transverse to the centre line.

Ans :—The cross sectional area, $A=(B+Sd)\,d$.

$A_0=(10+2\times{\cdot}7){\cdot}7 \quad =11{\cdot}4\times{\cdot}7 \quad =7{\cdot}98$ sq m

$A_1=(10+2\times1{\cdot}2)1{\cdot}2 \quad =12{\cdot}4\times1{\cdot}2 \quad =14{\cdot}88$ „

$A_2=(10+2\times2)2 \quad =14\times2 \quad =28{\cdot}00$ „

$A_3=(10+2\times1)1 \quad =12\times1 \quad =12{\cdot}00$ „

$A_4=(10+2\times1{\cdot}5)1{\cdot}5 \quad =13\times1{\cdot}5 \quad =19{\cdot}50$ „

$A_5=(10+2\times2{\cdot}1)2{\cdot}1 \quad =14{\cdot}2\times2{\cdot}1 \quad =29{\cdot}82$ „

$A_6=(10+2\times1{\cdot}8)1{\cdot}8 \quad =13{\cdot}6\times1{\cdot}8 \quad =24{\cdot}48$ „

$A_7=(10+2\times1{\cdot}5)1{\cdot}5 \quad =13{\cdot}0\times1{\cdot}5 \quad =19{\cdot}50$ „

Since the total number of sections is 8 i. e., even therefore, volume of last strip is to be calculated separately.

$\therefore$ Volume of earthwork upto 6th chain

$$V=\frac{D}{3}\left\{A_0+4\Sigma\text{ even areas}+2\Sigma\text{ odd areas}+An\right\}$$

Where, A_0=area of 1st and An=area of last sections.

$$\therefore\ V=\frac{30}{3}\left\{A_0+4(A_1+A_3+A_5)+2(A_2+A_4)+A_6\right\}$$

$$\text{or}\quad V=\frac{30}{3}\left\{7{\cdot}98+4(14{\cdot}88+12{\cdot}00+29{\cdot}82)+2(28{\cdot}00+19{\cdot}50)+24{\cdot}48\right\}$$

$$=10\times354{\cdot}26=3542{\cdot}6\text{ cu m.}$$

For last strip—

Mean depth $d_m=\frac{1{\cdot}8+1{\cdot}5}{2}=1{\cdot}65$ m,

$\therefore$ $A_m=(10+2\times1{\cdot}65)1{\cdot}65=13{\cdot}3\times1{\cdot}65=21{\cdot}95$ sq m

$\therefore$ Vol. of last strip applying prismoidal formula $V=\frac{L}{6}\left\{A_6+A_7+4A_m\right\}$

$=\frac{30}{6}\left\{24{\cdot}48+19{\cdot}50+4\times21{\cdot}95\right\}=658{\cdot}9$ cu m.

$\therefore$ Total volume of earthwork$=3542{\cdot}6+658{\cdot}9=4201{\cdot}5$ cu m.

8. Prepare a detailed estimate of earthwork for a length of 1 km of a road from the following datas—

Formation width of the road is 10m and the ground has no transverse slope. Side slopes 1½ : 1 in cutting and 2 : 1 in banking. The rate of earthwork in cutting is Rs. 260·00% cu m and in banking is Rs. 275% cum.

Distance in metre		100	200	300	400	500	600	700	800	900	1000
Ground level	72·76	72·41	71 80	72·00	71·48	70·75	70·44	70·46	70·96	71·23	71·64
Formation level	72·00 Downward gradient 1 in 400 upto 500m						Upward gradient 1 in 400 upto 1000m				

Draw also the longitudinal section of the ground showing the ground levels and formation levels.

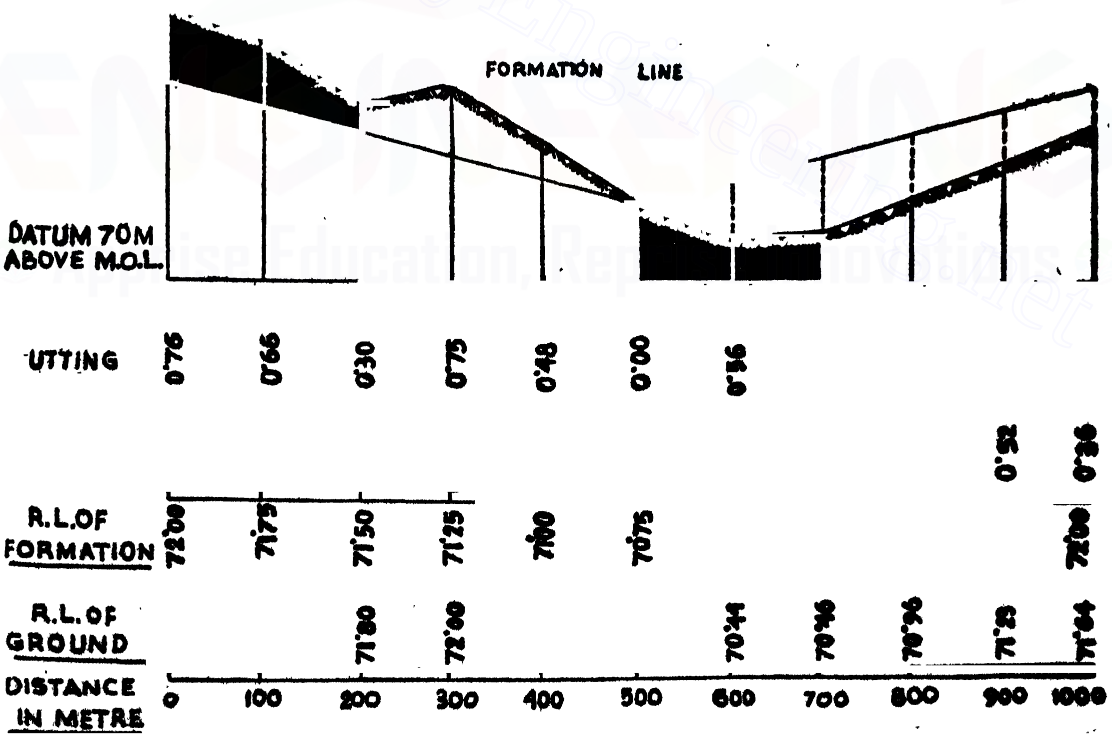


FIG. 8-7

Calculating the quantities of earthwork through Mid-section formula and denoting the depths of cutting by -ve sign and banking by + ve sign a table has been framed below.

B=10m, S=1½ for cutting, S=2 for banking.

Station at a dist. in m	Depth or height at station m	Mean depth or height m	Area of central portion B dm sq m	Area of sides S dm² sq m	Total area B dm + Sdm² sq m	Distance D m	Quantity D (Bdm + Sdm²) Banking cu m	Cutting cu m
0	—0·76	—	—	—	—	—	—	—
100	—0·66	0·71	7·10	0·76	7·86	100	—	786
200	—0·30	0·48	4·80	0·35	5·15	100	—	515
300	—0·75	0·525	5·25	0·41	5·66	100	—	566
400	—0·48	0·615	6·15	0·57	6·72	100	—	672
500	0·00	0·24	2·40	0·09	2·49	100	—	249
600	0·56	0·28	2·80	0·12	2·92	100	292	—
700	0·79	0·675	6·75	0·68	7·43	100	743	—
800	0·54	0·665	6·65	0·66	7·31	100	731	—
900	0·52	0·53	5·30	0·42	5·72	100	572	—
1000	0·36	0·44	4·40	0·29	4·69	100	469	—
						Total=	2807 cum	2788 cum

ABSTRACT OF ESTIMATED COST

Sl. No.	Description	Qu.	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Earthwork in embankment	2807	cu m	275·00	% cu m	7719·25
2.	Earthwork in cutting	2788	cu m	260·00	% cu m	7248·80

Total= 14,968·05

Add 5% for contingency= 748·40

„ 2½% for W. C. = 374·20

Grand Total=Rs. 16,090·65

Example-9 The ground surface of a proposed railway embankment has a downward slope, 1 in 50 from zero chainage for a length of 210m. The embankment should be of 0·60m height at zero chainage and have a falling gradient of 1 in 140 with formation width of 12m and side slopes 2 : 1. Estimate the quantity of earthwork in cubic metre for the entire work assuming the ground having no transverse slope Apply prismoidal formula.

Ans. :—Referring to the fig. 8-8

Fall of the ground surface.

$=210\times\frac{1}{50}=4{\cdot}2$m at 210m.

When formation level has no fall, then depth of embankment at 210m.

$=4{\cdot}2+{\cdot}60=4{\cdot}8$m.

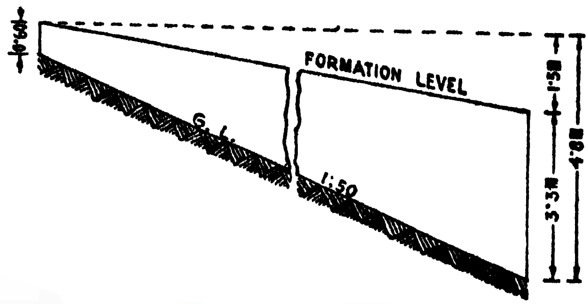


FIG.8-8

Since, the formation surface has a fall of $210\text{m}\times\frac{1}{140}=1{\cdot}5$m at 210m

$\therefore$ Actual depth of embankment at $210\text{m}=4{\cdot}8\text{m}-1{\cdot}5\text{m}=3{\cdot}3$m

Height at mid-length of the embankment $dm=\dfrac{{\cdot}60+3{\cdot}3}{2}=1{\cdot}95$m

Applying prismoidal formula, $\text{Quantity}=\dfrac{L}{6}(A_1+A_2+4Am)$

where, A_1 = Sec. area at one end $=(B+Sd_1)\,d_1=(12+2\times{\cdot}60)\,{\cdot}60=7{\cdot}92$ sq m

A_2 = Sec. area at other end $=(B+Sd_2)d_2=(12+2\times3{\cdot}3)3{\cdot}3=61{\cdot}38$ sq m

Am = area at mid-section $=(B+Sdm)\,dm=(12+2\times1{\cdot}95)1{\cdot}95=31{\cdot}00$ sq m

L = Total length = 210m

$\therefore$ $\text{Quantity}=\frac{210}{6}(7{\cdot}92+61{\cdot}38+4\times31)=6765{\cdot}5$ cu m.

8-6. Earthwork on curvature of a road without transverse slope :—

In case a road having no transverse slope and also superelevation being neglected cross section at any point on the curved length is symmetrical about the centre axis and therefore, curvature correction for volumes is not necessary. But in case a road having superelevation or cross slope curvature correction for volumes becomes necessary.

Example 10. A portion of road embankment (of uniform gradient) in a circular curve of radius 610m (centre line) subtends an angle of 90° at the centre. Calculate the quantity of earthwork if the height of the bank is 3m at one tangent point, and 1·2m at the other tangent point, crest width is 9·75m and side slope is 1 : 2. Neglect transverse slope of ground and superelevation.

Applying prismoidal formula, Quantity$=\frac{L}{6}(A_1+A_2+4A_m)$

Considering side slope vert : hor : : 1 : 2 : : 1 : S

where, A_1=Sec. area at one end$=(B+Sd_1)d_1$

$=(9{\cdot}75+2\times3)\times3=47{\cdot}25$ sq m. A_2=Sec. area at other end$=(B+Sd_2)d_2$

$=(9{\cdot}75+2\times1{\cdot}2)\times1{\cdot}2=14{\cdot}58$ sq m

A_m=area of mid. sec Mean depth $d_m=\frac{3+1{\cdot}2}{2}=2{\cdot}1$ m

$\therefore$ $A_m=(B+Sd_m)d_m=(9{\cdot}75+2\times2{\cdot}1)\times2{\cdot}1=29{\cdot}30$ sq m

L=Total length of embankment. $\frac{\cdot}{90}=\frac{2\pi R}{360}$ L=958·3m

$\therefore$ Quantity$=\frac{958{\cdot}3}{6}(47{\cdot}25+14{\cdot}58+4\times29{\cdot}30)=28{,}591{\cdot}1$ cu m.

Example 11. Estimate the quantities of earthwork for an embankment to support a railway track at a uniform down gradient from station A to I. The formation levels and stations A and I are R. L. 218·90 and R. L. 218·10 respectively. The ground levels at various stations 50m apart are as under :

Station	A	B	C	D	E	F	G	H	I
Ground level (m) R. L.	220·50	220·10	219·70	219·20	218·50	218·20	217·70	217·30	217·50

The formation widths are 5·5m in cutting and 6·0m in banking The side slopes are $1\frac{1}{2}$: 1 in cutting and 2 : 1 in banking. There is no transverse slope of the ground. Apply prismoidal formula for computations. (A.M.I.E. question).

Ans. : Difference of formation level between stations A and I$=218{\cdot}90-218{\cdot}10=0{\cdot}80$. This difference is for a total length of $50\text{m}\times8=400$m. $\therefore$ Formation levels at each 50m apart differ by $\frac{0{\cdot}8}{400}\times50=0{\cdot}1$m

The depth of cutting and the height of banking at each station is determined from the difference between the ground levels and formation levels as shown below

Station ...	A	B	C	D	E	F	G	H	I
Distance (m) ...	0	50	100	150	200	250	300	350	400
G. L. (m) R.L. ...	220·50	220·10	219·70	219·20	218·50	218·20	217·70	217·30	217·50
Formation level R. L.(m)	218·90	218·80	218 70	218·60	218·50	218·40	218·30	218·20	218·10
Depth of cutting (m) ...	1·60	1·30	1·00	0·60	–	–	–	–	–
Height of banking (m) ...	–	–	–	–	0·00	0·20	0·60	0·90	0·60

Denoting depth of cutting and banking by − ve and + ve signs respectively

B = 5·5m in cutting & 6·0m in banking

S = 1½ in cutting & 2 in banking

Applying prismoidal formula, calculations of quantities are shown in the table as below :

Station	Chainage m	Hight of Bank or depth of cutting m	Mean depth $\frac{d_1+d_2}{2}$ m	Sectional area of central portion $B\times\frac{d_1+d_2}{2}$ sqm	d_1^2 sqm	d_2^2 sqm	d_1d_2 sqm	$\frac{d_1^2+d_2^2+d_1d_2}{2}$	Sectional area of sides $\frac{d_1^2+d_2^2+d_1d_2}{2}\times S$ sqm	Total sectional area = area sum of cols. (5)+(10) sqm	Distance between stns. D m	Quantity col. (11)×D Cutting cum	Quantity col. (11)×D Banking cum
1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0	— 1·60	—	—	—	—	—	—	—	—	—	—	—
B	50	— 1·30	—1·45	7·95	2·56	1·69	4·32	4·28	6·42	14·37	50	718·50	—
C	100	— 1·00	—1·15	6·32	1·69	1·00	1·69	2·19	3·28	9·60	50	480·00	—
D	150	— 0·60	—0·80	4·40	1·00	0·36	0·36	0·86	1·29	5·69	50	284·00	—
E	200	— 0·00	—0·30	1·65	0·36	0·00	0·36	0·36	0·54	2·19	50	109·50	—
F	250	— 0·20	0·10	0·60	0·00	0·04	0·04	0·04	0·06	0·66	50	—	33·00
G	300	— 0·60	0·40	2·40	0·04	0·36	0·01	0·20	0·30	2·70	50	—	135·00
H	350	-- 0·90	0·75	4·50	0·36	0·81	0·29	0·73	1·09	5·59	50	—	279·50
I	400	— 0·60	0·75	4·50	0·81	0·36	0·29	0·73	1·09	5·59	50	—	279·50
											Total	= 1592·50 cum	727·00 cum

Total quantity of earthwork
= 1592·50 + 727·00 = 2319·50 cum

8-7. Earthwork for Hill roads having transverse slope i.e for Two Level Section—Where conture lines are very close to each other (as in a hilly area) transverse or cross slope can not be neglected in calculating earthworks. When these transverse and longitudinal slopes are uniform in between two cross sections this portion of a road is called Two-Level Section. The methods of estimating the volume of earthworks for such cases have been illustrated below.

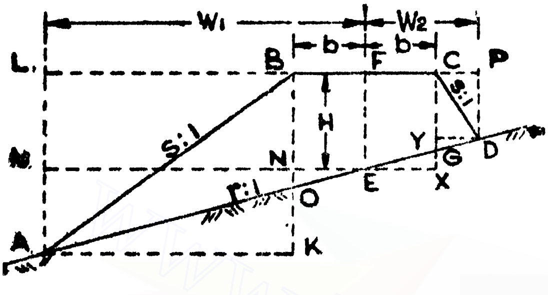


FIG. 8-9

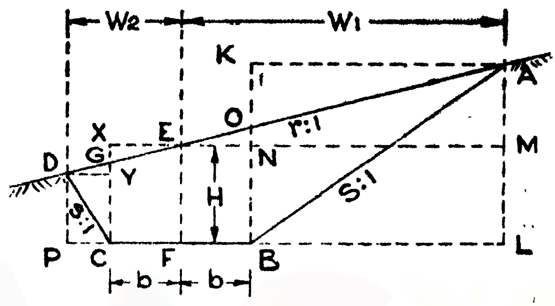


FIG. 8-10

Case—1. Wholly in Banking (Fig. 8-9) or wholly in cutting (Fig, 8-10)

Formula established :—Side width, $W_1 = b + \frac{r\,s}{r-s}\left(H + \frac{b}{r}\right)$ ....(1)

—do $W_2 = b + \frac{r\,s}{r+s}\left(H - \frac{b}{r}\right)$ ....(2)

Area, $ABCD = \frac{sb^2 - 2br^2H - r^2sH^2}{r^2 - s^2}$ ....(3)

Referirng fig. 8-9 and 8-10, Transverse slope $r : 1$ (r horizontal, 1 vertical)
Side slope $s : 1$ (s horizontal, 1 vertical)
H = Height of banking or depth of cutting at centre of road.
b = Half of formation width. W_1 and W_2 are the side widths

$$\frac{OK}{AK} = \frac{1}{r} \therefore OK = \frac{AK}{r};\ \frac{ON}{NE} = \frac{1}{r} \therefore ON = \frac{NE}{r} = \frac{b}{r};\ \frac{BK}{AK} = \frac{1}{s} \therefore BK = \frac{AK}{s}$$

Now, $BK = BN + ON + OK = H + \frac{b}{r} + \frac{AK}{r} \therefore \frac{AK}{s} = H + \frac{b}{r} + \frac{AK}{r}$

or $\frac{AK}{s} - \frac{AK}{r} = H + \frac{b}{r}$ or, $AK\left(\frac{r-s}{rs}\right) = H + \frac{b}{r}$ or $AK = \frac{rs}{r-s}\left(H + \frac{b}{r}\right)$

$\therefore$ Side width $W_1 = BF + LB = BF + AK = b + \frac{rs}{r-s}\left(H + \frac{b}{r}\right)$

Thus, $\frac{GX}{EX} = \frac{r}{1} \therefore GX = \frac{EX}{r} = \frac{b}{r}$, $\frac{GY}{DY} = \frac{1}{r} \therefore GY = \frac{DY}{r}$

$$\frac{CY}{DY}=\frac{1}{s} \quad \therefore \; CY=\frac{DY}{s}$$

Now, $CX=GX+GY+CY$ or $H=\frac{b}{r}+DY\left(\frac{1}{s}+\frac{1}{r}\right)$

or $H-\frac{b}{r}=DY\left(\frac{r+s}{r\,s}\right) \therefore \; DY=\frac{r\,s}{r+s}\left(H-\frac{b}{r}\right)$

$\therefore$ Side width $W_2 = CF+CP=CF+DY=b+\frac{r\,s}{r+s}\left(H-\frac{b}{r}\right)$

Area ABCD = area OBCG + ΔABO + ΔGCD $=2bH+\frac{1}{2}BO\times AK+\frac{1}{2}CG\times DY$

$$=2bH+\tfrac{1}{2}\left(H+\frac{b}{r}\right)\times\frac{rs}{r-s}\left(H+\frac{b}{r}\right)+\tfrac{1}{2}\left(H+\frac{b}{r}\right)\times\frac{rs}{r+s}\left(H-\frac{b}{r}\right)$$

$$=2bH+\tfrac{1}{2}\left\{\frac{rs}{r-s}\left(H+\frac{b}{r}\right)^2+\frac{rs}{r+s}\left(H-\frac{b}{r}\right)^2\right\}=\frac{Sb^2+2br^2H+r^2sH^2}{r^2-s^2}$$

side slope, $AB=\sqrt{AK^2+BK^2}=\sqrt{AK^2+\left(\frac{AK}{s}\right)^2}=\frac{AK}{s}\sqrt{1+s^2}=\frac{W_1-b}{s}\sqrt{1+s^2}$

Thus, it can be proved that Length $AE=\frac{W_1}{r}\left(1+r^2\right)$ and $DE=\frac{W_2}{r}\left(1+r^2\right)$

Case—2. Partly in Banking and partly in cutting—

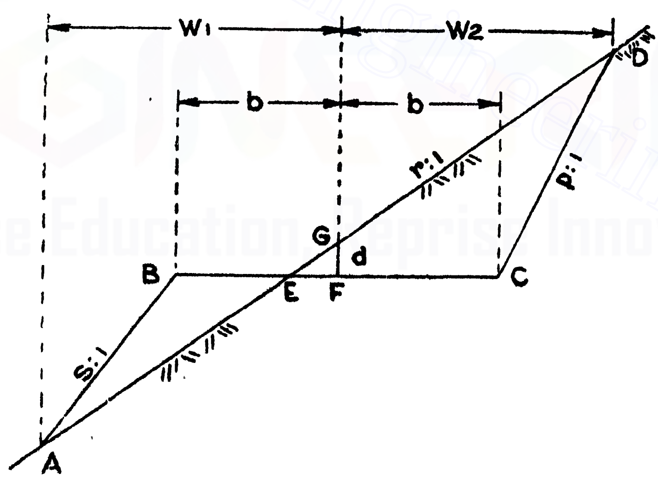


FIG. 8-11

It can be proved that—

Area of banking, $ABE=\frac{1}{2}\frac{(b-rH)^2}{r-s}$ ...(4) Area of cutting $DCE=\frac{1}{2}\frac{(b+rH)^2}{r-p}$ (5)

Side width, $W_1 = \frac{b-rH}{r-s}\times r$ .. (6) Side width, $W_2 = \frac{b+pH}{r-p}\times r$ (7)

Side slope, AB $= \frac{b-rH}{r-s}\sqrt{s^2+1}$ ...(8) Side slope, CD $= \frac{b+rH}{r-p}\sqrt{p^2+1}$ ...(9)

Referring to the fig. 8-11, where, r : 1=transverse slope of the ground.

p : 1=side slope of cutting. s : 1=side slope of banking.

In case when E is on the right side of the centre line F, then

Area ABE$=\frac{1}{2}\frac{(b+rH)^2}{r-s}$. and area DCE$=\frac{1}{2}\frac{(b-rH)^2}{r-p}$

8.8. Calculation of quantities of earthwork :—After finding the areas at different successive sections of a road by applying the formulae according to the equations given in (3) or (4) & (5) volumes of earthwork may be found out by any one of the following methods : (a) Mid-section formula, (b) Average end area or Trapezoidal formula, (c) Prismoidal formula.

(a) To apply Mid-Section formula—

1. Calculate mean height or depth, $H=\frac{H_1+H_2}{2}$ where H_1 and H_2 are the heights or depths at two ends of a section.

2. Calculate mean harmonic slope, $r=\frac{2r_1r_2}{r_1+r_2}$ where r_1 and r_2 are the transverse or cross slopes of the surfaces of the ground at the two ends of a section. In case where the cross slope varies at avery chainage the mean harmonic slope shall be calculated at every chainage and in this case Mid-section formula is not preferred to avoid extra calculations.

3. Calculate the Mid sectional area Am from the formula (3). In case of partly in Banking and partly in cutting apply formula (4) and (5).

4. Find out the volume for a section multiplying the Mid-sectional area Am by the length of the section. A table may be framed similar to table no I to calculate the quantities.

(b) To apply Average end area or Trapezoidal formula—

1. Calculate the areas at each chainage applying the formula (3) and find out the volume $V=\frac{D}{2}(A_0+2A_1+2A_2\cdots+2A_{n-1}+A_n)$ where D is the distance between two sections. The volume of earthwork for a number of sections may also be calculated from a similar table no 2. In case where there shall be a change over form cutting to filling and vice-versa the mean harmonic slopes, one at the end of cutting and other at the starting of banking shall be calculated by averaging the cross-slopes on both sides of zero point.

2. The area of end strip of cutting in case from cutting to filling shall be found out from formula (4) Similarly the area of banking which changes from cutting to banking shall be calculated from formula (5).

(c) **To apply prismoidal formula**—Calculate the areas of each chainage as in (b) and find out the volume similarly as described in article 8-4 (iii).

8-9. Prismoidal Correction—The volume of earthwork is calculated more correctly by Prismoidal formula than by other methods. But volumes of earthwork are often estimated by using the end area formula. In order to obtain more correct result a correction to the volume given the end area method is applied.

The difference between the volumes as calculated by the end area formula and that which would be obtained by the use of the prismoidal formula is termed the Prismoidal correction. The application of prismoidal correction to the approximate result gives the volume as it would be obtained from the prismoidal formula with less trouble than is involved by the direct use of this formula. Since the end area method of calculation over estimates the volume of a prismoid, the **correction for the prismoid is always subtractive.**

Formula for the Prismoidal correction for—(*i*) *Level sections*, P. C. $= \frac{DS}{6}(d-d_1)^2$

Where, d & d_1 = The depth of earthwork on the centre line,

S (horizontal) to 1 (vertical) = the side slopes, D = the distance between the stations.

(*ii*) ***Prismoidal correction for a two level section :***

(a) For wholly in cutting or wholly in banking (referring to the fig. 8-9 & 8-10.)

$$Cp = \frac{D}{6 \times S}(W_1 - w_1)\quad(W_2 - w_2);\quad Cp = \frac{D \times S}{6}\left(\frac{1}{r^2 - s^2}\right)\quad(H_1 - H_2)$$

(b) For partly in cutting and partly in banking i.e. for a Hill side section (referring to the Fig. 8-11).

For cutting $Cp = \frac{D}{12(r-p)} \times r^2(H_1 - H_2)^2$ For filling, $Cp = \frac{D}{12(r-s)} \times s^2(H_1 - H_2)^2$

Where, D = Distance between two successive sections

W_1 and w_1 ; W_2 and w_2 the side widths of two adjacent sections.

H_1 and H_2 are the depths at the centre of a road at two adjacent sections.

8-10. Curvature Correction :—Cross sections on curves are in radial lines, and consequently the earth solids between them do not have parallel end planes. In computing the volumes of earthwork of those solids, the common practice is to employ the usual methods of the prismoidal and the trapezoidal formula on the assumption that the end sections are in parallal to each other and normal to the chord and, if circumstances warrant, to apply a correction for curvature.

When the cross sectional area is symmetrical about the centre line, as in the case of level section these wedge-shaped masses practically balance, and no curvature correction is required. The more unsymmetrical the sectional area, the greater is the value of the correction, which falls to be applied positively or negatively to the calculated volume according as the greater half-breadth is on the convex or the concave side of the curve.

The formula, deduced for a three level section is equally applicable to two-level sections, if the half breadths employed are those of an equivalent three level section.

(i) For level section :—No correction is necessary since the area is symmetrical about the centre line.

(ii) For two level and three level section

$$c_c = \frac{d}{6R}\left\{W_1^2 - W_2^2\right\}\left\{H + \frac{6}{2n}\right\}$$

iii) For a two level section the curvature correction to the area $= \frac{Ae}{R}$ per unit length.

where, c_c = curvature correction, d = a constant distance

e = the excentricity, i.e. horizontal distance from the centre line to the centroid of the area $= \frac{W_1 W_2 (W_1 + W_2)}{3AS}$

(iv) For side hill two level section, $e = \frac{2}{3}\left\{W_1 + \frac{b}{2} - SH\right\}$ for the larger area,

and $e = \left\{W_2 + \frac{b}{2} + Sb\right\}$ for the smaller area.

S (horizontal) to 1 (vertical) = inclination of the side slope. A = sectional area.

The correction is positive if the centroid and the centre of the curvature are to the opposite side of the centre line ; while it is negative if the centroid and the centre of the curvature are to the same side of the centre line.

Example—1. *A road at formation level in cutting is 10m wide and the side slopes are $1\frac{1}{2}$: 1. The surface of the ground has a uniform side slope of 1 in 6. At adjacent cross sections, 30m apart, the depths of cutting at the centre line of road are 2m, 3m and 4m respectively. Estimate the volume of earthwork in cutting.*

Referring to the fig. 8-9, cross sectional area from equation (3)

$$A = \frac{Sb^2 + 2br^2H + r^2sH^2}{r^2 - s^2}$$

In this example, $b = \frac{10}{2} = 5$m ; H = 2, 3 and 4m ; $s = 1\frac{1}{2}$; r = 6.

For 1st section, $A_1 = \frac{1{\cdot}5 \times 5^2 + 2 \times 5 \times 6^2 \times 2 + 6^2 \times 1{\cdot}5 \times 2^2}{6^2 - (1{\cdot}5)^2} = 25{\cdot}63$

For 2nd section, $A_2 = \frac{1{\cdot}5 \times 5^2 + 2 \times 5 \times 6^2 \times 3 + 6^2 \times 1{\cdot}5 \times 3^2}{6^2 - (1{\cdot}5)^2} = 47{\cdot}51$

For 3rd section, $A_3 = \frac{1{\cdot}5 \times 5^2 + 2 \times 5 \times 6^2 \times 4 + 6^2 \times 1{\cdot}5 \times 4^2}{6^2 - (1{\cdot}5)^2} = 69{\cdot}38$

(a) The volume of cutting by the prismoidal formula

$$V=\frac{30}{6}(25{\cdot}63+69{\cdot}38+4\times47{\cdot}51)=2850{\cdot}5 \text{ cu m}$$

(b) Thus volume of the cutting by the trapezoidal formula,

$$V=\frac{30}{5}(25{\cdot}63+2\times47{\cdot}51+69{\cdot}38)=2850{\cdot}45 \text{ cu m}$$

Example—2. *Estimate the volume of earthwork in cutting for a road from the following data: Breadth of formation=10m side slope* $1\frac{1}{2}:1$.

Distance in metre	Depth of cutting (d) in metre	Cross slope of the surface of the ground
0	2·40	1 in 12
30	3·30	1 in 9
60	3·00	1 in 10

Let A_0, A_1 and A_2 are areas of the cross-sections at 0m, 30m and 60m respectively

From equation (3) cross sectional area $A=\dfrac{sb^2+2br^2H+r^2sH^2}{r^2-s^2}$

(i) Cross section at 0m ; $b=\dfrac{10m}{2}=5m$; $H=2{\cdot}4m$; $s=1\frac{1}{2}$; $r=12$

$$A_0=\frac{1{\cdot}5\times5^2+2\times5\times12^2\times2{\cdot}4+12^2\times1{\cdot}5\times2{\cdot}4^2}{12^2-1{\cdot}5^2}=33{\cdot}43 \text{ sq m}$$

(ii) Cross section at 30m ; $b=\dfrac{10\,m}{2}=5m$; $H=3{\cdot}3m$; $s=1\frac{1}{2}$; $r=9$

$$A_1=\frac{1{\cdot}5\times5^2+2\times5\times9^2\times3{\cdot}3+9^2\times1{\cdot}5\times3{\cdot}3^2}{9^2-1{\cdot}5^2}=51{\cdot}09 \text{ sq m}$$

(iii) Cross section at 60 m ; $b=\dfrac{10m}{2}=5m$; $H=3{\cdot}0m$; $s=1\frac{1}{2}$; $r=10$

$$\therefore\ A_2=\frac{1{\cdot}5\times5^2+2\times5\times10^2\times3+10^2\times1{\cdot}5\times3^2}{10^2-1{\cdot}5^2}=44{\cdot}89 \text{ sq m}$$

Using prismoidal formula,

Volume of earthwork $=\frac{30}{3}\{33{\cdot}43+44{\cdot}89+4\times51{\cdot}09\}=2826{\cdot}8$ cu m.

Example—3. The ground levels at various chainages along the centre line of a proposed road are as under :

Chainage	21	22	23	24	25
Ground level, R. L. (m)	180·50	183·36	185·52	187·10	186·50

The ground has uniform cross slope of 1 in 8. The chain is 30m long. The road formation is proposed at uniform gradient passing through the G. L. at end chainages with formation width as 8m and side slope of cutting as 1 : 1. Estimate the quantity of earthwork for the proposed road section, in a tabular form. (A. M. I. E. 1981)

Ans :—The difference of G. L. at the end chainages = 186·50 − 180·50 = 6·00m.
Distance between the end chainages = 120m ∴ Slope of the uniform gradient = $\frac{6}{120}$ or 1 : 20 and raising from 21 towards chainage 25.

The chainage, R. L. of ground and R. L. of the formation are given below :

Chainge	Distance (m)	R. L. of Ground at centre (m)	R. L. of Formation at centre (m)
21	0	180·50	180·50
22	30	183·36	182·00
23	60	185·52	183·50
24	90	187·10	185·50
25	120	186·50	186·50

The depth of cutting at every chainage is calculated by subtracting R. L. of the Formation from R. L. of the Ground and quantity is calculated in a tabular form.

The formation width = 8m ∴ b = ½ × 8 = 4m ; side slope, s = 1 ; Cross slope r = 8

Chainage m	Depth of cutting m	Transverse slope, r	Area of section $= \dfrac{Sb^2+2br^2H+r^2sH^2}{r^2-s^2}$	Mean area sqm	Dist. m	Quantity in Cutting cum
21	0	8	$\dfrac{1\times4^2+2\times4\times8^2\times0+8^2\times1\times0^2}{8^2-1^2}=0{\cdot}254$	—	0	
22	1·36	8	$\dfrac{1\times4^2+2\times4\times8^2\times1{\cdot}36+8^2\times1\times1{\cdot}36^2}{8^2-1^2}=13{\cdot}186$	6·72	30	201·60
23	2·02	8	$\dfrac{1\times4^2+2\times4\times8^2\times2{\cdot}02+8^2\times1\times2{\cdot}02^2}{8^2-1^2}=20{\cdot}816$	17·00	30	510·00
24	1·60	8	$\dfrac{1\times4^2+2\times4\times8^2\times1{\cdot}60+8^2\times1\times1{\cdot}60^2}{8^2-1^2}=15{\cdot}858$	18·34	30	550·20
25	0	8	$\dfrac{1\times4^2+2\times4\times8^2\times0+8^2\times1\times0^2}{8^2-1^2}=0{\cdot}254$	8·06	30	241·80
					Total	1,503·60 cum

∴ **Estimated quantity of earth work = 1,503·60 cum in cutting**

Example—4. Estimate the quantity of earthwork of a hill road when the formation width in cutting is 8m and side slope is $1\frac{1}{2}:1$. The formation width in banking is 10m and side slope 2 : 1. The Ground and Formation levels at the centre of road and also the transverse slopes of ground surface are as below.

Chainage	R. L. of Ground at centre	R. L. of Formation at centre	Transverse slope of ground
0m	150·00	149·20	1 in 12
30m	150·60	150·00	1 in 10
60m	151·50	150·80	1 in 14
90m	150·80	151·60	1 in 12
120m	151·50	152·40	1 in 14
150m	152·00	153·20	1 in 10

Ans.:—The depth of cutting and height of banking has been calculated from the difference between the R. L. of ground and R. L. of formation as below :—

Chainage	Depth of cutting	Height of banking	Transverse slope
0m	0·80m	—	12 : 1
30m	0·60m	—	10 : 1
60m	0·70m	—	14 : 1
90m	—	0·80m	12 : 1
120m	—	0·90m	14 : 1
150m	—	1·20m	10 : 1

Studying the above table it is noted that the change over from cutting to filling i. e. the zero point is in between chainage 60m and 90m. Let x be the distance from 60m to the zero point.

From properties of similar triangles (sec. fig. 8–6) $\frac{x}{0·70}=\frac{30-x}{0·80}$ $\therefore$ $x=14m$

The distance of zero point from chainage 90m $=30-14=16m$.

Mean harmonic slope, at zero point $r=\frac{2r_1r_2}{r_1+r_2}=\frac{2\times14\times12}{14+12}=12·92$ say 13.

At zero point the road is formed by partly in cutting and partly in banking

$\therefore$ Crest width, $b=\frac{1}{2}\left(\frac{8}{2}+\frac{10}{2}\right)=4·5m$ approx.

For cutting ;– $b=4m$, $s=1\frac{1}{2}$. For banking :– $b=5m$, $s=2$. At zero point, $b=4·5m$

Station or Chainage m	Depth or height m	Transverse slope r	Area of section $=\frac{sb^2+2br^2H+r^2sH^2}{r^2-s^2}$ sq m	Mean area sq m	Dist. m	Quantity Cutting cu m	Quantity Banking cu m
0	–·80	12	$\frac{1\frac{1}{2}\times4^2+2\times4\times12^2\times·8+12^2\times1\frac{1}{2}\times·8^2}{12^2-1\frac{1}{2}^2}=7·646$	—	—	—	
30	–·60	10	$\frac{1\frac{1}{2}\times4^2+2\times4\times10^2\times·6+10^2\times1\frac{1}{2}\times·6^2}{10^2-1\frac{1}{2}^2}=5·708$	6·677	30	200·31	
60	–·70	14	$\frac{1\frac{1}{2}\times4^2+2\times4\times14^2\times·7+14^2\times1\frac{1}{2}\times·7^2}{14^2-1\frac{1}{2}^2}=6·532$	6·120	30	183·60	
74	0	13 (Mean hermonic)	cutting portion, Area $=\frac{\frac{1}{2}(b+rh)^2}{r-p}$ $=\frac{(4·5+13\times0)^2}{13-1\frac{1}{2}}$ ... $=0·880$	3·706	14	51·88	
74	0	13 (Mean harmonic)	Banking portion, area $=\frac{\frac{1}{2}(b-rH)^2}{r-s}$ $=\frac{\frac{1}{2}(4·5-13\times0)^2}{13-2}$ ... $=0·920$				
90	·80	12	$\frac{2\times5^2+2\times5\times12^2\times·8+12^2\times2\times·8^2}{12^2-2^2}=9·902$	5·411	16	—	86·58
120	·90	14	$\frac{2\times5^2+2\times5\times14^2\times·9+14^2\times2\times·9^2}{14^2-2^2}=11·102$	10·502	30	—	315·06
150	1·2	10	$\frac{2\times5^2+2\times5\times10^2\times1·2+10^2\times2\times1·2^2}{10^2-2^2}=16·021$	13·561	30	—	406·83
					Total=	435·79 cu m	808·47 cu m

Abstract of quantities : – Earthwork in cutting = 435·76 cum
Earthwork in banking = 808·47 cu m

Example—5 *At hill side a road is to be constructed on the original ground having a cross fall of 1 in 6. The formation width of the road is 10m and the side slopes are in cutting 1 in 1 and in filling 1 in $1\frac{1}{2}$. The depths of cutting at the centre line of the road for two adjacent sections at a distance 30m apart are 0·4m and 0·7m. Estimate the quantities of earthwork in banking and in cutting for the above portion of road.*

Estimate also the cost of earthwork for this portion of road if excavated earth is utilised for banking on the opposite side and the rate of earthwork including blusting and dressing be Rs. 5 per cu m.

Referring to the fig. 8-11, For first section :—$b=\frac{10m}{2}=5m$; $r=6$; $H=0{\cdot}4m$ slopes for cutting, $p=1{\cdot}5$; and in filling, $s=1$.

From equ. 5, area of cutting portion $=\frac{1}{2}\frac{(b+rH)^2}{r-p}=\frac{1}{2}\frac{(5+6\times{\cdot}4)^2}{6-1{\cdot}5}=6{\cdot}08$ sq m

From equ. 4, area of filling portion $=\frac{1}{2}\frac{(b-rH)^2}{r-s}=\frac{1}{2}\frac{(5-6\times0{\cdot}4)^2}{6-1}=1{\cdot}18$ sq m

For the 2nd section at a dist. 30 m from the 1st section :—

$b=\frac{10m}{2}=5m$; $r=6$; $H=0{\cdot}7$ m ; slopes for cutting, $p=1{\cdot}5$; slope in filling $s=1\frac{1}{2}$

$\therefore$ Area of cutting portion $=\frac{1}{2}\frac{(5+6\times0{\cdot}7)^2}{6-1{\cdot}5}=9{\cdot}4$ sq m

Area of filling portion $=\frac{1}{2}\frac{(5-6\times0{\cdot}7)^2}{6-1{\cdot}5}=0{\cdot}07$ sq m

Volume of cutting by average end areas $=\frac{1}{2}(6{\cdot}8+9{\cdot}40)\times30=232{\cdot}2$ cu m

Accurate value by applying prismoidal correction.

For cutting $Cp=\frac{D}{12(r-p)}\times r^2(H_1-H_2)^2$

$$=\frac{30}{12(6-1{\cdot}5)}\times6^2(0{\cdot}4-0{\cdot}7)^2=1{\cdot}80 \text{ cu m}$$

$\therefore$ Correct volume $232{\cdot}2-1{\cdot}80=230{\cdot}4$ cu m

Volume of filling by average end areas $=\frac{1}{2}(1{\cdot}18+0{\cdot}07)\times30=37{\cdot}5$ cu m

Prismoidal correction $=\frac{D}{12(r-s)}\times r^2(H_1-H_2)^2$

$$=\frac{30}{12(6-1)}\times6^2({\cdot}4-{\cdot}7)^2=1{\cdot}6 \text{ cu m}$$

$\therefore$ Corrected volume $=37{\cdot}5-1{\cdot}6=35{\cdot}9$ cu m.

Since volume of cutting is in excess to that of filling, the cost of cutting only is to be taken into account for estimating. $\therefore$ Volume of earthwork to be paid $=230{\cdot}4$ cu m

Estimated cost of earthwork @ Rs. 5 per cu m $=230{\cdot}4\times5=$ Rs. 1,152·00.

8-11. Earthwork for Roads having Three-Level Sections : In this case, the cross slope on either side of the centre line of the formation is not uniform, as shown in the fig. 8-12.

Referring to the fig.

$$H_1=\left(H+\frac{W_1}{r}\right)\ldots\ldots(7)$$

$$H_2=\left(H-\frac{W_2}{r_2}\right)\ldots(8)$$

$$W_1=\frac{r_1 s}{r_1+s}\left(H+\frac{b}{s}\right)\ldots(9)$$

$$W_2=\frac{r_2 s}{r_2+s}\left(H+\frac{b}{s}\right)\ldots(10)$$

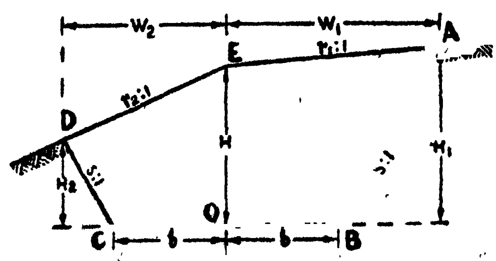
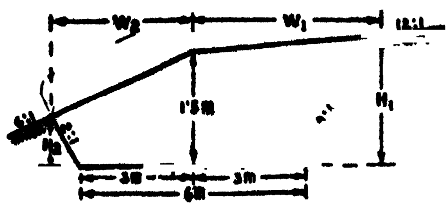


FIG. 8-12

Sectional area = Area EOA + Area EOD + Area OBA + Area ODC

$$=\tfrac{1}{2}H\times W_1+\tfrac{1}{2}H\times W_2+\frac{b}{2}\times\left(H_1+\frac{b}{2}H_2\right)=\tfrac{1}{2}H(W_1+W_2)+\frac{b}{2}(H_1+H_2) \quad (11)$$

Example—5. The width of formation of a cerntain hill road is 6m. In order to prepare a rough estimate, the details of average cross section is given below. Determine the volume of earthwork involved for a length of 200m.



From the equation (9) $W_1=\frac{r_1 s}{r_1-s}\left(H+\frac{b}{s}\right)$

We have, $r_1=12$; $S=2$; $H=1{\cdot}5$m , $b=3$m

$\therefore\ W_1=\frac{12\times2}{12-2}\left\{1{\cdot}5+\frac{3}{2}\right\}=7{\cdot}2$m

Also, $W_2=\frac{r_2 s}{r_2+s}\left\{H+\frac{b}{s}\right\}$ ...(10)

We have, $r_2=6$; $S=2$; $H=1{\cdot}5$; $b=3$m

$\therefore\ W_2=\frac{6\times2}{6+2}(1{\cdot}5+\frac{3}{2})=5{\cdot}5$m

Referring to the fig. 8-13, $H_1=1{\cdot}5+\frac{W_1}{r_1}=1{\cdot}5+\frac{7{\cdot}2}{12}=2{\cdot}1$m; $H_2=1{\cdot}5-\frac{W_2}{r_2}=1{\cdot}5-\frac{5{\cdot}5}{6}=0{\cdot}58$m

$\therefore$ Sectional area, $A=\tfrac{1}{2}H(W_1+W_2)+\frac{b}{2}(H_1+H_2)=\tfrac{1}{2}\times1{\cdot}5(7{\cdot}2+5{\cdot}5)+\tfrac{3}{2}(2{\cdot}1+0{\cdot}58)$

$=13{\cdot}55$ sq m

$\therefore$ Volume of earthwork for 200m length $=200\times13{\cdot}55=2{,}710$ cu m

Example—6. The width of a road in cutting at formation level is 6m and the side slopes $1\tfrac{1}{2}:1$. The particulars of cross sections at a dist. 30m apart are given below. Compute the volume of earthwork for this portion of the road.

Section	Left	Centre	Right
1	$\frac{0{\cdot}75}{3{\cdot}25}$	$\frac{1{\cdot}60}{0}$	$\frac{2{\cdot}45}{5{\cdot}36}$
2	$\frac{1{\cdot}20}{3{\cdot}76}$	$\frac{1{\cdot}90}{0}$	$\frac{3{\cdot}20}{6{\cdot}62}$
3	$\frac{1{\cdot}50}{4{\cdot}40}$	$\frac{2{\cdot}20}{0}$	$\frac{3{\cdot}60}{7{\cdot}50}$

The numerators show the depths of cutting and the denominators the respective horizontal distances from the centre line.

Ans:—Sectional area, $A=\tfrac{1}{2}H(W_1+W_2)+\frac{b}{2}\left(H_1+H_2\right)$ ... from equ (11)

For section 1 :—$2b=6$m ; $\therefore\ b=3$m ; $H=1{\cdot}6$m ; $W_1=5{\cdot}36$m ; $W_2=3{\cdot}35$;
$H_1=2{\cdot}45$m ; $H_2'=0{\cdot}75$m.

For section 2 :— $b=3m$; $H=1{\cdot}9m$; $W_1=6{\cdot}62m$; $W_2=3{\cdot}76m$; $H_1=3{\cdot}20m$; $H_2=1{\cdot}20m$

$$\therefore \quad A_2=\frac{1}{2}\times 1{\cdot}9(6{\cdot}62+3{\cdot}76)+\frac{3}{2}(3{\cdot}20+1{\cdot}20)=16{\cdot}46 \text{ sq m}$$

For section 3 :— $b=3m$; $H=2{\cdot}20m$; $W_1=7{\cdot}50m$; $W_2=4{\cdot}40m$; $H_1=3{\cdot}60m$; $H_2=1{\cdot}50m$

$$A_3=\frac{1}{2}\times 2{\cdot}20(7{\cdot}50+4{\cdot}40)+\frac{3}{2}(3{\cdot}60++1{\cdot}50)=20{\cdot}74 \text{ sq m}$$

Volume of earthwork by using standard prismoidal formula

$$V=\frac{D}{3}(A_1+4A_2+A_3)=\frac{30}{3}(11{\cdot}69+4\times 16{\cdot}46+20{\cdot}74)=98{\cdot}27 \text{ cu m.}$$

B—BRIDGES AND CULVERTS

8-12. Culvert and Bridge.—According to I. R. C. specification, a culvert is one which has a linear waterway upto 6m and structures having a linear waterway above 6m but below 30m as Minor Bridges and structures having a linear waterway of 30m or more as Major Bridges.

As a general rule, a minimum of 6m of linear waterway should be provided per 1·5 km of the road for efficient drainage.

8-13. Some Common terms—

(a) Abutments :—It is a masonry or reinforced concrete wall that constitutes the end support of bridges or similar structures by which it joins the banks of waterway.

(b) Wing wall :—Wing wall is a retaining wall which sustains the embankments of the approaches where they join the bridge.

(c) Return wall :—A return wall is a retaining wall built parallel to the centre line of a road to retain the embankment.

(d) Curtain walls :—Cross walls are built across the stream on the up-stream or down stream in order to protect the structure from erosion due to strong current of water induced by the restriction of free passage of water through the water way.

8 14 Estimate of a simple Arch culvert.—Prepare a detailed estimate of an arched culvert of 1·8m span and 4·4m clear road way from the given fig. 8-14. The general specifications are as follows—

Foundation will be of lime concrete, 18:36:100. All masonry work will be of 1st class brickwork in cement mortar, 1 : 4. But brickwork in arch masonry will be of cement mortar (1:3). All exposed surfaces including flooring, soffit of arches will be cement flush pointed, 1 : 2 upto 15cm below G.L. Present local market rates may be adopted to prepare the estimate.

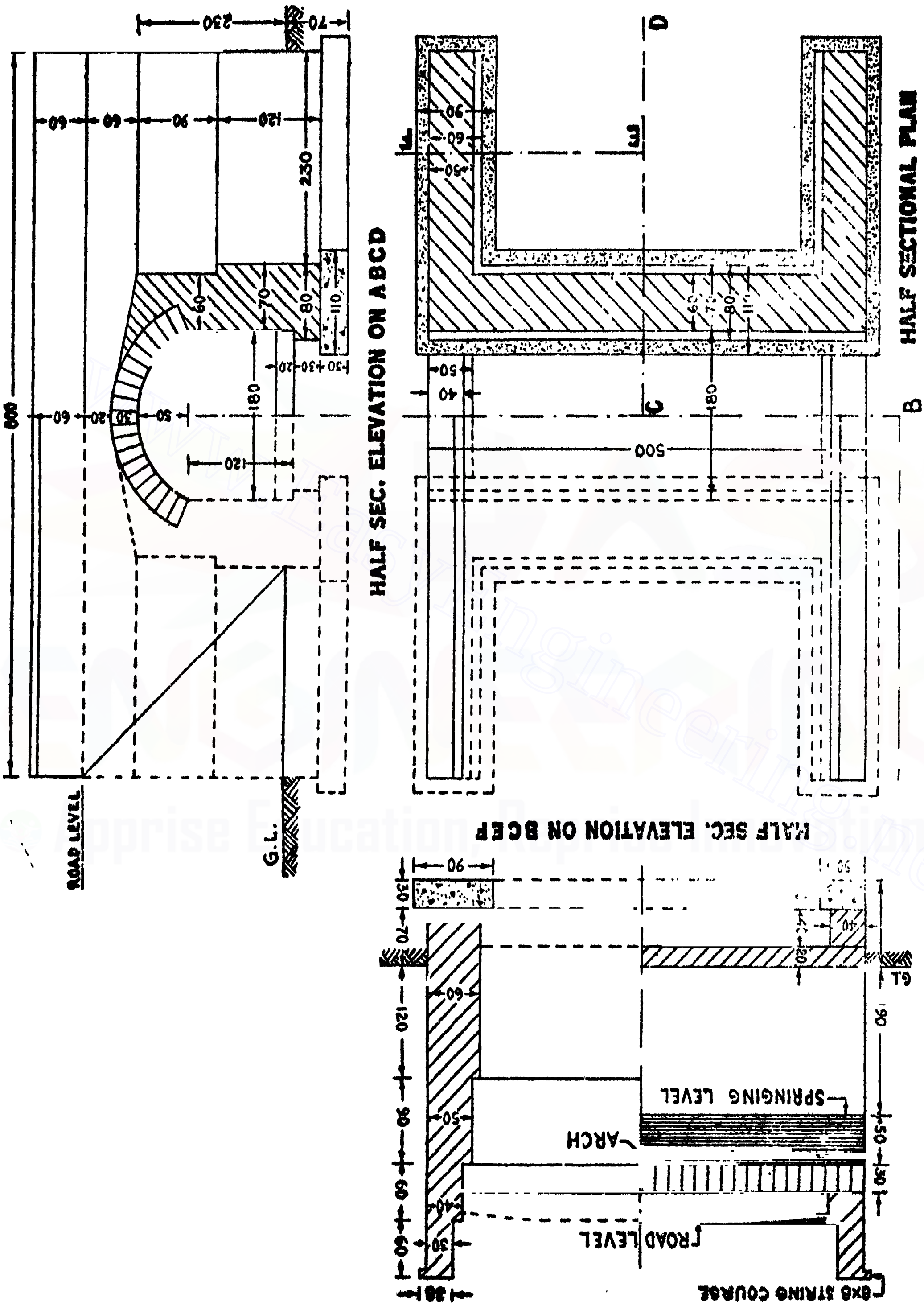


FIG. 8.14

dimensions are in centimetre Scale 1 : 75

Details of measurement and calculation of quantities (Art. 8·14)

Item No.	Description	No.	L. cm	B. cm	H. cm	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							
	(a) Abutments ...	2	590	110	70	11·29		$590 = 560 + 2 \times 15$
	(b) Wing walls ...	4	230	90	70	5·80		
	(c) Curtain walls ...	2	130	50	70	0·91		$130 = 180 - 2(10 + 15)$
	(d) Flooring ...	1	460	130	20	1·20		
							19·20 cu m	
2.	**Lime concrete (18:36:100) in foundation**							
	(a) Abutments ...	2	590	110	30	3·89		
	(b) Wing walls ...	4	230	90	30	2·48		
	(c) Curtain walls ...	2	130	50	30	0·39		
							6·76 cu m	
3.	**Arch masonry** — $b^2 = a^2 + h^2 = (80)^2 + (50)^2$ ∴ $b = 103$ Also, $b^2 = 2rh$ or, $(103)^2 = 2r \times 50$ ∴ $r = 106$ $r_m = 106 + 15 = 121$ Inner arc $= \frac{8b - 2a}{3}$ $= \frac{8 \times 103 - 180}{3} = 215$ ∴ Mean arc $= \frac{215}{103} \times 121 = 245$	1	560	245	30	4·12	4·12 cu m	
4.	**1st class brickwork in cement mortar (1 : 4)**							
	(a) Abutments for							
	80 cm layer ...	2	560	80	30	2·69		
	70 cm layer ...	2	560	70	90	7·06		50 170(above conc. to springing) – 120
	60 cm layer upto springing ...	2	560	60	50	3·36		
	From springing level upto top of crown (as solid first)	1	560	300	70	11·76		70 = 50 + 20 Deductions are to be made
	(b) Wing walls —							
	60 cm layer ...	4	230	60	120	6·62		
	50 cm layer ...	4	240	50	90	4·32		
	40 cm parapet (taken solid first)	2	800	40	60	3·84		Deductions are to be made
	30 cm parapet ...	2	800	30	60	2·88		
	(c) Curtain walls ...	2	160	40	30	0·38		$160 = 180 - 2 \times 10$
	(d) Flooring ...	1	560	180	20	2·02		
	C.O. ...	—	—	—	—	49·05		

Item No.	Description	No.	L. cm	B. cm.	H. cm.	Qu. cu m	Total	Explanatory notes
	B. F.	—	—	—	—	49·05		
	Deductions for—							
	(a) Arch opening segmental	1	560 ×	(⅔ × 18	0 × 50	3·36	(-ve)	Area of a segment = ⅔span × rise (apx.)
	(b) Arch masonry	Same as item No. 3 =				4·12	"	
	(c) Triangular portions above abutments	2	560 ×	½(150	× 40)	3·36		40 = (30+20+120+50+30)−(120+90)
	(d) Parapet walls (taken solid)	2	½ × 300	× 40 ×	0 =	0·48	37·73 cu m	300 = 180 + 2 × 60 40 = 60 − 20
5.	**Pointing** (upto 15cm below G.L.)							
	Inner faces of abutments	2	560	—	120	13·44		15 below G.L. is not required.
	Soffit of arch	1	560	215	—	12·04		215 = inner arc from item No 3
	Flooring	1	560	180	—	10·03		
	Face walls (from 15 cm below G. L. upto top of parapet) considering solid	2	800	365	365	48·80		365 = 230 + 60 + 60 + 15
	Inner faces of parapet including top, projection	2	800	108	—	17·28		108 = 10(offset) + 60 + 38 (top)
	Ends of parapet	4	—	30	60	0·72		
	Deductions for—							
	Rectangular openings	2	180	—	120	4·32	(-ve)	
	Segmental portion of arch	2 × ⅔ × 180	× 50		—	1·20	"	
	Triangular portion below earth slope	4	× ½(245 × 230)			11·27	" 85·97 sq m	245 = 230 + 15
6.	**String course** 8 × 8	2	800	—	—	16	16 r m	

Abstract of Estimated cost (Art. 8-14)

Item No.	Description	Quan.	Unit.	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Earthwork in excavation	19·2	cu m	320	%cu m	61·44
2.	Lime concrete (18:36:100) in foundation	6·76	cu m	190	cu m	1284·40
3.	Arch masonry in cement mortar 1:3)	4·12	cu m	305	cu m	1256·60
4.	Brickwork in cement mortar (1:4)	37·37	cu m	280	cu m	10,463·60
5.	Cement flush pointing (1:4) ..	85·97	sq m	3·00	sq m	257·91
6.	String course 8cm × 8cm ...	16·0	r m	2·80	r m	44·80

Total = 13,368·75
Contingencies @ 5% = 668·44
Work charge @ 2½% = 334·22

Grand Total = 14,371·41

8-15. Estimate of a simple Slab Culvert—Prepare a quantity survey for a slab culvert of 1·5m clear span and 4m road way as shown in the fig. 8-15.

The general specifications are as follows :—

Foundation shall be of cement concrete 1 : 2 : 4. Brickwork shall be of 1st. class in cement mortar 1:4. Exposed surfaces of brick masonry shall be cement pointed 1:3 carried upto 15cm below G.L. The exposed surfaces of R.C.C. slab shall be given a smooth finish during centering, and no plastering shall be allowed. The string courses shall be 8cm deep and 12mm thick with cement mortar 1 : 3 finished with neat cement. (Wt. of 16mm and 10mm dia. bars are 1·58kg & 0·62 kg respectively per rm)

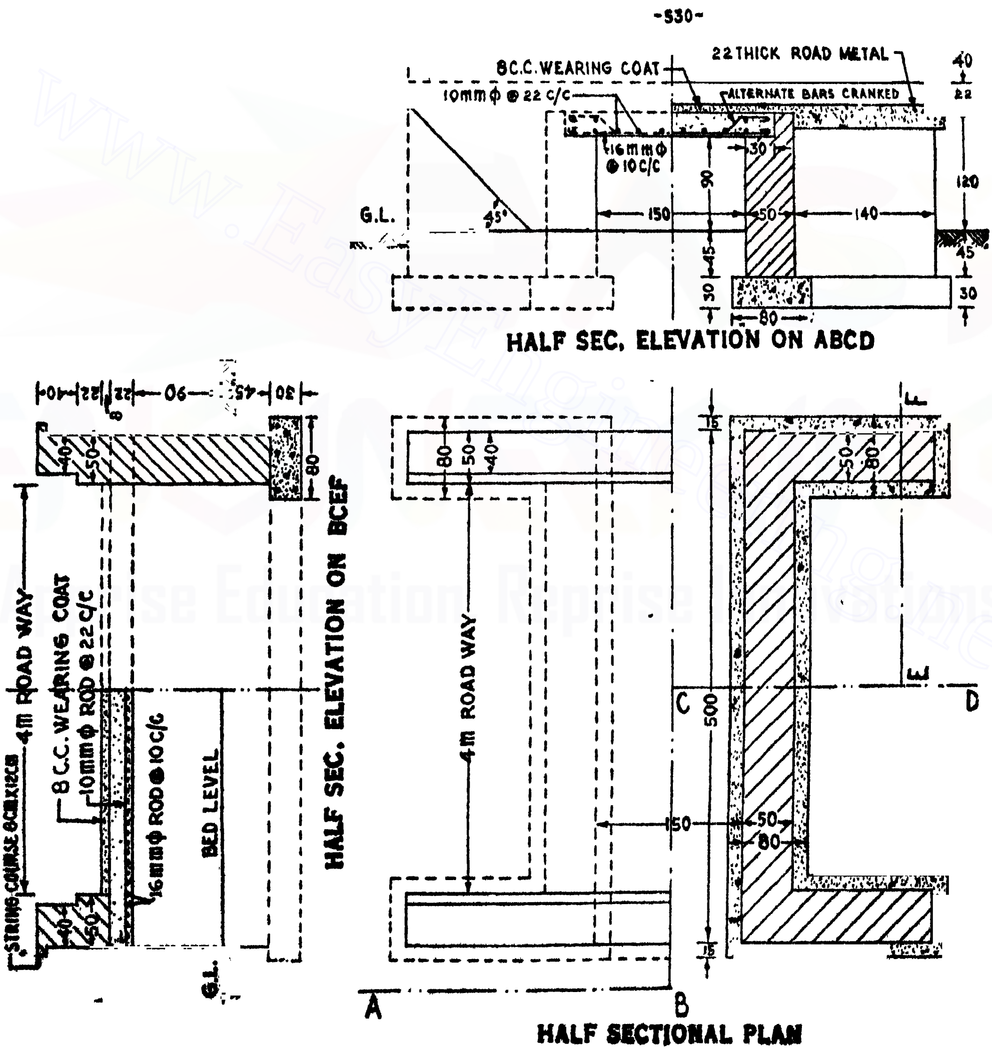


FIG. 8·15

All dimensions are in Centimetre. Scale 1 : 75

Details of Measurement and calculation of Quantities (Art. 8-15)

Item No.	Description	No.	L. cm	B. cm	H. cm	Qu.	Total	Explanatory notes.
1.	**Earthwork in excavation for**							
	(a) Abutment walls ...	2	530	80	75	6·36		
	(b) Wing walls ..	4	140	80	75	3·36		
							9·72 cu m	
2.	**Cement concrete in foundation** (1:2:4) for—							
	(a) Abutment walls ...	2	530	80	30	2·54		
	(b) Wing walls ...	4	140	80	30	1·38		
							3·88 cu m	
3.	**First class brickwork in cement mortar** (1:4) for—							
	(a) Abutment walls ...	2	500	50	157	7·85		157=45+90+22
	(b) Wing walls ..	4	140	50	157	4·40		
	(c) Parapets 50cm thick ..	2	530	50	30	1·59		
	(d) -do- 40cm thick ..	4	530	40	40	1·70		
	Deduction for bearing of R.C.C. slab in abutments	2	500	30	22	0·66	(–ve)	
							14·88 cu m	
4.	**Cement pointing** (1:3) to exposed surfaces of brickwork							
	a) Inner faces of abutments	2	500	—	50	10·5		15cm below G.L.
	(b) Face walls (as a whole)	2	530	—	189	20·0		189 is upto string course= 120+22+32+15
	(c) Inner side and top of parapets ..	2	530	—	112	11·9		
	(d) Ends of parapet ...	2×2	50	—	30	0·6		
	-do- -do-	2×2	40	—	40	0·6		
	Deductions for—							
	(a) Rectangular opening ..	2	150	105	—	3·2(–ve)		
	(b) Triangular portion of face walls hidden by earth	4×½	140	×140	=	3·9(–ve)		
							36·5	sq m
5.	**8cm×12cm String course** ...	2	530	—	=	10·6	10·6 r m	
6.	**R.C.C. slab excluding reinforcement but including shuttering** ...	1	500	210	22	2·31	2·31 cu m	210=150+2×30
7.	**Reinforcements**—							25mm cover & hook @9D considered, 10cm extra for each crank.
	(a) 16mm θ straight bars ...	25	234=	58·5 r m				
	(b) 16mm θ bent up bars ...	25	254=	63·5 r m				
				122 r	m@1·58kg=		193	
	(c) 10mm θ bottom distribution bars ...	10	513=	51·3 r m				513=500–5 covers+2×9×10mm
	(d) 10mm θ top -do-	4	513=	20·52 r m				
			T.L.=	71·82r	m@0·62kg=		45	
							238 kg	

ABSTRACT OF ESTIMATED COST (Art. 8-15)

Item No.	Description	Quantity	Unit	Rate Rs. P.	Unit Rate	Amount Rs. P.
1.	Earthwork in excavation in foundation	9·72	cum	300·00	% cu m	29·16
2.	Cement concrete (1:2:4) with stone chips in foundation	3·88	cum	425·00	cu m	1,649·00
3.	First class brickwork in cement mortar (1:4)	14·88	cum	290·00	cu m	4,315·20
4.	Cement pointing (1:3) ..	36·50	sqm	4·50	sq m	164·25
5.	8 cm × 12 mm string course ...	10·60	rm	2·00	r m	21·20
6.	R.C.C. work (1:2:4) excluding reinforcement but including shuttering	2·31	cum	460·00	cu m	1,062·60
7.	Mild steel bar for reinforcement including bending and binding	2·38	qu	550·00	qu.	1,309·00

Total—8,550·41

Add 5% for contingency—Rs. 427·52

„ 2½% for W. C. —Rs. 213·76

Grand Total=Rs. 9,191·69

8-16. Estimate of a 90 cm dia. double barrel Hume pipe culvert (as used in National High-way).

Prepare a quantity estimate for a barrel of 30 cm length (total length depends on the bank height) and the drop walls. In the estimate, the earth cushion whose depth has been indicated by X=60 cm min. and the Hard Crust are not to be included. General specification of works are same as mentioned in the drawing. Extra earthwork in excavation shall be considered in the estimate to provide a side slope of 1:2 in order to prevent collapsing of earthwork at water level.

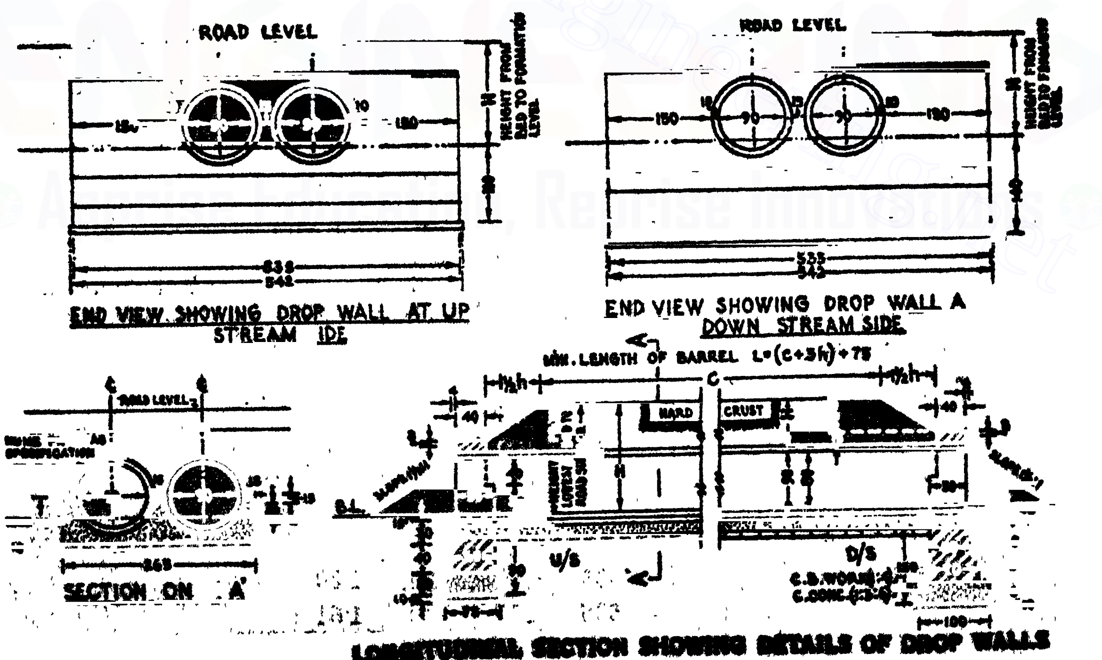


FIG. 8-16

All are in centimetre. Scale 1:75

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (Art. 8-16)

Item No.	Description	No.	L. cm	B. cm	H. cm	Qu. cu m	Total	Explanatory notes
	(A) For 30 cm length of Barrel—							
1.	Earthwork in excavation ...	1	30	310	45	0·418	0·418 cu m	$310=265+2\times\frac{45}{2}$
2.	Earthwork in filling and ramming complete ...	2	30	$\frac{45}{2}$	45	0·061	0·061 cu m	Extra work for a side slope of 1:2 to prevent collapsing of earth at water level.
3.	Single brick flat soling	1	30	265	—	7·95	7·95 sq m	
4.	Cement concrete (1:3:6) with brick ballast (considering whole first)	1	30	265	55	·437		55=70−15
	Chamfering portion ...	1	30	250	15	·113		$250=\frac{1}{2}(265+265-30)$
	Deduction for pipes ...	2	$30\times\frac{1}{2}\pi\times\frac{1}{4}(1{\cdot}10)^2=$			·138	(−ve) ·417	cu m
5.	90cm dia. 10 cm thick Hume pipe ...	2	30	—	—	0·60	0·60	r m
6.	Shuttering for concrete ...	2	30	—	70	0·42	0·42 sq m	
	(B) Quantities for drop walls							
1.	Earthwork in Excavation							Extra excavation to provide a side slope of 1:2 all round $195=75+2\times\frac{1}{2}(10+90+10+10)$
	Up-stream side ...	1	662	195	120	15·5		
	Down stream side ...	1	692	250	150	26·0	41·5 cu m	
2.	Earthwork in filling ...	—Item (1) —items (3), (4) and portion of work upto G.L. from (5) =41·5−·94−2·81−5·88				=31·93	31·93 cu m	All the items are from sub-head (B)
3.	Single brick flat soling							·94=9·4×·1
	U/S side ...	1	535	75	—	4·0		
	D/S side ...	1	535	100	—	5·4	9·4 sq m	
4.	Cement concrete (1:3:6) with brick ballast							
	U/S side ...	1	535	75	30	1·20		
	D/S side ...	1	535	100	30	1·61	2·81 cu m	

Item No.	Description	No.	L. cm	B. cm	H. cm.	Qu.	Total	Explanatory notes
5.	First class brickwork in cement mortar (1:4)							
	U/S side for—							
	60 cm layer ...	1	535	60	40	1·28		
	50 cm layer .	1	535	50	80	2·14		80=30+50
	40 cm layer ..	1	535	40	65	1·39		65=40+10+15
	D/S side for –							
	70 cm layer ...	1	535	70	40	1·50		
	60 cm layer ...	1	535	60	30	0·96		
	50 cm layer ...	1	535	50	80	2·14		
	40 cm layer ...	1	535	40	65	1·39		
	Deductions for— Pipe openings both U/S and D/S sides ...	2×2	$\pi \times (\frac{1 \cdot 10}{4})^2 \times 45$(av.)			1·71	(–ve)	$45 = \frac{50+40}{2}$
	Concreting under pipes ..	2	50×0·417 cu m/r m			·42	,, 8·67 cu m	
6.	12 mm cement plaster (1:2)							
	U/S and D/S faces (upto 15 cm below G.L.)	2	535	—	120	12·04		120=80+10+15+15 (below G.L.)
	Tops ...	2	525	40	—	4·20		
	Deductions for pipe openings ...	2×2	$\pi \times (\frac{1 \cdot 10}{4})^2$	—	—	3·80	(–ve) 13·24 sq m	
7.	Shuttering for concrete work in foundation ...	2×2	535	–	30	6·42	6·42 sq m	
8.	String course at top ...	2	535	–	—	10·7	10·7 rm	

8-17. Estimate of a Vented Cause-way.—From the fig. 8-17 prepare a detailed estimate for 10·25 m base and 4 m clear cause-way. All soling be 60 cm thick stone boulder pitching laid in two layers. Base, sides of cause-way and base of approaches shall be 12 mm thick cement plastered (1:3) All other general specifications shall be as per drawing

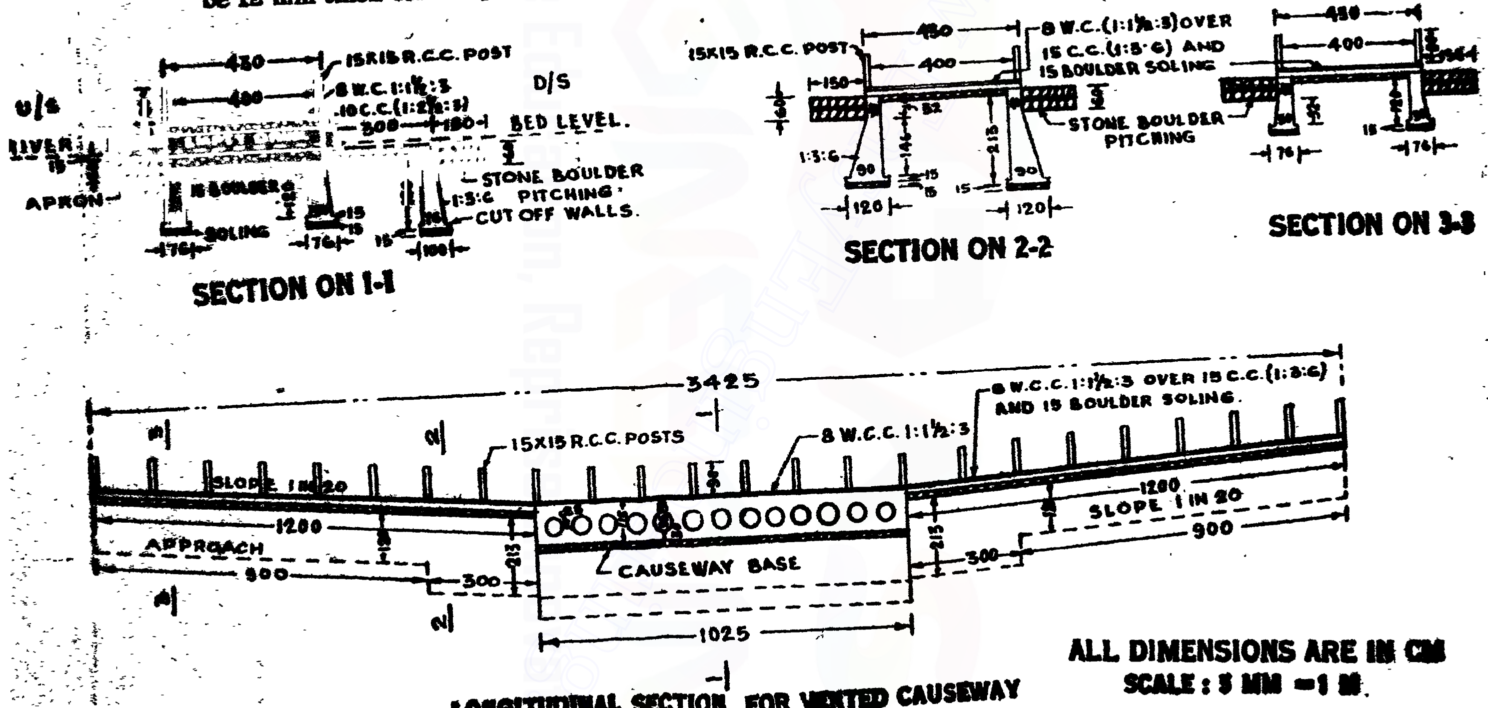


FIG.8-17

Item No.	Description	No.	L. cm	B. cm	H. cm	Qu. cu m	Total	Explanatory notes
1.	Earthwork in excavation (a) *Cause-way base* :— Abutment walls	2	1025	76	195	30·4		195=2×15+120 +30+15
	Cut-off walls ...	1	1025	100	215	22·0		
	Between abutment and cut-off walls at D/s apron	1	1025	224	38	8·7		224=300–(40+ 13)—(10+13)
	Extreme end of D/s apron	1	1025	102	75	7·8		102=150—35—13
	Bed (between abutments)	1	1025	324	60	33·2		324=430–2×40– 2×13
	For U/s apron ...	1	1025	127	75	9·7		127=150—10—13
	(b) *Approaches* :— Abutment walls ...	2×2	300	120	228	32·8		G. L. flushes with top of boulder.
	-do- -do- ...	2×2	900	76	135	37·1		
	Bed between abutments..	1×2	1200	324	15	11·6		
	For boulder ...	2×2	300	85	60	6·1		85=150-(120-15-40)
	-do- -do- ...	2×2	900	127	60	27·4	226·8	127=150-(76-13-40)
2.	Earthwork in filling for foundation trenches ...	⅕th. total	to that of item	of no. 1.	—	45·4	cum 45·4 cu m	
3.	15cm thick stone boulder soling (a) Walls ...	2	1025	76	–	15·58		
	...	1	1025	100	–	10·25		
	...	2×2	150	102	–	6·12		
	...	2×2	900	76	–	27·36		
	(b) Bases— ...	1	1025	350	–	35·88		
	...	1×2	1200	350	—	84·00		260=300—40 at D/s
	...	1	1025	260	—	26·65	205·84 sq m	

Item No.	Description	No.	L. cm	B. cm	H. cm.	Qu. cu m	Total	Explanatory notes
4.	**Stone boulder pitching at apron** ..	1×2	1025	150	60	18·45		
	..	2×2	1200	150	60	43·20		
							61·65 cu m	
5.	**Cement concrete (1:3:6) with 20mm down graded stone chips**							
	(*a*) *Vented portion*—							
	Abutment walls, bottom ..	1×2	1025	76	15	2·34		
	Trapezium portion ..	1	1025	$\frac{1}{2}(76+40)$	83	4·94		83—120—37
	Upper portion ..	1×2	1025	40	37	3·03		
	(*b*) *Cut-of wall*—							
	Bottom portion .	1	1025	100	15	1·54		
	Trapezium portion .	1	1025	$\frac{1}{2}(76+40)$	105	6·25		
	Upper portion	1	1025	40	60	2·46		
	(*c*) *Approaches*—							
	Bottom portion ..	2×2	300	120	15	2·16		
	Trapezium portion ..	2×2	300	$\frac{1}{2}(90+40)$	146	11·40		
	Upper portion ...	2×2	300	40	52	2·50		
	Bottom portion ...	2×2	900	76	15	4·10		
	Trapezium -do- ...	2×2	900	$\frac{1}{2}(50+40)$	53	8·64		53=120—15—52
	Upper portion ..	2×2	900	40	52	7·49		
	(*d*) *Cause-way base only*—	1	1025	430	115	50·69		
	(*e*) *Base of approaches*—	1×2	900	430	15	11·61		
	Deduction for vent holes	12	430	$\frac{\pi}{4}(55)^2$	–	12·15 (–ve)	62·00 cu m	

Item No.	Description	No.	L. cm	B. cm	H. cm	Qu.	Total	Explanatory notes
6.	**Shuttering—**							
7.	Sides of base ...	2	1025	—	123	25·22		123=115+8
8.	Approach base sides ...	2	430	—	123	10·58		
9.	Base, abutment walls ...	2×2	1025	—	135	55·35		135=120+15
10.	Approach, abutment walls ...	2×2 ×2	300	—	228	54·72		
11.	-do- -do- ...	2×2 ×2	900	—	135	97·20		
	Ends ...	4×1	50	—	120	2·40		
	" ...	4×1	90	—	228	8·20		
							253·67 sq m	
7.	**Laying 8cm thick cement concrete (1 : 1½ : 3 in) wearing course** ...	1	3425	430	—	147·28	147·28 sq m	3425=1025+2×1200
8.	**Laying 10 cm thick cement concrete (1:1½:3)** at U/s apron ...	1	1025	300	—	30·75	30·75 sq m	
9.	**R. C. work in post** ...	2×23	105	15	15	1·088	1·088 cu m	15cm extra for foundation.
10.	**Supplying and fitting, fixing empty tar drums**	12	430	—	–	51·6	51·6 r m	
11.	**12mm thick cement plaster (1 : 3)**							
	(a) Base, sides of cause-way only ...	1×2	1025	123	–	25·22		123=115+8
	(b) Base of approaches ...	1×2	1200	14	–	3·36		
	Deduction for ventholes	12	$\frac{\pi}{4}(55)^2$	—	–	2·38	(—ve)	
							25·75 sq m	

ABSTRACT OF ESTIMATED COST (Art. 8-16)

Item No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation of foundation trenches in all sorts of soil (including mixed soil but excluding stoney and mooram soil) including removing the spoils within a lead of 150m and including levelling, dressing and ramming the bottom, bailing or pumping out water etc. depth of excavation					
	(i) 0m to 1·5m and requiring shoring ..	172·00	cum	320 00	%cu m	550·40
	(ii) 1·5m to 3·0m -do- -do- ..	54·80	cum	360·00	%cu m	197·28
2.	Earthwork in filling in foundation trenches with good earth in layers not exceeding 15cm including watering and ramming layer by layer with earth obtained from excavation ..	45·40	cum	255·00	%cu m	115·77
3.	Supplying and laying 15cm (finished thickness) boulder soling in foundation including rough dressing the boulders, hand packing and ramming down small pices in the interstrices & ultimately filling up of voids with local sand.	205·84	sq m	16·00	sq m	3,293·44
4.	Boulder pitching including hand packing and rough dressing ..	61·65	cum	56·00	cu m	3,452·40
5.	Cement concrete 1:3:6 excluding reinforcement, and shuttering in any part of abutment walls, cutof wall, approaches, cause-way base, etc. with 20mm down stone chips.	62·00	cum	380·00	cu m	23,560·00
6.	Hire and labour charges for shuttering and staging for pier shaft and abutment walls etc. including striking off and removing after completion of work ..	253·67	sq m	16·00	sq m	4,058·72
7.	Laying 8cm thick cement concrete (1:1½:3) wearing course with stonechips finishing to camber and grade including hire charges for shuttering ..	147·28	sq m	28·00	sq m	4,123·84
8.	Laying 10cm thick cement concrete (1:1½:3) with stone chips including hire charges for shuttering. ...	30·75	sq m	35·00	sq m	1,076·25
9.	Supplying, fitting and fixing 15cm × 15cm R.C. (1:2:4) guard post 90cm long with stonechips including smooth neat cement finish as per drawing and painting the same ...	46	Nos.	25·00	Each	1,150·00
10.	Supplying and fitting, fixing empty tar drams in position as per drawing	55·90	rm	8·00	r m	
11.	12mm thick cement plaster (1:3)	·75	sq m	7·50	sq m	
					Total =	
					Add 5% to contingency =	2,101·27
					Add 2 " for workcharge =	
					Grand Total = Rs.	

8-18. Splayed Arch-culvert.—Find out the quantities of the following items from the enclosed drawing of a culvert :—(a) Earthwork in excavation below G.L. (b) Cement concrete in foundation proportion (1 : 2 : 4). (c) First class brickwork in cement below G.L. proportion (1 : 6). (d) First class brickwork in cement above G.L. proportion (1 : 6). (e) First class brickwork in "Arch".

Note—*(Dimensions not written may be found by direct measurement)*

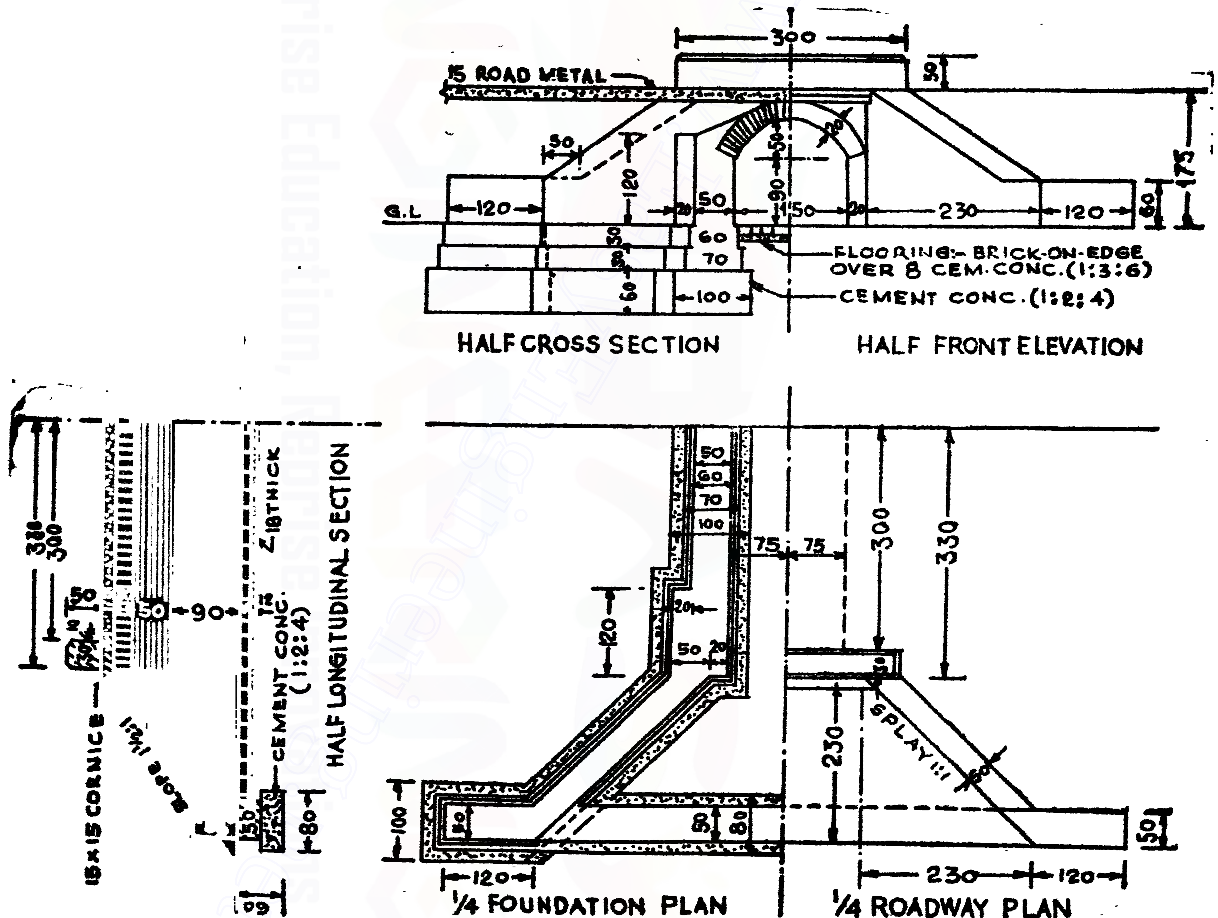


FIG. 8·18

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Description	L. cm	B. cm	H. cm	Qu. cu m	Total	Explanatory notes
(a) Earthwork in excavation below G. L						
(i) Abutments ...	710	100	120	17·04		710=2(330+25) 25 is the offset.
Counterforts (upto edge of abutment) ...	170	20	120	1·63		170=120+2×25
Triangular portion at shoulder ...	$\frac{35}{2}$	35	120	0·29		$35=25\times\frac{1}{\sin 45°}$
(ii) Wing walls (upto beginning of return walls)...	184	100	120	8·83		$184=\sqrt{(130)^2+130)^2}$ 130=230−50−2×25
(iii) Return walls ...	½(245+160)	100	120	9·72		245=120+25+100 160=245−(70+15)
(iv) Drop walls (half portion) ...	2×2 ½(295+225)	80	60	4·99		295=(75+20+230+120+25)−160−15 225=(25+120)+80
(v) Floor at approaches (half portion) ...	2×2 ½(22+85)	140	18	1·56		85=225−(230−50−15−25)
Floor between abutment wall foundation ...	710	100	18	1·28	45·34 cu m	
(b) Cement concrete in foundation						
Abutment, wind and return walls ...	of	item	(a)(i)+(ii)+(iii)	18·76		
Drop walls (half portion)...	½(316+246)	80	30	2·70		$316=295+\frac{15}{\sin 45°}$
Floor at approaches (half portion) ...	½(253+113)	175		1·02		$253=225+\frac{20}{\sin 45°}$ $113=85+\frac{20}{\sin 45°}$
Floor between abutments	670	70	8	0·38	22·86 cu m	670=710−2×15−2×5
(c) First class brickwork in cement below G. L.						
(i) Abutments						
70cm layer ...	680	70	30	2·86		680=710−2×15
60cm layer ...	670	60	30	2·41		
counterforts						
70cm layer ...	140	70	30	1·18		
60cm layer ...	130	60	30	0·94		140=170−2×15
Triangular portion a shoulder						
70cm layer ...	$\frac{14}{2}$	14	30	0·01		$14=\frac{10}{\sin 45°}$
60 cm layer ...	$\frac{7}{2}$	7	30	0·03		
C. O.					7·40	

Description.	No.	L. cm	B. cm	H. cm	Qu. cu m	Total	Explanatory notes
(ii) Wing walls—				B.F.		7·40	$226=\sqrt{(160)^2+(160)^2}$
70cm layer ...		226	70	30	1·90		$160=130+2\times15$
60cm layer ...		240	60	30	1·73		$240=\sqrt{(170)^2+(170)^2}$
(iii) Return walls— 70cm layer ...	4	$\frac{1}{2}$(209 +130)	70	30	1·42		$209=245-15-\frac{15}{\sin 45°}$ $130=160-15-15$
60cm layer ...	4	$\frac{1}{2}$(202 +125)	60	30	1·18		$125=130-5$(one side)
(iv) Drop walls— (half portion) 50cm layer ...	2×	$\frac{1}{2}$(323 +253	50	30	1·73		$323=295+\frac{20}{\sin 45°}$
(v) Floor at approaches (half portion) ...	2×	$\frac{1}{2}$(253 +113	175	10	1·28		50cm layer meets with 60cm layer of return walls.
Floor between abutments...		670	70	10	0·47		Flooring may be estimated separately.
						17·11 cu m	
(d) First class brickwork in cement mortar above G. L. (1:6) (i) Abutments upto springing level		660	50	90	5·94		
(considering rectangular solid) upto top of crown of arch ...		660	250	70	11·55		Deduction for arch masonry and segmental opening are to be made.
Counterforts ...		120	20	120	1·15		
Face wall— Rectangular portions above counterforts ...		20	40	60	0·19		Face wall :—see half long sec. below parapet $60=180-120$
Trapezoidal portions ...		200	40	38 (mean)	1·22		$54=\sqrt{(180)^2+(180)^2}$
(ii) Wing walls ...		254	50	118 mean	5·99		
(iii) Return walls ...		$\frac{1}{2}$(196 +120	50	60	1·90		$196=208-5-\frac{5}{\text{sign } 50°}$
(iv) Parapets ...		300	30	50	0·90		Area of segment= $\frac{2}{3}$ span × rise
Deductions for segmental portion ...	1	660	($\frac{2}{3}\times150$	$\times50$)	3·30	(-ve)	
do- Arch masonry ...	same as item no. (e)				2·45	(-ve)	
-do- Triangular portions above abutment ...	2	660	125	40	6·60	(-ve) 16·49 cu m	186 is the length of mean arch
(e) First class brickwork in "Arch"	1	660	180	20	2·45	2·45 cu m	

(C) PAVEMENT

8-19. Pavement portion of a Road Structure :—This consists of the following parts :—

(*a*) *Base course also called soling, Bearing course and* (*c*) *Wearing course.*

The function of pavement is to (i) distribute traffic loads over the soil formation also called sub-grade ; (ii) protect the sub-grade from ravages of weather, abrasive effect of traffic and (iii) provide a smooth riding surface. The thickness of pavement or road crust depends upon the nature and extent of the traffic and the sub-grade condition.

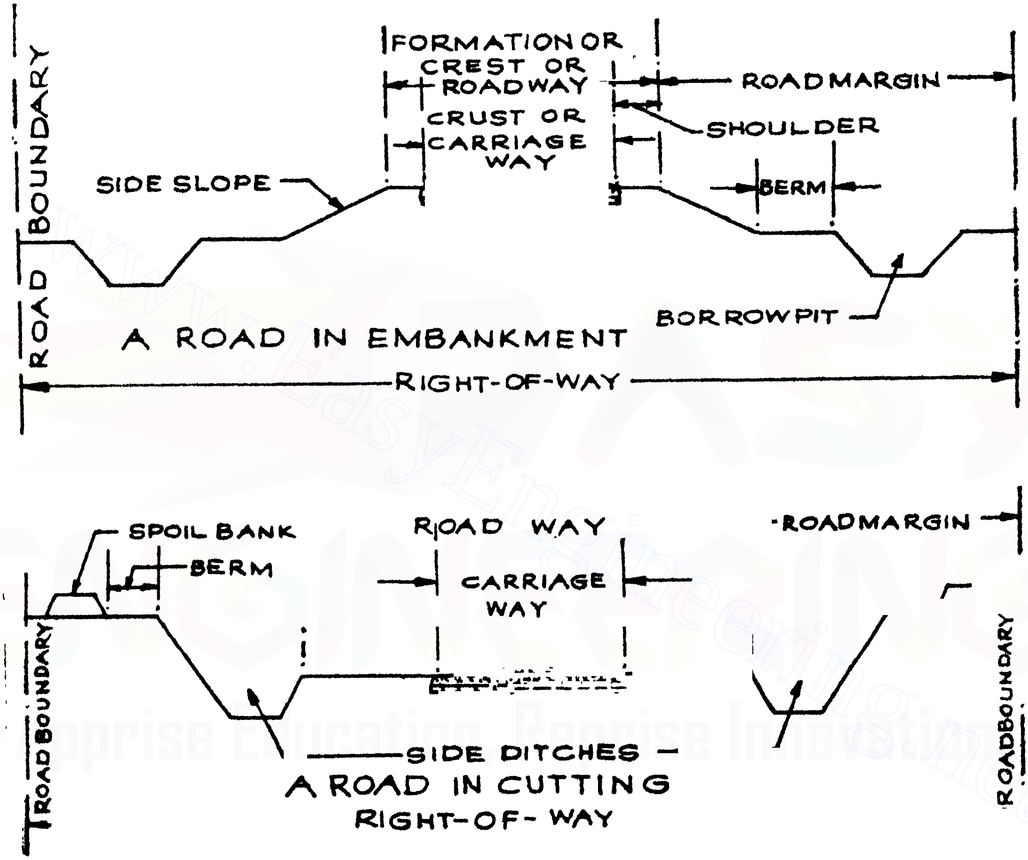


FIG. 8·19

Notes :—(*a*) *Blindage* is spread over the consolidated road metal @ 0·9 cu m per 100 sq m. But when the surface is to be painted blindage is not to be used.

(*b*) *Tack coat* may be with bitumen, tar or emulsion @ 73kg to 146 kg per 100 sq m (depending upon thinkness), 73kg over existing road surface, 114 kg over water-bound Macadam is essential before laying carpet over an old road surface if it is smooth.

(*c*) *Priming coat* is necessary over dusty, porous or soft roads before applying bitumen @ 48 to 146kg per 100 sq m depending upon the porosity of the road materials. 100 kg is for Water-Bound Macadam Road.

(*d*) *Seal coat* is a dressing of tar or bitumen, binded with sand, grit, etc. @ 127 kg per cu m of sand applied to open texture bituminous surface, so as to fill the voids in the chippings and thus to render the surface water tight. Seal coat which acts as a renewal coat of surface dressing should be tried to avoid in order to reduce the cost.

(e) **Sub-grade** :— The finished and compacted surface of earthwork which directly receive the traffic loads from the pavement is called sub-grade formation. The finished surface of the natural ground called sub-grade consists the required Camber and gradient. Its function is to provide an adequate and uniform bearing to the road structure.

Preparation of sub-grade or sub-base for W.B.M. road :— Except rock cutting areas, subgrade is in the form of a trench. The bottom of the trench is fixed after deducting the pavement thickness from the finished formation level. So a trench is dug in conformity with the lines, grade and cross-section. The subgrade is then thoroughly compacted by rolling.

(f) **Camber** :—The term camber implies the convexity provided to the surface of carriage-way or the rise of the centre of the road above its edges on straight portion of a road. It is the difference in level between the crown and the edge of the carriageway. It is also expressed as the slope of the line joining the crown with the edges of the carriageway and the horizontal line between the edges and is usually expressed as the percentage of rise given to the crown above its ends. Sometimes called cross slope or cross fall.

Objects of camber :— (i) To drain off rain water quickly from the surface of carriage way towards the edges of a road. (ii) To separate the traffic on the road. Excessive-camber induces drivers to drive his vehicle near the crown of the road and tends to accident and the uneconomical use of the highway.

(g) **Superelevation** :— The inward tilt or transverse inclination provided to the cross section of a carriage way at horizontal curved portion of a road to reduce the centrifugal force on a moving vehicle is called superelevation.

Objects of superelevation are:— To counteract the effect of centrifugal force on the moving vehicle and thus the vehicle can move at the same speed on a curved path as on a straight path without any danger of overturning. (ii) It provides drainge of the road and as such superelevation should not be less than the camber of the road. For hilly roads a steeper superelevation is provded. But greater the superelevation, more the inconvenience to slow moving traffic.

(h) **Per-mix carpet** :— A intimate mixture of stone chips, sand and binder (bitumen or tar) is laid in hot state for construction of wearing course of a bituminous road in the form of a carpet and rolled is called pre-mix carpet.

The thickness of premix carpet generally varies between 200 to 400 mm. This type of bituminous road construction is very popular and it provides smooth surface and pleasand looking finish. From the point of view of both stability and economy the primix method is superior to the grouting method.

8·20. Calculation of brick flat soling :—

Example : Calculate the number of bricks require for double brick flat soling for a pavement 4 m wide and one kilometre long. (Use modular bricks)

Ans.— For bottom layer area $= 1 \times 1000 \times (4 + \cdot 20) = 4{,}200$ sq m

For top layer area $= 1 \times 1000 \times 4 = 4{,}000$ sq m

Total area $= 8{,}200$ sq m

$\therefore$ Number of bricks @ 5000 nos per 100 sq m $= \dfrac{8{,}200}{100} \times 5000 = 4{,}10{,}000$ nos.

8·21 Calculation of Bearing Course :—

Example : Calculate the quantity of metals required which are laid in two layers each of 8 cm thick for a 4 m wide road in one kilometre length.

Ans. :— Quantity of consolidated meterials $= 1 \times 1000 \times 4 \times \cdot 16 = 640$ cu m. Increase this amount by $\frac{1}{2}$rd when loose $= 640 + 640 \times \frac{1}{2} = 960$ cu m. (Loose volume is variable from 20% to 40% depending upon (1) Classification of grading, (2) size range etc.

8-22. Caculation of Wearing Course :—The calculation of materials for different types of wearing course may be done with the help of the table as shown below.

Sl. No.	Description of item	Unit	Name of materials required	Quantity of materials required
1.	(a) Single coat surface dressing or the first coat of two coat surface dressing.	%sqm	1. Bitumen (Binder) 2. Stone chip 3. Sand	180 kg 1·50 cum 0·60 cum
2.	(b) Second coat of two coat surface dressing.	,,	1. Bitumen (Binder) 2. Stone chips	110 kg 1·0 cum
3.	25 mm thick Premix carpet (a) On Water Bound surface on stable coat	,,	1. Bituman or Road tar (including tack coat @ 100kg per 100 sqm) ... 2. Stone chips	280 kg 3·38 cum
	(b) On black top or concrete surface	,,	1. Bitumen or Road tar (including tack coat @ 50kg per 100sqm) ... 2. Stone chips ...	230 kg 3·38 cum
4.	For any other thickness of premix clipping carpet	,,	-do-	Multipleof25mm hick (approx)
5.	Bituminous macadam miller mixer (i) 75mm thick	,,	1. Mineral aggregates Total qty 10cum break up as follows 25mm Stone chips 12mm Stone chips 6mm Stone chips Sand ... ... 2. Matrix ...	 3·50 cum 2 50 cum 2·50 cum 1·50 cum 665kg
	(ii) For any other thickness ...	,,	-do-	Multiple of 75mm thick
6	For Tack Coat – (i) On W. B. M. surface ... (ii) On black top surface ...	 ,, ,,	 1. Matrix ... 1. Matrix ...	 100kg 50kg
7.	Premix Seal coat (sand flushing) for old black top or freshly laid bituminous surface.	,,	1. Sand (course)... 2. Matrix	6 0 cum 681·0kg
8.	Liquid seal coat on old black top surface.		1. Matrix 2. Stone chips(6mm)	98kg 0·9cum
9.	Ashphaltic concrete (Dense Graded) 50mm thick.	,,	Total mineral aggregate=8·12m³ break up as follows 12mm stone chips 6mm ,, ,, sand (F. M 1·5) Lime Stone dus. Matrix ...	 1·62 cum 3·25 cum 2·44 cum 0·81 cum 752kg.
10.	For any other thick ness of ashphaltic concrete the quantity shall be multiple of 50mm thick.	,,		

Example—1 A dimensioned sketch of a road crust 7·2 metres wide between the edgings is shown below. Prepare a detailed estimate for constructing 2·5km long road and calculate quantities of materials requires for the road. The crust is constructed with the following :—

(i) Two layers of brick flat soling with overburnt bricks.

(ii) 100mm thick consolidated Overburnt brick metal with 75mm thick consolidated stone.

(iii) 25mm thick premix chipping carpet with bitumen.

(iv) Brick on-end edging with Overburnt bricks.

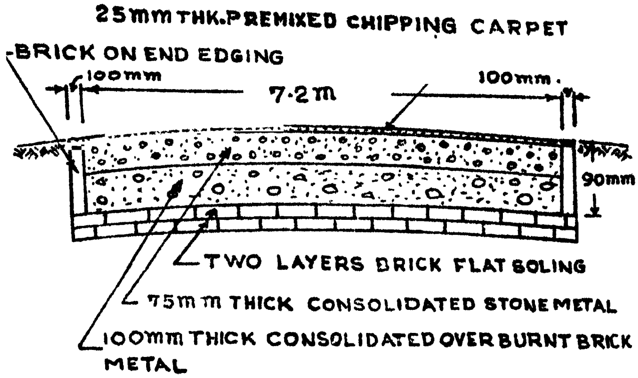


FIG. 8-20

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (Ex—1)

Item No.	Particulars of item	No.	Length m	B. m	H. of depth m	Qu.	Total	Explanatory notes.
	Box cutting in road crust, and con solidating and dressing the sub grade to the specified grade and camber		2,500	7·40	0·45	8325	8325 cum	0·45= 2×0·10+ 0·15+0·075
	Base course :—							
	(a) Double brick flat soling with overburnt bricks with the brea joints		2,500	7·40		18500	18,500 sqm	
	b) Bottom layer—							
	(i) Supplying overburnt brick meta 50 to 65mm size stacked at road side at regular intervals		2,500	7·20	0·150	2700	2,700 cum	150mm loos compaced to 100mm
	(ii) Labour for spreading and consolidating of brick metal		2,500	7·20	0·150	2700	2,700 cum	
	(c) Top layer—							
	(i) Supplying 40 to 25mm size trap stone metal and stacked a road side at regular intervals ..		2,500	7·20	0·112	2016	2016 cum	75 compacted when loose $75+\frac{1}{2}\times75$ =112mm
	(ii) Labour for spreading and consolidation of stone metal		2,500	7·20	·112	2016	2016 cum	
	Wearing Coat :—							
	(i) Supplying bitumen (asphalt 80/100) delivered and stacked at site		2,500	7·20 @	80 kg =	per 56400	100sqm =50·4	tons
	(ii) Supplying trap stone chips 12 to 6·3mm size delivered at site ...		2,500	7·20@	38 cu	m per 608·24 cu m	100sqm 608·4 c um	
	(iii) Premixing, laying the premix uniformly on W. B. M. surface applying tack coat and consolidating 25mm thick carpet ...		2,500	7·20		18,000	18000 sqm	
4.	Brickon end edging with overburnt brick laid true to line and level ...	×2	2,500			5,000	5,000 rm	

Item No.	Particulars of item	Qu.	Unit.	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Box cutting in road crest and consolidating and dressing sub-grade to the specified grade and camber ...	8,325	cu m	320·00	%cum	26,640·00
2.	(a) Double brick flat soling with overburnt bricks with the break joints ...	18,500	sq m	25·00	sq m	4,62,500·00
	b(i) Supplying overburnt brick metal 50 to 65mm size stacked at road side at regular intervals ...	2,700	cu m	80 00	cu m	2,16,000 00
	(ii) Labour for spreading and consolidation of brick metal thickness above 110mm ...	2,700	cu m	14·00	cu m	37,800·00
	c(i) Supplying 40 to 25mm size trap stone metal and stacked at road side ...	2,016	cu m	140·00	cu m	2,82,240·00
	(ii) Labour for spreading and consolidation of stone metal thickness above 100mm (loose) ...	2,016	cu m	17·00	cu m	34,272·00
3.	(i) Supplying Bitumen (asphalt80/100	50·4	tons	2700 00	M. T	1,36,680·00
	(ii) Supplying trap stone chips 12mm down ...	608·4	cu m	160·00	cu m	97,344·00
	(iii) Premixing, laying and consolidating 25mm thick carpet on W. B. M. surface ...	18,000	s q m	1·90	sq m	34,200·00
4.	Brick on end edging with overburnt bricks laid true to line and level ...	5,000	r m	50·00	%r m	2,500·00
					Total=Rs.	13,29,5760·00
					Contingeney @ 5%=Rs.	66,478 80
					W.C. Establishment @2½%=Rs.	33,239·40
					Grand Total =Rs.	14,29,294·20

Quantity of Materials (Ex. 1)

1. (a) Overburnt bricks For single soling @ $\frac{1 \cdot 0}{\cdot 20 \times \cdot 10}$ = 50 nos per sq m.

∴ For double soling@ 50 kg×2=100 nos per sqm for 18,500 sqm=18,50,000 nos.

(b) Brick edging=5,000 rm $=\frac{5,000}{0 \cdot 10}$=50,000 nos.

Total nos. of over burnt bricks = 19,00,000 nos.

2. Overburnt brick metal 50 to 65mm size ... ... = 2,700 cum
3. Trap stone metal ... ... = 2,016 cum
4. (i) Bitumen (asphalt 80/100) ... ... = 50·4 tons
   (ii) Trap stone chips 12mm down ... ... = 608·4 cum

Example—2. Detailed dimensioned sketch cross-section of a city street having metalled of 8 metre for the carriageway is shown in fig. 8-20 Prepare a detailed estimate for constructing 500 metre length of this street. Indicate also quantities of materials.

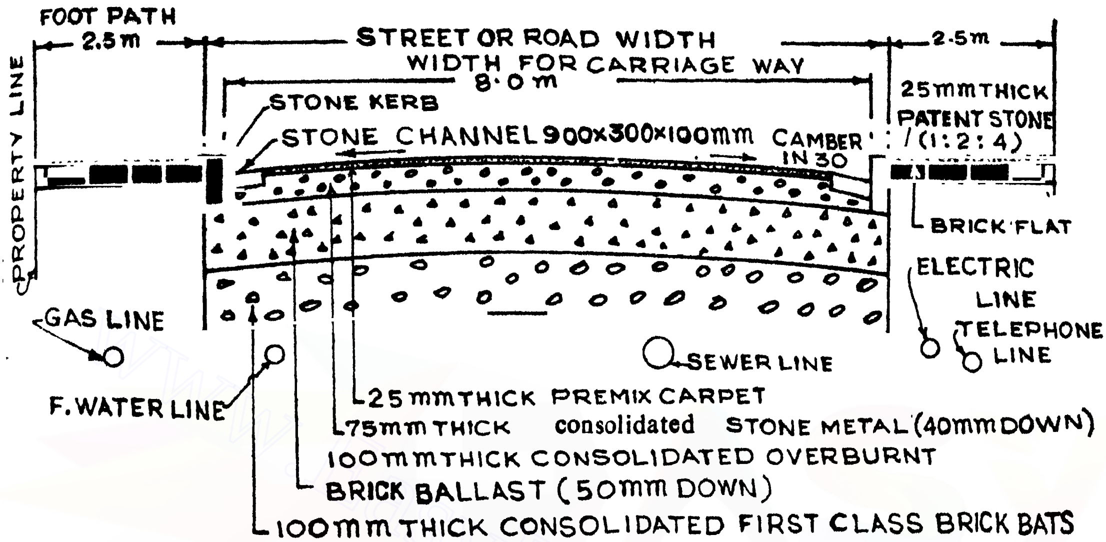


FIG. 8-20

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 2)

Item No.	Particulars of Item	No.	L. m	B. m	H. m or D.	Qu.	Total	Explanatory notes
1.	**Box cutting** in road crast and consolidating and dressing sub-grade ...	1	500	8·20	0·300	1230	1230 cu m	8·20 = 8·00+2 × 0 10 for kerb thickness
2.	**Base course** :— (a) *Soling* (i) Supplying first class brick bats ...	1	500	8·20	0·15	615·0	615·0 cu m	0·15m loose consolidated to 0·10m (i.e. 50% less)
	ii) Labour for laying, spreading and consolidating with departmental brick bats ...	1	500	8·20	0·15	615·0	615 0 cu m	
	(b) *Bottom layer* (i) Supplying overburnt brick metal 50 to 65mm size ...	1	500	8·20	0·15	615·0	615·0 cu m	0·15m loose consolidated to 0·10m
	(ii) Labour for spreading and consolidating to brick metal ...	1	500	8·20	0·15	615·0	615·0 cu m	
	(c) *Top layer* (i) Supplying 40 to 25mm size trap stone metal ...	1	500	8·00	0·100	400·0	400·0 cu m	0·075 m consolidated loose vol. =0·10m
	(ii) Labour for spreading and consolidation of stone metal...	1	500	8·00	0·100	400·0	400·0 cu m	

Item No.	Particulars	No.	L. m	B. m	H. or D m	Qu.	Total	Explanatory notes
3.	**Wearing coats :—**							
	(i) Supplying bitumen (asphalt 80/100, delivered and stacked at site ...	1	500	7·40	@280	kg/100	sq m	
					=	1036 kg	10·36	tons
	(ii) Supplying trap stone chips 12 to 6·3mm size ...	1	500	7·40	@3·38	cu m	/100	sq. m
						= 125·1	125·1	7·40=8·00
							cu m	—2×0·300 for chann-els widths
	(iii) Premixing, laying the pre-mix chips applying tack coat and consolidating 25mm thick carpet ...	1	500	7·40	—	3700	3700 sq m	
4.	**Edging:—**							
	(i) Supplying 900 × 300 × 100mm stone blocks for kerb and channel ...	2×2	500	—	—	2000	2000 r m	
	(ii) Laying, levelling kerb and channel on 75mm thick cement concrete (1:3:6) bed with brick ballast and pointing the joints with cement mortar (1:6) ...	2×2	500	—	—	2000	2000 r m	

ABSTRACT OF ESTIMATED COST (Ex. 2)

Item No.	Particulars of Item	Qu	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Boxcutting in road crust and consolidating and dressing the sub-grade ...	1230	cu m	320 00	%c u m	3936 00
2.	a(i) Supplying 1st class brick bats ...	615·0	cu m	58·00	cu m	35,670·00
	(ii) Labour for spreading and consolidating brick bats ...	615·0	cu m	12·00	cu m	7,380·00
	b(i) Supplying overburnt brick metal 50 to 65mm size ...	615·0	cu m	80·00	cu m	49,200·00
	(ii) Labour for spreading and consolidating brick metal ...	615·0	cu m	14 00	cu m	8,610·00
	c(i) Supplying 40 mm down stone metal...	400·0	cu m	150·00	cu m	60,000·00
	(ii) Labour for spreading and consolidating stone metal ...	400 0	cu m	17·00	cu m	6,800·00
3.	(i) Supplying Bitumen (asphalt 80/100)	10·36	tons	2700·00	M.T.	27,972·00
	(ii) Supplying trap stone chips 12 mm down ...	125·1	cu m	160·00	cu m	20,016·00
	(ii) Premixing laying and consolidating 25 mm thick carpet ...	3700	sq m	1·90	sq m	70,30·00
4.	(i) Supplying 900×300×100 mm stone blocks ...	2000	r m	10·00	r m	20,000·00
	(ii) Laying, levelling Kerb and channel sets ...	2000	r m	2·00	r m	400.00·00

Total = Rs. 2.86 614·00

Add5% for contingency ... = Rs. 14,330·70

Add $2\frac{1}{2}$% for W. C. ... = Rs 7,165·35

Grand total = Rs. 3,08,110·05

Quantity of Materials (Ex. 2) :

1. First class brick bats ...615·0 cu m
2. Overburnt brick metal 50 to 65 mm size ...615·0 cum
3. Stone metal 40 mm down ...400·0 cu m
4. Stone chips 12mm down ...125 1cu m
5. Bitumen ...10 36tons
6. Stone blocks 900 × 300 × 100mm...2,000 rm

Example-3. The details of cross-section of a road crust 4m wide are : (a) 15cm boulder soling, (b) 100mm wide 125mm deep boulder edging, (c) 10cm consolidated stone metaling, (d) Wearing course is 75mm thick a Bituminous macadam (miller mixer). Prepare a detailed estimate for 6 km length of the crust adopting current rates.

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 3)

Item N	Particulars of item	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Box cutting in road crust and consolidating and dressing the sub-grade ...		6,000	4·20	0 25	6,300	6,300 cu m	0·25 = ·15 + ·10
2.	Supplying boulders at road side at regular intervals for soling ...		6,000	4·20	0·15	3,780	3,780 cu m	
	Labour for laying 15cm average thick boulder soling including rough dressing ...		6,000	4·20	0·15	3,780	3,780 cu m	15cm loose compacted to 10cm
	Supplying boulders at road side for edging ...		6,000	0·10	0 125	150	150 cu m	
5.	Labour for laying stone edging laid to correct line and level 100mm wide & 125mm deep ...		6 000				12 000 r m	
6.	Supplying 40 to 25mm trap stone metal and stacked at road side at regular intervls ...		6,000	4·00	0·15	3,600	3,600 cu m	
	Labour for spreading and consideration of stone metal ...		6,000	4·00	0·15	3,600	3,600 cu m	For 75mm thick 25 mm = 3·5cu m 2mm = 2·6cu m 6mm = 1·80cu m per 100 sq m.
	For Bituminious Macadam:— (i) Supplying stone chips for Bituminous macadum from 25mm to 6mm size ...		6,000 per	4·00 100 sq m	8 5 cu m =	2,040	2,040 cu m	
	(ii) Sand ...		6,000 per	4 00 100 sq m	@ 1·5 cu m =	60	360 cu m	
	(iii) Matrix ...		6.000 per	4·00 @ 665 kg 100 sq m =		59,600 kg.	159·6 Tonne	
9.	Labour for Bituminous Macadam including through cleaning the surface etc. ...		6,000	4 00	0·075	1,800	1,800 cu m	

ABSTRACT OF ESTIMATE COST (EX. 3.).

Item No.	Particulars	Quantity	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Box cutting in road crust and consolidating and dresing ...	6,300	cu m	320·00	% cu m	20,160·00
2.	Supplying boulders at road side at regular intervals ...	3,780	cu m	40·00	cu m	1,51,200·00
3.	Labour for laying 15cm av. thick boulder soling ...	3,780	cu m	16·50	cu m	62,370·00
4.	Supplying boulders at road side at regular intervals ...	150	cu m	40·00	cu m	6,000·00
5.	Labour for laying stone edging 100mm wide and 125mm deep ...	12,000	metre	48·00	% metre	5,760·00
6.	Supplying 40 to 25mm size trap stone metal at road side ...	3,600	cu m	135·00	cu m	4,86,000·00
7.	Labour for spreading and consolidation of stone metal ...	3,600	cum	14·00	cu m	50,400 00
8.	Supplying (i) stone chips 25mm to 6m size ...	2,040	cu m	150·00	cu m	3,06,000 00
	(ii) sand ...	360	cu m	100·00	cu m	36,000·00
	(iii) matrix ...	159·6	Tonne	2700·00	Tone	4,30,920·00
9.	Labour for Bituminous Macadam ..	1,800	cu m	55·00	cu m	99,000·00

Total = Rs. 16,53,810·00

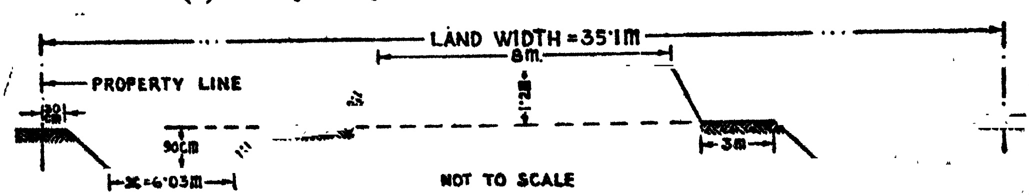
Add 5% for contingency = Rs. 82,690·50

,, $2\frac{1}{2}$% for W.C. = Rs 41,345·25

Grand Total = Rs. 17,77,845·75

Example—4 Prepare an estimated cost for a road project which is 8 k m in length the formation width is 8 m, metal width 3 m with 15 cm (consolidated) depth laid on two, brick flat soling and brick on end edging. Average height of embankment is 1·2m, bearm space should be 3 m on either side, side slope of embankment is 2 : 1 and that of borrow pit 1 : 1. The depth of borrow pit is restricted to 90 cm.

Rate :—(1) Value of land ... ... Rs. 10,000 per hectare
(2) Earthwork within a lead of 30 m and lift 2m ... ... Rs. 3·20 per cu m
(3) Brick flat soling (Modular brick) ... Rs. 18·00 per sq m
(4) Brick on end-edging (—do—) ... Rs. 5 00 per r m
(5) Stone metal supply ... Rs.140·00 per cu m
(6) Laying and consolidating ... Rs. 17·00 per cu m
(7) Lump-sum provision for culvert ... Rs.30,000 per k. m.



Ans: Vol. of earthwork per running metre $=(Bd+s_1d)^2\times 1$

$$=(8\times 1{\cdot}2+2\times 1{\cdot}2^2)=12{\cdot}48 \text{ cum}$$

With pits on both sides) vol. of pit per running metre (one side) $\frac{12{\cdot}48}{2}=6{\cdot}24$ cu m

Referring to the above fig. $(xd+s_2d^2)\times 1=6{\cdot}24$ or $x\times{\cdot}9+1\times{\cdot}9^2=6{\cdot}24$ $\therefore x=6{\cdot}03$ m

$\therefore$ Width requ. for one borrow pit $=x+2\times s_2d=6{\cdot}03+2\times 1\times{\cdot}9=7{\cdot}83$ m

Bottom width of embankment $= 8+2s_1d = 8+2\times2\times1{\cdot}2 = 12{\cdot}8$m

$\therefore$ Total land width require $= 12{\cdot}8+2\times3+2\times7{\cdot}83+2\times{\cdot}30 = 35{\cdot}06$ say $35{\cdot}1$ m

Details of measurement and calculation of quantities for one kilometre.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
1.	Land acquisition ...	1	1000	35·1	—	35,100	3·51 hect.	
2.	Earthwork within a lead of 30m and lift 2m ...	1	1000@	12·48	cu m/r m	12,480	12,480 cu m	12·48 cu m for 1m road length
3.	Brick flat soling (modular) (a) bottom layer ...	1	1000	3·38	—	3,380		
	(b) top layer ...	1	1000	3·0	—	3 000	6,380 sq m	
4.	Brick on end edging (both sides) ...	1×2	1000	—	—	2,000	2000 r m	
5.	Stone metal supply ...	1	1000	3·0	0·20	600	600 cu m	Increased by ⅓rd for loose.
6.	Laying and consolidations	Sa	me as	item	no.5	600	600 cu m	
7.	Lump-sum provisions culvert ...	1	—	—	—	1	k.m.	

ABSTRACT OF ESTIMATED COST (EX-4)

Item No.	Description	Qu.	Unit	Rate Rs.	Per	Amount Rs P
1.	Land acquisition ...	3 51	hectares	10,000	hec	35,100·00
2	Earthwork with a lead of 30m and lift 2m ...	12480	cu m	3·20	cu m	39,936·00
3.	Brick flat soling ...	6380	sq m	18·00	sq m	1,14,840·00
4.	Brick on end-edging ...	2000	r m	5·00	r m	10,000·0)
5.	Stone metal supply ...	600	cu m	140·00	cu m	84,000·00
6.	Laying and consolidation ...	600	cu m	17·00	cu m	10,200·00
7.	Lump sum provision for culvert ...	1	k m	3000	per km	30,000·00

Total = Rs. 3,24,076 00

∴ Cost for 8 k m = „ 25,92608 00

Add 5% for contingency = „ 1,29630·40

Add 2½% for workcharge = „ 64,815·20

Grand Total = Rs. 27,87,053·60

8-25 Short note on concrete roads :—The structural components of concrete pavements generally consists (a) Sub grade, (b) Sub-base and (c) Concrete slab. The function of Sub-base is (i) to provide a strong supporting layer, (ii) to reduce the thickness of slab, and (iii) to provide a capillary cut off, preventing due to mud pumping. When natural subgrade is not very hard, a sub-base over the sub grade is usually provided with any one of the following layers :—(1) A layer of well graded soil-gravel (Kanker) mixture of maximum thickness upto 15 cm. (2) 10 cm thick weak cement concrete, (3) One layer of W.B.M. upto 10cm over a brick flat soling. (4) Two layers of W.B.M. not exceeding the total thickness of 15 cm.

The concrete slab may be plain or reinforced with joints at regular intervals. Longitudinal joints in concrete roads along the centre is provided when the pavement width exceeds 4·5 m. Transverse joints are provided in the transverse direction of the road slab at distance of 5 m (maximum) intervals and at right angles to the centre line of the road. These joints may be filled up with a sealing compound such as bitumen. When concrete roads are reinforced longitudinal joints provide tie bars of 12 to 15 mm diameter of about 1m length and are placed at 600mm intervals across the joint. For transverse joints 15 to 18 mm diameter dowel bars of 300 to 600 mm in length are placed at 300 to 500mm intervals.

Example 5. A cement concrete road is 500 m long 8m wide and 15cm thick over the sub-base of 10cm thick gravel. Prepare a detailed estimate for this road.

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (Ex-5)

Item No.	Description of item	No.	L. m	B. m	H or D m	Quantity	Total	Explanatory notes
1.	Box cutting in road crust and consolidating and dressing the sub-grade ...	1	500		0·25	1000	1,00 cu m	0·25=0 15 +0·10
2.	Supplying soil gravel and stacking ...	1	500		0·15	600	600 cu m	15 cm is loose vol.
3.	Labour for spreading and consolidating soil gravel ...	1	500		0·15	600	600 cu m	
4.	Cement concrete (1:2:4) with 20 mm down stone chips for road slab including floating the concrete surface after compaction and Belting after floating for skid resistance and including Brooming, Edging etc.	1	500	8	0·15	600	600 cu m	
5.	Providing necessary joints in concrete slab and filling the joints with Bitumen							
	(a) For longitudinal joints ...	1	500			500		
	(b) For transverse joints @ 5m intervals	100	8			800		
							1300 r m	

ABSTRACT OF ESTIMATED COST (Ex. 5)

Item No.	Particulars	Quantity	Unit	Rate Rs. P.	Unit of rate	Amount Rs. P
1.	Box cutting in road crust and consolidating and dressing ...	1,000	cu m	320·00	%cu m	3,200·0(
2.	Supplying soil gravel and stacking at road side etc. ...	6·00	cu m	110 00	cu m	66,000·0
3.	Labour for spreading and consolidation soil gravel ...	600	cu m	14·00	cu m	8,4000·0
4.	Cement concrete (1:2:4) with 20 mm down stone chips ...	600	cu m	450 00	cu m	2,70,000·(
5.	Providing necessary joints in concrete slab...	1 300	rm	2 00	rm	3,250·(

Total = Rs. 3,50,850·
Contingency @ 5% = Rs. 17,542·
W. C. establishment @2½ = Rs. 8·771·
Grand Total = Rs. 3, 7,163·

CHAPTER IX

IRRIGATION WORKS

9·1. Earthwork in Canals—There are three types of canal sections generally involve in irrigational works and they are :—

(*a*) *Canal fully in excavation* (*Fig. 9·1*)

(*b*) *Canal partly in excavation and partly in embankment* (*Fig. 9·2*)

(*c*) *Canal fully in embankment* (*Fig. 9·3*)

To calculate the quantity of earthwork most of the Irrigation departments have their elaborate tabular form in which detail informative columns (viz., width of borrow pit, width between toes of banks, permanent land width etc.) besides the columns for earthwork are provided. But following the main principle the volume of earthwork for irrigational canals are calculated by the Trapezoidal formula also called as End area formula or by Mid section formula as illustrated hereafter.

The side slope in cutting is generally kept as 1 : 1 and in banking $1\frac{1}{2}:1$ ($1\frac{1}{2}$ horizontal) or 2 : 1 according to the soil condition.

(a) **Fully in excavation :**—

B=bed width. d=depth of excavation.

S :1=side slope (horizontal : vertical)

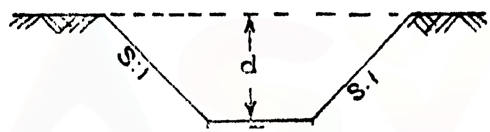


FIG. 9·1

Sectional area$=Bd+Sd^2$. The sectional area may be calculated either by Mid section formla or by Average end area formula as already described in Earthwork for Roads chapter. Quantity of earthwork = Sectional area × length.

For a number of sections, quantity of earthwork is estimated by a tabular form (as described Earthwork for Road).

Permanent land width$=B+2sd+$extra land widths beyond the canal.

∴ Area of permanent land=width of permanent land × length,

(b) **Partly in Excavation and partly in Embankment :**

B=bed width.

d=depth of excavation,

h=height of embankment

H=height of banking from bed of the canal.

∴ $h=(H-d)$

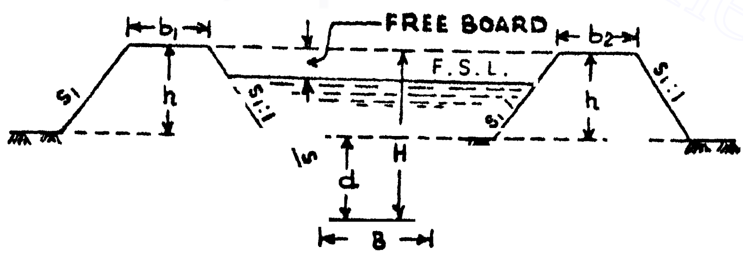


FIG. 9·2

b_1 and b_2 are top widths of banking (may be same). Usually on the left bank a service road is provided for inspection of the canal and so the width of the left bank becomes more than the right bank.

Sectional area in digging$=Bd+Sd^2$ Sectional area in banking$=(b_1+b_2)\ h+2s_1\ h^2$

Quantity of earthwork in digging and in banking are calculated separately by the same principle as described in (a).

If the earth obtained from digging in the bed is equal to the earth required for the formation of banks this is known as "*economical digging*" and the canal is said to be designed with the "*balancing depth*".

$\therefore$ Quantity of digging = Quantity in banking.

i.e., Sec. area of digging = Sec. area of two banks.

or, $Bd+sd^2=(b_1+b_2)\,h+2s_1h^2$ ... ... (1)

If the digging is more than the earth required for the banks then the surplus earth is thrown away to form spoil bank. If, however, the digging is less, than the extra earth required for the banks is taken from borrow pits in temporary land.

Only the excess quantity of earth as require for the formation of bank from borrow pits are considered in the estimate. That is if Q_1 and Q_2 are the quantities of earthwork in digging and banking respectively then the quantity of earthwork in banking $=Q_2-Q_1$. If Q_2 is lesser then Q_1 no earthwork is considered for banking.

(c) **Fully in Embankment** :—

B = bed width.

H = height of banking from bed of the canal

d = depth of filling between G.L. and bed of the canal.

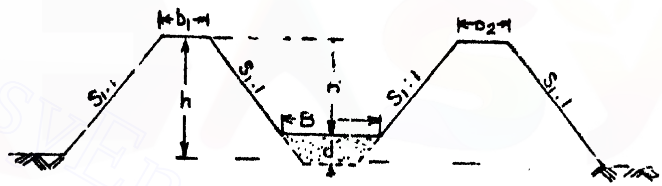


FIG. 9-3

For cutting 'd' is denoted by + ve sign, but for filling by — ve sign.

$\therefore$ h = height of banking $=H-(-d)$. Sectional area $=(b_1+b_2)h+2\,S_1\,h^2$.

No earthwork is to be done for graps between G.L. and bed level as shown by dotted mark as because this portion will be filled up in due course by silting. But in case if the canal is fully in embankment for the entire down stream side and the bed level is above ground level then the earthwork for this portion may be accounted. The quantity is found considering the whole area as solid first and then deducting the canal area.

= (Central area + out side slope areas) — area of canal

$=(xh+2s_1h^2)-(BH+s_1H^2)$ where $x=B+b_1+b_2+2s_1H^2$

To calculate quantity multiply the above area by length as worked out in Example—4

Example—1. Calculate the quantity of earthwork of a portion of a channel with the following datas :—

Bed width = 3m ; Free board = 44cm ; Slope of digging 1 : 1 ; Side slope of banking $1\frac{1}{2}:1$; Full supply depth = 1m ; Top width of both the banks = 1·5 m.

Rd.	Ground level	Proposed bed level
0 m	225·24 m	224·00 m
30 m	224·80 m	223·94 m
60 m	224·43 m	223·88 m
90 m	224·12 m	223·82 m
120 m	224·50 m	223·76 m
150 m	224·98 m	223·70 m

Calculation of quantities by Average End area formula Ex. (1):—

Depth of digging, d=G.L.—proposed bed level ; viz, d for 0 Rd=225·24m—224·00m=1·24m

DIGGING

B=3m ; S=1

Ht. of bank above G. L.=Full supply depth+Free board =1m+44cm=1·44 m.

EMBANKMENT

$b_1=b_2=1\cdot5$ m ; $S_1=1\frac{1}{2}$

Rd.	Depth of digging d (m)	Area of central portion=Bd (m^2)	Area of sides $=Sd^2$ (m^2)	Total sectional area $Bd+Sd^2$ (m^2)	Total mean sectional area (m^2)	Distance D (m)	Quantity Q_1= T. M. area×D (m^3)	Ht. of bank above bed H (m)	Ht. of banking above G. L. h=H—d (m)	Area of central portion= (b_1+b_2) h (m^2)	Area of sides $=2S_1h^2$ (m^2)	Total sectional area col 11+12 (m^2)	Total mean sectional area (m^2)	Quantity, Q_2= T. M. area×D (m^3)	Balance Q_2-Q_1 for borrow pit (m^3)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1·24	3·72	1·538	5·258	—	—	—	1·44	0·20	0·60	0·120	0·720	—	—	—
30	0·86	2·58	0 740	3·320	4·289	30	128·67	,,	0·58	1 74	1·009	1·749	1·235	37·05	—
60	0·55	1·65	0·303	1 953	2·636	30	79·08	,,	0·89	2·67	2·376	5·046	3·398	101·94	22 86
90	0·30	0·90	0·090	0·990	1·472	30	44·16	,,	1·14	3·42	3·900	7·320	6·183	185·43	141·27
120	0·74	2·22	0·548	2·768	1·879	30	56·37	,,	0·70	2·10	1·470	3·570	5·445	163·35	106·98
150	1·28	3·84	1·638	5·478	4·123	30	123·69	,,	0·16	0·48	0·077	0·557	2·064	61·92	—
							Total= 431·97 cu m							Total=271·11 cu m	

∴ Quantity of earthwork in excavation=431·97 cu m

Quantity of earthwork in embankment

to be taken from borrow pit = 271·11 cu m

Grand Total=703·08 cu m

Example 2. Find out the Economic Depth of a channel from the following data :– Bed width = 5·0m, Full supply level = 501·00m, Bed level = 500·00m, Height of bank above F.S.L. = 0·50m, side slope in cutting = 1 : 1, side slope in banking = $1\frac{1}{2}$: 1, Top width of bank = 2 m (P. B. T. E. 1979)

Ans. :— Full supply depth = 501·00m – 500m = 1·00m.

Height of banking from bed of channel = Full supply depth + ht. above F.S.L. = 1·00 + 0·5 = 1·5m

Let d = economic depth of excavation ∴ Height of banking, h = 1·5m – d

For economic depth of excavation, Quantity of digging = Quantity in banking

$$Bd + Sd^2 = (b_1 + b_2)h + 2S_1h^2 \quad \ldots \quad \ldots(1)$$

where, B = Bed width of channel, S : 1 = Side slope in cutting, S_1 : 1 = Side slope in filling

Putting the respective values in equ (1)

$$5d + 1.d^2 = (2+2)(1{\cdot}5 - d) + 2 \times 1{\cdot}5(1{\cdot}5 - d)^2$$

$$\text{or, } 5d + d^2 = 6 - 4d + 3(2{\cdot}25 - 3d + d^2)$$

$$\text{or, } 5d + d^2 - 6 + 4d - 6{\cdot}75 + 9d - 3d^2 = 0$$

$$\text{or, } 2d^2 - 18d + 12{\cdot}75 = 0 \quad \therefore \; d = \frac{18 \pm \sqrt{(-18)^2 - 4 \times 2 \times 12{\cdot}75}}{2 \times 2}$$

$$\text{or, } d = \frac{18 \pm 14{\cdot}90}{4} = 8{\cdot}23 \text{ and } 0{\cdot}88$$

But the value of 8·23 m being too high can not be adopted.

Therefore the economical depth of digging = 0·88m.

Example. 3. An irrigation canal has the following details :—

Bed width, m = 5, Top width of left bank, m = 3. Top width of right bank, m = 1·5.

Side slopes in cutting = 1 : 1. Side slopes of both banks = $1\frac{1}{2}$: 1.

Height of banks from the bed, m = 2·55. Longitudinal slope of the bed = 1 in 5000.

There is no transverse slope of the bed and the ground. Ground levels at 6 consecutive stations at 50m interval are as under :

Station	1	2	3	4	5	6
G.L.(m), R.L.	100	100·31	100·52	100·57	99·68	99·21

Bed level at station 1(m), R.L. 98·50

Estimate the quantity of earthwork in cutting and banking (A. M. I. E. 1980)

Ans. :—Longitudinal slope of the bed = 1 in 5000 ∴ For stations at 50m intervals the level changes @ $\frac{50\text{m}}{5000}$ = 0·01m The Bed level at station I. R. L. = 98·5 m

∴ Bed level at station 2 R. L. = 98·50 – 0·01 = 98·49 m

Bed level at station 3 R. L. = 98·49 – 0·01 = 98·48 and so on.

To Find out depth of cutting—

Station	1	2	3	4	5	6
G. L. (m) R. L. ...	100·00	100·31	100·52	100·57	99·68	99·21
Proposed bed level (m) R. L. ...	98·50	98·49	98·48	98·47	98·46	98·45
Depth of cutting (m) ...	1·50	1·82	2·04	2·10	1·22	0·76

Volume of earthwork is worked out in a tabular form as hereafter.

Calculation of Quantity by Mid-section Formula (Ex. 3)

CUTTING Bed width, B = 5m ; Side slopes, S = 1								BANKING Ht. of Banks from the bed H = 2·55m Top width of left bank b_1 = 3m Top width of right bank b_2 = 1·5m Side slopes, $S_1 = 1\frac{1}{2}$						
Station or chainage	Depth of digging d m	Mean depth dm m	Area of central portion B dm m	Area of sides Sd^2m m^2	Total area Bdm + Sd^2m (Am) m^2	Distance between stations D m	Quantity, Q_1 = Am × D m^3	Ht. of bank above bed H m	Ht of bank above G.L. (mean) h = H − dm/col(9—2) m	Area of central portion = $(b_1 + b_2)$ h m^2	Area of sides (mean) $2S_1h^2$ m^2	Total mean area col. 11 + 12 m^2	Quantity Q_2 = col. 13 × D m^3	Balance Quantity for banks from borrow pit $Q_2—Q_1$ m^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1·50	—	—	—	—	—	—	—	—	—	—	—	—	—
2	1·82	1·66	8·30	2 756	11·056	50	552·80	2·55	0 89	4·005	2·376	6·381	319·05	—
3	2·04	1·93	9 65	3 725	13·375	50	668·75	2·55	0·62	2·790	1·153	3 943	197·15	—
4	2·10	2·07	10·35	4·285	14·635	50	731·75	2·55	0·48	2·160	0·691	2 851	142·55	—
5	1·22	1·66	8 30	2 256	11·056	50	552·80	2·55	0·89	4·005	2 376	6·381	319·05	—
6	0 76	0·99	4·95	0·980	5·930	50	296·50	2·55	1 56	7 020	7·301	14·321	716·05	429·55
							Total = 2,802·6 cu m					Total —	1693·85 cu m	429·55 cu m

Quantity of earthwork in cutting = 2,802·6 cum

Quantity of earthwork for banking = 429·55 cum

Example—4 Fig. 9-4 shows the longitudinal section of the ground and the designed cross section of a portion of an irrigational channel. At a distance 500 metre there be a fall of 75 cm. Estimate the quantity of earthwork.

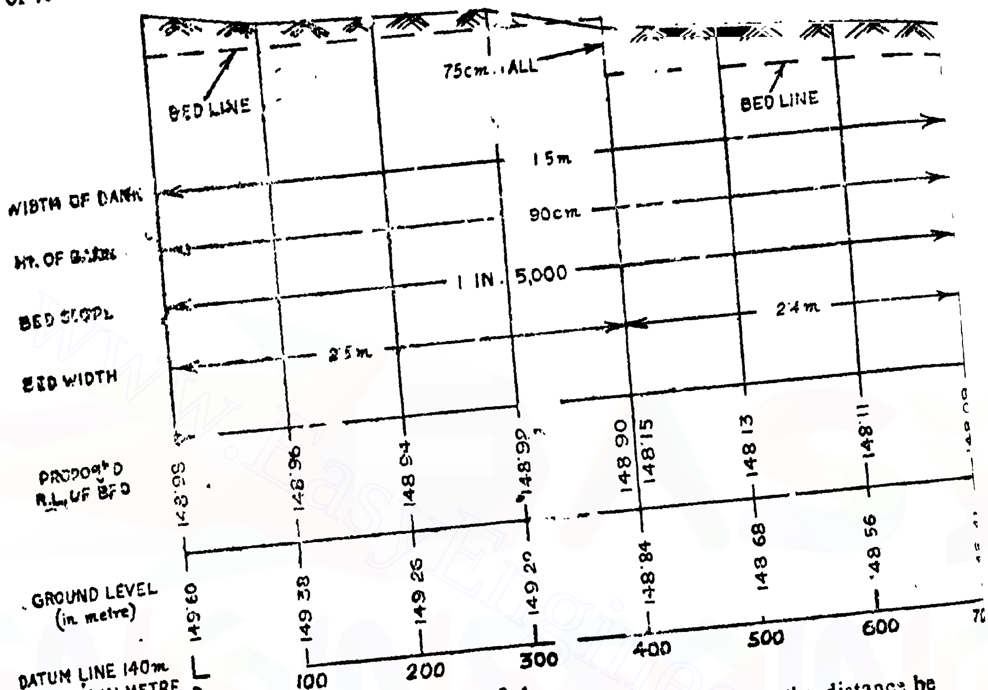
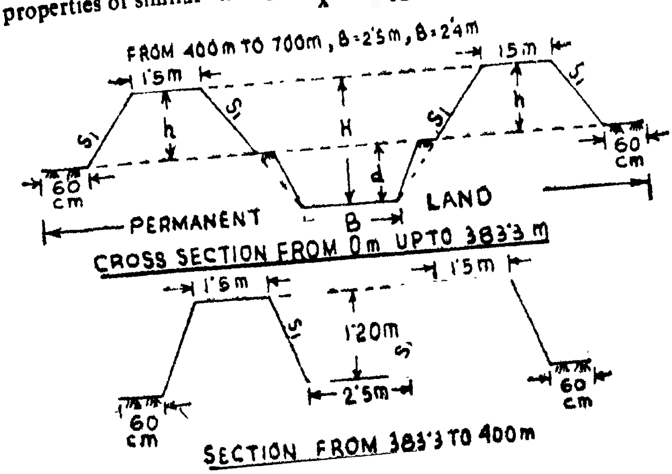


FIG. 9-4

From the above fig. the zero depth is in between 300m to 400 m. Let the distance be x from 300m where the depth of digging is zero. The depth of digging at one side (i.e at 300m) = 149·20 — 148·90 = 0·30m and the height for wholly in banking at the other side (i.e at 400m) = 148·90 — 148·84 = 0·06m.

Form the properties of similar triangle: $\frac{0.06}{x}=\frac{0.03}{12}$ $\therefore$ $x=83{\cdot}3$ m



Applying Average End Area formula Quantity has been calculated (Ex. 4)

DIGGING — $B = 2{\cdot}5$m upto 400m then $2{\cdot}4$m ; $S = 1$.

EMBANKMENT — $b_1 = b_2 = 1{\cdot}5$m ; $S_1 = 1\frac{1}{2}$

Distance in metre m	Depth of digging d m	Area of central portion = Bd m²	Area of sides sd² m²	Total sectional area Bd+sd² m²	Total mean sectional area m²	Distance D m	Quantity Q_1 = D×T. M. area m³	Ht. of bank above bed H m	Ht. of bank above G.L. h = H−d m	Area of central portion $(b_1+b_2)h$ m²	Area of side $2s_1h^2$ m²	Total sectional area	Total mean sectional area m²	Quantity Q_2 = D×T. M. area m³	Balance Q_2-Q_1 from borrow pit m³
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0·62	1·55	0·38	1·93	—	—	—	1·20	0·58	1·74	1·01	2·75	—	—	—
100	0·38	0·95	0·14	1·09	1·51	100	151	,,	0·82	2·46	2·02	4·48	3·62	362	211
200	0·32	0·80	0·10	0·90	0·99	100	99	,,	0·88	2·64	2·32	4·96	4·72	472	373
300	0·30	0·75	0·09	0·84	0·87	100	87	,,	0·90	2·70	2·43	5·13	5·05	505	418
383·3	0	0	0	0	0·42	83·3	27	,,	1·20	3·60	4·32	7·92	6·53	544	517
400u/s	−0·06	Fully in bank		ing	—	16·7	—	,,	1·26	3·78	4·76	8·54	8·23	137	137
400D/s	0·69	1·65	0·48	2·13	—	—	—	,,	0·51	1·53	0·78	2·31	—	—	—
500	0·55	1·32	0·30	1·62	1·88	100	188	,,	0·65	1·95	1·26	3·21	2·76	276	88
600	0·45	1·08	0·20	1·28	1·45	100	145	,,	0·75	2·25	1·69	3·94	3·57	357	212
700	0·32	0·77	0·10	0·87	1·0	180	107	,,	0·88	2·64	2·32	4·96	4·45	445	338
						Total =	804 cum								Total = 2294 cum

∴ Quantity of earthwork in digging = 804 cu m.

Quantity of earthwork in embankment to be taken from borrow pits ..... = 2294 cu m.

Total quantity = 3098 cu m.

Example —5 Find the Permanent area of land to be acquired to construct the irrigational canal as shown in Fig. 9-4. The area shall be calculated for every 200 metre length taking the maximum width within this reach.

Permanent width of land for partly in excavation and partly in banking

$=B+b_1+b_2+2s_1H+2s_1h+$extra widths beyond outer toes of bank to property line.

Permanent area of land = permanent width × length.

In this example extra width beyond outer toes of bank to property line

$b=b_1=1.5m,\ s_1=1\frac{1}{2}$ $=60\ cm+60cm=1{\cdot}20m$

Length or Distance m	B m	H m	h m	Maximum width of permanent land within 200m m	Area of permanent land m^2
0	2·5	1·2	0 58	—	
100	,,	,,	0 82	—	
200	,,	,,	0·88	12·94	2588
300	,,	,,	0·90	—	
400U/s	,,	,,	1·20	14·08	2816
400D/s	2·4	,,	0·51	—	
500	,,	,,	0 65	—	
600	,,	,,	0 75	12·45	2490
700	,,	,,	0·88	12 84	2568

Total = 10462 sq m

∴ Total area of permanent land is to be acquired = 1·0462 hectare

Example-6 (a) A Canal with side slopes $1\frac{1}{2}$: 1 and bed width 3·5m with water depth of 0·60m is carried in full embankment. The side slopes of the embankment are $1\frac{1}{2}$:1 on both sides and the bank widths are 3·3m and 1·8m on the left and right sides respectively. The G.L. for a length of 600m are as tabulated below. The canal bed level at chainage 1000 is R. L. 203·900 and the bed slope of the canal is 1 in 5,000. Estimate the quantity of earthwork in embankment. Take free board for the canal as 0 45m.

Chainage (m) :	1000	1100	1200	1300	1400	1500	1600
G.L.R.L. (m) :	208·90	208·75	208·60	208·50	208·50	208·40	208 35

(b) Determine the width of temporary land to be hired if the depth of excavation of borrowpits is limited to 0·60m (A.M.I.E. 1981)

(a) Bed slope 1 in 5,000 ∴ For 100m distance slope changes by $\frac{1}{5000}\times 100=0{\cdot}02m$

Chainage (m)	1000	1100	1200	1300	1400	1500	1600
G.L.R.L. (m)	238·90	208·75	208·60	203·50	203 50	208·40	208·35
Bed level (m)	208·90	208 88	208·86	208·84	208·82	208 80	208·78
Ht. of bed level above G.L. (m)	0·00	0·13	0·26	0 34	0 32	0·40	0·43

As the condition of the canal section at the U/s and D/s sides is not known the portion between the G.L. and bed level has been accounted in filling. Generally the condition of a canal section changes from filling to cutting and the above mentioned portion becomes silted up in due course and is not accounted in filling.

Quantity of earthwork has been calculated first finding the whole sectional area as solid and then deducting the constant area of canal by Mid-section formula in a tabular form as below.

Bed width B = 3·5m ; width of left bank b_1 = 3·3m ; width of right bank b_2 = 1·8m

$S_1 = S_2 = 1\frac{1}{2}$; Height of bank above bed H = 0·60 + 0·45 = 1·05m

Chainage m	Ht. of bank above G L. d m	Mean Ht. of bed dm m	Ht. of bank above bed H m	Ht. of bank above G L. h=H+dm m	Top overall width $x=B+b_1+b_2+2S_1H$ m	Central area as solid = xh m^2	Outerside slope areas S_1h^2 m^2	Whole area as solid = $xh+S_1h^2$ m^2	Central area of canal = BH m^2	Side slope areas of canal = SH^2 m^2	Total area of canal = $BH+SH^2$ m^2	Net sectional area of earthwork col. 9 — col. 12 m^2	Distance D m	Quantity col. 13 × D m^3
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1000	0·00	—	—	—	—	—	—	—	—	—	—	—	—	—
1100	0·13	0·065	1·05	1·115	11·75	13·101	1·865	14 966	3·675	1·654	5·329	9 637	100	963·7
1200	0·26	0·195	1·05	1·245	11·75	14·629	2·325	16·954	3·675	1·664	5·329	11·625	100	1162·5
1300	0·34	0·300	1·05	1·350	11·75	15·863	2·734	18·597	3·675	1·654	5·329	13·268	100	1326·8
1400	0·32	0·330	1·05	1·380	11·75	16·215	2·857	19 072	3·675	1·654	5·329	13·743	100	1374·3
1500	0·40	0·360	1·05	1·410	11·75	16·568	2·982	19·550	3·675	1·654	5·329	14·221	100	1422·1
1600	0·43	0·415	1 05	1·465	11·75	17·214	3·219	20·433	3·675	1·654	5·329	15·104	100	1510·4

Total = 7759 8

∴ Quantity of earthwork in embankment = 7759·8 cu m.

(b) Let W = Width of temporary land to be hired. Length of borrow pit = 2 × Length of canal = 2 × 600m. Depth of borrow pit = 0·60m ; Quantity of earthwork from borrow pit = 7759·8cu m.

∴ 2 × 600 × 0·60 × W = 7759·8 ∴ W = 10·77 metre

Width of temporary land to be hired at the sides of the canal = 10·77 metre.

Example – 7 To form Embankment of a canal partly in excavation and partly in embankment the balance quantity of earth as required from borrow pit for every 100m distance are 105 cum, 246 cu m, 284 cu m, 385 cu m. 107 cu m 2 cu m and 103 cu m Find the area of Temporary land required for every 100m distance separately when the depth of excavation is limited to 30 cm. Find out also the estimated cost for hire charge of the temporary land@ Rs. 2·50 per sq m.

Distance in metre	Quantity of earth from borrow pit cu m	Area of temp. land = Quantity / depth of excavation sq m	Distance in metre	Quantity of earth from borrow pit cu m	Area of temp. land = Quantity / depth of excavation sq m
0 to 100	105	350·0	400 to 500	107	356·7
100 to 200	246	820·0	500 to 600	2	6·7
200 to 300	284	946·7	600 to 700	108	360·0
300 to 400	385	1283·3			
		Total = 3400·0 sq m.			Total = 723·4 sq m.

∴ Grand total area = 3400·0 + 723·4 = 4123·40 sq. m.

Cost of hire charge for temporary land required @ Rs. 2·50 per sq. m = Rs. 10308·50

9-2. AQUEDUCT :—In irrigation engineering the term is confined to mean an irrigation canal for carrying water passes over a drainage channel (nala or stream etc.) without having to lower down the bed of the drainage channel for the crossing. The canal and the drainage channel are crossed at right angles with fairly straight lengths at both up stream and downstream sides. The aqueduct structure of the waterway may be built of R.C. rectanguler channel or duck, box culvert, masonry arches or R.C. spun pipes. The structure is supported by constructing masonry walls on the bed of the drainage channel. Generally, the sectional area of the canal at the aqueduct and the sectional area of the drainage channel are reduced at crossing. The velocity thus increases and so the up stream and down stream sides of the aqueduct and also the sides of the drainage channel are paved by stone boulders or by concrete blocks.

Example-8. Estimate of an R.C.C. trough type aqueduct for a minor canal crossing a stream The fig 9-5 shows the details of an R.C.C. trough type aqueduct (150 cm wide × 110 cm deep) for a minor canal (180 cm bed width × 80 cm full supply depth with side slopes ($1\frac{1}{2}$:1) crossing a small stream (250 cm bed width). (a) Rule out the measurement sheet and estimate the quantities of all items. The general specifications are as below :—

(i) Foundation concrete shall be of 1:4:8 cement concrete with brick ballast ;
(ii) First class brickwork in 1:4 cement mortar.
(iii) Cement pointing in 1 : 2 cement mortar for the brickwork ;
(iv) R.C.C. work for trough including 1% steel, centering and shuttering etc.
(v) Dry brick pitcting with overburnt bricks.

(b) Also prepare the abstract sheet and estimate the cost with the rates prevailing in year localily. (A.M.I.E. 1981 modified).

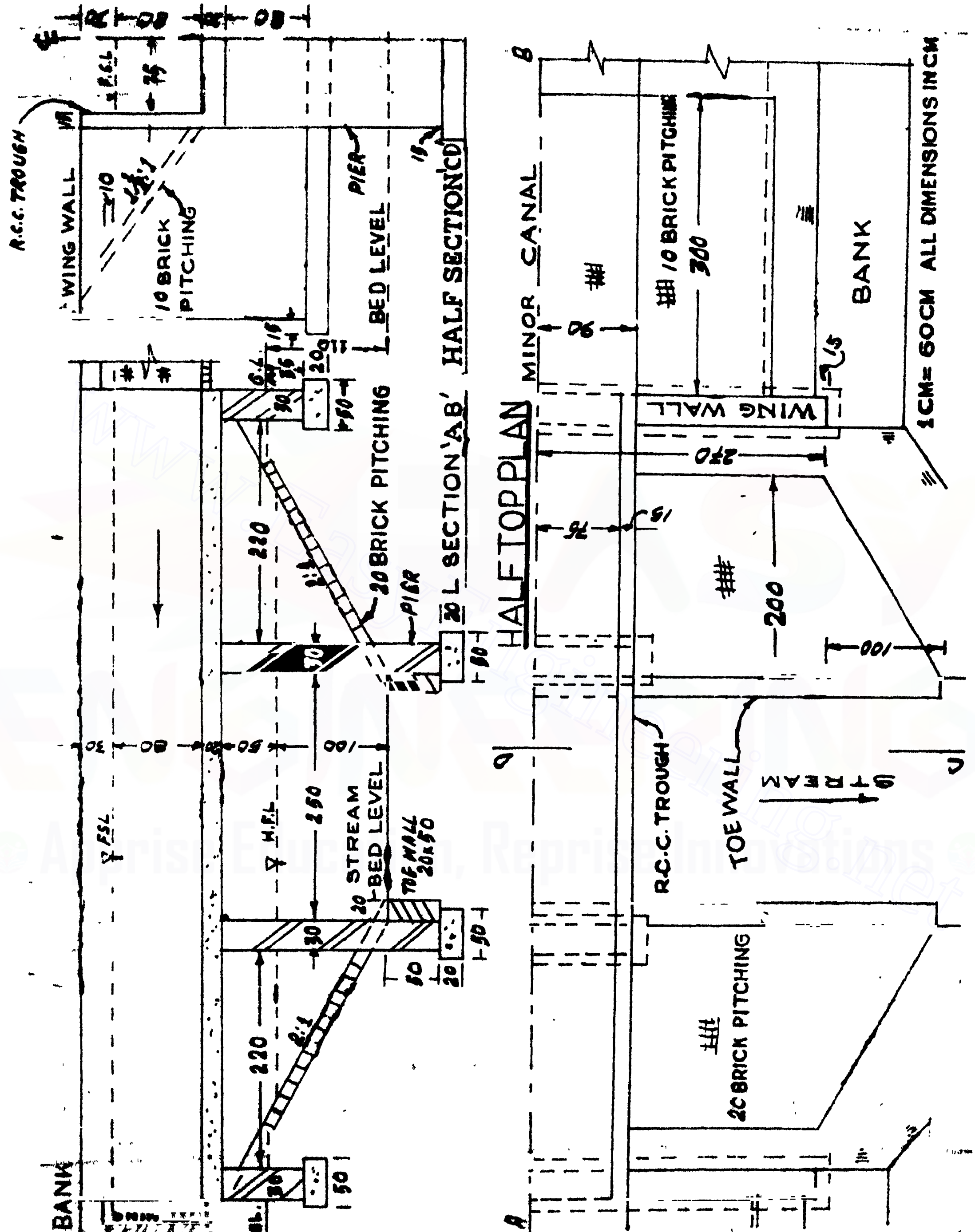

HALF SECTION 'CD'
L SECTION 'AB'
HALF TOP PLAN
MINOR CANAL
R.C.C. TROUGH
WING WALL
10 BRICK PITCHING
20 BRICK PITCHING
PIER
BED LEVEL
STREAM
TOE WALL
BANK
1 CM = 60 CM ALL DIMENSIONS IN CM

FIG. 9-5

Item No	Description	No	L. m	B m	H. m	Qu.	Total	Explanatory notes.
1.	**Earthwork in excavation in foundation**							
	Pillars at bed ...	2	2·10	0 50	0·70	1·47		2 10 = 2(0·75 +0·15+0·15)
	End pillars at banks including wing walls ...	2	5·60	0 50	0·55	3·08		5·60 = 2(2·70 +0·10)
	Side slopes of stream for pitching ...	2	$\frac{5·40+7·40}{2}$	2·28	0·22	6·42		7·40 = 2(2·7 +1·00)
	Toe walls for pitching ..	2	7·40	1·20	0·50	1·48		2 28 = $\sqrt{2^2+0·1^2}$
	Side slopes of minor Canal for pitching at U/s and D/s sides	2×2	3·00	1 44	0 10	1·73		1·44 = $\sqrt{1·3^2+1·2^2}$
	Bed of minor canal for pitching	2	3·00	1·80	0·10	1 08		1 2 = 0·8 × 1½
							15·26 cum	
2.	**Cement Concrete 1 4 8 with brick ballast in foundation**							
	Pillars at bed	2	2·10	0 50	0·20	0·42		
	End pillars at bank including wing walls	2	5·60	0 50	0·20	1·12		
							1·54 cum	
3.	**First class brickwork in (1:4) cement mortar**							
	Pillars at bed	2	1·80	0·30	2·00	2·16		
	End pillars at banks ...	2	1 80	0 30	0·80	0·86		For wing walls
	Wing walls	2×	1 80	0·30	2·10	4·54		1·80 = 2·70 − 0·90
							7·56 cum	
4.	**R C.C. Work for trough including 1% steel, centering and shuttering**							
	Base slab	1	8·10	1·80	0·15	2 19		
	Vertical slab	2	8 10	0·15	0·10	2 67		
							4·86 cum	
5.	**Cement pointing 1:2 in cement mortar for brickwork.**							4·20 = perimeter = 2(1·80 + 0·3)
	Pillars at bed	2	4·20	—	1·50	12·60		
	End pillars at bank ...	1	1·80	—	0·45	0·81		0·45 =
	Wing walls	2×2	1·80	—	1·75	12·60		0·80—0 35
							26·01 sqm	Same as earth work
6.	**Dry brick pitching with over burnt bricks**							Pitching may also be calculated in sqm stating the thickness.
	Side slopes of stream (20cm)	2	$\frac{5·40+7·40}{2}$	2·28	0 20	5 84		
	Slopes of minor canal at U/s and D/s (10cm) ...	2×2	3·00	1 41	0·10	1·73		
	Bed of minor canal at both U/s and D/s sides (10cm)	2	3·00	1 80	0·10	1·08		
							8·65	cum

(b) Abstract of Estimated cost (Ex.8)

Item No.	Description	Qu.	Unit	Rate Rs. P.	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation in foundation	15·26	cu m	3 20	% cu m	48·83
2.	Cement concrete (1:4:8) with brick ballast in foundation	1·45	cu m	258·18	cu m	397·60
3.	First class brickwork in(1:4) Cement mortar	7·56	cu m	280·00	cu m	2,116·80
4.	R C.C. work for trough including 1% steel, centering and shuttering	4·86	cu m	480·00	cu m	2,332·8
5.	Cement pointing 1:2 in cement mortar for brickwork	26·01	sq m	4·50	sq m	117·04
6.	Dry brick pitching with over burnt bricks.	8·65	sq m	200·00	cu m	1,730·00

Total = 6,743·07
Add 5 % for Contingency = 337·15
Add $2\frac{1}{2}$% for workcharged = 168·58
Grand Total = 7,248·80

9-3. Estimate of a R. C. C Spun Pipe Sluice:—Prepare a detailed estimate of a R C.C. spun pipe sluice from the attached drawing sheet. To prevent collapsing of earth from the embankment excess earthwork with a slope of 1 : 1 should be considered in the estimate. All materials for mild steel works including fittings, weighing 4·5 quintals are to be supplied from the departmental store. Only the carrying and fitting charge Rs. 1200 is to be provided in the estimate. The anchorage plank shall be of sal wood 15cm × 15 cm × 1·7m long.

Specification :—

All brickwork shall be 1st class in cement mortar (1 : 4) and the joints be racked out. The up-stream and down-stream floors only shall be cement plastered (1 : 2). The R.C.C. spun pipe of 1100 mm dia. shall be 'A' class with requisite collar. Cement concrete shall be of proportion 1:3 6

To calculate the volume of earthwork above bed level of the Spun pipe :—

Depth from top of the embankment upto the bed level = 19 32 − 15·21 = 4.11 m.

Width of embankment at top = 2·4m. Width of embankment at base = 2·4m + 2(2 × 4·11m) = 18·84m.

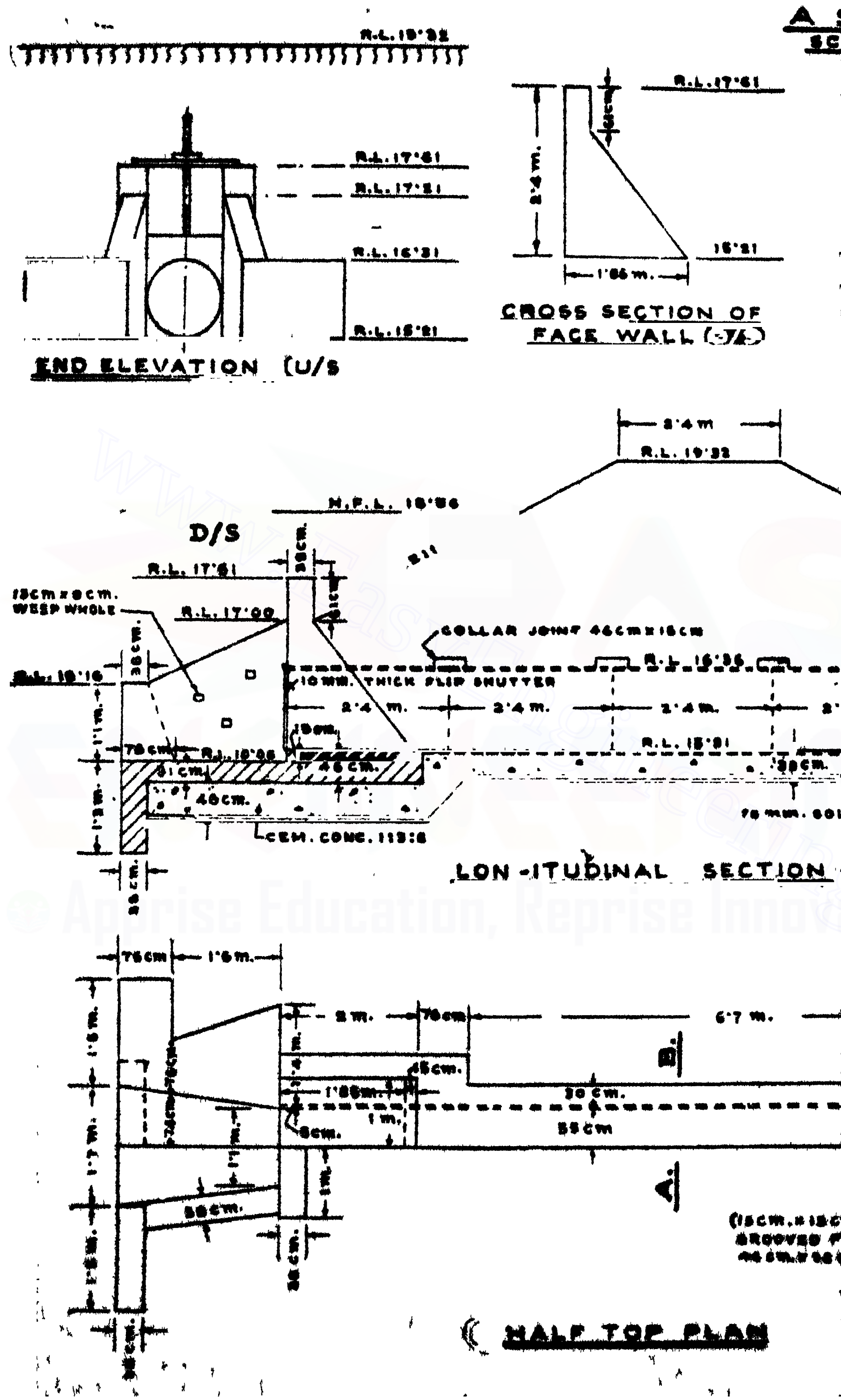
∴ Average width of embankment = $\frac{1}{2}$(2·4m + 18·84m) = 10·62 m

Length of excavation at base = 1·5m + 1·7m + 1·5m = 4 7m.

But to provide a slope 1 : 1 during excavation to prevent collapsing of earth, length of excavation at top = 4·7 + 2 × 1 × 4·11 = 12·92m.

∴ Average length of excavation = $\frac{1}{2}$ (4·7 m + 12·92 m) = 8·81 m.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1A.	**Earthwork in excavation**							
	(a) Above bed level of Spun pipe ...	1	8·81 (av.)	10·62 (av.)	4·11	384·54		
	(b) Below bed level of Spun pipe—							4·7=1·5+1·7 +1·5
	(i) Below return walls and intervening floor U/s ...	1	4·7	·76	·90	3·37		·31+·51+·076 =·90 (say)
	-do- -do- D/S ...	1	4·7	·76	1	3·57		
	(ii) Below wing walls and intervening floor U/S ...	1	$\frac{(3·9+3·02)}{2}$	2	·90	6·23		3·9=2(1·4 +·55)
	-do-do- D/S ...	1	$\frac{(3·9+3)}{2}$	1·6	1	5·52		3·02=2(·76 +·75)
	(iii) Below face wall and intervening floor U/S ...	1	2·73	2·6	·90	6·46		2·73=2·35 +½×·76 2·6=2(1+·30)
	-do- -do- D/S ...	1	2·38	2·6	1	6·19		2·4=2×1·20
	(iv) Cut-off wall U/S ...	1	2·4	·38	·40	0·36		·40=1·3—·90
	-do- -do- D/S ...	1	2·4	·38	·30	0·27		7·46=6·7+ 2×½·76
	(v) Central portion ...	1	7·46	1·8	·38	5·10		·38=·30+·076
						421·61		
1B.	**Earthwork in filling**	= −38	(1A)a—vol 4·54—$\frac{\pi}{4}$ (1·	of Sp 2)^2 × 12	un pipes −31·28 =	item(4) 339·69	761·30 cu m	
2.	**7·6 cm thick brick flat soling**			—				
	(i) Below return walls and intervening floor U/S and D/S ...	2	4·7	·76	—	7·14		Deductions are to be made
	(ii) Below wing walls and intervening floor U/S...	1	$\frac{(3·9+3·02)}{2}$	2	—	6·92		
	-do- -do- D/S ...	1	$\frac{(3·9+3)}{2}$	1·6	—	5·92		3·11=2·35 +·76
	(iii) Below face wall and intervening floor U/S...	1	3·11	2·6	—	8·09		2·6=2(1+·30)
	-do- -do D/S ...	1	2·76	2·6	—	7·18		8·22=6·7+ 2×·76
	(iv) Central portion ...	1	8·22	1·8	—	14·80		
	Deduction for cut-off walls	2	2·4	·38	—	1·82	(-ve)	
							47·83	sq m



Explanatory notes

Deduction for cut-off wall is to be made

12—2·4×5
1·2 is the outer dia.

cu m

1·55=av. length
=½[1·5+(17·+1·5—·75)]

Wing walls meet with inclined sides of return wall

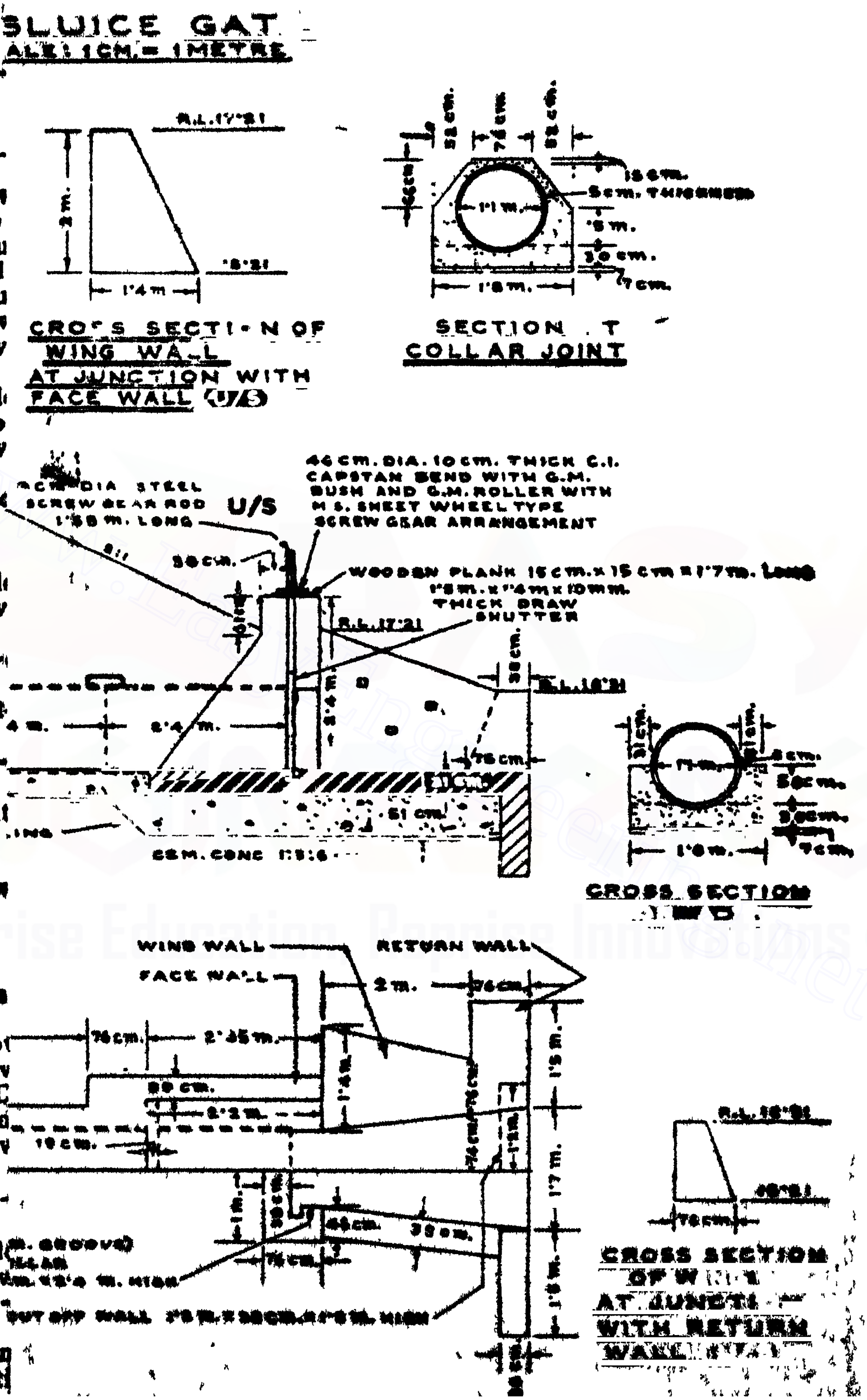
2·13 av. length
=2+½(·76—·38)

Item No.

1A. Earthw
(a) Ab
Spu
(b) Bel
Spu
(i) Belov
interv
-do- -d
(ii) Belo
interv
-do-
(iii) Bel
interv
-do-
(iv) Cut
-do-
(v) Cent

1B. Earthw

2. 7·6 cm
ceiling
(i) Belo
interv
and D
(ii) Belo
interv
-do-
(iii) Bel
interv
-do-
(iv) Cen
Deducti



Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
3.	**Cement concrete in foundation** (1 : 3 : 6)							
	(i) Below return walls and intervening floor U/s ...	1	4·7	·76	·51	1·82		Deduction for cut-off wall is to be made
	-do- do- do- ...	1	4·7	·76	·46	1·64		
	(ii) Below wing walls and intervening floor U/s ...	1	$\frac{(3{\cdot}9+3{\cdot}02)}{2}$	2	·51	3·53		
	(iii) Below face walls and intervening floor U/S ...	1	2·73	2·6	·51	3·62		
	-do- do- do- ...	1	2·38	2·6	·46	3·26		
	(iv) Central portion ...	1	7·46	1·8	·30	4·03		
	(v) For embading pipe half portion (considering first solid) ...	1	1	1·8	0·5	10·80		
	Deduction for pipe half portion (as considered solid) ...	1	12	$\frac{\frac{1}{2}\pi\times(1{\cdot}2)^2}{4}$	—	6·78	(-ve)	$12-2{\cdot}4\times5$ 1·2 is the outer dia.
	-do-for cut-off wall U/S ...	1	2·4	.38	·51	0·47	(-ve)	
	-do- do- D/S ...	1	2·4	·38	·46	0·42	(-ve)	
							21·03	cu m
4.	**First class brickwork in cement mortar** (1:4)							
	(i) Return walls U/S and D/S ...	4	1·55(av.)	$\frac{(\cdot38+\cdot76)}{2}$	1·1	3·89		$1{\cdot}55=$ av. length $=\frac{1}{2}[1{\cdot}5+(17{\cdot}+1{\cdot}5-{\cdot}75)]$
	(iia) Below wing walls and intervening floor U/S ...	1	$\frac{(3{\cdot}9+3{\cdot}02)}{2}$	2	·31	2·12		
	-do- do- D/S ...	1	$\frac{(3{\cdot}9+3)}{2}$	·016	·31	1·71		Wing walls meet with inclined sides of return wall
	(iib) For wing walls U/S	2	2·13	$\frac{(\cdot38+1{\cdot}03)}{2}$	$\frac{(1{\cdot}1+2)}{2}$	5·02		2·13 av. length $=2+\frac{1}{2}(\cdot76-\cdot38)$

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	For wing walls D/S	2	1·73	$\frac{(\cdot 38+1\cdot 03)}{2}$	$\frac{(1\cdot 1+2)}{2}$	4·8		
	(iiia) Below face walls and intervening floor U/S ...	1	2·35	1·96	·31	1·40		Deductions for pipe openings are to be made
	-do- do-D/S ...	1	2	1·96	·46	1·80		
	(iiib) For face wall unbattered top of U/S and D/S ...	2	2	·38	·61	0·93		2=2×1
	-do-battered portion U/S ...	1	2	$\frac{(2\cdot 2+\cdot 38)}{2}$	1·79	4·62		1·79=2·4−·61
	-do-do-D/S	2	2	$\frac{(1\cdot 85+\cdot 38)}{2}$	1·79	4·01		
	(iv) Cut-off walls U/S and D/S ...	2	2·4	·38	·99	1·81		·99=1·3−·31
	(v) Pillars for groove at U/S only ...	2	·46	·38	2·44	0·85		Deductions in ·38 wall only considered and no deductions in battered portion for extra cost.
	Deductions for—							
	(a) Pipe openings U/S and D/S ...	2	$\frac{\pi}{4}(1\cdot 2)^2 \times$	·38	—	0·84	(-ve)	
	(b) Pillars for groove ...	2	·15	·13	2·44	0·10	(-ve) 1·28 cu m	
5.	**12mm thick cement plaster** (1:2)							2·76=2+·76
	U/S floor ...	1	$\frac{1}{2}$(1·7+	1·1)×	2·76	3·86		
	U/S floor ...	1	$\frac{1}{2}$(1·7+	1·1)×	2·36	·30	7·16 sq m	
6.	**Making 13cm×8cm weep holes** including providing brick filter and cement plaster (1 : 2) ...	4	×3			12	12 Nos.	
7.	**Supplying, laying etc. 1100mm dia. 'A' class R.C.C. spun pipe including caulking collar joint** ...	5	2·4	—	—	12	12 m	
8.	**Carrying and fitting fixing all M.S. work** ...	1	—	—	—	1	item	
9.	**Sal wood work for anchorage planks** ...	2	1·7	·15	·15	0·0765	0·0765 cu m	

ABSTRACT OF ESTIMATED COST

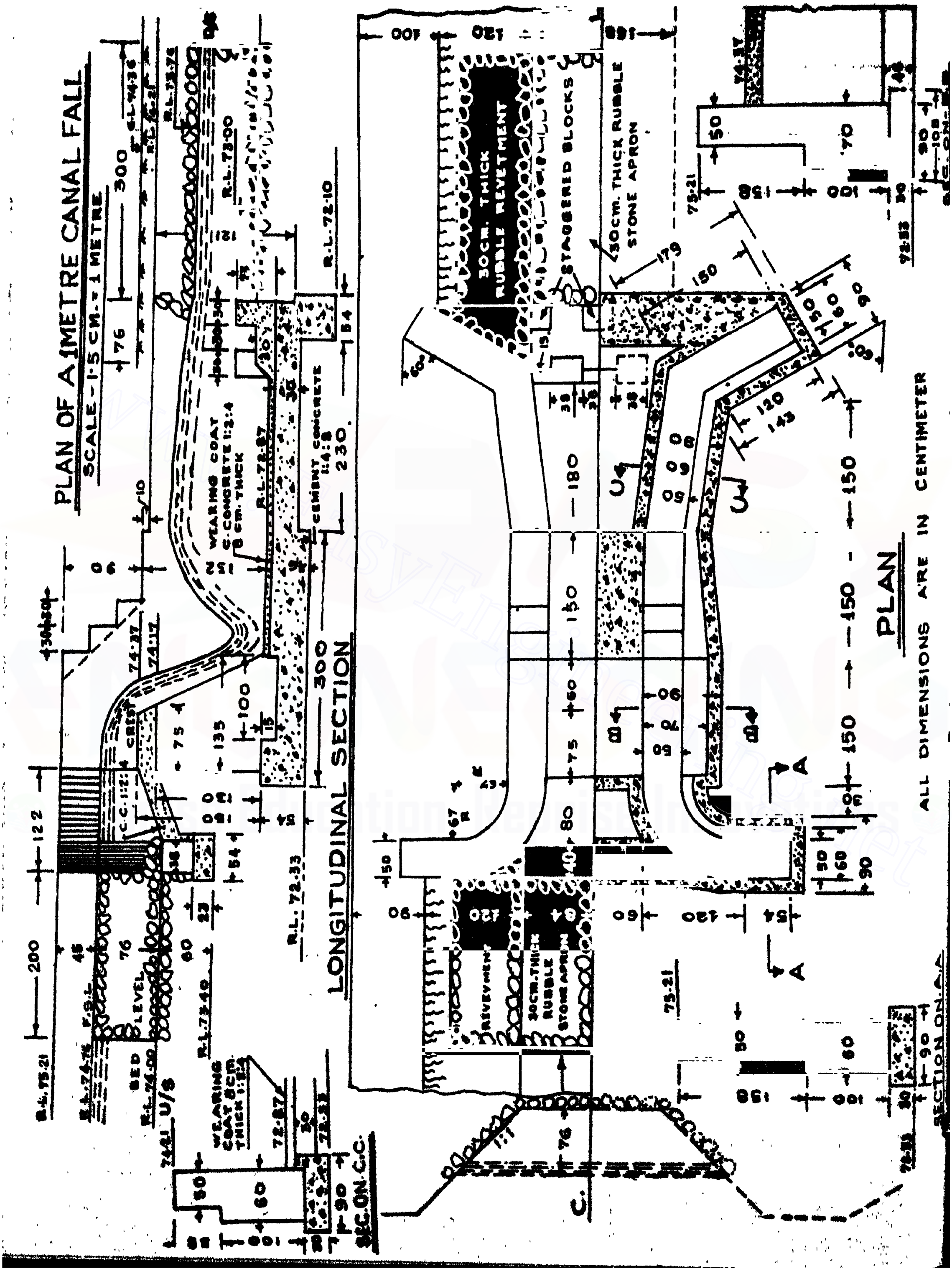
em o.	Description	Quantity	Unit	Rate Rs. P	Unit of Rate	Amount Rs. P.
	Earthwork in all kinds of soil including rough dressing to slops and fine dressing to crest	760·64	cu m	3·20	cu m	2,434·05
	7·6 cm thick brick flat soling	47·85	sq m	18 00	sq m	861·30
	Cement concrete work (1:3:6) with stone chips	21·03	cu m	380·00	cu m	7,991·40
	First class brickwork in cement mortar 1:4) including racking out joints ...	31·28	cu m	280·00	cu m	8,758·40
	12mm thick cement plaster(1:2)	7·16	sq m	9·25	sq m	66·23
	Making 13 cm×8cm weep holes including providing brick filter and cement plaster (1:2) ...	12	Nos.	9·00	Each	108·00
	Supplying, laying etc. 1100mm dia. R. C. C. spun pipe including caulking collar joints.	12	r m	300·00	r m	3,600·00
	Carrying from departmental stores and fitting, fixing all M. S. works as per drawing and instruction ...	1	Item	350·00	L. S.	350·00
	Sal wood work for anchorage planks	0·0795	cu m	2700·00	cu m	214·65

Total ... = 24,384·03

Contingencies @ 5% = 1,219·20

Work charge @ 2½% = 609·60

Total estimated cost ... = Rs. 26,212·83


PLAN OF A 1 METRE CANAL FALL
SCALE - 1·5 CM. = 1 METRE
LONGITUDINAL SECTION
PLAN
ALL DIMENSIONS ARE IN CENTIMETER
SEC. ON C.C.
SECTION ON A-A
30 CM. THICK RUBBLE REVETMENT
STAGGERED BLOCKS
30 CM. THICK RUBBLE STONE APRON
WEARING COAT C. CONCRETE 1:2:4 8 CM. THICK
CEMENT CONCRETE 1:4:8
WEARING COAT 8 CM. THICK 1:2:4
U/S
BED LEVEL
F.S.L.
CREST

9 4. Estimate of a 1 metre Fall :—Prepare a detailed estimate of a 1m fall for a branch canal having 1·68m bed width 76cm depth of water from the Fig. 9·6 The general specifications are as follows :—

(1) Foundation of abutment, wing and drop walls and flooring shall be cement concrete (1:4:8)

(2) Wearing coat, floor between u/s wing walls, friction block, stagerred blocks, and crest shall be cement concrete (1:2:4).

(3) All brickwork shall be of 1st class in cement mortar (1:4).

(4) All exposed surfaces of brickwork shall be made flush pointed in cement mortar (1:3). Assume suitable rates of your locality.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	**Earthwork in excavation**							
	(a) Abutment walls— Straight portion ...	2	1·5	1·05	2·03	6·39		$1·05 = ·90 + ·15$
	Tapper portion ...	2	1·5	0·98 (av.)	2·03	5·97		$0·98 = \frac{1}{2}(1·05 + ·90)$; $1·82 = \sqrt{(1·8)^2 + \left(\frac{1·68 - ·60}{2}\right)^2}$
	Splayed portion ...	2	1·82	·90	2·03	6·65		$1·99 = ·15 + ·54 + 1·3$
	b) Wing walls U/s ...	2	1·99	0·90	2·03	7·28		$1·35 = \frac{2\pi \times ·83}{4}$ 0·83 in mean radius for earthwork.
	·d · D/s ...	2	$\frac{1}{2}$(1·35 +1·79)	0·90	2·03	5·74		$2·4 = \frac{1}{2}[2(·60 + 1·80)]$
	(c) Drop walls— Up-stream side ...	1	2·4(av)	0·54	0·96	1·24		small overlaping neglected.
	Down stream side...	1	3·68	0·54	2·26	4·49		3·68 is the centre length $= 1·68 + 2 \times (·76 - \frac{·38}{2}) \times \tan 60°$
	(d) Floor— Between straight abut.	1	3	0·90	2·03	5·48		$·90 = 2(·60 - ·15)$
	Between splayed abut.	1	1·95	1·14 (av.)	1·87	4·16		$1·95 = 1·8 + ·15$; $1·14 = \frac{1}{2} \times 2[·60 - ·15 + (1·68 - ·30)]$
	Between U/s wingwalls	1	0·58	1·44 (av.)	0·36	0·30		$0·58 = 0·80 - 0·07 - 0·15$ i.e. concrete projection
	Between D/s wingwalls and drop wall ...	1	0·21	1·38	1·87	0·54		$0·21 = 3 \times ·30 - ·54 - ·15$; $1·38 = 1·68 - 2 \times ·15$
	C. O.					48·24		

Item No.	Description	No.	L. m.	B. m	H. m.	Qu.	Total	Explanatory notes
	B. F.					48·24		
	(e) For stone appron							
	U/s ...	1	2	1·68	0·30	1·01		$1·07 = \sqrt{(0·76)^2+(0·76)^2}$
	-do-revetment U/s ...	2	½(2+2·40)	1·07	0·30	1·41		
	-do- appronD/s ...	1	3	1·68	0·30	1·51		
	-do-revetment D/s ...	2	½(3+3·76)	0·91	0·30	1·85		
							54·0 cu m	
2.	**Cement concrete in foundation (1 :4 : 8)**							
	(a) Abutments—							
	Straight portion ...	2	1·5	1·05	0·30	0·945		
	Tapper portion ...	2	1·5	0·98	0 30	0·882		
	Splayed portion ...	2	1·82	0·90	0·30	0 983		
	(b) Wing walls U/s..	2	1·99	0·90	0 30	1·075		
	-do- D/s...	2	½(1·35×1·79)	3·90	0·30	0·848		
	(c) Drop walls—							
	Up stream side ...	1	2·4(av)	0·54	0·23	0·293		0·69=72·87—·08
	Down stream side..	1	3·68	0·54	0·69	1·371		—72·10
	(d) Floor between—							
	Straight abutments	1	1·5	0·90	0·54	0·729		
	-do- -do- ...	1	1·5	0·90	·46	0·828		Deductions are to be made
	Splayed abutments...	1	1·95	1·14	0·30	0·667		
	Between D/s wings...	1	0·21	1·38	0·30	0 087		
	Deductions for—							
	Grooving below breast wall ...	1	1	1·20	0·15	0 180	(-ve)	
							8·528 cu m	
3.	**Cement concrete 1:2:4**							
	(a) Between U/s wing walls ...	1	0·88	1·44	0·20	0·250		$0·88=\sqrt{(·80)^2+(·37}$
	Portion laid on drop wall (left out) ...	1	1·68	0·08	0·10 (apx)	·0·130		$1·44=\frac{1}{2}\times 2(·60+·84)$
	(b) Wearing coat between							
	Straight abutments	1	1·5	1·20	0·08	0·360		
	Splayed abutments...	1	1·95	1 14	0·08	0·178		
	Sloping top portion	1	0·15	1·68	½×·13	0·038		
	Between D/s Wings	1	0 61	1·68	0·30	0·307		
	(c) Friction block ...	2	0·38	0·30	0·23	0·052		0·61=·76—·15
	(d) Stagerred blocks...	3	0·38	0 30	0·23	0·072		
	(e) Top of breast wall...	1	0·75	1·20	0·20	0·180		
							1·471	cu m

Item No.	Description	No.	L. m	B. m	H.	Qu.	Total	Explanatory notes
4.	**1st class brickwork in cement mortar (1:4)** (a) Wing walls u/s 60 cm	2	1·84	0·60	1	2·208		1·84=1·99 (as in earthwork) —·15
	-do-do- 50cm	2	1·95	0·50	1·58	3·081		1·95=·54 $+\frac{2\pi\times0{\cdot}92}{4}$
	-do-D/S 60cm	2	½(1·2+1·5)	0·60	1	1·620		
	-do-do- 50cm	2	½(1·2+1 5)	0·50	0 58	0·783		0·92 is mean radius
	(b) Abutments—							
	Straightportion 70cm	2	1·35	0·70	1	1·890		1·35= 0·75+0 60
	-do-do- 50cm	2	1·35	0·50	1·58	2·133		
	Tapper portion Bottom ...	2	1·5	·75 (av.)	1	2·250		
	-do-steping 50cm	2	0·30	0·50	1·28	0·384		1·28=1·58—0·30
	-do-do- -do-	2	0·30	0·50	0·98	0 294		
	-do-do- -do-	2	0·90	0·50	0·68	0·612		0 90=1 50—2×0·30
	Splayed portion 60cm	2	1 82	0·60	1	2·184		
	-do-do- 50cm	2	1·82	0·50	0·58	1·056		Variation of length between 46 cm and 60cm layer is negligible
	(c) Drop walls U/S ...	1	2·4 (av.)	0·40	0·37	0·355		
	-do- D/S ...	1	3·68	0·40	0·15	0·221		
	(d) Breast wall ...	1	1·2	1·05(av.)	1·45	1·827	—ve)	0·35= 1·35—1·00
	Deduction, grooveing	1	1·2	0·35	0·15	0·063		
							20·961 cu m	
5.	**Flush or Rule pointing to exposed joints of brickwork in cement mortar (1:3)** (a) Wing walls U/S top	2	1·26	0·50	—	1·26		·126= $\frac{2\pi\times1{\cdot}14}{4}$
	-do-inner side ...	2	1·59	—	2·85	9 00		
	-do-outer side ...	2	2·32	—	0 85	3·94		0·85= 75·21—74·3
	(b) Wing walls D/S top ...	2	½(1·2+1·5)	0·50	—	1·35		1·34= 74·21—72·87
	-do-inner side ...	2	1·5	—	1·34	4·02		
	C.O. ...		...	...		19 57	sq m	

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.	...	...	...	..	19·57		
	(c) Abutments—							
	Top of st. portion ...	2	2·85	0·50	—	2·85		2·50=2·58 —0·08
	Inner side -do- ...	2	1·35	—	2·50	6·75		For brest wall
	-do- steping ...	2	0·30	—	2·20	1·32		deductions are
	do- -do- ...	2	0·30	—	1·90	1·14		to be made
	-do- -do- ...	2	0·90	—	1·60	2·88		
	Top of splayed portion ...	2	1·82	0·50	—	1·82		$2·1=\sqrt{(1·95^2+(·84)^2}$
	Inner side-do- ...	2	2·1	—	1·34	5·63		
	(d) Breast wall ...	1	1·2	—	1·3	1·56		1·3=74·17—72·33−0·54
	-do-inner side ...	1	1·2	—	1·43	1·72		1·43=
	Deduction for breast wall joining abutments ...	2	1·06	—	1·3	2·67	—ve	$\sqrt{(·60)^2+(1·3)^2}$
							42·49 sq m	
5.	**Rubble stone pitching**							No deductions for drop walls
	Up stream appron ...	1	2	1·68	—	3·36		joining wing walls as area
	-do-revetment ...	2	½(2+2·40)	1·07	—	4·71		being lesser than 1·1 sq m
	Down stream appron ...	1	3	1·68	—	5·04		for each $1·07=\sqrt{(·76)^2+(·76)^2}$
	-do-revetment ...	2	½(3+3·76)	1·07	—	7·23	20·34 sq m	

ABSTRACT OF ESTIMATED COST (Art. 9·4)

Item No.	Descridtion	Qu.	Unit	Rate of	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation in all kinds of soil including rough dressing ...	54·02	cu m	3·00	cu m	162·06
2.	Cement concrete in foundation (1:4:8)...	8·528	cu m	297·00	cu m	2,532·82
3.	Cement concrete (1:2:4) ...	1·471	cu m	425·00	cu m	625·18
4.	1st class brickwork in cement mortar(1:4)	20·34	cum	280·00	cu m	5,695·20
5.	Flush pointing to exposed joint of brickwork in cement mortar (1:4) ...	42·49	sqm	3·43	sq m	146·07
6.	Rubble stone pitching ...	20·34	sqm	30·00	sq m	610·20

Total=9,771·53

Add contingency @ 5%=488·58

Work charge @ 2½%=244·29

Grand Total=Rs. 10,504·40

9-5. Estimate of a Hume Pipe Syphon :—Prepare a detailed estimate of a Hum Pipe Syphon from the attached drawing. Assume any suitable rate of your locality.

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes.
1.	**Earthwork in excavation for foundation—**							
	Canal Guard-walls U/S and D/S sides ...	2×2	2·34	·70	·50	3·28		·50=31 21—30·71
	Face walls U/S & D/S sides ...	2	5·50	1 00	1·50	27·50		1·50=31·21—29·71
	Collar walls ...	3	2·41	·80	1·42	8·18		1·42=31·21—29·29
	For Hume pipes ...	1	5·70	1·61	0·64	5·87		5·70=9·80—3×0·80 —2×·85
	Bed pitching U/S side— Horizontal portion ...	1	1·50	1·22	·30	0 55		1·12=2—2×·44(for side pitchings)
	Inclined portion ...	1	1·84	1·39 (av)	·30	0·77		1·84= $\sqrt{(1\ 9)^2+(\ 6)^2}$—·15
	Bed pitching D/S sides— Horizontal portion ...	1	2·40	1·12	·30	·088		
	Inclined portio ...	1	2·42	1·39	·30	1·01		
	Side pitching U/S insides— 1st portion from guard wall	2	3·35	2·60	·30	3·67		
	2nd portion ...	2	1·75	2 20 (av)	·30	2·31		2 60= $\sqrt{(1{\cdot}84)^2+(1{\cdot}84)^2}$ 1·84=1·40+·44 2·20=½(2·60+0·80) 1·80= $\sqrt{(0{\cdot}84)^2\times(\ 92)^2}$
	Side pitching D/S insides— 1st portion from guard wall	2	3·35	2·60	·30	5·23		
	2nd portion ...	2	2 35	2·20	·30	3·10		
	Outside pitching U/S side— 1st portion from guard	2	2·25	2·99	30	4·00		
	2nd portion ...	2	2·15	2·43 (av.)	30	3·14		
	Outside pitching D/s side— 1st portion from guard	2	3·25	2·99	·30	5·52		
	2nd portion ...	2	2·80	2·99	·30	5 02	8 004 cu m	
2.	**Cement concrete in foundation. (1: 3 :6)**							
	Canal guard walls U/S & D/S ...	2×2	2·34	·70	·15	0·98		
	Face walls U/S and D/S ...	2	5·50	1·00	·30	3·30		
	Collar walls ...	3	2·41	·89	·15	0·87	5·15 cu m	

Item No.	Description	No.	L. m	B. m	H. m	Qu	Total	Explanatory notes
3.	**Brickwork in cement matar (1:4)**							
	Canal Guard walls u/s&D/s	2×2	2·04	·40	·30	0 98		2 04=2·34—2×·15
	2nd footing ...	2×2	1·64	·40	·40	1·05		1 64=2·04—·40
	3rd " ...	2×2	1·24	·40	·40	0·75		
	4th " ...	2×2	0·84	·40	·40	0·54		Note that the superstructure walls are 144 above G.L. So brickwork in foundation and above has been considered in one item.
	Top ...	2×2	0·60	·40	·24	0·23		
	Face walls U/S and D/S							
	1st footing 70 cm ...	2	5·20	·70	·90	6·55		
	2nd footing 60 cm ..		5·20	·60	·70	4·37		
	3rd footing 50 cm ...	2	5·20	·50	·50	2·50		
	4th footing 40 cm ...	2	5·20	·40	·50	2·08		2·11=2·41—2×·15
	Collar walls ...	3	2·11	·50	·79	2·51		
	Deductions for—							·68=·60+2×·04
	U/S and D/S face walls ...	2×2	$\frac{\pi}{4}$×('68	)²×·65	av.)	0 94	(-ve)	·65=½('70+·60)
	Collar walls ...	3×½	×$\frac{\pi}{4}$('68	)² ×	2 11	1·18	(-ve) 19·44 cu m	
4.	**Earthwork in filling for—**							
	Canal Guard walls u/s&D/s	3·28	—('98	+·98)	=	1 32		Quantities are from items 1, 2, and 3
	Face walls U/S&D/s sids	27·5	—('33	+15·2	8)=	8·92		15·28=vol, of brickwork up to G L. (approximately).
	Collar walls	8·18	—('87	+2·51)	=	4·80	15 04 cu m	
5.	**Loose boulder pitching** 15 cm tihck over hume pipes	1	8·60	5·20	—	44·72	44·72 sq m	
6.	**Constructing 30 cm thick stone boulder pitching** on canel and drain side slopes with 1:4 cement mortar including pointing top surface							
	Bed pitching U/S side—							
	Horizontal portion ...	1	1·50	1·22	—	1·61		1 99=1·84 (as earthwork)+·15
	Inclined portion ...	1	1·99	1·39 (av.)	—	2·72		
	Bed pitching D/S side—							
	Horizontal portion ...	1	2·4	1·22	—	2·93		
	Inclined portion ...	1	2·57	1·39	—	2·19		
	C.O. ...					9·45		

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	B.F.					9·43		
	Side pitching U/S insides—							
	1st portion from Guard	2	2·50	2·60	—	13·00		
	2nd portion ...	2	1·90	2·20 (av.)	—	8·36		
	Side pitching D/S insides—							
	1st portion from Guard	2	3·50	2·60	—	18 20		
	2nd portion	2	2·50	2·20	—	11·00		
	Outside pitching for U/S—							
	1st portion from Guard	2	2·25	2·99	—	12·45		
	2nd portion	2	2·15	2·43	—	10·45		
	Outside pitching for D/S—							
	1st portion ...	2	2·25	2·99	—	13·45		
	2nd portion ...	2	2·80	2·99	—	16·75		
							113·11 sq m	
7.	**Fitting and fixing 60cm dia. 40mm thick Hume pipe** including supply and carriage of all materials of site	4×2	2·45	—	—	19·60	19·60 r m	
8.	**Site clearing.**			...	...	1	1 item	

ABSTRACT OF ESTIMATED COST

Item No.	Description	Quan.	Unit	Rate Rs P.	Unit of Rate	Amount Rs. P.
1.	Earthwork in excavation in all kinds of soil including all leads and lifts ...	80 03	cu m	320·C0	%cu m	256·10
2.	Cement concrete in foundation (1:3:6) with stone chips ...	5·15	cu m	380·C0	cu m	1,957·10
3.	First class brickwork (or stone masonry) in cement mortar (1:4) ...	19·44	cu m	280·00	cu m	5,443·20
4.	Earthwork in filling in 20cm layers ...	15·04	cu m	255·00	%cu m	38·35
5.	Loose boulder pitching 15cm thick ...	44·72	sq m	20·00	sq m	894·40
6.	Constructing 30cm stone boulder pitching on canal and drain side slope with 1:4 cement mortar including pointing top surface with 1:3 cement mortar ...	113·11	sq m	50·00	sq m	5,655·50
7.	Fitting and fixing 60cm internal dia. 40 mm thick Hume pipe including supplying and carriage of all materials ...	19·60	r m	225·00	r m	4,410·00
8.	Site clearing ...	1	item	100·00	L.S.	100·00

Total = 18,754·65

Add 5% contingency = 937·73

Add 2½% for work charge = 468·87

Grand Total = 20,161·25

9-5. Bill of Quantities or Schedule of Quantities :— This is a complete list of all items of work involve in connection of the estimate for a scheme giving the item number, description or particular of works with quantity of work against each work and thus enable to prepare the estimated cost of work. The Bill of quantities are prepared from drawings and specification in accordance with the rules of the Standard Method of Measurement and arranged them in a tabular form similar to the Abstract of Estimated cost of the detailed estimate without filling up the columns of rate and amount. This is particularly require for inviting item rate tender where the contracter fill up the rate and amount columns with their own competative rates.

For an example the Bill of Quantities for a proposed boundary wall has been shown below.

Item No.	Description of works	Quantity	Rate Rs. P.	Unit	Amount. Rs P
1.	Earthwork in excavation in foundation	12 cu m		One cu m	
2.	Lime concrete (1:2:5) in foundation ...	2·5 cu m		One cu m	
3.	Brickwork in cement mortar (1:4) ...	6·55 cu m		One cu m	
4.	10cm thick cement plaster (1:3) ...	60·08cu m		One sq m	
5.	12 mm thick cement plastering (1:6)	156·80sqm		One sq m	
6.	Colour wash over two coats of white washing	156·80sqm		One sq m	

9-6. Taking off in Quantity Surveying :— This is finding out the quantities of works from the detail measurements of various items of works involved in a scheme. The estimater takes off the various dimensions from the plan, sections and drawings and tabutate them in a measurement sheet also called dimension paper which usually contains the following columns in order viz. description, number, length, breadth, depth or thickness and quantity.

9 7 Abstracting in Quantity Surveying :— This is also part of the working up process which contains of assembling and grouping of works of a similar description transfered from the measurement sheet to specially ruled "Abstract paper" where they are totalled and reduced to their specified unit of measurement.

9-8. General Abstract of cost :— This, includes the name of the scheme and cost of different sub-heads are added. The detailed cost of each sub-head is not shown in the general abstract of cost, along with contingency, work charges, Tools and plant, operation and Maintenance during constraction etc.

9-8. Abstract of cost of estimate :— The cost under each sub-head from the general abstract of cost is detailed in the abstract of cost.

CHAPTER—X

ELECTRIFICATION OF BUILDING

10-1 Different parts of Electrification :— Electrification of a building includes the following heads (a) Service connection including meter box ; (b) Main fuse board, earthing, and Electric wiring ; (c) Supply of bulbs, fans etc.

(a) Service connection including meter box, main fuse board with fuse and earthing : These are carried out by the local electric supply company and are charged on the owner. Such charges increase if the location of the building be at a distance from the main supply line causing erection of intermediate pole or poles to carry out the service connection line.

(b) Electric wiring : This includes supplying and fitting, fixing cables, battens, wooden blocks, screws, nails, clips, cut-outs, switch boards, switches, ceiling rose, brackets, plug etc. Such detailed materials and fittings may be accounted after a detailed analysis from the wiring plan. Thus an accurate estimate may undoubtedly be prepared after including the cost of materials, labour, overhead charges and profit. But estimates for electrical wiring are generally prepared on the average cost per point basis as light points, fan points plug points etc. which includes the supply of all materials, labour, overhead charges and profit. All the different kinds of points are listed separately and different rates and fixed up. Before fixing up a rate per point an assessment of the average "runs" from the drawing or from an inspection of the building becomes necessary. When the number of points per room is high, the cost per point is usually less than when the number of points is low. Main switch board with switch and fuse is taken as a separate item and rate is fixed per number. During fixing up a rate per point, kind of wiring (conduit or cable), kind and quality of material must be specifically mentioned. Usually wiring is done on 5 amps circuit with 3/0·029 cables and 8 to 10 points are grouped in one circuit. The load of such circuit should be restricted to 500 watts. The distribution fuse board should be located as near possible to the centre of the load which are inteded to control. The wiring from the distribution board to the different switch boards are estimated on running metres and from switch boards to different points on point basis. The point should include all the accessories as described in the short note for different points.

(c) *Supply of bulbs, fans etc :* Fans with regulator are usually supplied by the owner and the wiring contractors fit and fix the same in position including supplying hanging fixtures etc. Thus bulbs are also supplied by the owner. But such initial cost of fans, bulbs etc, should be included in the total estimated cost.

10-2. Different systems of wiring commonly adopted for building electrification-

The following systems of wiring for building electrification are adopted :—

(a) Teak Wood (T.W.) batten wiring,

(b) Surface conduit system of electric wiring,

(c) Concealed conduit wiring,

(d) Cleat wiring for temporary electrification.

(a) Teak wood batten wiring : Teak wood battens shall be 12mm thick made from 1st class well seasoned teak wood, free from knots and saps and wide enough to accommodate the size and number of wires to be placed in parallel on battens. Battens shall be secured to the wall or ceiling by means of 37 mm long counter-sunk iron wood screw driven into rawl or phil-plug (wooden-plug for old building). The spacing of the securing screws shall not exceed 60 cm for vertical run and 45cm for horizontal run. Teak wood bend, corners, Rounds shall be of the same thickness as that of the batten and shall be individually secured at the end of the main batten.

Link clips made from heavily tinned brass sheet shall be secured by means of flat-headed brass pin on batten, bends, block etc, spaced 10 cm apart for both vertical and horizontal run. Unless otherwise mentioned T. R. S. or P. V. C. wire shall then be laid on the batten and fastened with link clips. Where cables pass through walls, alkathene pipe having minimum internal diametre of 12mm shall be firstly be inserted by making a hole in the wall. The wire shall then be passed freely through the pipe.

Unless otherwise specified the regulator board shall be surface type and be same thickness as that of batten. The size of the board shall be sufficient to accomodate the fan regulators, switches, plug etc. that are to be controlled from the board. The board shall be fixed on the wall. Connecting wires from the distribution wiring are drawn inside of the box and necessary connections of the different switches shall be made.

Connector Boxes shall be 18 cm × 10 cm minimum. The bottom piece of box shall be of the same thickness as that of batten. Connectors shall be single way porcelain connectors and shall consist of a brass limb in a porcelain block fixed by screw. The current carrying capacity of connectors shall not be less than 5 amps. Within connecting boxes connections of two ends of wires one comming from the Regulator board and the other comming from the metre shall be through the porcelain block of the connecting box. For more than one connections from the regulator board the end of the service line are multipled by making different parallel ends.

All teak wood blocks, connector boxes regulator boards, etc. shall be painted with 2 coats of anti-corrosive paint at back before fixing on wall. The front of the board, blocks etc. shall be highly polished. The batten and other teak wood materials shall be painted.

(b) Surface conduit system of electric wiring :—In this system of wiring the V. I. R. conduits are run in metallic tubes called conduits. The conduit is usually alkathine, but in places where damp and humid condition exists, such as, near sea or river beds or low laying area G. I. conduit is used for surface wiring.

The conduit is secured to wall or ceiling by means of saddles, pipe hooks, secured with screws to the rawl / phil-plug with correct size of holes, drilled on walls or ceiling, spaced not more than 75cm apart for vertical run, 60 cm apart for horizontal run. The conduits are generally erected first and wiring is done later. The drawing in method of wiring the conduit is most commonly adopted. First the galvanised wires are inserted in the conduits and later P. V. C. insulated cable are pulled through by means of the galvanised wires. In order that the wires may be easily pulled they are some times rubbed with French chalk. Inspection boxes and bends are provided at frequent intervals to facilitate drawing in of the wires not more than 6 to 9 metres per length of conduit. Where two or more switches are required to be fixed and in case of regulator boards the switches, regulators or socket outlets, as the case may be, is mounted on C. I. box provided with a cover made of 3mm thick, bakelite or perspex sheet. Cables of different colours are used for D. C. 3-wire system, and for 3 phase, 4 wire A. C. system. Neutral conductor is always wired up with conductor with black colour.

(c) **Concealed conduit wiring :**—Where conduits are to be concealed, only alkathene conduit shall be used. After completion the rainforcement of roof slab and beams, the alkathene pipe is laid under the top layer of roof reinforcements and through the beams as require for different positions of light, fan and plug points etc. Before laying the conduits G. I. wires are inserted in the conduits exposing a considerable length out side the conduits for pulling out. After completion of concreting work of roof P. V. C. insulated cable is binded up at one end of the exposed G. I. wire and pulled out at the other end with the help of the G. I. wire laid previously. The alkathene conduit is laid on wall before plastering work is done. To conceale the conduit, the brick walls are nearly cut by chasel, just sufficient in depth (normally 12mm) to hide the cable after plastering and sufficient in width to accomodate the number of conduit pipe required to be laid, To conceal the switch board, distribution board, inspection box, ceiling rose, main board and all conduit accessories and fittings the brick wall and ceiling are neatly cut just to accomodate them at the related places. The conduit pipe line and fittings are then securely fiixed with L-hooks or clips inside the chase before cementing in. All boxes are flush type burried in wall at proper level with the plastered surface. The conduit accessories to be burried inside the chase are of solid type. The chase is filled with cement and sand mortar (1 : 4).

Inspection type of accessories such as bend, boxes, etc. are provided at intervals of not more 6 to 9 metres per length of conduit. Rectangular type of boxes are used where two or more conduits intersect at right angle.

No cable inside the conduit or conduit accessories are cut or jointed. A continuous cable from one and to other is provided and cable ends are terminated at switch boards, branch distribution board or accessories.

The switch and / or regulator boards are flush types. All switches, regulator, socket outlet are of such designes that only knobs of the switches or regulators remain projected outside for operation. Where two or more switches are required to be fixed and in case of regulator boards the switches, regulators or socket outlets as the case may be, is mounted on C. I. box provided with a cover made of 3mm thick, bakelite or perspex sheet. Cables of different colours are used to indicate the positive and negative lines.

(d) Cleat wiring or Temporary wiring :—The temporary installation done is not allowed to be service for a period not longer than three months and providing the supply voltage does not exceed 250 volts A. C. or D. C.

All cables in a temporary installation are P. V. C. insulted and run on cleats. In this system cables are supported in porcelain cleats. The cleats are made in two halves one of which is grooved to receive the wire and the other half is put over it and the whole of it is fixed on the wall by means of screws further tightens the grip of the wire between the two halves of the cleat. A row of cleats are fixed in a straight line, and the screws should nearly be tightened to the full extent and then loosened sufficiently to allow the cable to be sliped between the cleats. Cleats are spaced sufficiently close to one another so as to prevent cable comming in contact with each other or other parts of the structure. The spacing of the cleats should be 30cm for 1/1·4 cable and 60cm for the larger sizes. Sharp bends should be avoided. The cables should be open to view throughout the entire length. When the cable runs within floor, walls etc. in which case they are not normally open to view, the cable should be adequetly protected with alkathene pipe of proper bore.

10-3. Short notes : (a) Point : A point shall consist of the branch wiring from the branch distribution board, together with a switch as required, as far as and including the ceiling rose or socket-outlet or suitable termination. A three pin socket-outlet point shall include, in addition, the connecting cable or wire from the earth pin of the socket to the earth stud of the branch distribution board.

(b) Fan Point .—Distribution wiring to fan point shall consist of necessary wiring from a connector box or from fixture to the ceiling rose at the other end ; and also switch wiring for the fan from the connector box or from any other source as decided by the Engineer-in charge. The point shall comprise, a switch, a ceiling rose, and regulator board, including circuit wiring from branch distribution board to connector box.

(c) Light Point :—Distribution wiring to light point shall consist of necessary wiring from a connector box or another fixture to ceiling rose, batten holder, bracket at the other end, and switch wiring from connector box or other source as decided by the Engineer-in-charge. The point shall comprise, switch, including circuit wiring, cealing rose, batten holder, block for bracket light fittings.

(d) **3-Pin plug point** (5 amp) :—3 Pin plug point shall consist of necessary wiring from nearest connector box or from branch distribution board to 3-pin plug and shall include supply and fixing of 3-pin socket-outlet with plug and a 5 amp. control switch. In all cases the plugs shall be provided with a continuous earth with sorft copper wire (No. 16 S.W.G.) which shall be drawn along with the wiring from the nearest earth and the same shall be deemed to be the part of distribution wiring.

10·4. Earthing :—*(a) What is earthing ?* A connection to the general mass of earth by means of an earth electrode i.e. a matal plate, pipe or other conductor electrically connected to the general mass of the earth.

(*b*) *Object of earthing* :—The earthing system are of supreme importance for protective purposes in both electricity supply and utilisation. Apart from the employment of earthing in power system to limit the potentials of live conduits with respect to earth, the primary purpose of earthing is to prevent a dangerous potential occuring on part of the electrical installation or equipments that are not normally alive.

It is essential, therefore that the earthing should be carried out in an efficient and permanent manner in order that risk attended upon the use of electricity wherever breakdowns occur may be eliminated. Proper low resistance earthing forms the corner stone of the usual protective measures against electric shock.

(*e*) *Aspects of Design* :—While designing an earthing system the following points for attaining desired value of earth resistance shall be bourne in mind.

(i) It must have sufficiently low resistance at any time of the year, to pass enough current to operate the protective gear under fault conditions.

(ii) It must carry the fault current for a sufficient time to operate the protective gear and as such it must have adequate carrying capacity.

(iii) The voltage gradient on the surface of the ground arround the electrode must not be dangerously steep.

(i) The electrode and its connection must have high resistance to soil and atmospheric corrosion.

10-5. Earthing with G. I. Pipe Electrode ; (i) *Dimension and quality of pipe :*—For pipe electrode galvanised steel pipe shall be of class 'B' Medium quality, having 50mm. dia. bore and the length shall not be less than 2·45 metre. The top end shall be threaded and a hole 15 mm in diametre shall be drilled through at 10 cm from top end to receive a 12mm galvanised bolt. (ii) *The galvanised wire of No. 6 S. W. G. or copper conductor* shall be connected securely on the cleaned surface of pipe so as to make electrically sound conductor. (iii) *The bottom end of pipe* shall be chisel out to facilitate easy penetration into soil, if requires to be driven. A trench shall first be made 45 cm deep and then a hole for such electrode shall be drilled by means of augur, in order to place the electrode at an average depth of 3 metres below ground level. The top end of the electrode shall be at an average depth 30 cm below the ground level. The excavated and drilled area arround the electrode shall be back filled and consolidated. Neither the use of short piece of pipe nor any joint on earth lead conductor is permitted. Where joint is unavoidable, the pipe shall be rigidly jointed by means of screwed socket etc. as done by the plumbers. (iv) The protective G. I. pipe shall be filled with bituminous compound of approved make and brand, in order to make it hermetically sealed. The molten compound shall be poured from the top end of pipe topped up to overflowing. (v) The earth lead conductor from electrode shall not be cut or terminated unless the same reaches in desired length for making connection with earth busbar, switchboard, pole, service braket, lightning arrester or the object to be earthed. (vi) The electrode shall be buried or driven at least 2 metre clear from building or the object to be earthed. The electrode and lead shall be kept free from paints, grease or the like substance to prevent the poor conductivity. (vii) For the ease of examination of earthening, provision shall be made, where desirable, for an inspection pit, similar to those done by the plumbers.

10·6. Rating of Lamp, Fan and Socket-Outlet Points :—In estimating the current to be carried by any conductor for loading of circuits the following figures shall be assured as recommended by IS : 732-1963 unless otherwise specified.

1.	Incandescent lamps	... ...	60 watts
2.	Fluorecent lamps tube	... ...	40 „
3.	Ceiling fans, table fans	... .	60 „
4.	Ordinary socket-outlet	... ...	60 „
5.	Power socket-outlet	... ...	1000 „
6.	Exhaust fans	...	according to their capacity.

Note : *The height of the light bracket from floor level—2·5 m ; the height of switch etc. from floor level—1·5 m; the height of ceiling fans to be suspended should be 3·0 metre measured from the bottom of the blades of fans to the floor.*

Example : Prepare a detailed estimate for electrification of the building as shown in the figure 3-10 page 162 for ground floor. Assuming that electrification of the first floor shall be the same as that ground floor estimate also the total cost of electrification of the building. The wiring shall be with P. V. C. Aluminium wire concealed conduit wiring. The provision of electric points shall be as follows : (a) drawing room—one ceiling fan, one tube light, two bracket lights and a power plug point, (b) each bed room one tube light, one bracket light, one bed light and a plug, (c) Corridor—one tube light and a plug, (d) kitchen—one bracket light and a power plug, (e) each lavatory and store with a batten light, (f) staircase with a twin control light and one batten light at the underside of 1st landing, (g) at the main gate—one bracket light and a calling bell. Assume the total length of wiring be 60·0 m from distribution board to different switch boards.

Schedule of Points (Ex. 1)

Sl. No.	Particulars of location	Light No.	Tube No.	Fan No.	Plug No. (ordinary)	Power Plug No.	Bell No.	Remarks
1.	Drawing room ···	2	1	1	—	1	—	
2.	Bed room 3·1m × 3·1m ···	2	1	1	1	—	—	
3.	Bed room 4·2m × 3·5m ···	2	1	1	1	—	—	
4.	Corridor ··· ···	—	1	—	1	—	—	
5.	Kitchen ··	1	—	—	—	1	—	
6.	Lavatory (2 Nos.) ···	2	—	—	—	—	—	
7.	Store ···	1	—	—	—	—	—	
8.	Staircase ···	1	—	—	—	—	—	
9.	Under side of staircase ···	1	—	—	—	—	—	
10.	Main gate ··· ···	1	—	—	—	—	1	
	Total of each point	= 13 Nos.	4 Nos.	3 Nos.	3 Nos.	2 Nos.	1 No.	

Total number of points = 13 + 4 + 3 + 3 + 1 = 24 Nos. ordinary and 2 Nos. power

Load calculation (assuming wattage per point according to IS 732) :—

(i) Wattage per light points $= 13 \times 60 = 780$

(ii) —do— for tube points $= 4 \times 40 = 160$

(iii) —do— for fan points $= 3 \times 60 = 180$

(iv) —do— for plug points $= 3 \times 60 = 180$

(v) —do— per power points $= 2 \times 1000 = 2000$

(vi) —do— for calling bell $= 1 \times 60 = 60$

Total load = 3360 watts out of which wattage for power points = 2000

Number of circuits :—Providing a separate circuit for power plug load of 2,000 watts total load = 3360 − 2000 = 1360 watts. Supply voltage = 230. Total load permitted in a circuit = 500 watts (more load upto 800 watts may be permitted. but a provision for future extention has been made) ∴ Number of circuits $= \frac{1360}{500}$ i. e. 3 Number of points 24 and divide the numbers in 3 circuits 8+8+8 and therefore no circuit exceeds 10 points. A separate power circuit of 2,000 watts shall be provided.

Main Switch : The line current in the main circuit $= \frac{3360}{230} = 14{\cdot}5$ amps. Although a 15 amps main switch can carry the current but for future alterations provide one 30 amps 230 volts switch for the main board and for 4 nos. of circuits provide 4-way Distribution

SCHEDULE OF QUANTITIES AND COST (Ex. 1)

Item No.	Particulars of items	Quantity	Rate Rs. P.	Unit of rate	Amount Rs. P.
1.	Supplying, fitting and fixing metal clad 30 amp. Grade I main switch of approved brand with kit-kat (fuse) inside the flat as per instruction.	1 No.	80·00	Per switch	80·00
2.	Supplying, fitting and fixing 4 way 15 amps, metal distribution box (concealed type) of approved brand with necessary cutting in walls and finishing the same as per instruction complete.	1 No.	100·00	Each	100·00
3.	Drawing internal circuit lines with 2·5 sq mm two single core P. V. C. Aluminium wire in 20 mm dia alkathene conduit with 14 S. W. G. G. I. earthing attachment from distribution box of different switch boards (Rate shall include supplying and laying alkathene conduits, earthing wire, laying of alkathene pipe in concrete before casting and cutting chases in wall surfaces and mending good all damages all complete)	60 rm	8·50	per rm	510·00
4.	Supplying 2·50 sq mm two single core P. V. C. Aluminium wire of approved brand. (length—3 times the length of travel)	180 rm	300·00	per 100 rm	540·00
5.	Supplying, fitting and fixing 'metal concealed switch boxes with milk white plastic cover for :— (a) One regulator and 4 piano-type switches and one same type switch for one plug point. Rate shall include necessary cutting in walls and mending good all damages complete (for drawing and 2 bed rooms)	3 Nos.	35·00	Each	105·00
	(b) For one piano-type switch and one for plug -do- -do- (for kitchen and corridore)	2 Nos.	15·00	Each	30·00
7.	(c) For one piano type switch only —do— —do— (for each lavatory, store, underside of stair, at main gate, call bell and one two-way switch.)	7 Nos.	9·00	Each	63·00
8.	Providing and drawing cables for lights, fans, call bell 5 amp. plug points with 2×1·5 sq mm P.V.C. Aluminium wire of approved brand in 12mm to 20mm dia alkathene conduit and piano-type anchor switches or any other approved brand. Charge includes necessary cutting chases on walls surface and laying in R.C. wherever required before casting and making good all damages complete (this is a point basis item)	23 points	110·00	per point	2530·00
9.	Providing and drawing cables for 2-way staircase light point as in item No. 8	1 point	130·00	-do-	130·00
	C. O.				4088·00

Item No	Particulars of Items.	Quty.	Rate. Rs. P.	Unit	Amount Rs. P.
	B. F. ...				4,088·00
10.	Providing and drawing cables for 15 amp. plug points with 2×6 sq.m. P.V.C. aluminium stranded wire of approved brand as in items 8.	2 Points	130·00	per Point	260·00
11.	Supplying, fi ting, fixing fan clamps of 12 mm. dia. M.S. Rod as per instructions before casting of concrete.	3 Nos.	5·00	Each.	15·00
12	Earthing with 50 mm. dia. G.I. pipe class 'B' Medium quality driven in ground for a length of 3 m with top end 30 cm below G.L. connected with G.I. wire No. 6 S.W.G, or Copper conductor as per drawing and in accordance with IS : 3043 code of practice for Earthing.	1 Set.	230·00	Per Set.	230·00
13.	Charges incurred in obtaining permission from Electric Supply company for construction power (temporary).	1 Item	250·00	L.S.	250 00
14.	Charges for service connection to the Electric Supply Co. for meter, main fuse board with fuse, earthing and necessary drawing cables from main service to metres and chasing up the work to the respective authority.	1 Item.	500 00	L.S.	500·00
15.	Supplying 122 cm. (48″) ceiling fan with regulator and fitting, fixing in position with necessary fixtures.	3 Nos.	425·00	Each.	1,275·00
16.	Supplying Fluorecent lamps (Tube) 122 cm. (4′-0″) long of approved quality & make included fitting, fixing the same in position with all necessary fixtures.	4 Nos.	130·00	Each.	520·00
17.	Supply of light balbs of approved make.	13 Nos.	4·75	Each.	61·75
18.	Supplying and fitting fixing call bell of approved quality and make including fitting, fixing the same in position with necessary fixtures.	1 No.	50·00	Each.	50 00

Total = Rs. 7,249·75

Add 5% for contingency... ... ... = Rs. 362·48

Add 2½% for work-charged establishment... ... = Rs. 181·24

Grand Total = Rs. 7,793·47

∴ Cost of electrification for of the building consisting 2 floors = 2 × Rs. 7,793·47 = Rs. 15,586·94

CHAPTER XI

ANALYSIS OF RATE

11·1. What is analysis of rate and how is this to be prepared ? The basis of arriving at a correct and reasonable rate per unit work or supply, for a particular item following its specification and detail survey of materials, labour, equipments etc. as required for the unit work and their prevailing rates may be called as an analysis of rate. The procedure of analysing rate per unit of an item has been described in the Chapter I article 1·5. This consists of the following heads :—

(a) Quantity of materials required per unit rate of work and its cost delivered at work site including firstcost, freight, transportation, sales tax and insurance charges as arrises in question. In case when materials like cement, steel, stone chips and bitumen are supplied departmentally then profit on the cost of materials is not allowed, but cost of carriges from godown to work site shall be added.

(b) Number of labour or labour hours required to complete per unit rate of work and its cost.

(c) Overhead or equipment and establishment charges required to complete per unit rate of work.

(d) Profit.

While arriving at workable rates the factors those are to be considered has already been described in the Chapter I article 1-4.

The method of preparation of an analysis of rate has been based on All India Standard Schedule of Rates which is documentary and prepared by the National Building organisation and U. N. Regional Housing Centre, ESCAP (India). The conference of State Housing Ministers held at Bhopal during October 1975 has recommended that the Standard Schedule of Rates being a necessary adjunct to the National code should also be adopted by all construction agencies in the country. There may be some variations between the prevailing practice and the provisions made in the analysis of rates but "All India Standard Schedule of Rates" may be considered as authentic and a basic document.

Water Charge :—For drinking purpose of the workers and for the work, arrangement of water either by sinking tubewell or by taking temporary water connection from the Corporation or Municipality becomes necessary. In order to meet up the expense an amount of 1% of the total cost of materials and labours has been prov ded in the analysis of rate as per provision made in the Standard Analysis of Rate.

Overhead :—All India Standard Schedule of Rates recommends that an amount of 10% of the total cost of materials, labours and water charge shall be added with the above total cost for contractors profit and overhead. Accordingly the actual profit becomes 8% to 9%.

11·2 Quantity of materials per unit rate of work—Preplexity arises to keep in mind the indent of materials which ard required per unit rate of works without knowing the basis of calculations or veteran practical knowledge. Basis of some calculations has, therefore, been shown in most of the items of works in preparing their analysis of rates.

11·3 Estimating labour—During preparation of labour estimates due allowance must be made for variations in wages, working conditions and for the different classes of labour required for different kinds of works.

The length of time required to do a certain piece of work may vary according to the skill and mental development of the workman and also to the working conditions on the particular job. When work is plentiful, labour acarce, and jobs are easy to get the time required for a labour to do a certain peice of work is generally more than the average and vice-versa. However, the experience of a contractor for a few months when he has had a number of workmen working for him should enable to estimate quite closely the length of time that any of the workmen will need to do a certain job. Local customs or union regulations often require to specify number and classes of labours for a certain work. The recommendations of All India Standard Schedule of Rates for different kinds of labour as required to do a certain peice of work has closely been adopted.

Students and beginners having a little practical experience often find it difficult to bear in mind the number of labours (skilled and unskilled) which are to be engaged to complete different types of works. Therefore, a number of labour gangs having different working strength has been shown in a tabular form and the item of works that are to be completed by such a gang has been indicated against them. Considering all the factors as discussed above a variation unto 5% in some cases, if it ever occurs, should not be taken into account.

11-4. Task or out-turn work:—This is the quantity of work which can be done by an artisan or skilled labour of the trade working for 8 hours a day. Although out-turn work is variable but in order to specify the same an average approximate quantity has been worked out following the Standard Analysis of Rates as far as possible. The out-turn work does not mean that the quantity of work can be completed only by the labourer as designated below. But other types of labourers or helpers are also to be engaged to complete the quantity of work. For an example a Mason can complete 1·50 cum of brickwork per day (8 hours a day) provided he is helped by 2 Mazdoors to carry and mix the ingradients of mortar and also to carry and place all other materials at his disposal etc. Instruction from a Head Mason for a few hours is also necessary to complete the quantity of brickwork.

	Description of Work	**Quantity of Work per day** (8 hours a day)
1.	Earthwork in excavation in foundation trenches in ordinary soil, lead upto 50m and lift up to 1·5m	2·75 cum per Mazdoor
2.	Earthwork in excavation in foundation trenches in hard soil -do- -do- -do-	2·10 cum ,, ,,
3.	Excavation in soft or decomposed rock by blusting lead upto 50m and lift upto 1·5m. ...	0 55 ,, ,, ,,
4.	Sand filling in plinth, consolidating and dressing ...	4·00 ,, ,, ,,
5.	Single layar brick flat soling including ramming and dressing the bed etc. ...	9·00 sqm ,, ,,
6.	Lime concrete in foundation	10 ·00 cum per Mason
7.	Cement concrete	5 00 ,, ,, ,,
8.	Cement concrete (1 : 2 : 4) for R.C.C. work ...	3·25 ,, ,, ,,
9.	Brickwork in foundation and plinth	1·40 ,, ,, ,,
10.	Brickwork in superstructure ground floor ...	1 25 ,, ,, ,,
11.	Half brickwork in partition wall	7·00 spm ,, ,,
12.	Brickwork in plain arches	1·00 cum ,, ,,
13.	Reinforced Brickwork in slabs	1·00 ,, ,, ,,

Description of Work	Quantity of Work per day (8 hours a day)
14. 2·5 cm thick cement concrete D.P.C.	.. 12·50 sqm per Mason
15. 20mm thick D.P.C. with cement mortar	.. 20·00 ,, ,, ,,
16. Random rubble masonry in foundation and plinth	.. 1·00 cu m ,, ,,
17. ,, ,, ,, in superstructure	.. 0·90 ,, ,, ,,
18. Ashlar masonry in superstructure	. 0·40 ,, ,, ,,
19. Coursed rubble stone masonry in superstructure	.. 0·67 cu m per Mason
20. Brick on edge floor with cement mortar	.. 1·00 sq m ,, ,,
21. 7·5cm thick cement concrete floor (1 : 4 : 8)	.. 10·00 ,, ,, ,,
22. Terraced flooring 7·5 cm thick	.. 20·00 ,, ,, ,,
23. 2·5 cm thick cement concrete flooring	.. 12·50 ,, ,, ,,
24. Neat cement punning (about 1·5 mm thick)	. 40·00 ,, ,, ,,
25. Terrazo floor 6mm thick mosaic work over 2cm thick cement concrete (1 : 2 : 4)	.. 5·00 ,, ,, ,,
26. Terrazo skirting or dado 6mm thick Terrazo layer over 12mm. thick cement plaster	.. 3·85 ,, ,,
27. Precast Terrazo tiles 20mm thick laying on a bed of 25mm thick lime mortar ...	.. 5·00 ,, ,,
28. Precast Terrazo tiles 20mm thick in skirting and rises of steps on 12mm cement plaster	. 3·20 ,, ,, ,,
29. 10cm average thick lime terracing on R C. roof	9·10 ,, ,, ,,
30. Flat terrace roofing average 10cm thick over two layers of tiles (with 2·5 cm mortar) ...	5·00 ,, ,, ,,
31. Ranigung Tile roofing	6·70 ,, ,, ,,
32. Mangalore Tile roofing including wooden battens, Tiles set in cement mortar	20·00 ,, ,, ,,
33. Corrugated Galvanised Iron sheet roofing	. 10·00 ,, ,, Carpenter
34. 12mm thick cement plaser on new brickwork	10·00 ,, ,, Mason
35. 6mm thick cement plaster to R.C. ceiling	10·00 ,, ,, ,,
36. Rule pointing on brickwork	. 10·00 ,, ,, ,,
37. Single coat white washing over old white washed surface	133·00 ,, ,, Painter
38. White washing two coats on a coat of priming	66·70 ,, ,, ,,
39. Distempering two coats to new cement plaster	. 20·00 ,, ,, ,,
40. Lime punning over interior plaster	5·00 ,, ,, Mason
41. Water proofing cement paint to new cement plaster	. 20·00 ,, ,, Painter
42. Snow-Cem washing on plaster surface two coats	. 20·00 ,, ,, ,,
43. Priming coat with ready mixed primer on wood or steel work	. 40·00 ,, ,, ,,
44. Painting two coats (excluding priming coat) with ready mixed paint for wood work	. 18·00 ,, ,, ,,
45. Painting two coats (excluding priming coat) ready mixed paint on old wood work	. 28·00 ,, ,, ,,
46. Breaking of over burnt brick to ballast 40mm down	.. 0·75 cum ,, Mazdoor
47. Breaking of overburnt brick to ballast 25mm down	. 0·55 ,, ,, ,,

(i) Name of Gang.	(ii) Strenght of Gang.	(iii) Any one item of work which may be completed by the gang. Volume of work is as in column (iv)	(iv) Volume of work	(v) Adjustment for colume (ii)
(A)	¼ Head Mason	(1) Lime concrete in foundation ...	10 cu m	
	1 Mason	(2) Lime punning over plastering ...	10 sq m	Sl (2) decrease 18 Madoors and the head mason.
	20 Mazdoors (Beldars)	(3) Cement concrete in foundation ...	10 cu m	Sl (3) Increase 1 Mason
(B)	½ Head Mason	(1) Brickwork in ground floor ...	10 cu m	(1) For plinth and foundation reduce 2 Masons and increase 2 Mazdoors (Beldars) & for first floor reduce 1 Mason and increase 5 Mazdoors
	10 Masons	(2) Brickwork in plain arches	10 cu m	
	15 Mazdoors (Beldars	(3) Brick on enge floor	100 sq m	(3) Add 4 more Mazdoors. For ground floor add 1 Mason and 2 Mazdoors overplinth
		(4) Reinforced conc. brick slab	10 cu m	
		(5) Random Rubble masonry in foundation and plinth	10 cu m	
		(6) 6 mm thick cement plastering to ceiling ...	100 sq m	(6) Less 3 Mazdoors
		(7) 12 mm thick cement plastering on walls ...	100 sq m	(7) Less 5 Mazdo rs
		(8) Rule pointing on brick wall ...	100 sq m	For SL. (8) reduce 5 Mazdoors
		(9) 7·5cm thick cement concrete floor ...	100 sq m	(9) Increase 5 Mazdoors
(C)	½ Head Mason	(1) Ashlar Masonry in superstructure at ground floor	10 cu m	(1) Add 10 Masons and 10 Mazdoors
	15 Masons	(2) Coursed Rubble stone Masonry in superstructure at ground floor ...	10 cu m	(2) Add further 4 nos Mazdoors.
	20 Mazdoors	(3) Half brickwork at ground floor ...	100 sq m	(3) Less 1 Mason, increase 1 Mazdoor.

11·5. Quantity of Materials Required for Different Items of works.

Name of work		Quantity of material	
1. Brickwork—	per 10 cu.m.	Bricks 20 cm. × 10 cm × 1 cm ...	5000 nos.
		„ 25·4 cm × 12·7 cm × 7·6 cm...	4100 „
		„ 22·9 cm × 11·4 cm × 7·6 cm...	5000 „
		Dry cement mortar ...	3·5 cu m
		„ lime „ „ ...	4·0 „
2. Half brickwork—	per 100 sq m	Bricks 20 cm × 10 cm × 10 cm ...	5000 nos
		„ 25·4 cm × 12·7 cm × 7·6 cm ...	4100 „
		„ 22·9 cm × 11·4 cm × 7·6 cm ...	5000 „
		Dry mortar	3·15 cu m
3. Random Rubble stone Masonry—	per 10 cu. m.	Stone	12·5 cu m
		Lime mortar	4·4 „
		Cement mortar	4·2 „
4. Ashlar Masonry—	per 10 cu. m.	Stone	10 cu m
		Dry cement mortar ...	3·0 „
		„ Lime mortar	3·2 „
5. Coursed Rubble stone Masonry—	per 10 cu.m.	Stone	12·5 cu m
		Dry cement mortar ...	4·0 „
		„ Lime mortar	4·2 „
6. Single brick flat soling	per 10 sq m	Bricks 20 cm × 10 cm × 10 cm ...	425 nos.
		„ 25·4 cm × 12·7 cm × 7·6 cm...	320 „
		„ 22·9 cm × 11·4 cm × 7·6 cm...	425 „
7. Brick on edge floor with cement mortar	per 10 sq.m.	Bricks 20 cm × 10 cm × 10 cm ...	500 nos.
		„ 25·4 cm × 12·7 cm 7·6 cm ...	410 „
		„ 22·9 cm × 11·4 cm 7·6 cm ...	500 „
		Dry mortar	3·5 cu m
8. 20 mm. thick D.P.C. with cement mortar	per 100 sq.m.	Cement	27 bags
		Sand	1·8 cu m
		Water proofing compound ...	27 kg.
9. Reinforced Brickwork	per 10 cu m	Bricks	4,500 nos.
		Dry cement mortar ...	4·8 cu m
10. Precast Terrazo Tiles 20 mm thick on 12 mm thick cement plaster	per 100 sq.m.		
(a) For Terrazo work		Tiles	110 sq m
		Cement	13 bags
		Pigment	46 kg
(b) For 12 mm thick cement plaster		Cement	14 bags
		Sand	1·31 cu m
11. Lime terracing in roof with brick ballast (proportion 2:2:7)	per 10 sq m		
(a) For 7·5 cm thick		Lime	2·1 cu m
		Surki	2·1 cu m
		Brick ballast	7·5 cu m
(b) For 10cm thick		Lime	2·9 cu m
		Surki	2·9 cu m
		Brick ballast	10·2 cu m

	Name of work		Quantity of materials	
12.	Ranigunj Tile roofing in lime mortar —	per 10 sq.m.	Ranigunj Tiles ...	124 nos
			Dry lime mortar ...	0·15cum
			Cement ,, ...	0·14 ,,
13.	C. G. I. Sheet roofing—	per 10 sq.m.	G. I. sheet ...	12·8 sq m
14.	A.C. Corrugated sheet roofing	per 10 sq.m.	A. C. sheet ...	11·50 ,,
15.	12 mm thick cement plaster...	,, 100 sq.m.	Dry mortar ...	1·92 cu m
16.	Neat cement punning (about 1·5 mm.)...	per 100 sq.m.	Cement ...	5·5 bags
17.	Flush pointing in cement mortar...	per 100 sq.m.	Dry mortar ...	0·7 cu m
18.	Single coat white washing to old work ...	per 100 sq.m.	Stone lime (unslaked) ...	10 kg
19.	Two coats white washing on a coat of priming to new work...	per 100 sq.m.	Stone lime (unslaked) ...	1 30 kg
20.	Distempering two coats to new cement plaster ...	per 100 sq.m.	Tropic dry Distemper	
			1st coat ...	12 kg
			2nd coat ...	7 5 kg
21.	Lime punning over plastered surface—	per 10 sq.m.	Slaked stone lime ...	18 kg
			Shell lime ...	8 kg
22.	Snow-cem washing on plastered surface—	per 100 sq.m.	1st coat ...	30 kg
			2nd coat ...	20 kg
23.	Priming coat on steel work with ready mixed primer...	per 100 sq.m.	Primer ...	5·5 litres
24.	Priming coat on wood work with ready mixed primer...	per 100 sq.m.	Primer ...	7·5 litres
25.	Painting two coats on new work with ready mixed paint	,, —do—	Ready mixed paint ..	12·5 litres
26.	Water proofing cement painting two coats to new plaster to exterior walls...	per 10 sq.m.	Mixed cement paint ..	2 litres
27.	Spray painting with wall paints on new work including priming ...	per 100 sq.m.	Priming coat pimer	8·1 litres
			wall paint	11 litres
28.	Painting with synthetic enamel paint on new work (excluding priming coat)	per 100 sq.m.	Enamel paint ...	11·6 litres
29.	Varnishing with Copal varnish on new work including an under coat	per 100 sq.m.	Under coat varnishing...	7·0 litres
			Copal varnish ...	11·6 ,,
30.	Wax polishing, on new wood work with ready made polish	per 100 sq.m.	Ready-made wax polish...	50 kg
31.	Flooting coat of cement	per sq.m.	Cement ...	22 kg

32. Quantity of coarse aggregate, sand and cement for different proportions.

In the analysis of rates per cu m at first a volume of 10 cu m has been considered in the calculations to avoid one place of decimal.

But it is difficult to assess exactly the amount of each material required to produce 10 cu m of wet concrete when deposited in place. Quantities of ingredients may closely be determined by a 'thumb rule' as given below.

To find out the volumes of cement, sand and coarse aggregate divide a numerical number 15·4 variable upto 15·7 according to the proportioning and ' Water cement ratio" by the summation of the proportions of the ingredients used and then multiply the result thus obtained by their respective strength of proportioning. In case of brick ballast (or jhama chips) the numerical number is variable from 15·7 to 16·0 as void in brick ballast is higher than that of stone chips. Variation should be adjusted with an aim to get a round number as far as possible.

Example 1.—For 1 : 2 : 4 proportion with stone chips :—

Summation of proportion = 1 + 2 + 4 = 7. The numerical number should be 15·4 to obtain a round figure (as far as possible) after dividing the number by 7.

$\therefore$ Cement $= \frac{15{\cdot}4}{7} = 2{\cdot}2$ cu m ; Sand $= 2{\cdot}2 \times 2 = 4{\cdot}4$ cu m ; Stone chips $= 2{\cdot}2 \times 4 = 8{\cdot}8$

For 1 : 2 : 4 proportion with brick ballast (or jhama chips) the numerical number (variable from 15·7 to 16·0) may be considered nearly as 15·8.

Cement $= \frac{15{\cdot}8}{7} = 2{\cdot}25$ cu m ; sand $= 2{\cdot}25 \times 2 = 4{\cdot}5$ cu m ; brick ballast $= 2{\cdot}25 \times 4 = 9{\cdot}0$ cu m

Note that *the last figure of the numerical number has been adjusted in both the cases during division to obtain the result as round as possible.*

Note : *Weight of 1 bag of cement = 50kg. Volume of 1 bag of cement = 0·0347 cu m.*

A table has been prepared for quantity of materials that may be required in different proportions, subject to a variation of plus/minus five percent and mostly same as adopted by Government departments and also recommended by All India schedule of rates.

Quantity of materials for 10 cu m of concrete (variation 5% allowed) based on assumption that dry sand with necessary allowance for bulking is used.

Volumetric proportion	Cement		Dry Sand cu m	Stone chip 20mm to 6mm cu m	Cement		Dry Sand cu m	Brick ballast 20mm to 6mm	Water per bag of cement
	cu m	bags			cu m	bags			
1 : 1 : 2	3 9	112·4	3·9	7·8	Not	to be	recommen	ded	7½ litres
1 : 1½ : 3	2·8	80·7	4·2	8·4	-d	o-	-do-	-do-	8¾ ,,
1 : 2 : 4	2·2	63·4	4·4	8·8	2·25	64·8	4·5	9·0 cu m	9½ ,,
1 : 2½ : 5	1·8	51·9	4·6	9·2	1·80	51·9	4·6		
1 : 3 : 6	1·57	45·2	4·7	9·4	1·60	46·1	4·8	9·6	11 ,,
1 : 4 : 8	1·20	34·6	4·8	9·6	1·23	35·4	4·9	9 8	13½ ,,
1 : 5 : 10	0 98	28 2	4·9	9·8	1·00	28·8	5·5	10·0	14 ,,

11-6. Rate of Materials and labour.—*This is variable place to place and time to time. But as a general guidance the following rates have been adopted in the analysis of rates. In practice the actual local market rates should be collected from the area concerned. For metropolitan towns the rates of bricks, sand, stone chips and surki should be increased even upto 10%.*

	Description of Item	Unit of Rate	Rate Rs. P.	Rate for hilly or sandy area Rs. P.
(A)	**Materials as per approved specifications delivered at worksite including stacking.**			
1.	Bricks first class (kiln burnt) 20cm × 10cm × 10cm or traditional 9″ × 4½″ × 3″ (nominal) ...	% Nos.	490·00	450.00
2.	Bricks first class (kiln burnt) 10″ × 5″ × 3″ (nominal)	% Nos.	520·00	460·00
3.	Bricks 2nd class (kiln burnt) 20cm × 10cm × 10cm or traditional 9″ × 4½″ × 3″ ...	%, Nos.	480·00	430·00
4.	Bricks second class (kiln burnt) 10″ × 5″ × 3″ ...	%, Nos.	510·00	450·00
5.	Over burnt or Picked jhama brick 20cm × 10cm × 10cm or traditional 9″ × 4½″ × 3″	%, Nos.	460·00	430·00
6.	Over burnt or Picked jhama bricks 10″ × 5″ × 3″ ...	%, Nos.	490·00	460·00
7.	Sand (coarse)	cu m	115·00	125·00
8.	Sand (Medium)	cu m	65·00	70·00
9.	Sand (local)	cu m	40·00	—
10.	Surki	cu m	90·00	80·00
11.	Cement	per bag	34·00	—
12.	Lime (slaked stone or white)	cu m	335·00	—
13.	Lime (unslaked stone or white)	quintal	90·00	—
14.	Stone ballast 40 mm down	cu m	160·00	—
15.	Stone chips 20 mm down	cu m	170·00	—
16.	Stone chips 12mm down	cu m	175·00	—
17.	Hard stone ballast 40 mm down (local) ...	cu m	135·00	—
18.	Over burnt brick ballast 25 mm down ...	cu m	110·00	—
19.	Brick ballast or Jhama chips 40 mm down ...	cu m	100·00	80·00
20.	Marble chips (grit Daradun)... ...	qu	45·00	—
21.	M. S. bar upto 16 mm diameter ...	quintal	500·00	—
22.	M. S. bar upto 32 mm diameter ...	quintal	490·00	—
23.	Black iron wire	kg.	6·50	—
24.	H. B. wire netting	sq m	20·00	—
25.	Water-proofing compound	kg.	5·75	—
26.	Gum	kg.	15·00	—
27.	Distemper primer	Litre	24·00	—
28.	Tropic distempering	kg.	10·00	—
29.	Raniganj Pattern Tiles	% Nos.	105·00	—
(b)	**Labour** (8 hours working period in day time)	Each per day		**Note :**— *For a short period work increase the rate @Rs.2·00 for each kind of labourer.*
1.	Head Mason	,, ,,	18·00	
2.	Mason (ordinary)	,, ,,	16·00	
3.	Mazdoor (Beldar)	,, ,,	10·00	
4.	,, (Female)	,, ,,	10·00	
5.	Carpenter	,, ,,	18·00	
6.	Black-smith and Fitter	,, ,,	18·00	
7.	Painter	,, ,,	15·00	

Volume of cement :— 1 cu cm of ordinary portland cement = 1·44 grams

∴ 1 cu m ,, ,, ,, ,, = 1440 kg

Weight of 1 bag of cement = 50 kg ∴ Vol. of 1 bag of cement = $\frac{50}{1400}$ = 0·0347 cum

11-7. Analysis of Rates for Manufacturing materials :—

1 Manufacturing common Burnt Clay Bricks in kilns. Unit = 1000 nos.

It is not economical to burn less than 6 to 7 lakhs of bricks in a single kiln. The quantity of coal required for burning is very variable depending upon the sub-soil water level, nature of soil and climatic condition. To burn one lakh bricks (19cm × 19cm × 9cm) where water level is low 14 tonnes of coal may be considered fair, but where the sub-soil water level is high the quantity of coal may be as high as 24 tonnes. Considering such variations about 20 tonnes of coal may be considered to burn one lakh bricks in Bull type kiln.

Particulars	Quantity	Rate Rs. P.	Amount Rs P.
(a) **Materials :—**			
Steam coal and coal dust ...	0·2 Tonne	360·00 per Tonne	72·00
Fuel wood for first fuelling ...	0·5 kg	0·80 per kg	0·40
Sand (local) for moulding ...	0·11 cum	50·00 per cum	5 50
Pugmill charge	Lump Sum	20 00 L S.	20·00
Cost of land or Royalty ...	Lump Sum	18·00 L.S.	18·00
Moulding boxes, chimney & kiln charge	Lump Sum	12 00 L.S.	12·00
Sundries, T. & P. etc. ...	Lump Sum	6 00 L.S.	6 00
(b) **Labour** :—Head Mason (Mistry)	$\frac{1}{10}$ no.	18·00 Each per	1 80
Mazdoor for Moulders ...	5 nos.	16·00 ,, day	80 00
,, ,, loading in kiln	3 nos.	10·00 ,, ,,	30·00
,, ,, unloading & stacking	$2\frac{1}{2}$ nos.	10·00 ,, ,,	25·00
Fireman	$\frac{1}{2}$ no.	18·00 ,, ,,	9·00
Mazdoor (as waterman i.e. Bhishti)...	$\frac{1}{2}$ no	10·00 ,, ,,	5·00
		Total =	284·70
(c) **Water charge :—**	@ 1% of the	total ... =	2·85
		Total =	287·55
(d) **Profit and Overhead** ...	@ 10% ...	... =	28·75
		Grand total =	316·30

∴ Rate per 1000 nos. = Rs. 316·30 and this consists the following categories of bricks. *for ideal burning* :—1st class...60%, 2nd class... 15%, 3rd class...10%, Overburnt...10%, and breakage...5%

2. Manufacturing and Burning Kankar Lime. Unit=1 cu m

1·1 cu m of Kankar shall be taken to produce 1 cu m of lime (Note : 1 cu m of unslaked lime=580 to 600 kg.)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** :—Kankar	1·1 cu m	60·00	66 00
Carcoal	150 kg	1·00	150·00
Fuel wood for first burning	25 kg	0 80 per kg	20·00
(b) **Labour** :—Head Man ...	$\frac{1}{10}$	18·00	1·80
Mazdoor (Beldar) ...	3·5 nos	10·00	35·00
Mazdoor (Female) ...	1·5 nos	10·00	15·00
Grinding of burnt kankar ...	L.S.	1·50 L.S.	1·50
Cost of land or Royalty ...	L.S.	2·00 L.S.	2·00
Kiln etc. ...	L.S.	1·00 L.S.	1·00
Contingencies, T. & P. Insu. etc.	L.S.	1·00 L.S.	1·00
		Total=	293·30
(c) **Water Charge** :—	@ 1% of the	total =	2·93
		Total=	296 23
(d) **Profit and Overheads**— ...	@ 10% ...	... =	29·62

∴ Rate per cu m = Rs. 325·85. Grand Total=325·85

3. Production of Brick Ballast (i.e. jhama metal) from Overburnt bricks to 40 mm. gauge. Unit=1 cu m.

For convention of brick materials from one to another 380 nos. of Matric Bricks of 20 cm × 10 cm × 10 cm (nominal) or traditional bricks 22·9 cm × 11·4 cm × 7·6cm (nominal) and in case of traditional bricks 25·4 cm × 12·7 cm × 7·6 cm (nominal) 314 nos. shall be taken as equivalent to 1 cu m of bats. 1·1 cu m of bats shall be taken to produce 1 cu m of brick ballast.

1·1 cu m of bats shall be taken to produce 1 cu m of brick ballast.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** :—Overburnt brick bats	1·10 cu m	70 00 per cu m	77·00
(b) **Labour** :—Mazdoors	$1\frac{1}{3}$ nos	10·00 Each perday	13·33
Contingencies, T. & P. etc. ...	L.S. @$\frac{1}{2}$% a+b)	0·45	0·45
		Total=	90·78
(c) **Profit and Overhead** ...	@10% of the	total =	9·08

∴ **Rate per cu m=Rs 99 86** Grand Total=99·86

4. Production of Brick Ballast from overburnt bricks to 25 mm gauge. Unit=1 cu m

The number of Mazdoor shall be $1\frac{3}{4}$ nos. in the labour column (b) of item no 3. All other particulars are same as in item no. 3.

10-8 Analysis of Rate for Earth work :—

5. Earthwork in excavation in trenches for foundations and for pipes, cables etc. not exceeding 1·5m in width including dressing of sides and ramming of bottoms, lift upto 1·5m and lead upto 50m (a) *in ordinary soil (i.e. loose or soft)*

Consider first 10 cu m Unit=1 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Labour**—Mazdoor (Beldar) ...	$1\frac{3}{4}$	10·00	17·50
Female Mazdoor ...	$1\frac{1}{2}$	10·00	15·00
		Total=	32·50
(b) **Water charges**	@ 1% of the	total	0·32
		Total=	32·82
(c) **Profit and Overhead** ...	@ 10%	=	3·28

∴ **Rate per cu m Rs.=3·61** Grand Total=Rs. 36·10

(*b*) *For Dense or Hard soil, Mazdoor (Male)=$2\frac{3}{4}$ nos. & Mazdoor (Female)=2 nos.*

(*c*) *For Mud, Mazdoor (Male)=$3\frac{1}{3}$ nos. & Mazdoor (Female)=$2\frac{3}{4}$ nos. Other particulars are same as sl. 5*

For additional Lead and Lift.—For evey additional lead of 30m beyond the initial lead add $\frac{1}{2}$ Mazdoor. For every additional lift of 1·5m beyond the initial lift add $\frac{1}{2}$ Mazdoor.

For shoring—If the work requires shoring but not pumping add an amount 25% of the total labour charge from (a).

6. Excavation in trenches for foundations and for pipes, cables, etc. not exceeding 1·5m, in width and for shafts, walls etc. not exceeding 10m² on plan including dressing of sides upto 1 5m and lead upto 50m for disintegrated or soft rock (not requiring blasting)

Consider first 10 cu m. Unit=1 cu m

Particulars	Quantity	Rate		Amount
(a) **Labour** :—Excavator ...	$1\frac{3}{4}$ nos.	12·00	Each per day	21·00
Breaker ...	$3\frac{1}{2}$ nos.	12·00	,,	42·00
Hole driller ...	1 no.	12·00	,,	12·00
Mazdoor (Male) ...	3 nos.	10·00	,,	30 00
Mazdoor (Female) ...	$4\frac{1}{2}$ nos.	10 00	,,	45·00
(b) **Materials** :—Fuse ...	3 nos.	3·00	Each	9·00
Powder ...	$2\frac{1}{4}$ kg	10·00	per kg	22·50
Contingencies, T. & P. etc....	L.S $\frac{1}{2}$% (a+b)	9·00	L. S.	9·00
			Total=	190 50
(c) **Water charges**—	@ 1%		=	1·90
			Total=	192·40
(d) **Profit and Overhead**—	@ 10%		=	19·24

∴ **Rate per cu m=Rs. 21·16** Grand Total= 211·64

When the excavation for item no. 6 shall be in Hard rock requiring blasting :—
Labour for Excavators, Breakers and Hole drillers shall be considered as twice for Decomposed rock (as in sl.6.). Mazdoor (Male) and Mazdoor (Female) shall be same as item no.6. Fuse shall be 7 nos. and powder shall be 6·5 kg.

7. Filling available excavated earth in trenches, plinth sides of foundations in layers not exceeding 20 cm in depth consolidating layer by layer ramming and watering, lead upto 50m and lift upto 1·50m.

Consider first 10 cu m Unit = 1 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Labour** :—Mazdoor (includes Bhishti)	1 no. ...	10 00 Each perday	10.00
Mazdoor (Female)	$\frac{1}{3}$ no.	10·00 „ „	13·33
		Total =	23·33
(b) **Water charge** :—	@ 1%	=	·23
		=	23·56
(c) **Profit including overhead** —	@ 10%	... =	2·36

∴ Rate per cu m = Rs. 2·59 Grand Total = Rs. 25·92

8. Filling in plinth with local sand under floors including ramming, consolidating and dressing complete.

Consider first 10 cu m Unit = 1 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** :—Fine sand (Local) ...	10 cu m	40·00 per cu m	400·00
(b **Labour** —Head Mason ...	$\frac{1}{12}$ „	18·00 Each perday	1·50
Mazdoor (includes $\frac{1}{3}$rd as Bhishti) ...	2 nos.	10 00 „ „	20·00
		Total =	401·50
(c) **Water charge** — ...	@1%	=	4·01
		Total =	405·51
(d) **Profit including Overhead** — ...	@ 10%	=	40·65

∴ Rate per cu m = Rs. 44·62 Grand Total = 446·16

9. One layer brick flat soling joints filled with local sand or powdered earth.

Consider first 10 sq m Unit = 1 sq m

Calculation of materials :—Metric brick allowing to occupy a space of 10 cm × 20cm by each matric brick, number of bricks per 10 sq m = $\frac{10 \text{ sq m}}{10\text{cm} \times 20\text{cm}}$ = 500 nos. But due to irregular shape of overburnt bricks and also as greater space between bricks practically remains, less 15% = $500 - 500 \times \frac{15}{100}$ = 425 nos. (as adopted by All India Standard schedule of rates)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Brick metric, (for 22·9 × 12·7 × 10cm = 320 nos).	425 nos	460·00 per %. nos.	195·50
(b) **Labour**—Mazdoor	$\frac{4}{5}$ nos	10 00 Each per day	8·00
Contingencies ; T. & P. etc.	L.S. $\frac{1}{2}$%(a+b)	1·00	1·00
		Total =	204·50
(c) **Water charges**—	@1% ...	=	2·04
		Total =	206·54
(d) **Profit and overhead**—	@10% of the	total =	20·65

∴ Rate per sqm = Rs. 22·72 Grand Total = Rs. 227·19

11-9. Analysis of Rate for Concrete Works :

10. Lime concrete in foundation with 25mm down brick ballast (or Jhama chips) with 1 lime and 2 Surki mortar. Prof. 1 : 2 : 5½ (18 : 36 : 100).

Consider first 10 cu m Unit = 1 cu m

Calculation of Materials :—Summation of proportion $=1+2+5.5=8.5$. Following the procedure as described in the article 11-5. Sl. 32

Lime $=\frac{15.5}{8.5}=1.8$ cu m, Surki $=1.8\times2=3.6$ cum ; Brick ballast $=1.8\times5.50=9.9$ say 10cum

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Brick ballast (or Jhama chips)	10 cu m	110·00 per cu m	1100·00
Surki	3·6 cu m	90·00 ,, ,,	324 00
Stone lime (slaked) ...	1·8 cu m	335·00 ,, ,,	603·00
(b) **Labour**—Head Mason ...	½ no.	18 00 Each per day	9·00
Mason ...	1 no.	16·00 ,, ,, ,,	16 00
Mazdoor (Beldar) ...	20 nos.	10·00 ,, ,, ,,	200 00
(2 Mazdoors as Bhishti)			
Contingencies, T. & P. etc.	L.S. ½%(a+b)	11·00 L. S.	11·00
		Total =	2263·00
(c) **Water charge...** ...	@ 1 %	=	22·63
		Total =	2285 63
(d) **Profit including overhead...**	@ 10%	=	228·56

∴ **Rate per cu m = Rs. 251 42** Grand Total = Rs. 2514·19

11. Lime concreté in foundation with 40mm down stone ballast, lime and sand prof. 1:2 4

Unit = 1 cu m

Consider first 10 cu m

Calculation of Materials:—Summation of proportion = 7. Following the article 11-5. Sl. 32

Lime $=\frac{15.4}{7}=2.2$ cu m, sand $=2.2\times2=4.4$ cu m ; stone ballast $=2.2\times4=8.8$ cu m.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Stone ballast (local)	8·8 cu m	160 00 per cu m	1408·00
Sand (local) ...	4 4 cu m	50 00 ,, ,,	220·00
Stone lime (slaked) ...	2·2 cu m	335·00 ,, ,,	737 00
(b) **Labour**—	same as in (10)	...	225·00
Contingencies, T. & P. etc. ...	L S ½%(a+b)	13 00 L.S.	13·00
		Total =	2603 00
(c) **Water charges**— ...	@ 1%	=	26·03
		Total =	2629 03
(d) **Profit**— ...	@ 10%	=	262·90

∴ **Rate per cu m = Rs. 289·19** **Grand Total = Rs. 2891·93**

12. Cement concrete 1 : 5 : 10 with graded brick ballast (jhama chips) 450mm down in foundation. *Consider first 10 cu m.* 1 Unit = cu m

Calculation of Materials—Same as described in the article 11-5. Sl. 32

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
Brick ballast (or Jhama chips)	9·8 cu m	100·00 per cu m	980·00
Sand (medium) ...	4·9 cu m	115 00 per cu m	563·50
Cement ...	0·98 cu m =29·4 bags	34·00 per bag.	999·60
(b) Labour—Head Mason ...	¼ no.	18·00 Each per day	4·25
Mason ...	2 nos	16·00 „ „	32 00
Mazdoor (male 2 nos as Bhishti) ...	12 nos	10·00 „ „	120·00
Mazdoor (Female)...	8 nos.	10·00 „ „	80·00
Contingecies, T. & P. etc. ...	L.S.½%(a+b)	14·00 L. S.	14 00
		Total =	2793·35
(c) Water charges	@1% of	the total =	27·93
		Total =	2821·28
(d) Profit and Overhead	@10%	=	282·13

∴ **Rate per cu m=Rs. 310 34** Grand Total=3103·41

13. Cement concrete 1 : 4 : 8 with granded stone chips 40mm down in foundation

Consider first 10 cum

Calculation of Materials—Same as described in the article 11-5. Sl. 32.

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—Stone (ballast) ...	9·6 cu m	160 00 per cu m	1536·00
Sand (coarse) ...	4·8 cu m	115 00 per cu m	552·50
Cement ...	1·2 cu m =36 bag	34·00 per bags	1224·00
(b) Labour—	Same as in	item no. (12)=	236·25
Contingencies, T. & P., risk etc. ...	L.S. @ ½% (a+b)	17·70	17·70
		Total =	3565·95
(c) Water charges—	@1% of	the total =	35·65
		Total =	3601·60
(d) Profit and Overhead	@10%	=	360·16

Grand Total=3961·76

Rate per cu m=Rs. 396·18

For proportion 1:3:6 the above labour strength is to be considered. But for 1:2:4 or 1:1½:3 propriton quantity of materials as in page 432 and increase the strength of Mason by ¼ no. and Mazdoor by 2 nos. for greater care of mixing and compaction of concrete work in foundation.

14. Cement concrete 1 : 2 : 4 with graded stone chips from 20mm down to 6mm for R. C. works excluding shattering and reinforcement Unit=1 cu m

Consider first 10 cu m

Calculation of Materials—Same as in the article 11-5. Sl. 32 *Labour Gang*—(b)

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Stone chips	8·8 cu m	170.00 per cu m	1496 00
Sand (coarse)	4 4 cu m	115 00 per cu m	506·00
Cement ...	2·2 cu m =66 bags	34·00 per bag	2244·00
(b) **Labour**—Head Mason ...	½ no.	18·00 Each perday	9·00
Mason ...	3 nos.	16·00 ,, ,,	48·00
Mazdoor (includes 4 Bhishti)...	16 nos.	10 00 ,, ,,	160·00
Mazdoor (Female) ...	7 nos.	10 00 ,, ,,	70·00
Contingencies T. P. etc. ...	L.S. ½%(a+b)	23 00 L.S.	23·00
		Total=	4577·00
(c) **Water charges** ...	@1% of	the total =	45·77
		Total=	4622·77
(d) **Profit and Overhead** ...	@ 10%	=	462·22

∴ **Rate per cum=Rs. 508·50** Grand total=5084 99

Note:—For each additional storey the strength of Mazdoor (Beldar) should be increased by 6 nos. for volume of 10 cum to lift the materials. All India Standard Schedule of Rates provides an increase of rate by 1% per floor per cu m for lifting the materials assuming each floor to be average of 3m height.

15. Cement concrete work (prop. 1:2:4) pouring into moulds complete. Unit=1 cu m

Consider first 10 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Stone chips ...	8·8 cu m	170·00 per cu m	1496·00
Sand (coarse) ...	4·4 cu m	115·00 per cu m	506 00
Cement ...	2·2 cu m =66 bags	34·00 per bag	2244·00
(b) **Labour**— (For pouring concrete in thin section as provided by All India Standard Schedule of Rates)			
Mason I class ...	5 nos.	18·00 Each per day	90·00
Mason II class ...	5 nos.	16·00 ,, ,,	80·00
Mazdoor (Female) ...	10 nos.	10·00 ,, ,,	100·00
Contingencies, T. & P., risk etc. ...	L.S. ½%(a+b)	22·50 L. S.	22·50
		Total=	4538·50
(c) **Water charges** ...	@1% of the	total ... =	45·38
		Total=	4583·88
(d) **Profit and Overhead** ...	@10% ...	=	458·39

∴ **Rate cu m=Rs. 504·23** **Grand Total 5042·27**

Note :—The above analysis of cost does not include labour for mixing of concrete.

17. Supplying, fitting, fixing and removing shuttering and staging. Unit=1sq m

Consider a room=5m × 4m with an intermediate T-beam 25 cm deep × 20 cm wide web Height of the room=3 5m (Fig. 11-1). Area of shuttering—(a) For beam=(20cm + 2 × 25cm) × 4m=2·8 sq m. (b) For slab=5m × 4m – (20cm × 4m)=19·2 sq.m. ∴ Total area=22 sq m.

Particulars	No.	L.	B. cm	Thickness cm	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—							
(i) *For beam*—							
Side planks ...	2	4m	25	2·5	0·050cu m		
Side cleats @ 1m c/c	2×4	30cm	8	4	0·008 ,,		
Bottom Plank ..	1	4m	25	5	0·050 ,,		
Base beam (at prop only) ...	4	50cm	10	5	0·010 ,,		
Brackets (2 nos. at prop.) ...	2×4	50cm	5	4	0·008 ,,		
(ii) *For slab*—							
Planks=(5m—20cm —2×2·5 cm)	1	4·75m	4	2·5	0·475 ,,		
Beam @ 1mc/c=½×4 75	2×4	2·375m	5	15	0·143 ,,		
(iii) *For beam and slab*—							
(a) Short side ...	7	4m	10	4	0·112 ,,		
(b) Long side ...	4	5m	10	4	0·080 ,,		
Wedges under props ...	28	22cm	10	8	0·049 ,,		
Bearing planks under wedges ...	28	50cm	22	5	0·154 ..		
				Total	=1·139,,	1500·00 cu m	1708·50
10 cm av. dia. Ballie props @ 1m c/c (Ht. of props under beam=3 33m but taken as 3·45m to have a grip of 7·5cm with beams. ...	28	3·45m	—	—	96·60r.m.	4·00r.m.	386·40
						Total =	Rs.2094·90
Deduct the cost of scrap value of timber @ 8% ...					—	—	167·59
						Total =	1927·59
Assuming that this set of shuttering and staging becomes unserviceable after being used for 12 times (time of use is governed by the availability of work, cutting the frame work to suit different dimensions, damage for nailing etc.) cost for using once. ...					—	—	160·61
(b) **Labour**—Head Mason ...					½ no.	18·00 Ea.	9·61
Carpenter ...					3 nos.	18 00 ,,	54·00
Mazdoor (Beldar) ...					6 nos.	10 00 ,,	60·00
Carriage within a town ...					2 times	22 00 ,,	44·00
Nails ...					L.S.	20·00L.S	20·00
Contingencies, T. & P. etc. ...					L.S.	1·70 L.S.	1 70
						Total=	349 92
(c) **Profit and overhead** @ 10%						=	34·99
						Grand Total=Rs.	384·91

$$\therefore \text{ Rate per sq. m.} = \frac{384 \cdot 91}{22} = \text{Rs. } 17 \cdot 50$$

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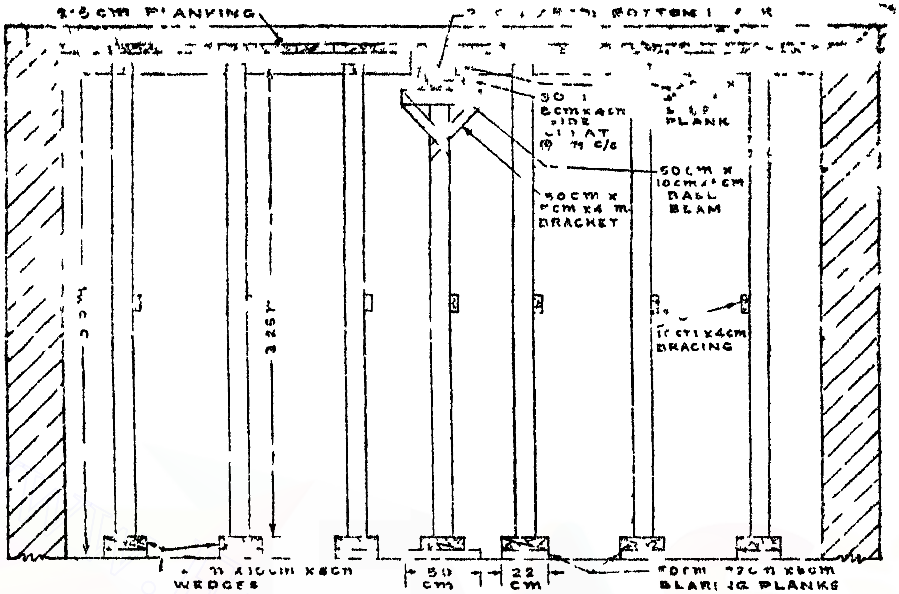
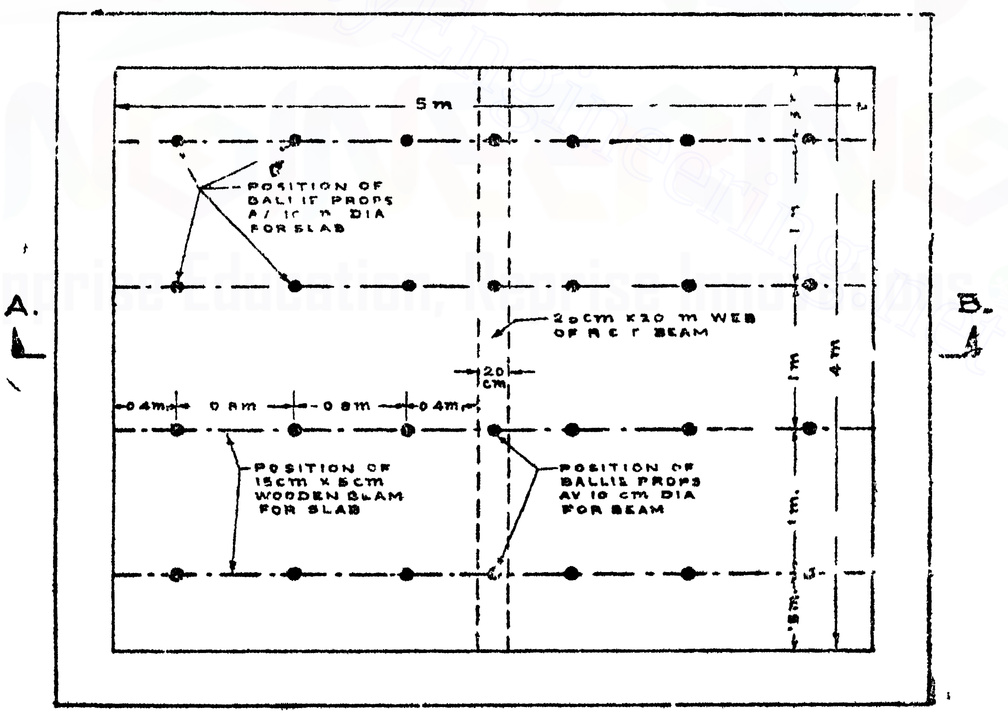


SECTION ON A-B.



PLAN OF SHUTTERING

FIG. 11·1

18. Providing mild steel reinforcement for R. C. C. work including bending, binding and placing in position complete upto two floor level. **Unit = 1 quintal.**

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—M.S. reinforcement ...	1 Quintal		
Wastage 5% ...	0·05 qu.	500·00 per quintal	525·00
	1·05 qu		
Black iron wire ...	1 kg	6·50 per kg	6·50
(b) **Labour**—Mason cum black smith ...	1 no.	18·00 Each per day	18·00
Mazdoor (Beldar) ...	1 no.	10·00 Each per day	10·00
Contingencies, T. & P. etc ...	L. S. ½% (a+b).	2 80 L. S.	2·80
		Total =	562·30
(c) **Water charges** ...	@ 10% of	the total =	5·62
		Total =	567·92
(d) **Profit and Overhead** ...	@ 10%	=	56·79

∴ **Rate per quintal = Rs. 624·71** Grand Total = 624·71

19. Cold twisted steel reinforcement R. C. C. work :— Same as M. S. reinforcement (as adopted by All India standard schedule of rate)

20. Supplying. bending placing in position and binding M. S. reinforcement consisting of 10 mm dia rods (0·62 kg/rm) at 10 cm centres and 6 mm dia. rods (0·22 kg/rm) at 20cm centres for the roof slabs L C. E. Nov. 61 converted in metric system).

Consider first a section 10m × 10m of a continuous slab.

$$10\text{mm dia. rods} = \frac{10\times10}{0\cdot10} = 1000 \text{ m}$$

Since alternate bars of continuous slabs are carried into the next span to a point ¼th. span away from the support from each side, increase this amount by 25% and 5% for hooking, bending etc. ∴ Total length $= 1000 + 1000\times\frac{30}{100} = 1300$m. Weight of 100 m @ 0·62kg/rm =806 kg. 6 mm dia. rods$=\frac{10\times10}{0\cdot.0}=$500m. Increase this amount by 5% for hooking, bending etc. $= 500 + 500 \times \frac{5}{100} = 525$m. Weight of 525m. @ 0·22 kg./rm = 115·5 kg.

∴ Total M.S. work in the slab = 805 + 115·5 = 922 kg. (say) = 9·22 quintals. Black iron wire @ 0·75 kg. per 10sq m = 7·5 kg.

Labour—Mason-cum blacksmith @ 1 no. per quintal = 9 nos. Mazdoor @ 1 no. per quintal = 9nos. *Analysis* :—

Particulars	Quantity	Rate	Amount
(a) **Materials**—M.S. reinforcement ...	9·22 qu		
	0·46		
Wastage @ 5% ...	9·68 qu	500 per qu	4840 00
Black iron wire (18 G) ...	7·5 kg	6·50 per kg	48·75
(b) **Labour**—Mason-cum blacksmith ...	9 nos.	18·00 Each per day	162·00
Mazdoor (Beldar) ...	9 nos.	10·00 ,,	90·00
Sundries, T. & P. ...	L. S.½%(a+b)	25·00	25·00
		Total =	5165·75
(c) **Water charge** ...	@ 1% of the	total =	51·65
		Total =	5217·41
(d) **Profit and Overhead**—	@10%		521·15

∴ **Rate per sq. m. = Rs. 57 39** Grand Total 5739·15

Note:—R.C.C. work are paid separately for (a) cement concrete work, (b) for work and for (c) shuttering and staging as per practice of C.P.W.D. and also the procedure as adopted by All India standard Schedule of rates.

21. Reinforced Brickwork in slab with cement mortar (1 : 3). Unit=1 cu m.

Consider first 10 cu m. Mortar required per 10 cu m=4·8 cu m.

Cement=4·8÷4=1·2cu m, sand=1·2×3=3·6cu m

Particulars	Quantity.	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
1st. class bricks @ 450 nos. per cu m...	4500 nos	490·00 per % nos.	2205·00
Cement ...	1·2 cu m =36 bags.	34·00 per bag	1224·00
Sand (coarse) ...	3·6 cu m	115·00 per cu m	414·00
M.S. bar @ 0·8%=0·8×$\frac{10}{100}$ =0·08cu m			
@ 78·5 quintal per cu m (as wt. of 1 cu m of M. S. bar=78·5 qu) ...	6·28 qu.	500 00 per qu.	3140·00
(b) **Labour—**			
Head Mason ...	½ no.	18·00 Each per day	9 00
Mason ...	10 nos.	16·00 ,, ,,	160·00
Mazdoor (4 nos as Bhishti) ...	14 nos.	10·00 ,, ,,	140·00
Mazdoor (female) ...	7 nos.	10·00 ,, ,,	70·00
(c) **M. S. work**—Bending, binding etc.			
Black smith ...	5 nos.	18·00 ,, ,,	90·00
Mazdoor ...	6 nos.	10·00 ,, ,,	60 00
(d) **Centering and Shuttering—**			
Hirecharge of timber planks and bollies=½ labour charge for M. S. work ...	½(90+60)	75·00 L.S.	75·00
Carpenter ...	7 nos.	18·00 Each per day	126·00
Mazdoor ..	8 nos.	10·00 ,, ,,	80·00
Nails ...	L. S.	15·00 L.S.	15·00
Contingencies T. & P. etc. L.S.	@½%(a+b)	39 00	39·00
		Total=	7847·00
(e) **Water charges—** ...	@1%of the	total =	78·47
		Total=	7925·47
(f) **Profit including Overhead** ...	@ 10%	=	792·55

∴ **Rate per cu m Rs.**=871·80 Grand Total=8718·02

22. R.B. work in roof slab when the unit is per sq m. Unit=1 sq m consider first 10 sq m

For (i) One brick thick 10cm slab :— Materials and labour = 1/10th of item no. 20.

(ii) Two brick thick 20cm slab :— Materials and labour=⅕th. of item no 20.

23. R.B. work in roof slab with cement mortar for any other proportion to that of item no. 20, find out quantity of cement and sand dividing 4·8 cu m of mortar by the summation of proportion. Others are same as in item no. 20.

24. 2·5 cm thick cement concrete 1 : 2 : 4 Damp proof Course. **Unit=1 sq m.**

Consider first 100 sq m

Calculation of Materials—Vol. of concrete$=0·025\times100=2·5$ cu m. Summation of prof. $=7$. Following the same principle as in the article 10-5 ; cement$=\frac{15·4}{10}\times\frac{2·5}{7}=0·55$cu m $=16\frac{1}{2}$ bags ; sand$=0·55\times2=1·10$ cu m ; stone chips$=0·55\times4=2·20$ cu m.

Water-proofing compound$=3\%$ by the weight of cement$=\frac{3}{100}\times(16·5\times50)=25$ kg (say)

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a)	**Materials**—Stone chips ...	2·20 cu m	175·00 per cu m	385·00
	Sand (coarse) ...	1·10 cu m	115·00 per cu m	126·50
	Cement ...	$16\frac{1}{2}$ bags	34·00 per bag	561·00
	Water proofing compound ...	25 kg	5·75 per kg	143·75
(b)	**Labour**—Head Mason (Mistri)	$\frac{1}{2}$ no.	18·00 Each per day	9·00
	Mason	8 nos.	16·00 ,, ,,	128·00
	Mazdoor(including 1 no. as Bhishti) ...	9 nos.	10·00 ,, ,,	90·00
	Form work ..	Lump sum	12·00 L.S.	12·00
	Contingencies, T. & P. etc ...	L.S.$\frac{1}{2}\%$(a+b)	7·25 L. S.	7·25
			Total=	1462·50
(c)	**Water charges**	@ 1% of the	total =	14·62
			Total=	1477·12
(d)	**Profit and Overhead** ..	@ 10%	=	147·71

∴ **Rate per sq m=Rs. 16·24** Grand Total=1624·83

25. 20 mm thick Damp-proof course with cement mortar (1 : 2) **Unit=1 sq m**

Consider first 100 sq m

Calculation of Materials—Vol. of wet mortar $=0·02\times100=2$ cu m ; Vol. dry mortar $=2+2\times\frac{1}{3}=2·7$ cu m. For 1:2 prof. Vol of cement$=\frac{2·7}{3}=0·9$ cu m$=27$ bages. Sand$=0·9\times2=1·8$ cu m. Water proofing compound @ 2% by wt. of cement$=(2·7\times50)\times\frac{2}{100}=27$kg.

		Quantity	Rate	Amount
(a)	**Materials**—Cement ...	27 bags	34·00 per bag	918·00
	Sand (coarse) ...	1·80 cu m	115·00 per cum	207·00
	Water proofing compound ...	27 kg	5·75 per kg	155·25
(b)	**Labour**—Head Mason (Mistri)	$\frac{1}{2}$nos	18·00 Each per day	9·00
	Mason ...	5 nos.	16·00 ,, ,, ,,	80·00
	Mazdoor (1 no. as Bhishti including curing)	6 nos.	10·00 ,, ,, ,,	60·00
	Form work ...	Lump sum	10·00 L. S.	10·00
	Contingencies, T.&P. etc....	L.S.@$\frac{1}{2}\%$ (a+b)	7·20	7·20
			Total=	1446·45
(c)	**Water charges**—	@ 1% of the	total =	14·46
			Total=	1460·91
(d)	**Profit including Overhead**— ..	@ 10%	=	146·09

Grand Total=1606·90

∴ **Rate per sq m 16·07**

11·10. Analysis of Rates for Brickwork :

Calculation of materials per 10 cu m volume of brickwork :—

Number of metric brick having size with mortar 10cm × 10cm × 20cm

$$=\frac{10}{0\cdot1\times0\cdot1\times0\cdot2}=5{,}000 \text{ nos.}$$

The size of one metric brick without mortar is 9cm × 9cm × 19cm.

∴ Mortar required per 10 cu m = 10 − (5,000 × ·09 × ·09 × ·19) = 2·3 cu m. Due to frog filling, brick bonding courses and wastage etc. increase this quantity by 15% ∴ Volume of wet mortar = 2·3 + 2·3 × ·15 = 2·64 cu m. When dry increase this quantity by $\frac{1}{3}$rd = 2·64 + 2·64 × $\frac{1}{3}$ = 3·50 cu m (approximately).

In case of lime mortar the above quantity 3·50 cu m reaches upto 4·0 cu m. Such increase may be justified considering the void in surki is more, joints are generally thicker as well as less care is observed towards wastage.

With 2nd class bricks, the quantity of cement mortar of 4·0 cu m and lime mortar of 4·2cu m are required according to the shape and size of 2nd class bricks.

Number of traditional bricks having size with mortar 25·4 cm × 12·7 cm × 7·6 cm (i.e. 10″ × 5″ × 3″) $=\frac{10}{\cdot254\times\cdot127\times\cdot76}$ = 4131 nos. say 4,100 nos. (due to thicker joints). With this traditional size of bricks joints are less and therefore lesser amount of mortar should be required. But due to larger size of frog and wider area of a brick such variation may be minimised.

Number of traditional bricks having size with mortar 22·9 cm × 11·4 cm × 7·6cm (i.e. 9″ × 4$\frac{1}{4}$″ × 3″) $=\frac{10}{\cdot229\times\cdot114\times\cdot076}$ = 5041 nos. say 5,000 nos. (due to thicker joints). The number of bricks being same to that metric brick the quantity of mortar is also same.

26. First class brickwork in lime and Surki mortar (1:3) in foundation and plinth.

Consider first 10 cu m Unit = 1 cu m

Calculation of Materials :— Lime $=\frac{4\cdot0}{4}$ = 1·0 cu m, Surki = 1·0 × 3 = 3·0 cu m

Labour Gang : —(B) with adjustment.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** —Brick (kiln)			
Metric 20cm × 10cm × 10cm ...	5,000 nos	490 per %₀ nos.	2450·00
Traditional 25·4cm × 12·7cm × 7·6cm	4 100 nos.		
22·9cm × 11·4cm × 7·6cm	5,000 nos		
Surki	3·00cu m	90·00 per cu m.	270·00
Lime	1·00 cu m	335 00 per cu m.	335·00
(b) **Labour**—Head Mason ...	$\frac{1}{2}$ no.	18·00 each per day	9 00
Mason ...	8 nos	16·00 ,, ,,	128·00
Mazdoor (2nos as Bhishti) ...	10 nos.	10·00 ,, ,,	100·00
Mazdoor (Female) ...	6 nos .	10·00 ,, ,,	60·00
Contingencies, T. & P., risk etc ...	L.S. $\frac{1}{2}$%(a+b)	16·75	16·75
		Total =	3368·75
(c) **Water charges**	@ 1% of	of the total =	33·69
		Total =	34002·44
(d) **Profit and Overhead** ...	@ 10%	=	340·24

Rate per cum = Rs. 374·26 Grand total = 3742·6

27. First class brickwork in cement mortar (1:4) in superstructure ground floor.

Consider first 10 cu m. 1 Unit= cu m

Calculation of Materials—Cement $\frac{3\cdot5}{5}$=·70 cu m ; Sand=·70×4=2·8 cu m.

Labour Gang—(B) with adjustment

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
Bricks (kiln) 20cm×10cm×10cm	5·000 nos.	490·00 per‰ nos.	2450·00
Sand (medium)	2·8 cu m	65·00 per cu m.	182·00
Cement 0·70 cu m=21 bags	21 bags	34·00 per bag	714 00
Scaffolding ...	L.S.	10·00	10 00
(b) **Labour—**			
Head Mason ...	½ no.	18·00 each per day	9·00
Mason ...	8 nos.	16·00 ,, ,,	128·00
Mazdoor (2nos. as Bhishti)	10 nos.	10·00 ,, ,,	100·00
Mazdoor (Female)	7 nos.	10 00 ,, ,,	70·00
Contingencies, T. & P. etc.	L.S.½%(a+b)	18·00 L.S.	18 00
		Total=	3681·00
(c) **Water charges—**	@ 1%	of the total	36·81
		Total=	3717·81
(d) **Profit and Overhead**	@10%		371·78

∴ **Rate per cu m=Rs.** 408·96 Grand Total=4089·59

Brickwork for additional storey, labour cost of 1 Mason, 3 Mazdoors (Beldars), and a lump sum amount Rs. 18·00 for scaffolding per 10 cu m volume of work are to be added over the ground floor as illustrated below. According to All India standard schedule of rate an extra over rate of 1% shall is added per floor of brickwork (taking each floor to be of av. 3m ht.).

28. First class brickwork in cement mortar 1 6 in superstructure,first floor.

Consider first 10 cu m

Calculation of Materials :— Cement— $\frac{3\cdot5}{7}$ =0·5 cu m ; Sand =·5×6 =3·0 cu m.

Labour Gang—(B) with additions as stated in the above note.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
Bricks (kiln) 20cm×10cm×10cm...	5,000 nos.	490 00 per‰nos.	2450·00
(For 25·4cm×12·7cm×7·6cm) ...	4,1000 nos.		
(For 22 90cm×11·4cm×7·6cm ...	5,000 nos.		
Sand (medium)	3 cu m	65·00 per cu m	195·00
Cement=0·5 cu m=15 bags ...	15 bags	34·00 per bag	510·00
Scaffolding	L. S.	18·00 L.S.	18·00
(b) **Labour—**			
Head Mason	½ no.	18·00 each per day	9·00
Mason	9 nos,	16·00 ,, ,,	135·00
Mazdoor (2 nos. as Bhishti) ...	13 nos.	10·00 ,, ,,	130 00
Mazdoor (Female) ...	7 nos.	10 00 ,, ,,	70·00
Contingencies, T. & P. etc. ...	L.S ½%(a+b)	18·00 L. S.	18·00
		Total=	3535·00
(c) **Water charges—**	@1% of	the total =	35·35
		Total=	3570·35
(d) **Profit and Overhead—**	@10%	=	357·04

∴ **Rate per cu m=Rs. 392·74** Grand Total=3927 39

29. First class brickwork in plain arches in superstructure span not exceeding 6m in cement mortar 1 : 4 including centering and shuttering complete. Unit = 1 cu m

Consider first 10 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
First class bricks (Metric) ...	5000 nos.	490 00 per ‰ nos.	2450·00
Sand (medium) ...	2·80 cu m	65·00 per cu m	182·00
Cement 0·70 cu m = 21 bags ...	21 bags	34 00 per bag	714·00
Centering and shuttering— Considering a semicircular arch 3 6m clear span 3·0m long and 0·40m thick— area of centering $= \pi rL = 3{\cdot}142 \times 1{\cdot}8 \times 3{\cdot}0 = 16{\cdot}97$ sq m. Brickwork in arch $= \pi \times r_m \times t \times L = 3{\cdot}142 \times 2 \times {\cdot}4 \times 3{\cdot}0 = 7{\cdot}54$ cu m. Area per 10 cu m $= \frac{16{\cdot}97}{7{\cdot}54} \times 10 = 22{\cdot}5$ sqm	22·5 sq m	17·00 per sq m	382·50
Scaffolding ...	Lump sum	12·00 L.S.	12 00
(b) Labour—			
Head Mason (Mistri) ...	1 no	18 00 each per day	18·00
Mason ...	10 nos	16·00 „ „	160·00
Mazdoor (2 nos. as Bhishti) ...	22 nos	10·00 „ „	220·00
Contingencies, T. & P. etc ...	L.S. ½%(a+b)	20·50 L.S.	20·50
		Total =	4159·00
(c) Water Charges—	@1% of the	Total =	41·59
		Total =	4200·59
(d) Profit and Overheads—	@10%	=	420 60
		Grand Total =	4621·19

∴ **Rate per cu m = Rs. 462·12**

Note : Extra rate for brickwork (1: 4) = difference of item no. 28 and item no. 26
= Rs. 462·12—Rs. 408·91 = Rs. 53·21 per cu m

Extra labour rate for brickwork only = Difference of labour charges of item nos. 28 and 26
= Rs. 398—Rs. 307 = Rs. 91 per 10 cu m
= Rs. 9·10 per cu m for span upto 6m.

Payment for centering and shuttering may be paid separately and extra labour for brickwork for different spans may be paid at the same time.

According to IS-1200 the brickwork rate for arches of span not exceeding 6m hire and labour charges for centering and shuttering shall be included in the item and for spans exceeding 6m centering and shuttering shall be measured separately.

30. Half brick i.e. 10cm brick wall in cement mortar (1:3) with H. B. netting in every third layer (ground floor). Unit=1 sq m

Consider first 100 sq m

Calculation of Materials :—Bricks (metric)= $\frac{100}{\cdot10\times\cdot20}$=5,000 nos.

Volume of mortar 35% to the volume of work=100×·10×·35=3·5 cu m. Due to half brickwork volume of mortar becomes 10% less than 3·5 cu m.=3·5—0·35=3·15 cu m.

∴ Cement=$\frac{3\cdot15}{4}$=0·79 cu m ; Sand=0·79×3=2·37 cu m.

Wire netting for every third layer i.e., 30 cm intervals (considering a wall 10m length ×10m height)=10×$\frac{10}{\cdot30}$=334 rm ; with 10 cm wide, area of netting=334×·10=33·4 sq m

Labour Gang—(C)

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
Bricks 20cm×10cm×10cm	5,000 nos.	490·00 per %₀ nos.	2450·00
(For 25·4cm×12·7 cm×7·6 cm) ...	4,100 nos.		
(For 22·9 cm×11·4 cm×7·6 cm) ...	5,000 nos.		
Sand (medium)	2·37 cu m	65·00 per cu m	154·05
Cement	0·79 cu m =26·5 bags	34·00 per bag	901·00
Wire netting	33·4 sq m	20·00 per sq m	668·00
Scaffolding	L. S.	10 00 L. S.	10·00
(b) **Labour—**			
Head Mason	½ no.	18·00 Each per day	9·00
Mason	14 nos.	16·00 ,, ,,	224·00
Mazdoor (3 nos as Bhishti) ...	21 nos.	10·00 ,, ,,	210·00
Contingencies, T. & P. etc. ...	L.S.½% (a+b)	23 00 L S.	23·00
		Total=	4649 05
(c) **Water charges—**	@ 1% of the total	=	46·49
		Total=	4695·54
(d) **Profit and Overhead—**	@ 10%	=	469·55
		Grand Total=	5165·09

∴ **Rate per sq m=Rs. 51·65**

31. Half brickwork for each higher storey :—Labour cost of 3 Mazdoors (Beldars) is to be added to lift the materials over and above sl. 30.

32. Second class Brickwork in mud mortar in superstructure, ground floor

Consider first 10 cu m. Unit = 1 cu m

Calculation of Materials :—Bricks (metric size) = 5000 nos. Selected clay = 4·0 cu m.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
Brick 2nd class (metric)	5,000 nos	480·00 per % nos.	2400·00
Clay (selected loaming soil)	4·0 cu m	10·00 per cu m	40·00
Scaffolding	L. S.	12·00 L. S.	12·00
(b) Labour			
Head Mason ...	¼ no.	18·00 Each per day	4 50
Mason ...	8 nos	16·00 ,, ,,	128·00
Mazdoor (1 no. as Bhishti)	12 nos.	10 0 ,, ,,	120·00
Contingencies, T. & P. etc.	L.S ½% (a+b)	13·50 L. S.	13·50
		Total =	2718·00
(c) Water charges	@ 1% of the	total	27·18
		Total =	2745·18
(d) Profit and Overhead	@ 10%		274·52
∴ **Rate per cu m = Rs. 301 97**		Grand Total =	3019·70

11-10. Analysis of Rates for Stone Masonry :—

33. Random Rubble Masonry in lime mortar (1:2) in foundation and plinth. Unit = 1 cu m

Consider first 10 cu m.

Calculation of Materials :—Volume of mortar per 10 cu m = 4·4 cu m, Lime = $\frac{4 \cdot 4}{3}$ = 1·50

Sand = 1·50 × 2 = 3·0 cu m.

Labour Gang—(B) with adjustment.

Particulars	Quantity	Rate Rs P.	Amount Rs. P.
(a) Materials—			
Stone ...	11·7 cu m	25·00 per cu m	292·50
Through stone or Headers	0·8 cu m	30·00 ,, ,,	24·00
Lime (Slaked)	1·5 cu m	335·00 ,, ,,	502·50
Sand (medium)	3·0 cu m	65 ·00 ,, ,,	195·00
(b) Labour—			
Head Mason	½ no.	18·00 ,, ,,	9·00
Mason	10 nos.	16·00 ,, ,,	160·00
Mazdoor (1½ nos. as Bhishti)	19 nos.	10·00 ,, ,,	190 00
Contingencies, T. & P. etc.	L.S.½% (a+b)	6·85 L.S.	6·85
		Total =	1379 85
(c) Water charges—	@ 1% of	the total	13·80
		Total =	1393·65
(d) Profit and Overhead—	@ 10%		139·36
Rate per cu m = Rs. 154·30		Grand Total =	1543·01

The calculation of mortar for Random Rubble Stone Masonry.

Consider 10 cu m volume of work

Lime mortar of 4·4 cu m and cement mortar of 4·2 cu m per 10 cu m volume of work will be required. Dividing these quantities of mortars by the summation of proportions and multiplying the result by the respective strength of proportion, quantities of ingredients have been shown below.

Lime mortar	Lime		Sand or Surki
Proportion 1 : 2	1·5 cu m	...	3·0 cu m
„ 1 : 3	1·1 cu m	...	3·3 cu m
„ 1 : 4	0·9 cu m	...	3·6 cu m

Cement mortar	Cement	Sand
Proportion 1	1·2 cu m	2·4 cu m
„ 1	1·0 cu m	3·0 cu m
„ 1	0·8 cu m	3·2 cu m
„ 1	0·7 cu m	3·5 cu m
„ 1	0·6 cu m	3·6 cu m

Labour remains same for different proportions.

34. **Random Rubble masonry in cement mortar (1 : 6) in superstructure ground floor** :—

Consider first 10 cu m Unit=1 cu m

Labour Gang—(*B*) with adjustment.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Stone ...	11·7 cu m	25 00 per cu m	292·50
Through stone or Headers	0·8 cu m	30 00 per cu m	24 00
Cement 0·6 cu m = 18 bags	18 bags	34 00 bag	612·00
Sand (medium) ...	3·6 cu m	65 00 per cu m	234·00
Scaffolding ...	L. S.	15·00 L. S.	15·00
(b) **Labour**—			
Head Mason ...	½ no.	18 00 Each per day	9·00
Mason ...	11 nos.	16·00 „ „	176·00
Mazdoor (1½ nos. as Bhishti)	21 nos.	10 00 „	210·00
Contingencies, T. & P. etc.	L.S.½%(a+b)	7·85 L. S.	7 85
		Total:	1580·35
(c) **Water charges** –	@1% of	the total	15 80
		Total=	1596·15
(d) **Profit and Overhead**	@10 %		159·62

∴ **Rate per cu m=Rs. 175·52** Grand Total=1755·77

35. Ashlar Masonry in cement mortar (1:6) in superstructure ground floor

Consider first 10 cu m Unit=1 cu m

Calculation of Materials :— Volume of mortar per 10 cu m =3·0 cu m.

$\therefore$ Cement$=\frac{3}{7}=$0·43 cu m. Sand=0·43×6=2·6 cu m.

Labour Gang—(C) with adjustment.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** :—Stone	10 cu m	25 00 per cu m	250·00
Cement ...	0·43 cu m =13 bags	34·00 per bag	442·00
Sand (medium)	2·60 cu m	65·00 per cu m	169·00
Scaffolding ...	L.S.	12·00 L.S.	12·00
(b) **Labour** :— Head Mason ...	½ no.	18·00 Each per day	9 00
Mason ...	25 nos.	16·00 ,, ,,	400·00
Mazdoor (1½ nos. as Bhishti)	35 nos.	10·00 ,, ,,	350·00
Contingencies	L.S.½%(a+b)	8·00	8·00
		Total=	1640 00
(c) **Water charge**—	@1% of	the total =	16·40
		Total=	1656·40
(d) **Profit and overhead**—	@10%	=	165·40
		Grand Total=	1822·04

$\therefore$ **Rate per cu m Rs.=182·20**

Calculation of ingredients for Ashlar Masonry for different proportions :—

Consider first 10 cu m volume of work

Lime mortar of 3·2 cu m and cement mortar of 3·0 cu m per 10 cu m volume of work will be required. Dividing these quantities of mortars by the summation of proportions and multiplying the result by the respective strength of proportion, quantities of ingredients have been shown below.

Lime motar	**Lime**	**Sand or Surki**
Proportion 1 : 2 ...	... 1·1 cu m	2·2 cu m
,, 1 : 3 ...	... 0·8 ,, ...	2·4 ,,
,, 1 : 4 ...	... 0 65 ,, ...	2·6 ,,
Cement motar	**Cement**	**Sand**
1 : 3 ...	... 0·75 cu m	2·25 cu m
1 : 4 ...	... 0·60 ,, ...	2·40 ,,
1 : 5 ...	... 0·50 ,, ...	2·50 ,,
1 : 6 ...	... 0·43 ,, ...	2·60 ,,

3ℷ. **Coursed Rubble Stone Masonry in cement mortar (1:6) in superstructure. ground floor.**

Unit = 1 cu m

Consider first 10 cu m

Volume of mortar per 10 cu m = 4·0 cu m ∴ Cement = $\frac{4 \cdot 0}{7}$ = 0·57 cu m

Sand = 0·57 × 6 = 3·4 cu m. *Labour Gang—(C)* with adjustment

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Stone ...	11·7 cu m	25·00 per cu m	292·50
Through stone or Headers ...	0·8 cu m	30·00 per cu m	24 00
Cement ...	0 57 cu m = 17 bags	34·00 per bag.	578·00
Sand (medium) ...	3 40 cu m	65·00 per cu m	221·00
Scaffolding ...	L.S.	12·00 L.S.	12·00
(b) **Labour**—Head Mason ...	½ no.	18 00 Each per day	9 00
Mason ...	15 nos.	16·00 ,, ,,	240·00
Mazdoor (1½nos as Bhishti)	24 nos.	10·00 ,, ,,	240·00
Contingencies T. & P., etc.	L.S ½%(a+b)	8·00 L.S.	8.00
		Total =	1624·50
(c) **Water charges**— ...	@ 1% of	the total =	16·24
		Total =	1640 74
(d) **Profit and Overhead** ...	@ 10%	=	164·07
		Grand Total =	1804 81

∴ **Rate per cu m = 180·48**

Calculation of materials for different proportions of mortar in Coarsed Rubble Masonry per 10 cu m volume of work :—Same procedure as has been describ.d in Ashlar Masonry sl. 35. The quantity of lime mortar should be nearly 4·2 cu m and cement mortar of 4·0 cu m.

Lime mortar	**Lime**	**Sand or Surki**
Prop : 1 : 2 ...	1·4 cu m ...	2·8 cu m
,, 1 : 3 ...	1·1 ,, ...	3·3 ,,
,, 1 : 4 ...	0·84 ,, ...	3·36 ,,
Cement mortar	**Cement**	**Sand**
Prop : 1 : 2 ...	1·3 cu m ...	2·6 cu m
,, 1 : 3 ...	1·0 ,, ...	3·0 ,,
,, 1 : 4 ...	0·8 ,, ...	3·2 ,,
,, 1 : 5 ...	0·7 ,, ...	3·5 ,,
,, 1 : 6 ...	0·6 ,, ...	3·6 ,,

11-11. Analysis of Rates for flooring :—

37. Brick on edge floor with cement mortar (1:3) Unit=1 sq m

Consider first 100 sq m.

Calculation of Materials—Same as half brickwork from sl. 30. Wire netting is not required. *Labour Gang—(B)*

Particulars		ntity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**				
Bricks 20cm × 19cm × 19 cm	...	5,000 nos.	490·00 per %, nos.	2450·00
(,, 25·4cm × 12·7cm × 7·6cm)	...	4,100 nos.		
(,, 22 9cm × 11·4cm × 7 6cm)	...	5,000 nos.		
Sand (medium)	...	2·64 cu m	65·00 per cu m	171·60
Cement	...	10·88 cu m =26½ bags	34·00 per bag	901·00
(b) **Labour**—Head Mason	...	½ no.	18 00 Each per day	9·00
Mason	...	10 nos.	16·00 ,, ,,	160·00
Mazdoor (1 no. as Bhishti)		15 nos.	10·00 ,, ,,	150·00
Contingencies, T. & P. etc.		L.S ½%(a+b)	19·00 ,, ,,	19·00
			Total =	3860·00
(c) **Water charges** ...	...	@ 1 . of the	total =	38 61
			Total =	3899·21
(d) **Profit and Overhead**	...	@10%	=	389·92
Rate per sq m=Rs. 42 89			Grand Total=	4289·13

Note—Size of metric brick being 10cm × 10cm × 20cm with mortar and so brick flat flooring becomes same to that brick on edge flooring. For brick soling the quantity of sand is same to that quantity of mortar for 10 cu m of brickwork=3 5cu m.

38. 7·5 cm thick cement concrete floor 1 4:8 with overburnt brick ballast Unit=1 sq m

Consider first 100 sq m.

Calculation of Materials :—Vol. of concrete= ·075 × 100=7·5cu m ; summation of proportion=1+4+8=13. Following the same procedure as stated in 11-5 Cement $=\frac{16}{10}\times\frac{7.5}{13}$=0 92cu m, sand=0·92 × 4=3·68 cu m, brick ballast=·92 × 8=7·36 cu m.

(a) **Materials**—Brickballast (20mm down)		7·36 cu m	115 00 per cu m	846·40
Sand coarse)	...	3·68 cu m	65 0 ,, ,,	239·20
Cement	...	092 cu m =27·6 bag	34·00 per bag	938·40
(b) **Labour**— Head Mason	...	½ no.	18·00 Each per day	9·00
Mason	...	10 nos.	16 00 ,, ,,	160·00
Mazdoor (2nos. as Bhishti)		20 nos.	10·00 ,, ,,	200·00
Contingencies, T. & P. etc.		L.S.½%(a+b)	12·00 L.S.	12·00
			Total =	2405·00
(c) **Water charges**—		@ 1% of	the total =	24·05
			Total =	2429·05
(d) **Profit and Overhead**—		@ 10%	=	242·90
∴ **Rate per sq m=Rs. 26·72**			Grand Total =	2671·95

39. Terraced flooring with brick ballast, surki, and stone lime ($1\frac{1}{2}$:2:7) 7·5 cm thick
Unit=1 sq m

Consider first 100 sq m

Calculation of Materials :—Wet volume of concrete=·075×100=7·5 cu m. For 10cu m of wet volume dry vol. required=16cu m ∴ For 7·5 cu m of wet vol. dry vol. required $=\frac{16}{10}\times 7{\cdot}5=12$cu m. Dividing this by the summation of proportion $1\frac{1}{2}+2+7=10{\cdot}5$ and then multiplying the same by the ratio.

Lime$=\frac{12}{10{\cdot}5}\times 1\frac{1}{2}=1{\cdot}7$cu m ; Surki$=\frac{12}{10{\cdot}5}\times 2=2{\cdot}3$cu m, Brick ballast$=\frac{12}{10{\cdot}5}\times 7=8$ cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** —			
Brick ballast (Jhama khoa) ...	8 cu m	110·00 per cu m	880·00
Surki ...	2·3 cu m	90·00 per cu m	207·00
Lime (Slaked white) ...	1·7 cu m	335·00 per cu m	569·00
(b) **Labour**—			
Head Mason ...	$\frac{1}{2}$ no	18·00 Each per day	9·00
Mason ...	5 nos.	16·00 ,, ,,	80·00
Mazdoor (3 nos. as Bhishti) ...	40 nos.	10·00 ,, ,,	400·00
Contingeney, T. & P., etc. ...	L.S. $\frac{1}{2}$% (a+b)	10·70 L.S.	10·70
		Total=	2156·20
(c) **Water charges**—	@1% of	the total =	21·56
		Total=	2177·76
(d) **Profit and Overhead** ...	@10%	=	217·78
		Grand Total=	2395·54

∴ **Rate per sq m=Rs. 23·96**

40. Making chequers on Cement concrete floors, pavements steps etc. Unit=1 sq m

Consider first 100 sq m

(a) **Labour**—Mason	3 nos.	16·00 Each per day	48·00
Mazdoor	$3\frac{1}{2}$ nos	10·00—do—	35·00
Contingencies, T. & P., etc ...	L.S. $\frac{1}{2}$%	0·83 L.S.	00·42
		Total=	83·42
(b) **Water charges** ...	@1%of the	total =	·83
		Total=	84·25
(c) **Profit and Overhead** ...	@10%	=	8·42
		Grand Total=	92·67

∴ **Rate per sq m=Rs. 0·93**

41. 25 mm thick Cement Concrete or artificial stone flooring (1:2:4). Unit=1 sq m

Consider first 100 sq m.

Calculation of Materials :—Vol. of concrete=0·025×100=2·5 cu m.

Summation of proportion=1+2+4=7. Following the same procedure as stated in 32 of 11-5.

Cement $=\frac{15\cdot4}{10}\times\frac{2\cdot5}{7}=0\cdot55$ cu m $=\frac{0\cdot55}{0\cdot034}=16\cdot17$ say 16 bags.

Sand=0·55×2=1·10 cu m, stone chips=0·55×4=2·20 cu m.

Analysis :—

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Stone chips (12 mm down)	...	2·20 cu m	175·00 per cu m	385·00
Sand (coarse)	...	1·10 cu m	115·00 per cu m	126·00
Cement	...	16 bags	34·00 per bag	544·00
(b) **Labour**—Head Mason	...	½ no.	18·00 Each day	9·00
Mason	...	8 nos.	16·00 ,, ,,	128·00
Mazdoor (2 nos. as Bhishti)	...	10 nos.	10·00 ,, ,,	100·00
Mazdoor (Female)	...	4 nos.	10·00 ,, ,,	40·00
Contingencies T. & P., etc.	...	L.S.½%(a+b)	6 65 L.S.	6·65
			Total =	1339·15
(c) **Water charges**—	...	@1% of the	total =	13·39
			Total =	1352·54
(d) **Profit and overhead**—	...	@10@	=	135·25

Rate per sq m=Rs. 14·88 Grand total=1487·79

42. Neat Cement Punning (about 1·5mm thick) to floor, wall, dado, window sills etc.

Consider first 100 sq m Unit=1sq m

Calculation of materials :—Vol. for 100 sqm with a thickness of 1·5 mm 100×0·0015=0·15 cu m. Increase the Vol. by 25% when day

$=0\cdot15+0\cdot15\times\frac{25}{100}=0\cdot19$ cu m $=\frac{0\cdot19}{0\cdot034}=5\cdot59$ say $5\frac{1}{2}$ bags

Analysis :—

Particulars		Quantity	Rate	Amount
(a) **Materials**—Cement	...	5½ bags	34·00 per bag	187·00
(b) **Labour**— Mason	...	2½ nos.	16·00 Each per day	40·00
Mazdoor	...	2½ nos.	10 00 ,, ,,	25 00
Contingencies, T. & P. etc.		L.S.½%(a+b)	1·25 L.S.	1·25
			Total =	253·25
(c) **Water charges**—	...	@1% of the	total =	2·53
			Total =	255·78
(d) **Profit and overhead**—	...	@10%	=	25·58

Grand total=281·46

∴ **Rate per sq m=Rs. 2·81**

43. 2·5 cm thick artificial stone or cement concrete (1:2:4) floor with neat cement punning at top :—Combination of item nos. 41 and 42.

44. When the cement punning shall be of Red Oxide cement punning, the quantity of red oxide shall be @ 3·5 kg per bag of cement.

Mason = 3 nos. instead of $2\frac{1}{2}$ nos. and all other particulars are the same as SL. 42.

45. 40 mm thick flooring under layer of 30 cm thick cement concrete (1:2:4) and top layer of 10 mm thick red oxide cement plaster (1:3) using 3·5 kg. of red oxide of iron per bag of cement (each bag of 50 kg) finished with a floating coat of neat cement red oxide mix of same proportion. **Unit = 1 sq m.**

Consider first 100 sq m.

Calculation of materials :—(*i*) *For under-bed of 30 cm thick Cement concrete* (*1:2:4*).

Vol. = 0·030 × 100 = 3 cu m. Following the same procedure as in sl. 32 article 11-5.

Cement $= \frac{15.4}{10} \times \frac{3}{7} = 0{\cdot}66$ cu m = 19·4 bags. Sand = 0·66 × 2 = 1·32 cu m

stone chips = 0·66 × 4 = 2·64 cu m.

(ii) *For Top layer 10 mm thick mortar* (*1:3*) :—Vol. of mortar = 0·010 × 100 = 1·0 cu m for rough under bed increase this vol. by 20% = 1·0 + ·20 = 1·2 cu m (wet.) $= 1{\cdot}2 + \frac{1{\cdot}2}{3} = 1{\cdot}60$ cu m (dry). ∴ Cement $= \frac{1{\cdot}60}{4} = 0{\cdot}40$ cu m = 11·76 bags ; sand = 0·4 × 3 = 1·2 cu m.

(iii) *For floating coat* :—cement @ 2·2 kg/sq. m = 100 × 2·2 = 220 kg = 4·40 bags.

∴ Total quantity of cement for top layer = 11·76 + 4·40 = 16·16 bags.

Quantity of red oxide @ 3·5 kg per bag of cement = 16·16 × 3·5 = 57 kg.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a **Materials**—(i) *For under bed*—			
Stone chips (12 mm down) ...	2·64 cu m	175·00 per cu m	462·00
Sand (coarse) ...	1·32 cu m	115·00 per cu m	151·80
Cement	19·40 bags	34·00 per bag	659·60
(ii) & (iii) *For top layer & finishing*–			
Sand (medium) ...	1·3 cu m	65·00 per cu m	84·50
Cement	16·16 bags	34·00 per bag	549·44
Red oxide	57 kg.	10·00 per kg	570·00
(b) **Labour**—Head Mason ...	1 no.	18·00 Each per day	18·00
Mason (9+8+3)	20 nos.	16·00 ,, ,,	320·00
Mazdoor (5 nos. as Bhishti) ...	27 nos.	10·00 ,, ,,	270·00
Mazdoor (Female) ...	4 nos.	10·00 ,, ,,	40·00
Special Mazdoor for rubbing ...	3 nos.	14·00 ,, ,,	42·00
Contingencies T. & P. etc. ...	L. S. ½% (a+d)	15·75 L. S.	15·75
		Total =	3169·09
(c) **Water charges**— ...	@ 1%	=	31·69
		Total =	3200·78
(d) **Profit and Overhead**— ...	@ 10 %	=	320·08

Rate per sqm = Rs. 35·21 Grand Total = 3520·86

46. Cement plastered skirting (1:6) finished with a floating coat of neat cement red oxide mix@3·5 kg per bag of cement. (2·2 kg of cement per sq m for floating coat). Method of calculation is same as (iii). For cement plaster see item no. 58 Labour-cobination of sl. 42+58.

11-12 Notes on Terrazzo Flooring:—This is a special type of concrete flooring in which marble chips are used as coarse aggregates and laid over conventional cement concrete under layer. Terrazzo concrete comprises a mixture of cement and marble chips of sizes from 1 mm to 4 mm nominal of selected colours as coarse aggregate in a proportion 1 : 2 or 1 : 3. Marble powder by $\frac{1}{3}$rd. weight of cement is mixed with cement. The excess volume due to addition of marble powder may be considered for surface cutting volume and slurry for buttering after each cut. Marble chips are sold by weight, 1 cu m = 16·5 quintal. Pigment is used with cement @ 3·5 kg per bag of cement (1 bag = 50 kg).

(a) For dark shade pigment ordinary cement is used ; (b) for light shade pigment white cement is used and (c) for medium shade pigment approximately 50% white cement and 50% ordinary cement is used. Terrazzo work is polished three times as 1st cut, 2nd cut and final cut.

47. Terrazo floor, 6mm thick Terrazzo (1:2) over 20 mm cement concrete (1:2:4)

Consider first 100 sq m (Dark shade using ordinary cement) Unit = 1 sq m

Calculation of materials —(i) Volume of concrete at base $= 0{\cdot}02 \times 200 = 2$ cu m (wet)

Increase this volume by 20% for rough sub-base $= 2 + 2 \times \frac{20}{100} = 2{\cdot}4$ cu m (wet) $= 2{\cdot}4 \times 1{\cdot}5 = 3{\cdot}6$ cu m dry.

$\therefore$ Cement $= \frac{3{\cdot}6}{7} = 0{\cdot}50$ cu m ; Sand $= 1{\cdot}00$ cu m ; Stone chips $= 0{\cdot}50 \times 4 = 2{\cdot}00$ cu m.

Volume of Terrazzo $= 0{\cdot}006 \times 100 = 0{\cdot}6$ cu m (wet) $= 0{\cdot}6 \times 1{\cdot}5 = 0{\cdot}90$ cu m (dry).

$\therefore$ Cement $= \frac{0{\cdot}90}{3} = 0{\cdot}3$ cu m $= 9$ bags, Marble chips $= 0{\cdot}3 \times 2 = 0{\cdot}6$ cu m $= 0{\cdot}6 \times 16{\cdot}5 = 9{\cdot}90$ qu. Marble powder $= \frac{1}{3}$rd by weight of cement $= \frac{9 \times 50}{3} = 150$ kg. $= 1{\cdot}5$ qu.

Analysis :—

Particulars.		Quantity	Rate	Amount Rs. P.
(a) **Materials**— (i) *For c. c. base*—				
Stone chips (12 mm down)	...	2·0 cu m	175·00 per cu m	350·00
Sand (coarse)	...	1·0 cu m	115·00 per cu m	115·00
Cement — 0·50 cu m = 15 bags	...	15 bags	34·00 per bag	510·00
(ii) *For Terrazzo*—	...			
Marble chips (1 mm to 4 mm size)	...	9·90 qu.	45·00 per qu.	445·50
Cement	...	9 bags	34·00 per bag	306·00
Marble powder	...	1·50 qu	50·00 per qu.	75·00
Pigment @ 3·5 kg per bag	...	31·5 kg	7·00 per kg.	220·50
(b) **Labour** —Head Mason	...	1 no.	18·00 Each per day	18·00
Mason	...	20 nos.	16·00 ,, ,,	320·00
*Mazdoor (4 nos. as Bhishti)	...	30 nos.	10·00 ,, ,,	300·00
Polisher	...	98 nos.	10·00 ,, ,,	980·00
Polishing stone (carborandum)	...	L. S.	50·00 ,, ,,	50·00
Oxalic acid powder	...	L. S.	40·00 ,, ,,	40·00
Contingencies T. & P. etc	...	L. S. ½% (a+b)	18·60 L. S.	18·60
			Total =	3748·10
(c) **Water charges**—		@ 1% of the	total =	37·48
			Total =	3785·58
(d) **Profit and Overhead**—		@ 10%	=	378·56

$\therefore$ Rate per sq m = Rs. 41·64 Grand Total = 4164·14

Extra for providing and fixing aluminium strips 40 mm wide and 1·5 mm thick.

Details of cost for 100 m Aluminium sheets for strips $= 100 \times 0{\cdot}04 = 4$ sq m $+ 0{\cdot}2$ (for wastage) $= 4{\cdot}2$ sq m @ 4·1 kg per sq m $= 17{\cdot}2$ kg. For labour see notes on (48).

***Note** :—Machine is usually engaged for polishing. The labour charge for polisher should equalise the hire charge of machine and the labour cost of operator with helper.

48. Terrazzo skirting or Dado (upto 30 cm height) top layer 6mm thick Terrazzo 1:2 over 12 mm thick cement plaster under layer (1:3). Black or white colour.

Unit = 1 sq m.

Consider first 100 sq m

Calculation of materials—For 12 mm thick cement plaster (*1* : 3) same procedure as for plastering. Vol. of cement $=\frac{1\cdot86}{4}=0\cdot47$ cu m $=\frac{0\cdot47}{0\cdot034}=13\cdot82$ say 14 bags sand $=1\cdot31$ cu m

For Terrazzo :—Same as for flooring.

Analysis :—

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—(i) *For cement plaster base*—				
Sand (medium)	...	1·31 cu m	65·00 per cum	85·15
cement	...	14 bags	34·00 per bag	476 00
(ii) *For Terrazzo*—				
Marble chips (1 mm to 4mm)	...	9 90 qu.	45·00 per qu	445·50
Cement ...	...	9 bags	34·00 per bag	306·00
Marble powder ...	...	1·50 qu.	58·00 per qu	75·00
Pigmen @ 3:5 kg per b g	..	31·5 kg	7·00 per kg	220·50
(b) **Labour** —Head Mason	...	1 no.	18·00 Each per day	18·00
Mason	...	26. nos.	16·00 ,, ,,	416·50
Mazdoor (4 nos. as Bhishti)	...	44 nos.	10·00 ,, ,,	440·00
Polisher ...	...	98 nos.	10·00 ,, ,,	980·00
Oxalic acid powder	...	L. S.	40·00 L S.	40·00
Polishing stone	...	L S	50 00 L. S.	50·00
Contingencies T. & P., etc.	...	L. S. ½%(a+b)	17·75 L. S.	17·75
			Total =	3569·90
(c) **Water charges** —		@1% of the	total =	35·70
			Total =	3605·60
(d) **Profit and Overhead**—		@ 10%	=	360.56

∴ Rate per sq m = Rs. 39·66 Grand Total = Rs. 3966·19

Note : If chocolate, grey or yellow marble chips are used instead of white, black or white and black chips then extra cost shall be added with allowance for water charges and contractors profit.

(2) If aluminium strips 40 mm wide and 1·6 mm thick are used in joints of Terrazzo floor then cost of aluminium strips and labour charge @ ¼th Mason and ¼th Mazdoor per 10 m of Aluminium strip shall be added along with the additions of wastage of Aluminium strip @ 5% and water charges, contractors profit etc.

(3) For laying terrazzo floor on staircase, treads not exceeding 30 cm in width including the cost of forming nosing etc, extra labour charge per 100 sq m. Mason 3 nos. and Mazdoor 6 nos. shall be added in the labour gang.

(4) Extra for laying terrazzo in narrow band not exceeding 7·5 cm wide shall be added thus :—5 cm band 200 m long ½ Mason and ¾ Mazdoor.

49. Precast terrazzo tiles 20 mm thick white and black marble chips of sizes up to 6 mm laid in floors, treads of steps and landings on 25 mm thick bed of lime mortar (1:2) jointed with neat cement slurry mixed with pigment to match the shade of the tiles and high polishing.

Unit = 1 sq m.

Consider first 100 sq m (Dark shade using ordinary cement)

Calculation of materials :—Terrazzo tiles = 100 sq m + 10% wastage = 110 sq. m.

(Note : The wastage has been allowed by the All India standard schedule of Rates)

Vol. of lime mortar = 0 025 × 100 = 2·5 cu m (wet). Increase this vol. by 20% for rough sub-base = $2{\cdot}5 + 2{\cdot}5 \times \frac{20}{100} = 3{\cdot}0$ cu m (wet) $= 3{\cdot}0 + \frac{1}{3} \times 3 = 4{\cdot}0$ cu m dry.

∴ Slaked white lime $= \frac{4{\cdot}0}{3} = 1{\cdot}33$ cu m ; surki = 2·67 cu m.

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials.**—			
20 mm thick terrazzo tiles (including 10% wastage)	110·00 sq m	32·00 per sq m	3520·00
Sutki	2 67 cu m	90·00 per cu m	240·30
Slaked white lime	1·33 cu m	335·00 per cum	445·55
Cement for slurry over bedding @ 4·4 kg/sq m = 440 kg = 8 8 bags ...	8 80 bags	34·00 per bag	299·20
*Cement for grouting	8 80 bags	34·00 per bag	299·20
Pigment (dark shade) @3·5 kg per bag of cement (for grouting) ...	30·8 kg	7·00 per kg	215 60
(b) **Labour.**—			
Male Mason	1 no.	18·00 Each per day	18·00
Mason	20 nos.	16·00 ,, ,,	320·00
Mazdoor	21 nos.	10·00 ,, ,,	210·00
Polisher	65 nos	10·00 ,, ,,	650·00
Polishing stone (carborandum) ...	L. S.	50·00 L. S.	50.00
Oxalic acid powder ...	L. S.	40·00 L. S.	40·00
Contingencies, T. & P. etc ...	L. S.	31·50 L S.	31·50
		Total =	6338·95
(c) **Water charges.**—	@1% of the	total =	63·39
			6402·34
(d) **Profit and Overhead.**—	@ 10%	=	640·23

∴ Rate per sq m = Rs. 70·42 Grand Total = 7042·57

*(i) For medium shades 50% of white cement and 50% ordinary cement shall be accounted for grouting i.e 4·4 bags white cement @ Rs. 100·00 per bag and 4·4 bags @ Rs. 34 per bag.

(ii) For light shades 8·8 bags of white cement @ Rs. 100·00 per bag shall be calculated.

Note :—(1) If terrazzo tiles are laid in treads of steps not exceeding 30 cm in width extra labour shall be added per 100 sq m Mason 2 nos., Mazdoor 2 nos. and polisher 6½ nos.

(2) Floors are polished three times. After polishing each time cement grout with colouring pigment is lapped over the floor to fill up joints etc. and left out for some days before the 2nd time polishing.

50. Precast terrazzo tiles 20 mm thick with marble chips of sizes upto 6 mm in skirting and risers of steps not exceeding 30 cm in height on 10 mm thick cement plaster (1 3) jointed with neat slurry, including rubbing and polishing complete.

*Consider first 100 sq. m (*Dark shade using ordinary cement)* Uint=1sq m.

Calculation of materials :—For 12 mm thick cement plaster (1 :3) same procedure as for plastering. Vol. of dry mortar=1·60 cu m Vol. of cement$=\frac{1\cdot60}{4}$=0·40cu m i e. 11·5 bags Sand=0·40×3=1·20 cu m.

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials :—**			
20 mm thick terrazzo tiles (including 10% wastage) ...	110 00 sq m	32·00 per sq m	3520 00
Sand (medium) ...	1·20 cu m	65·00 per cu m	78·00
Cement ...	11·5 bags	34·00 per bag	39 00
*Cement for slurry for buttering tiles bed, sides (@ 4·4 kg+2·2kg per sq m)=660 kg=13·2 bags ...	13·2 bags	34 00 per bag	448·80
Pigment (dark shade) 3·5 kg per bag of cement ...	46·2 kg	7·00 per kg	323·40
(b) **Labour :—**			
Head Mason ...	1 no.	18·00 Each per day	16 00
Mason ...	31 nos.	16·00 ,, ,,	496 00
Mazdoor ...	32 nos.	10·00 ,, ,,	320 00
Polisher ...	76 nos.	10 00 ,, ,,	760·00
Polishing stone (carborandum) ...	L. S.	50·00 L. S.	50·00
Oxalic acid powder ...	L. S.	40·00 L. S.	40·00
Contingency, T. & P., etc. ...	L.S.½%(a+b)	32·20 L. S.	32·20
		Total=	6477·40
(c) **Water charges :—**	@ 1% of the	total ... =	64·77
		Total=	6542·17
(d) **Profit and Overhead :—**	@ 10%	... =	654·22
		Grand Total=	7196·39

∴ **Rate per sq m=Rs 71·96**

*For medium shade 50% of white cement and 50% ordinary cement shall be accounted for light shade all the cement for slurry and buttering shall be white @ Rs. 120 per bags.

Note:—(1) In case if precast tiles are fixed on walls then labour charge per 100 sq m shall be a little less. Mason=30 nos. Mazdoor=30 nos, Polishers=73 nos. all other particulars shall be the same.

(2) Extra if cut tiles other than half tiles are used then labour charge for cutting and rubbing per 100 sq m shall be Mason=17 nos. and Mazdoor=17 nos.

11·13. Analysis of Rates for Roofing.

51. 10 cm average thick lime terracing on R. C. roof with 25 mm gauge overburnt brick ballast at first floor (proportion 2:2:7).

Unit = 1sq m.

Consider first 100 sq m

Calculation of materials :—Summation of proportions $= 2+2+7 = 11$.

Wet volume of concrete $= 0{\cdot}10 \times 100 = 10$ cu m. Following the same procedure as stated in the article 11-5 sl. 31, Lime $= \frac{18}{10} \times \frac{10}{11} \times 2 = 2{\cdot}9$ cu m, Surki $= 2{\cdot}9$ cu m.

Brick ballast $= \frac{18}{10} \times \frac{10}{11} + 7 = 10{\cdot}20$ cu m.

Analysis :—

Particulars	Quantity	Rate Rs. P.	Amount R. P.
(a) Materials—			
Overburnt brick ballast (25 mm gauge) ...	10·2 cu m	115·00 per cu m	1173·00
Surki ...	2·9 cu m	90·00 per cu m	261·00
Lime (white slaked) ...	2·9 cu m	335·00 per cu m	971·50
Molasses (Gur) ...	L. S.	25·00 L.S.	25·00
(b) Labour—			
(i) For *laying—*			
Head Mason ...	½ no.	18·00 each per day	9·00
Mason ...	1 no.	15·00 ,, ,,	16·00
Mazdoor (3 nos. as Bhishti) ...	20 nos.	10·00 ,, ,,	200·00
(ii) *For beating lime concrete—*			
Mason ...	10 nos.	16·00 ,, ,,	160·00
Mazdoor (3 nos, as Bhishti) ...	22 nos.	10·00 ,, ,,	220·00
Mazdoor (female) ...	65 nos.	10·00 ,, ,,	650·00
Contingencies, T. & P., etc. ...	L.S. ½ %(a+b)	18·40 L.S.	18·40
		Total =	3703·90
(c) Water charges—	@ 1% of the	total ... =	37·04
		Total =	3740·94
(d) Profit and Overhead	@ 10%	=	374·09

Grand Total = 4115·03

∴ **Rate per sqm = Rs. 41·15**

Note :— In case if the thickness is not specified consider 10 cu m volume of work. Then the quantity of materials and labour are same as above. From the cost of 10 cu m find out the rate per cu m.

52. Ranigunj The roofing in lime mortar (1:2) pointing the joints with cement mortar (1:2) excluding framework.

Unit=1 sq m.

Consider first 10 sq m.

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Ranigunj Tiles	...	124 nos.	105·00 per % nos.	130·20
White lime (slaked)	...	0·05 cu m	335·00 per cu m	16·75
Surki	...	0·10 cu m	90·00 „ „	9·00
Cement	...	0·14 cu m		
		4·2 bags	34·00 per bag	142·80
Sand (medium)	...	0·28 cu m	65·00 per cu m	18·20
(b) **Labour**— Tiler Mason	...	1½ nos.	16·00 Each per day	24·00
Mazdoor (Beldar)	...	2 nos.	10·00 „ „	20 00
Contingencies T. & P. etc	...	L. S. ½% (a+b)	1·80 L. S.	1·80
			Total=	362·55
(c) **Water charges**—	...	@ 1% of	the total =	3·63
			Total=	366·18
(d) **Profit and Overhead**—	...	@ 10%	=	36·62

Rate per sq m=Rs. 40·28 Grand Total=402·80

53. Mangalore Tile roofing including Teak reepers of size 50 mm×25 mm to centre set in lime mortar (1:2)

Unit=1 sq m

Consider first 10 sq m

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Mangalore tiles	...	150 nos.	90·00 per % nos.	135·00
Mangalore ridge tiles	...	10 nos.	2·25 Each	22·50
Teak reeper 50×25mm	...	3·7 m	5·00 per r. m,	22·20
Reeper nails	...	0·5 kg	15,00 per kg,	7·50
Surki	...	0·08 cu m	90·00 per cu m	7·20
White lime (slaked)	...	0·04 cu m	335·00 per cu m	13·40
(b) **Labour**—Carpenter	...	½ no,	18·00 Each per day	9·00
Tile layer	...	½ no.	16·00 „ „	8·00
Mozdoor (Beldar)	...	3½ nos.	10·00 „ „	35·00
Contingencies T. & P. etc	...	L. S. ½% (a+b)	1·30 L. S.	1·30
			Total=	261·10
(c) **Water charges**—		@ 1 % of	the total =	2·61
			Total=	263·71
(d) **Profit and Overhead**—		@ 10%	=	26·37

∴ **Rate sq m=Rs. 29·01** Grand Total=290·08

54. Corrugated Galvanised iron (C.G.I.) 0·63 mm thick (i.e. 24 B.G.) sheet Roofing (excluding the cost of purlines and rafters) Unit = 1 sq m

Consider first 10 sq m

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—				
C.G.I. sheets (with 15cm end lap and 2 corrugation side lap)	...	12 8 sq m =0·7 quin	350 00 per qu.	266·00
G.I. bolts and nuts	...	0·7 kg.	25·00 per kg.	17·50
G.I. screws	...	1·0 kg.	25·00 „ „	25·00
G.I. hooks and nuts	...	1·4 kg.	20 00 „ „	28 00
Limpet washers	...	5 doz.	2·00 per doz.	10 00
(b) **Labour**—				
Carpenter	...	1 no.	18·00 Each per day	18·00
Blacksmith	...	½ no.	18 00 „ „	9·00
Mazdoor (Beldar)	...	2 nos.	10·00 „ „	20·00
Sundries, T. & P.	...	L. S.	5·00 L. S.	5 00
	...		Total =	398·00
(c) **Water charges**—		@ 1% of	the total =	3·98
			Total =	401·98
(d) **Profit and Overhead**—	...	@ 10%	=	40·20

Rate per sqm = Rs. 44·22 Grand total = 442·18

55. Flat Terrace roofing average 10 cm thick when beaten 1:2: 5½ over 2 layers of tiles (with 2·5 cm mortar 1:2 between two layers of tiles). Unit = 1 sq m.

Consider first 10 sq m

Particulars		Quantity	Rate Rs. P.	Amount Rs. p.
(a) **Materials**—(*i*) *For Tile setting*—				
First class Tiles 30 cm × 30 cm	...	220 nos.	120 per % nos.	264·00
(*For 2·5 cm mortar*—				
Lime (slaked)	...	0·14 cu m	320·00 per cu m	44·80
Surki	...	0·28 cu m	70·00 per cu m	19·60
(*iii*) *For Terracing*—				
Brick ballast 20 mm down	...	1·00 cu m	115·00 per cu m	115·00
Surki	...	0·36 cu m	70·00 „ „	25·20
Lime (slaked)	...	0·18 cu m	320·60 „ „	57·60
(b) **Labour**—Head Mason	...	½ no.	18·00 Each per day	9 00
Mason	...	2 nos.	16·00 „ „	32·00
Mazdoor	...	3 nos.	10·00 „ „	30·00
Mazdoor (Famale)	...	12 nos.	10·00 „ „	120·00
			Total =	717 20
(c) **Water charges**—	...	@ 1% of	the total =	7·17
	...		Total =	724·37
(d) **Profit and Overhead**—		@10%	=	72·44

∴ **Rate per sqm = Rs. 79·68** **Grand Total = 796·81**

56. Providing and fixing on wall face 100 mm dia. C. I. rain water pipe including filling the joints with spun yarn soaked in neat cement slurry and cement mortar.

Unit=per metre

Consider first 9m. i.e. 5 nos pipes @ 1·80 m each.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
100mm dia (internal) pipe 1·8m long	5 nos.	80 Each pipe	400·00
Cement mortar and spun yarn etc. ...	L. S.	3·00 L. S.	3·00
(b) **Labour—**			
Mason ...	½ no.	16·00 Each perday	8·00
Mazdoor ...	2½ nos.	10·00 ,, ,,	35·00
Scaffolding ...	L. S.	4·00 L. S.	4·00
Contingencies, T. & P. etc. ...	L.S.@1%(a+b)	2·25 L. S.	2·25
		Total =	452·25
(c) **Water charges—** ...	@ 1% of the	Total ... =	4·52
		Total =	456·77
(d) **Profit and Overhead—**	@10%	=	45·68
		Grand Total =	402·45

$\therefore$ **Rate per metre=Rs.** $\frac{402·45}{9}=$ **44·72**

Note : (1) For 75mm dia. pipe Mason=⅓rd no. Mazdoor=2 nos.

(2) Cost of M.S. holder bat clamps 5 nos., shall be separate ; labour charge for fixing the clamps, Mason-cum fitter=1 no ; Mazdoor=½ no.

57. Providing and fixing on wall face 100 mm dia. asbestos cement (A. C.) rain water pipe including joining with spur yarn soaked in bitumen and cement mortar (1 : 2)

Unit=per metre

Consider first, 9m i.e. 5 nos pipes 1·80 m each

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—**			
100mm dia pipe 1·8m long each ...	5 nos.	16 00 Each pipe	80·00
Cement mortar, spun yarn etc. ...	L. S.	3·00 L.S.	3·00
(b) **Labour—**			
Mason ...	½	16 00 Each per day	8·00
Mazdoor ...	2 nos	10·00 ,, ,,	20 00
Scaffolding	L. S.	4 00 L. S.	4·00
Contingencies, T.&P. etc. ...	L S.%½%(a+b)	0·58	0·58
		Total =	115·58
(c) **Water charges—** ...	@1%% of	the total =	1·15
		Total =	116·73
(d) **Profit and Overhead—** ...	@ 10%	=	11·67
		Grand Total=	128·40

$\therefore$ Rate per metre $= \frac{128·40}{9} = 14·27$

Note : (1) For 80 mm dia pipe, Mason=¾. ; Mazdoor=2 nos. Other particulars, are the same. (2) Cost of clamp is separate.

11·14 Analysis of Rates for Plastering

58. 12mm thick cement plastering 1·6 on new brickwork. Unit = 1 sq m

Consider first 100 sq m.

Method of Calculation :—Calculate first the volume of mortar (wet) from the thickness and surface area. Increase this amount by 20% for filling the depressions, joints, wastage etc. Calculate then the volume of mortar when dry by increasing $\frac{1}{3}$rd volume. For richer proportions such as 1 : 2 or 1 : 3 the total dry volume of motar should be 3% less than the quantity calculated by the above procedure due to more care towards wastage and lesser amount of void from the lesser volume of sand.

In this case, volume of mortar = 0·012 × 100 = 1·2 cu m. Increase by 20% for filling the depressions etc. = $1{\cdot}2 + 1{\cdot}2 \times \frac{1}{5} = 1{\cdot}44$ cu m (wet) = $1{\cdot}44 + 1{\cdot}44 \times \frac{1}{3} = 1{\cdot}92$ cu m (dry).

$$\therefore \text{ Cement} = \frac{1{\cdot}92}{7} = 0{\cdot}274 \text{ cu m} ; \text{ Sand } 0{\cdot}274 \times 6 = 1{\cdot}64 \text{ cu m}$$

Labour Gang—(B)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials.—			
Cement ...	0·274 cu m = 8·2 bags	34·00 per bag	278·80
Sand (medium) ...	1·64 cu m	65·00 per cu m	106·60
Scaffolding ...	L. S.	10·00 L.S.	10·00
(b) Labour.—			
Head Mason ...	½ no.	18·00 Each per day	9·00
Mason ...	10 nos.	16·00 ,, ,,	160·00
Mazdoor (1 no as Bhishti) ..	15 nos.	10·00 ,, ,,	150·00
Contingencies, T. & P. etc. ...	L. S. ⅓% (a+b)	3·50	3·50
		To al =	717·90
(c) Water charges.—	@1% of	the total =	7·18
		Tutal =	715·08
(d) Profit and Overhead.— ...	@10%	=	71·51

∴ Rate per sq m = Rs. 7·86 Grand Total = 786·59

Materials required for cement plastering with different proportions per 100 sq m

	Proportion	*Cement*	*Sand*
(a) For 12 mm thick plastering ...	1 : 3 ...	0·47 cu m = 14·1 bags	1·41 cu m
	1 : 4 ...	0·38 ,, = 11·4 ,, ...	1·52 ,,
	1 : 5 ...	0·32 ,, = 9·6 ,, ...	1·60 ,,
(b) For 20 mm thick plastering ...	1 : 2 ...	1·00 ,, = 30 ,, ...	2·00 ,,
	1 : 3 ...	0·80 ,, = 24 ,, ...	2·40 ,,
	1 : 4 ...	0·64 ,, = 19·2 ,, ...	2·56 ,,

Labour for any one of the above plastering work per 100 sq m is same as that of 12mm thick cement plastering (1 : 6)

59. 12mm thick cement plaster (1:2) in floor with neat cement.

Consider first 100 sq m. Unit=1sq m

Calculation of Materials :—Considering 2mm thick neat cement finish and 10mm thick plastering—

Cement for top finish=0·002×100=1·2 cu m

Volume of mortar=0·010×100=1·0 cu m (wet)=1·0+1·0×$\frac{1}{3}$=1·33 cu m (dry)

Cement=$\frac{1\cdot33}{3}$=0·443 cu m, Sand=0·89 cum, Total cememt=0·643 cu m

Labour Gang—(*B*)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials.**—Cement ...	0·643 cu m =19·3 bags	34·00 per bag	656·20
Sand (medium) ...	0·89 cu m	65·00 per cu m	57 85
(b) **Labour.**—Head Mason ...	½ no.	18·00 Each per day	9·00
Mason ...	10 nos.	16·00 " "	100 00
Mazdoor (1 no. as Bhishti) ...	15 nos.	10·00 " "	150·00
Contingencies, T. & P., etc....	L.S.½%(a+b)	5·00 " "	5·00
		Total=	1038·05
(c) **Water charges** — ...	@1% of the	total =	10·38
		Total=	1048·43
(d) **Profit and Overhead.**— ...	@ 10%	=	104 84

∴ Rate per sq m = Rs. 11·53 Grand Total = 1153·27

60. 6mm thick cement plaster (1:3) to R C. Ceiling Unit=1 sq m

Consider first 100 sq m.

Calculation of Materials :—Same procedure as stated in SL. no. 58.

Labour Gang :—(*B*)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials.**—Cement ...	0·24 cu m =7·2 bags	34·00 per bag	244·80
Sand (medium) ...	0·72	65·00 per cu m	46·80
Scaffolding ...	L. S.	10·00 L. S.	10 00
(b) **Labour.**— Head Mason ...	½ no.	18 00 Each per day	9·00
Mason ...	10 nos.	16·00 " "	160 00
Mazdoor (1. no, as Bhishti) ...	12 nos.	10·00	120 00
Contingencies, T.&P.etc	L.S.½%(a+b)	3·00	3·00
		Total=	593·60
(c) **Water charges.**— ...	@ 1% of	the total =	5·94
		Total=	599·54
(d) **Profit and Overhead.**— ...	@ 10%	=	59·95

∴ Rate per sq m Rs.=6·59 Grand Total=659 49

61. Rule pointing in cement mortar (1 : 3) on brickwork on walls Unit=1 sq. m.

Consider first 100 sq m.

Calculation of materials—An emperical quantity of 0·63 cu m (dry) motar should be considered per 100 sq m for Rule and Tuck pointing. In case of Flush pointidg take 75% of the above quantity.

Here, cement$=\frac{0\cdot63}{4}=0\cdot16$ cu m ; sand$=0\cdot16\times3=0\cdot48$ cu m.

Labour Gang—(B)

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—Cement ...	0·16 cu m =4·8 bags	34·00 per bag	163·20
Sand (medium) ...	0·48 cu m	65·00 per cu m	31·20
Scaffolding ...	L. S.	10·00 L. S.	10·00
(b) Labour— Head Mason ...	½ no.	18·00 Each per day	9·00
Mason ...	10 nos.	16 00 ,, ,,	160 00
Mazdoor(1 no. as Bhishti)	10 nos.	10·00 ,, ,,	100·00
Contingencies.T.&P., etc...	L.S.½%(a+b)	2·35 L. S.	2·35
		Total=	475·75
(c) Water charges— ...	@ 1% of the	total =	4·76
		Total=	480·51
(d) Profit and Overhead—	@ 10%	=	48·05

Grand Total=528·56

∴ Rate per sq m=Rs. 5 28

Note :—*For pointing work on floor, requirement of materials and labour will be 25% less than that on walls. For flush pointing labour charge shall be 10% less than that of Rule pointing.*

11·45. Analysis of Rates for finishing. Unit=1 sq m

62. White washing 2 coats on a coat of priming to new plaster.

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials - Stone Lime (unslaked)...	30·0 kg.	0·90 per kg	27·00
Gum	0·15 kg	15·00 per kg	2·25
Blue pigment colour ...	L. S.	4 00 L. S.	4·00
(b) Labour—Painter ...	1½ nos.	15·00 Each per day	22 50
Mazdoor (Beldars) ...	2 nos.	10·00 ,, ,,	20·00
Contingencies, laders, etc...	L.S.½%(a+b)	·35	0·35
		Total=	76 10
Water charges— ...	@ 1% of	the total =	0·76
		Total=	76·86
(d) Profit including Overhead— ...	@ 10%	=	7·69

∴ **Rate per sq m Rs.=0·84** Grand Total=84·55

63. Colour washing two coats over a coat of white wash to new plaster.

Consider first 100 sq m. Unit = 1 sq m

Calculation of Materials—All particulars are same to that white washing, only add 2·5 kg of paint in material column. Labour Gang same as white washing

64. Distempering two coats with dry distemper to interior walls or ceilling with a coat of priming. Unit = 1 sq m

Consider first 100 sq m.

Particulars		Quantity	Rate Rs. P.	Amount Rs. P
(1) *Priming coat with distemper primer*—				
(a) **Materials**—Distemper primer	...	8 litres	24·00 pes litre	192·00
Brushes, putty, sand parer	...	L. S.	5·00 L. S.	5·00
(b) **Labour**—Painter	...	$2\frac{1}{2}$ nos.	15·00 Each per day	37·50
Mazdoor	...	$2\frac{1}{2}$ nos.	10·00 ,, ,,	25·02
Contingencies, ladders, ete	...	L. S. $\frac{1}{2}$ %(a+b)	1·30 L. S.	1·34
(2) *Top coats*—				
(a) **Materials**—Dry distemper	...	10 kg.	10·00 per kg	100·00
Brushes, putty, Sand paper	...	L. S.	4·00 L. S.	4·00
(b) **Labour**—Painter	...	6 nos.	15·00 Each per day	90·00
Mazdoor	...	3 nos.	10·00 ,, ,,	30·00
Contingencies, ladders ete.	...	L. S. $\frac{1}{2}$ %(a+b)	1·00 ,, ,,	1·00
			Total =	485·80
(c) **Water charges**—		@ 1% of the	total =	4·85
			Total =	490·65
(d) **Porfit and Ove head**—		@ 10%	=	49·06

Grand Total = 539·71

∴ Rate per sq m = Rs. 5·39

65. Distempering two coats with oil bound distemper with a coat of priming. Same procedure and same labaur as in (64). Only the quantity of distemper for Top coats shall be 15 kg.

66. Lime punning (about 3mm thick) ovver interior plaster with shell lime and white lime (2 : 1)

Consider first 10 sq m Unit = 1 sq m

Labour Gang :—*(A)*

(a) **Materials**—Slaked stone lime	...	8 kg	0·90 per kg.	4·00
				16·00
(b) **Labour**—Mason	...	1 no.	15·00 Each per day	15·00
Mazdoor	...	2 nos.	10·00 ,, ,,	20·00
Sundries, ladder, T. & P.	...	L. S.	3·00 L. S.	3·00
			Total =	53·00
(c) **Water charges**—	...	@ 1% of	the total =	0·58
			Total =	58·58
(d) **Profit and overhead**—	...	@ 10%	=	5·86

∴ Rate per sq m = Rs. 6·44 Grand Total = 64·44

67. Single coat of white washing over old white washed surface. Unit=100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials:—Stone lime unslaked ...	10 kg	0·90 per kg	9·00
Gum ...	L. S.	2·00 L. S.	2 00
Blue colour ...	L. S.	2·00 L. S.	2·00
(b) Labour—Painter	$\frac{3}{4}$ no.	15·00 Each per day	11·25
Mazdoor (helper) ...	$\frac{3}{4}$ no.	10·00 ,, ,,	7 50
Contingencies, ladder etc. ...	L. S.	4·00 L. S.	4·00
		Total=	35·75
(c) Water charges.—	@ 1% of the	total =	·36
		Total=	36·11
(d) Profit and Overhead.—	@10%	=	3·61

∴ Rate per 100 sq m=Rs. 39·72 Grand Total=39·72

68. **Decorative Water proofing cement coating on plastered surface (may be snow.cem Bluncem etc.) two coats.**

Consider first 100 sq m Unit=1 sq m

Particulars	Quantity	Rate	Amount
(a) Materials.—Snowcem for 1st coat ...	30 kg		
2nd coat ...	20 kg		
	50 kg	9·50 per kg	475·00
(b) Labour.—Painter ...	50 nos	15·00 Each per day	75·00
Mazdoor (Helper) ...	5 nos.	10·00 ,, ,,	50·00
Contingencies, ladder, T &P. etc. ...	L S.	4 00	4·00
		Total=	600 00
(c) Water charges.— ...	@1% of the	total	6 04
...		Total=	610·04
(d) Profit and Overhead.— ...	@ 10%		61·00

∴ Rate per sq m=Rs. 6·71 Grand Total=671·04

69. **Wall Painting (two or more coats) with plastic emulsion paint** of approved brand and manufacture on new work to give an even shade. Unit=1 sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—Plastic emulsion paint	12 Litre	46 litre	552 00
Materials for filling in holes and cracks (putty etc.) ...	L. S.	5·00 L S.	5 00
(b) Labour—Painter (class I) ...	5·5 nos.	16·00 Each per day	88 00
Helper (Mazdoor) ...	5·5 nos.	10 00 ,, ,,	55·00
Brushes, Sand-paper etc....	L. S.	12·00 L. S.	12 00
Sundries ...	L. S.	5·00 L. S.	5·00
		Total =	710 00
(c) Water charges.— ...	@ 1% of	the total =	7·10
...		Total =	717 10
(d) Profit and Overhead— ...	@ 10%	=	71·70

∴ Rate per sq m=Rs. 7 88 Grand Total = 788·81

70. Wall painting (one or more coats) with plastic emulsion paint of approved brand and manufacture on old work to give an even shad.

Consider first 100 sq m Unit=1 sq m

(a)	**Materials.**—Plastic emulsion paint...	7·5 litre	46·00 litre	345·00
	Materials for filling in cracks and holes (putty etc.) ...	L. S.	6·00 L. S.	6·00
(b)	**Labour.**—Painter ...	$3\frac{1}{2}$ nos.	16·00 each per day	56·00
	Helper (Mazdoor) ...	$3\frac{1}{2}$ nos.	10·00 " "	35·00
	Brushes, Sand-paper etc. ...	L. S.	9·00 L. S.	9·00
	Sundries ...	L. S.	5·00 L. S.	5·00
			Total	456·00
(c)	**Water charges.**— ...	@ 1% of the	total	4·56
			Total	460·56
(d)	**Profit and Overhead.**— ...	@ 10%		46·06
	∴ Rate per sq m=Rs. 5·06		Grand Total =	506·62

71. Priming coat with ready mixed primer on steel work. Unit = 1 sq m

Consider first 100 sq m.

Materials	Labour
Primer Rs. 22·00 per litre) 5·5 litres,	Painter—$2\frac{1}{2}$ nos.
Sundries, brushes, sand paper. Rs. 12·00 L. S	Mazdoor (helper)—$2\frac{1}{2}$ nos.

72. Priming coat with ready mixed primer on Wood work. Unit= 1 sq m

Consder first 100 cu m.

Primer (Rs. 23·75 per litre)	7·5 litres	Painter—$2\frac{1}{2}$ nos.
Putty	L. S. Rs. 4·00	Mazdoor (helper)—$2\frac{1}{2}$ nos.
Sundries, brushes, sand paper, L. S. Rs. 12·00		

73. Priming coat with ready mixed cement primer on plastered surface Unit=1 sq m

Consider first 100 cu m

Primer (Rs. 25·00 per litre)	8·5 litres	Painter—$2\frac{1}{2}$ nos.
plaster of paries & putty	L. S. Rs. 12·00	Mazdoor (helper)—$2\frac{1}{2}$ nos.
Sundries ...	...L. S. Rs. 4·00	

74. Painting two coats (excluding priming coat) with ready mixed paint for wood work to give an even surface. Unit=1 sq m

Consider first 100 sq m

	Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a)	**Materials.**—Paint (Enamal, Jonson)	12 litres	46·00 per litre	552·00
	Putty, sand paper etc.	L. S.	8·00 L. S.	8·00
(b)	**Labour.**—Painter (class I)	$5\frac{1}{2}$ nos.	16·00 Each per day	88·00
	Mazdoor (helper)	$5\frac{1}{2}$ nos.	10·00 " "	55·00
	Contingencies, T. & P. etc	L. S.	8·00 L. S.	8·00
			Total=	711·00
(c)	**Water charges**—	1% of the	total	7·11
			Total=	718·11
(d)	**Profit and Overhead**—	@ 10%		71·81
	∴ Rate per sq m=Rs. 7·89		Grand Total=	789·62

75. Painting two coats (excluding priming coat) on Wood work. **Unit=1 sq m**

For 100 sq m. paint = 7·5 litres, painter=3·5 no : Mazdoor (helper)=3·5 nos.

77. Painting two coats (excluding priming coat) with ready mixed paint for steel work :

Same as wood work.

78. Varnishing two coats with copal varnish on new work including and under coat of flatting varnish (or double boiled linseed oil). **Unit=1 sq m**

Consider first 100 sq m.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Under coat flatting varnish ...	7 litre	24·00 per litre	168·00
Glue for sizing ...	0·7 kg.	12·00 per kg.	8·40
Copal varnish ...	$11\frac{1}{2}$ litre	27·00 per litre	380·50
Putty, etc. ...	L. S.	2·00 L. S.	2·00
(b) **Labour**—Painter=3·5+5·5 ...	9 nos.	16·00 Each per day	144·00
Mazdoor=3·5+5·5 ...	9 nos.	10·00 ,, ,,	90·00
Brushes, sand paper ...	L. S.	8·00 L. S.	8·00
Contingencies etc. ...	L. S.	5·00 L. S.	5·00
		Total=	805·90
(c) **Water charges**— ...	@ 1% of the	total =	8·06
		Total=	813·96
(d) **Profit and Overhead**—	=10%	=	81·40

Grand Total=895 36

∴ Rate per sq m=Rs. 8·95

79. Polishing on wood work with ready made wax polish on new work. unit=1 sq m

Consider first 100 sq m.

Materials.—Readymade wax polish=5 kg @ Rs. 50·00 per kg.

Labour.—Painter=8 nos., Mazdoor=8 nos.;

Cloth etc.=L. S. Rs. 4·0. Sundries=Rs. 600 L. S.

80. Spray painting with wall paints on new work including priming coat. unit=sq m

Consider first 100 sq m

Materials :—For priming coat (same as sl. 73)

Spray painting coat :—Wall paint=11 litre @ Rs. 40·00 per litre

Putty for filling holes=Rs. 10·00 L. S.; sundries=Rs. 6·00 L. S.

Hire charges for spraying machine including electric charges=3 days @ Rs. 18·00 per day.

81. Coal tarring two coats on new work unit=1 sq m consider 100 sq m.

Labour :—Painter=$5\frac{1}{2}$ nos. Mazdoor=$5\frac{1}{2}$ nos.

Materials.—Coal tar for 1st coat=16 litres; 2nd coat=12 litres; @ 3·50 per litre

Sundries (including firing charge)=Rs. 6·00 L. S.; Brushes=Rs. 6·00 L.S.

Labour.—Mazdoor=$4\frac{1}{2}$ nos.

75. Painting two coats excluding priming coat) on Old Wood work. Unit=1 sq m. For 100 sq m. paint=7·5 litres ; painter=3·5 nos : Mazdoor (helper)=3·5 nos.

76. Painting two coats (excluding priming coat) with ready mixed paint for steel work same as wood work.

78. Varnishing two coats with copal varnish on new work including an under coat of flatting varnish (or double boiled linseed oil), Unit=1 sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—Under coat flatting varnish	7 litres	24·00 per litre	168·00
Glue for sizing	0·7 kg.	12·00 per kg.	8·40
Copal varnish .	11½ litres	27·00 per litre	310·50
Putty, etc. ...	L. S.	2·00 L. S.	2·00
(b) **Labour**—Painter=3·5+5·5	9 nos.	16·00 Each per day	144·00
Mazdoor=3·5+5·5	9 nos.	10·00 Each per day	90·00
Brushes, sand paper	L. S.	8·00 L. S.	8·00
Sundries	L. S.	5·00 L. S.	5·00
		Total=	735·[illegible]
(c) **Water charges** —	@ 1% of the	total =	7·35
		Total=	743·85
(d **Profit and Overhead**—	@ 10%	.. =	74·38

Grand Total=818·23

∴ Rate per sq m=Rs. 8·18

79. Polishing on wood work with ready-made wax polish on new work, unit=1 sq m

Consider first 100 sq m

Materials—Readymade wax polish=5 kg. @ Rs. 50·00 per kg.

Labour—Painter=8 nos. ; Mazdoor=8 nos. ;
Cloth etc=L. S. Rs. 4·00. sundries=Rs. 6·00 L. S.

80. Spray painting with wall paints on new work including priming coat. unit=sq m

Consider first 100 sq m

Materials :—For priming coat (same as sl. 74)
Spray painting coat : —Wall paint=11 litre @ Rs. 40·00 per litre
Putty for filling holes=Rs. 10·00 L. S. ; sundries=Rs. 6·00 L. S.
Hire charges for spraying machine including electric charges=3 days @ Rs. 18·00 per day.

Labour :—Painter=5½ nos. Mazdoor=5½

81. Coal tarring two coats on new work. unit=sq. m consider 100 sq m.

Materials :—Coal tar for 1st coat=16 litres, 2nd coat=12 litres ; @ 3·50 per litre
sundries (including firing charge, =Rs. 6·00 L. S. ; Brushes=Rs. 6·00 L. S.

Labour=Mazdoor=4½ nos.

11·16. Analysis of Rates for Demolishing :–

82. Demolishing lime concrete and disposal of material within a lead of 50 metres.

Consider first 10 cu m Unit=1 cu m

	Particulars		Quantity	Rate R. P.	Amount Rs. P.
a	Labour –Mazdoor	..	8 nos.	10·00 Each per day	80 00
	Sundries, T. & P.	...	L S	1·50 L. S.	1·50
				Total=	81·50
(b)	Water charges–	...	@1% of the total	=	·81
				Total=	82·31
(c)	Profit and overhead–	...	@10%	=	8·23

Grand Total=90·54

∴ **Rate per cu m=9 05**

83. Demolishing cement concrete 1 : 2 : 4 or 1 : 3 : 6 including disposal of material within a lead of 50 m.

Consider first 10 cu m. Unit=1 cu m.

Labour—Mazdoor=23 nos. Sundries T. & P.=Rs. 5·00 L. S.

84. Demolishing R C. C. Work including disposal of unserviceable materials with a lead of 50m.

Consider first 10 cu m Unit=1 cu m

Labour—Mazdoor=$33\frac{1}{3}$ nos.

Sundries, T. & P.=Rs. 8·00 L.S.

85. Demolishing brick vork in lime mortar including stacking of serviceable material and disposal of unserviceable materials within a lead of 50 metres. Unit=1 cu m

Consider first 10 cu m

Labour—Mazdoor=8 nos.

Sundries, T. & P.=Rs. 1.50 L. S.

86. Demolishing brickwork in cement mortar including stacking of serviceable material and disposal of unserviceable materials within a lead of 50 metres.

Consider first 10 cu m Unit=1 cu m

Labour—Mazdoor=$19\frac{1}{2}$ nos.

Sundries, T. & P.=2·50 L. S.

87. **Removing mortar from and cleaning bricks and stacking cleaned bricks.**

Considee first 10 cu m. Unit=1 cu m

Labour—*(a)* For lime mortar :—Mason=4 nos.

Mazdoor=21 nos. Sundries=Rs. 5·00 L.S.

(b) For cement mortar :—Mason=6 nos.

Mazdoor=25 nos. Sundries=Rs. 5·00 L.S.

11-17. Analysis of Rate Water Supply and Saniatry Installations.

88. Supplying, and fitting, fixing 12mm diameter G.I. pipes with G.I. fittings and M.S. clamps including cutting holes in walls and mending good the same complete for internal work. Unit—rm

Consider first 100 r m

Particulars	Quantity	Rate Rs. P.	Amount R. P.
(a) **Materials**—			
12 mm dia. G.I. pipes ...	100 r m	17·00 per r m	1700·00
Fittings and wastage ...	5% of pipe cost	—	85·00
White lead, oil, hemp ..	L. S.	10 00 L. S.	10·00
Cement, sand, grift (for mending wall)	L. S.	12·00 L. S.	12·00
b **Labour**—			
Fitter ..	3 nos.	18·00 Each per day	54·00
Assistant fitter	4 nos.	12·00 ,, ,,	48·00
Mazdoor Beldar)	6 nos.	10·00 ,, ,,	60·00
		Total=	1969·00
(c) **Water chagres**	@ 1%	the total —	19·69
		Total=	1988·69
(d **Profit and overhead**	@ 10%	=	198·87

Grand Total=2187·56

∴ **Rate per r m=21·88**

89. Supplying and fitting, fixing 20 mm dia. G. I. pipes with G. I. fittings and M. S. clamps including outting holes in walls and mending good the same complete for internal work.

Consider first 100 r m

Same procedure as (1), For labour Gang increase the strength of Assistant fitters by 1½ nos. cost of 20 mmdia. pipe @ 19· 20 per r m.

90. **Sypplying, fitting and lying 25mm dia. G. I. pipes with G. I. fittings** complete including trenching and refilling etc. for external work. Unit=r m

Consider first 100 r m.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
25 mm dia. G. I. pipes ...	100 r m	25·60 per r m	2560·00
For fitting and wastage	2% of pipe cost	—	51·20
White lead, oil, hemp etc,	L. S.	12·00 L. S.	12·00
(b) **Labour** -			
Fitter	1 no.	18·00 Each per day	18·00
Mazdoor (Belders)	2 nos.	10·00 ,, ,,	20·00
For trenching and refilling etc,—			
Mazdoor (Belders)	6 nos.	10·00 ,, ,,	60·00
		Total=	2721·20
(c) **Water charges**	@ 1% of	the total =	27·21
		Total=	2748·41
(d) **Profit and Overhead**	@ 10%		274·82

Rate per r m=Rs. 3023 Grand Total=3023·23

91. **Supplying, fitting and laying 40 mm dia. G. I. pipes with G. I. fittings** complete including trenching and refilling etc. for external work. Unit=r m

Consider first 100 r m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
40 mm dia. G. I. pipes .	100 r m	34·25 per r m	3425·00
For fittings and wastage	2% of pipe cost	—	68·50
White lead, oil, hemp etc.	L. S.	20·00 L. S.	20 00
(b) **Labour**—			
Fitter	1½ no.	18 Each per day	27·00
Mazdoor (Belder)	3 nos.	10 00 ,, ,,	30·00
For trenching and refilling etc.—			
Mazdoor (Beldars) .	8 nos.	10·00 ,, ,	80·00
		Total=	3650·50
(c) **Water charges** .	@ 1% of	the total =	36·51
		Total=	3687·01
(d) **Profit** .	@ 10% after overhead	=	368·70

Rate per r m=Rs. 40·56

92. **Laying, fitting, fixing 80 mm dia. C. I. pipes providing with lead caulked joint** including testing of the joint and trench cutting for the pipe laying upto a depth of invert 60 cm and refilling, dressing etc. complete.

(Length of each pipe is 4·0 m and supplied from departmental store within 10 k m

Consider first a length of 20 r m of pipe line.

Number of joints for a length of 20 r. m. with 4 r. m. long pipes $=\frac{20}{4}=5$ nos.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Carriage of materials weighing approx. 320 kg within 10 k. m distance	L. S,	25·00 L. S.	25·00
For 5 nos. joints— Pig lead 1·8×5=9 kg ...	9 kg	25·00 per kg	225·00
Spun yearn=·12×5=0·6 kg	0·6 kg	3·50 ,, ,,	2·10
Fuel wood .	18 kg	0·80 ,, ,,	14·40
Kerosine oil	¾ litre	2·50 ,, ,,	1·87
b) **Labour** –			
**For trench and refilling etc.* Section 90cm×60cm	21·50 cu m	3·50 per cu m	75·25
For pipe laying and jointing— Fitter	1 no.	18·00 Each per day	18·00
Assistant Fitter ..	1 no.	12·00 ,, ,,	12·00
Mazdoor (Beldar) .	3 nos.	10·00 ,, ,,	30·00
		Total=	403·62
c **Water charges**— ...	@ 1% of	the total =	4·04
		Total=	407·66
(d) **Profit and Overhead** .	@ 10%	=	40·77
		Grand Total=	448·43

∴ **Rate per r m=22·42**

***Vol. for trenching=·90×·60×20=10·70=10·80 cu m**

$$\text{Vol. for refilling}=10{\cdot}8-\frac{\pi}{4}\times(0{\cdot}8)^2\times20=10{\cdot}70 \text{ cu m}$$

Total=21·50 cu m

93. Laying fitting, and fixing 150 mm dia. C.I. **pipes providing with lead caulked joint** including testing of the joint and trench cutting, depth of invert 75 cm and refilling dressing, etc. complete. (Length of each pipe is 4·00m supplied from departmental store).

Unit = rm

Consider first a length of 20 r m of pipe line

No. of joints $= \frac{20}{4} = 5$ nos.

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials—** Carriage of materials— weighing approx. 660kg with 10 km distance	.	L.S.	L.S.	35·00
(i) *For 5 nos. joints —*				
Pig lead $= 3 \times 5 = 15$kg	...	15 kg	25·00 per kg.	375·00
Spun yarn $= \cdot17 \times 5 = \cdot86$kg	...	0·85 kg	3·50 ,, ,,	2·97
Fuel woord	...	25 kg	0·80 ,, ,,	20·00
Kerosin oil	...	1 litre	2·50 ,, litre	2·50
Sundries, T. & P. etc.	...	L.S.	8·00 ,, L.S.	8·00
(b) **Labour—**				
**For Trenching and refilling etc.* Section 75cm × 60cm	...	17·65 cu m	3·50 per cu m	61·77
For pipe laying and jointing— Fitter	...	1½ nos.	18·00 each per day	27·00
Assistant fitter	...	1½ nos.	12·00 per day	18·00
Mazdoor (Beldar)	...	5 nos.	10·00 each per day	50·00
			Total =	600·24
(c) **Water charges** –		@1%	of the Total =	6·00
			Total =	606·24
(d) **Profit** and overhead	...	@ 10%		60·62

∴ **Rate per rm = 33·34** Grand Total = Rs. 666·86

*Vol. for trenching $= \cdot75 \times \cdot60 \times 20 = 9{\cdot}00$ cu m

Vol. for refilling $= 9{\cdot}00 - \frac{\pi}{4} \times (\cdot15)^2 \times 20 = 8{\cdot}65$ cu m

Total = 17·65 cu m

94. Spigot and Socket ended water pipes,

Following I.S. 1056—1960 the standard lengths of socket and spigot C.I. pipes are 3·66, 4, 4·88 and 5·5 metres and nominal diameters in mm are 80, 100, 125, 152, 200 225 300, 250, 400 and 450. To withistand different heads of water pressure pipes have been classified as LA, A and B according to their thickness. The test pressure of different classes of pipes are as below :—

Test pressures in kg/cm^2	Class LA	Class A	Class B
Upto and including 600mm nominal diameter ...	20	25	30
Over 600mm ...	15	20	25

Quantities of materials have been given in (95) are for class A pipes. For class LA weight of materials may be decreased by 10% as the pipe thickness decreases by 10%. Thus, for class B pipes weight of materials may be increased by 10% then class A. For special uses class C, D, É, etc. pipes may be derived increasing the thickness of pipes.

95. List of materials and labour etc. per 5 nos. of lead caulked joints in the Spigot ended class A type pipes.

Dia. of pipe mm	Wt. of pig lead	Span Yarn	Fuel wood	Kerosine oil	Labours		
					Fitters	Assist. Fitter	Mazdoor (Beldar)
100 (4″)	15 kg	0·85 kg	14 kg	1/8 litre	1/2	1/2	1
200 (8″)	27 kg	1·5 kg	28 kg	1/8 litre	1	1	2
250 (10″)	35 kg	1·9 kg	30 kg	3/8 litre	1 1/2	1 1/4	2 1/4
300 (12″)	40 kg	2·8 kg	37 kg	1/2 litre	1 3/4	1 1/2	3

96. Supplying, laying and jointing 100 mm dia. glazed stone wire pipes with cement mortar 1 : 1 (costs of concrete for embedding the pipe and earthwork are to be calculated as per design and drawing). Unit=1 r m

Consider first 15 r m

Number of joints with length of each piece is 60cm $\frac{15}{0.60}$=25 nos.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
100mm dia. S.W. pipes 60cm long each	25 nos.	10·00 per paise	250·00
Allowance for breakage ...	5% the cost of materials	—	12·50
Cement for 25 joints (0 022 cu m) ...	=0·66 bags	34·00 per bag	22·64
Sand (coarse) ...	0·022 cu m	120·00 per cu m	2·64
Spun yarn or plain gaskin @ 0·1 kg per joint	2·5 kg.	5·00 per kg	12·50
Sundries, T. & P. etc. ...	L. S.	8·00 L. S.	8·00
(b) Labour—			
Mason ...	1 no.	16·00 Each per day	16·00
Mazdoor (Beldar) ...	2 nos.	10·00 Each per day	20·00
		Total=	344·00
(c) Water charges ...	@ 1% of the	total =	3·44
		Total=	347.44
(d) Profit including overhead ...	@ 10%	=	34·74

Cost per r m=Rs. 25·47 Grand Total=382·18

97. Supplying, laying and jointing 150mm dia. glazed stone wire pipes with cement mortar 1 : 1 (costs of concrete for embedding the pipe and earthwork are to be calculated as per design and drawing). Unit=1 rm

Consider first 15 r m

Number of joints with length of each=$\frac{15}{0.60}$=25 nos.

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
a Materials—			
150mm dia. S.W. pipes 60cm long each	25 aos.	18·00 per piece	450·00
Allowance for breakage ...	5% of the materials	—	22·50
Cement for 25 joints 0·034 cu m ...	=1·02 bags	34·00 per bag	34·68
Sand, (coarse) ...	0 034 cu m	120·00 per cu m	4·08
Spun yarn or plain gaskin @ 0·18 kg per joint=25×0·18 ...	4·5 kg	5·00 kg	22·50
Sundries, T. & P. etc ...	L. S.	8·00 L. S.	8·00
(b) Labour—			
Mason ...	1½ nos.	16·00 Each per day	24·00
Mazdoor (Beldar) ...	2½ nos.	10·00 Each per day	25·00
		Total=	590·76
(c) Water charges—	@ 1% of the	total =	5·91
		Total=	5 6·67
(d) Profit including overhead	@ 10%	=	59·67

Rate per r m=Rs. 43·75 **Grand Total=656·34**

98. Supplying and fitting, fixing 60 cm × 45 cm Porcelain wash basin with C.I. brackets painted white. a pair of 12mm brass pillar taps, 32mm brass plug with brass chain, and 32mm brass waste complete including cutting walls and mendin good the same.

Unit = Each

Particulars		Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—				
60cm × 45cm Porcelain basin	...	1 no.	200 Each	200·00
C. I. bracket	...	1 pair	7·00 pair	7·00
12mm brass pillar tap	...	2 nos.	20·00 Each	40·00
32mm rubber blug with brass chain	...	1 no.	6·00 ,,	6·00
32mm brass waste		1 no.	12·00 ,,	12·00
32mm dia. lead pipe 75cm long	...	I no.	30·00 ,,	30·00
White lead, red lead and gaskin	...	L.S.	6·00 L.S.	6·00
Cement, sand and grit	...	L.S.	8·00 L.S.	8·00
Painting brackets	...	L.S.	4·00 L.S.	4·00
Sundries, T. & P. etc.	...	L S.	8·00 L.S.	8·00
(b) **Labour**—				
Fitter	...	1 no.	16·00 Each perday	16·00
Mason	...	½ no.	15·00 ,, ,,	7·50
Mazdoor (Beldar)	...	1 no.	10·00 ,, ,,	10·00
			Total=	254·50
(c) **Profit** including overhead	...	@10%	=	35·45
			Grand Total=Rs.	389·95

∴ **Rate per basin=Rs.** 390·00

99. Supplying and fitting, fixing 61 cm×45cm×25cm white glazed fireclay sink with M. S. brackets painted white, 32 mm rubber plug with C.I. chain, 32 mm C.I. waste, 32 mm C.I. trap with necessary unions complete, including cutting walls and mending good the same.

Unit=Each

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
61cm×45cm×25cm white glazed fireclay sink (H. T.) ...	1 no.	750·00 Each	750 00
C.I. brackets ...	1 pair	18·50 pair	18·50
32 mm rubber plug and C.I. chain ...	1 no.	5·00 Each	5·00
32 mm C.I. waste ...	1 no.	10·00 Each	10·00
32 mm dia. lead pipe 75 cm long ...	75 cm	30·00 Each	30·00
32 mm C.I. Trap with unions ...	1 no.	18·00 Each	18 00
White lead, red lead and gaskin ...	L. S.	5·00 L. S.	5·00
Cement, sand and grit etc. ...	L. S.	8·00 L. S.	8·00
Painting brackets	L. S.	4·00 L. S.	4·00
Sundries, T. & P. etc. ...	L. S.	10·00 L S.	10·00
(b) Labour—			
Fitter ...	½ no.	18·00 Each per day	9·00
Mason ...	½ no.	16·00 Each per day	8 00
Mazdoor (Beldar) ...	1 no.	10·00 Each per day	10·00
		Total=	885·50
(c) **Profit including overhead** ...	@ 10%	=	88·55

Grand Total=974·05

∴ **Rate of each sink=Rs. 974·05 say Rs. 974·00**

100. **Supplying fitting, fixing Indian type white glazed earthenwire W. C. pan 45cm with** 100 mm dia. H. C. I. (Heavy Cast Iron) trap, 15 litres C. I. flushing cistern with G.I. unions and G. I. chain and pull, telescope flush pipe with fittings and clamps, 25 mm dia. G. I. overflow pipe with specials and mosquito proof coupling complete including cutting floors and walls and mending good the same and painting the cistern with fittings.

Unit=Each

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials—			
45cm white glazed earthenwire W.C. pan ...	1 no.	115·00 Each	115·00
100 mm H.C.I. P-trap ...	1 no.	36·00 Each	36·00
15 litres C.I. flushing cistern with fittings and G. I. chain etc. ...	1 no.	160·00 Each	160·00
C. I. brackets ...	1 pair	18·50 pair	18·50
32mm telescope flush pipe with G. I. unions (G.I. pipe) ...	1 no.	25·00 Each	25·00
32mm holder bat clamp ...	1 no.	5·00 Each	5·00
25mm dia. G. I. overflow pipe with specials ...	L. S	8·00 L. S.	8·00
25mm mosquito proof coupling ...	1 no.	5·00 Each	5·00
White lead, red lead and gaskin ...	L. S	5·00 L. S.	5·00
Cement, sand and grit ...	L. S.	8·00 L. S.	8·00
Painting to cistern etc. ...	L. S.	5·00 L. S·	5·00
Sundries, T. & P. etc. ...	L. S.	8·00 L. S.	8·00
(b) Labour—			
Fitter ...	1 no.	18·00 Each per day	18·00
Mason ...	½ no.	16·00 Each per day	8·00
Mazdoor (Beldar) ...	1 no.	10·00 Each per day	10·00
		Total=	434·50
(c) Profit including overhead ...	@ 10%	=	43·75

∴ **Rate of each pan=Rs. 478·00** Grand Total=477·95

101. Supplying, fitting and fixing lipped front and flat back urinal basin of 36cm × 37cm × 39cm and 46cm × 35cm × 36cm sizes respectively earthenwire with 4·5 litres C. I. automatic flushing cistern with fittings, C. I. brackets, flush pipe and spreader with G. I. union and C. I. clamps complete, including painting the cistern and cutting of walls and mending good the same.

Unit = Each

Particulars	Quantity	Rate R. P.	Amount Rs. P.
a) **Materials**—			
36 × 37 × 39 cm lipped front and 46 × 35 × 36 cm flat back white glazed earthenwire urinal basin ...	1 no.	155·00 Each	155·00
4·5 litres C. I. automatic flushing cistern with fittings ...	1 no.	100·00 Each	100 00
C. I. brackets .	1 pair	18·00 Each pair	10·00
Flush pipe with G. I. union and calmps including fittings ...	1 no.	15·00 Each	15·00
White lead, red lead and gaskin ...	L. S.	6·00 L. S.	6·00
Cement, sand and grit ...	L. S.	8·00 L. S.	8·00
Painting cistern with fittings ...	L. S.	8·00 L. S.	8 00
Sundries, T. & P. etc. ...	L. S.	8·00 L. S.	8·00
(b) **Labour**—			
Fitter ...	¾ no.	18·00 Each per day	13·50
Mason ...	¾ no.	16·00 Each per day	12 00
Mazdoor (Beldar) ..	1 no.	10·00 Each per day	10·00
		Total =	345·50
(c) **Profit** including overhead ..	@ 10%	=	34·55

Grand Total = 380·05

∴ **Rate of Urinal basin = Rs. 380·00**

11·17. ANALYSIS OF RATE (ROAD WORKS.

102. Earthwork in excavation from borrow pits and depositing the soil in layers of 23cm including rough dressing within a lead of 30m and lift of 90cm. Unit = 1 cu m

Consider first 10 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** ...	Nil	—	Nil
(b) **Labour—**			
Mazdoor (Beldar) for cutting earth and placing the same in busket ...	$1\frac{1}{2}$ nos.	10·00 Each per day	15·00
Mazdoor for carrying and unloading the earth	2 nos.	10·00 Each per day	20·00
Mazdoor for rough dressing	$\frac{1}{5}$ no.	10·00 Each per day	2·00
		Total =	37·00
c) **Water charges** ...	@ 1% of	the amount =	·37
		Total =	37·37
(d **Profit and overheads** .	@ 10%	=	3·74

∴ **Rate per cu m = 4·11** Grand Total = 41·11

Note.—(a) For each additional lead 30 m beyond the initial lead add the labour cost of $1\frac{1}{2}$ Mazdoors for carrying the earth.

(b) For each additional lift beyond the initial 90cm lift add the labour cost of 1 Mazdoor.

(c) In case of mooram or gravelley soil increase the number of Mazdoor for excavation by 50%.

103. 5 cm to 8 cm thick turfing with sods available within 75 m Unit = 1sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials** ...	Nil	—	Nil
(b) **Labour—**			
Mazdoor (Beldar) for cutting turf sods ...	$2\frac{3}{4}$ nos.	10·00 Each per day	21·75
Mazdoor for cutting ...	$1\frac{1}{3}$ nos.	10·00 Each per day	10·33
Mazdoor for pitching —	1 no.	10·00 Each per day	10·00
		Total =	42·08
(c) **Water charges** ...	@ 1% of	the total ...	·42
		Total =	42·50
(d) **Profit and overheads** ...	@ 10%	=	4·25

∴ **Rate per sq m = 0·47** Grand Total = 46·80

N. B.—For each additional lead of 90m add labour cost of $1\frac{1}{2}$ Mazdoor.

104. One brick flat soling joints filled with local sand or powdered earth.

same as in Previous

105. Brick-on-end edging 7·5cm wide and 25cm deep with traditional bricks (10″×5″×3″)

Unit=1 r m

Consider first 30 r m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Bricks traditional (10″×5″×3″) ..	250 nos.	490·00% nos.	147·00
For modular bricks ...	300 nos.		
b) **Labour**—			
Mason ...	1/3 no.	16·00 Each per day	5·33
Mazdoor ...	1 no.	10·00 Each per day	10·00
Contingency etc. ...	L. S.	3·00 L. S.	3·00
		Total=	165·33
(c) **Water chagres** .	@ 1%	=	1·65
		Total=	166·98
(d) **Profit and overhead**	@ 10%	=	16·70

∴ **Rate per r m=Rs. 6·12** Grand Total=183·68

106. Dressing stone edging 15cm wide and 25cm deep stone supplied departmentally.

Unit=1 r m

Consider first 30 r m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Labour**—			
Mazdoor (Beldar) for cutting trenches	1 no.	10·00 Each per day	10·00
Mazdoor for laying and dressing top and sides of stones ...	3 nos.	10·00 Each per day	30·00
Contingencies etc. ...	L. S.	2·00 L. S.	2·00
		Total=	42·00
(b) **Water charges** ...	@ 1% of	the amount =	·42
		Total=	42·42
(c **Profit and Overheads** ..	@ 10%	=	4·24

Rate per r m=Rs. 1·56 Grand Total=46·66

107. Laying stone soling including packing with smaller stone.

Consider first 10 cu m Unit=1 cu m

Labour—Mazdoor—7 nos.

Sundries L. S. Rs. 1·50

108. Average out-put of a steam roller (working 8 hours in a day)

Nature of work	Quantity
(a) On Embankment	370 sq m (4,000 sft)
(b) On stone boulder	90 sq m (1 000 sft)
(c) On stone ballast for Macadam	20 cu m (700 cft)
(d) On brick ballast for Macadam	28 cu m (1,000 cft)
(e) On Laterite ballast for Macadam	34 cu m (1,200 cft)

Hire charge of a road roller (8 to 10 tons) excluding the wages of driver, cleaner, and nightguard may be taken as Rs. 120·00 per day. But including wages of such attendant staff Rs. 160·00 may be considered per day. Cost of fuel is to be taken separately. Hire charge of Tar Boiler @ Rs. 10·00 per day.

109. Laying overburnt Brick ballast or Jhama metal true to Camber including consolidation with power roller carrying the metal from road side within a lead of 150 r m Thickness 75 mm to 100 mm (compacted) Unit=1 cu m

Consider first 10 cu m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Labour** – Mazdoor for			
(i) Spreading and carrying ..	$10\frac{1}{2}$ nos.		
(ii) Hand packing and rectifying diffects during consolidation ...	$3\frac{1}{2}$ nos.		
(iii) Watering and blinding ...	7 nos.		
(iv) Shouldering at edge ...	$3\frac{1}{2}$ nos.		
	$24\frac{1}{2}$	10·00 per day	245·00
(v) Rolling—Hire charge of a roller @ 28 cu m per day including pay of its attendant staff ..	$\frac{1}{3}$rd day (apx.)	160·00 per day	53 33
(vi) Diesel for road roller @ 18 litres per day ...	6 litres	2·65 per litre	15·90
Contingencies (including lighting arrangement) etc. ...	L. S.	8·00 L. S.	8·00
		Total=	322·23
(b) **Water charges** ...	@ 1% of the	total =	3·22
		Total=	325·45
(c) **Profit and overhead** ...	@ 10%	=	32·55

∴ **Rate per cu m=Rs. 35·80** Grand Totoal=Rs. 358·00

Note :–In case of stone metal increase the number of Mazdoor by one for spreading, add further one Mazdoor for hand packing. Hire charge of roller becomes ½ day @ 20 cu m per day.

11.18. Short notes on Bituminous road surfacing—The main types of bituminous road surfacing are as follows :—

(a) Surface Dressing, (b) Penetration or Grouting method and (c) Premix.

(*a*) *Surface Dressing* :—This method consists of the application of a thin film of bitumen on a cleaned macadam road face and then binding this film with stone chippings. Surface dressing may be applied in one or two coats according to the surface condition. For two coats surface dressing larger sized chipping should be used for binding the first year.

(*b*) *Penetration or Grouting* :—In this method metal is spread first on the road surface to the specified thickness and profile, lightly rolled in such a way that the interstrices between the stones are fairly open. Bitumen is then applied on the road and allowed to penetrate between the stones through the interstices; in this way the dry chipping are coated with bitumen and bound together. The grouted surface is then rolled to specified compaction.

When the bitumen is allowed to penetrate to the full depth of the stone layer it is called *Full-Grout ;* while, it penetrates to only half the depth or less, it is known as *Semi Grout.*

110. **Surface dressing or Bituminous painting one coat.**

Consider first 100 sq m Unit=1 sq m

Particulars		Unit	Rate Rs. P.	Amount Rs. P.
(a) Materials—				
(i) Stone chips 12 nm standard size @ 152 cu m per 100 sqm	...	1·52 cum	175·00 per cu m	266·00
(ii) Bitumen (Transported upto work site) @ 194 kg per 100 sqm+2½% wastage		197 kg 0·197 T	2700·00 per tonne	531·90
(b) Labour—Mazdoor (Beldar)				
(i) For brushing off road surface	...	4½ Nos.		
(ii) For heating and spraying Bitumen	...	2½ Nos.		
(iii) For spreading chippings	...	2 Nos.		
		9 Nos.	10·00 per day	90·00
(c) Plant—Hire of one tar Boiler including sprayer @ 600 sq m per day	...	1/6th day	10·00 per day	1·67
(d) Rolling—Hire of Roller @ 600 sqm per day including attendent staff	...	1/6th day	160·00 per day	26·67
(e) Fuel—Firewood for heating Bitumen—4 quin. per tonn of Bitumen	...	79 kg	0·40 per kg	31·60
Diesel for roller @ 18 litres of per day	...	50 litres	2·65 per litre	132·50
Contingency (including lighting arrangement) etc.	...	L. S.	5·00 L. S.	5·00
			Total=	1085·34
(f) Water charges	...	@ 1% of	The total=	10·85
			Total=	1096·19
(g) Profit and overhead	...	@ 10%	=	109·62

Grand Total=Rs. 1205·81

∴ **Rate per sq m=Rs. 12·06**

112. Surface dressing or Bituminous painting second coat. Unit=1sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
(i) Stone chips 12mm standard size @ 1 cu m per % sqm ...	1 cu m	175·00 per cu m	175·00
(ii) Bitumen (transported upto work site) @120 kg% sq m + 2½% wastage ...	0·12 tonne	2,700·00 tonne	324·00
(b) **Labour**—Mazdoor (Belder)			
(i) For brushing off road surface ...	2 Nos.		
(ii) For heating and spraying of Bitumen...	1½ Nos.		
(iii) For spreading stone chips ...	1½ Nos.		
	5 Nos.	10·00 each	50·00
(c) **Plant**—Hire of one tar Boiler including sprayer @ 800 sq m per day ...	⅛th day	10·00 per day	1·25
(d) **Rolling**—Hire of Roller @ 800 sq m per day including attendant staff ...	⅛th day	160·00 "	20·00
(e) **Fuel**—Fire wood for heating Bitumen @ 4 quintals per ton of Bitumen ...	0·48 quin	40·00 per quin	19·20
Diesel for roller @ 18 litres per day ...	6 litres	2·65 per litre	15·90
Contingency, etc. ...	L. S.	5·00 L. S.	5·00
		Total—	610·35
(f) **Water charges**—	@1% of the	Total—	6·10
		Total—	616·45
(g) **Profit and overhead**	@ 10%		61·65

Grand Total—678·10

∴ **Rate per sq m—Rs. 6·78**

Note :—(1) If coal is used for heating Bitumen the quantity of fuel required will be 5 % of the quantity indicated for firewood.

(2) Usually materials are supplied departmentally, then only the cost of carriage of the matrix from the departmental godown to work site should be taken in material column.

(3) Sand blinding that is required when the surface bleeds, is not included in the analysis.

11-12. 5cm thick (finished) Semi-Grouting with bitumen without seal coat.

Unit—1sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) Materials.—			
(i) Bitumen (transported to work site) for grouting @ 218kg per 100 sq m + $2\frac{1}{2}$% wastage ...	224 kg= 0·224 T		
(ii) Stone metal 40mm standard size spread to a thickness 65mm loose i.e. ·065 × 100 ...	6·5 cu m		
(iii) Stone chips 12mm standard size for blinding the grouted surface @1·183 cu m per 100 sq m ...	1·83 cu m		
(b) Labour.—Mazdoor			
(i) For picking, sectioning and removing old road surface to 5cm thick ...	4 Nos.		
(ii) For spreading 40mm size stone metal, levelling and cambering. ...	$2\frac{1}{2}$ Nos.		
(iii) For cleaning the surface before grouting ...	3 Nos.		
(iv) For heating and grouting bitumen ...	4 Nos.		
(v) For spreading 22mm size stone chips over grouted surface ...	1 Nos.		
(vi) For brushing off loose chippings after rolling ...	$1\frac{1}{2}$ Nos.		
	16 Nos.		
(c) Plant—Hire of one tar Boiler including sprayer with an out put of 560 sq m per day ...	$\frac{1}{6}$th day		
(d) Rolling—Hire of roller with attendants staff @ 560 sq m per day ...	$\frac{1}{6}$th day		
(e) Fuel—Fire wood (for coal half of the amount) for heating bitumen @ 2 quin. per Ton ...	0·45 quin		
Diesel for roller @ 28 litres per day ...	3 litres		
Sundries (including lighting arrangement and brushes) ...	L. S.		
(f) Water charge ...	@ 1% of the	total =	
(g) Profit and overheads ...	@ 10%		

Grand Total=

Rate per sq m—Rs.

11-13. 25mm thick premix chipping carpet or premix Bituminous Road surfacing.

Unit—1sq m

Consider first 100 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
For tack coat.—Bitumen (shelmac or shelsra) @ 73 kg per 100 sq m + 2½% wastage ...	75 kg 0·075 T		
For premix carpet—			
(i) Stone chips 12mm standard @ 3cu m per 100sq m ...	3 cu m		
(ii) Bitumen (shelmac or shelspra) @ 64kg per cu m of stone + 2½% wastage ...	·197 tonns		
Sand (coarse) for flushing @ 0·75 cu m per 100 sq m ...	0·75 cu m		
(b) **Labour**—Mazdoor (Beldar)			
(i) For brushing off the old surface ...	4 nos.		
(ii) For heating and applying tack coat ...	2 nos.		
(iii) For heating mixing and spreading chippings ...	9 nos.		
(iv) For flushing sand ...	1 nos.		
	16 nos.		
(c) **Plant**—Hire of one tar Boiler including spreader @ 560 sq m per day ...	$\frac{1}{6}$th day		
(d) **Rolling**—Hire of roller including attendant staff @ 560 sq m per day .	$\frac{1}{6}$th day		
(e) **Fuel**—Fire wood for heating Bitumen @ 4 quin. per ton of Bitumen ...	0·3 quin		
Diesel for roller @ 18 litres per day ...	3 litres		
Sundries (including lighting arrangements and brushes) ...	L. S.	6·00 L.S.	
(f) **Water charges** ...	@1%		
		Total—	Rs.
(g) **Profit and Overhead** ...	@10%		Rs.

Grand Total = Rs..

Rate per sq m Rs..

11-14. Providing seal coat with paving bitumen S-90 and stone chips 10mm nominal size. (**Materials per 100 sq m shall be bitumen 150 kg and stonechips 1·05 cu m.**)

Consider first 100 sq m Unit = 1 sq m

Particulars	Quantity	Rate Rs. P.	Amount Rs. P.
(a) **Materials**—			
Bitumen S-90 @ 150 kg/100 sq m ..	0·15 t		
Stone chips @ 1·05 cu m/100 sq m ..	1·05 cu m		
(b) **Labour**—Mazdoor (trained)			
(i) For cleaning and brushing ..	$1\frac{1}{2}$ nos.		
(ii) For heating and spraying bitumen ..	$1\frac{1}{2}$ nos.		
(iii) For screening and spreading stonechips ..	$1\frac{1}{2}$ nos.		
(c) **Plant**—Hire charges of one tar Boiler including sprayer @ 900 sq m per day ..	$\frac{1}{9}$th. day		
(d) **Rolling**—Hire charges of roller including attendant staff @ 900 sq m per day ..	$\frac{1}{9}$th. day		
(e) **Fuel**—Steam coal for heating bitumen @ 2q per tonne of bitumen	0·3 q		
Diesel for roller @ 18 litres per day ..	2 litres		
(f) **Misc.**—Brushes etc. for cleaning—			
Wire brushes (with thick wire) ..	0·05 no	6·00 each	
Soft brushes ..	0·12 no	5·00 each	
Brooms and gunny bags ..	L. S.	0·45 L. S.	
Sundries (including lighting arrangement) ..	L. S.	1·20 L. S.	
		Total =	
(g) **Water charges**— ..	@ 1% of	the total =	
		Total =	
(h) **Profit and Overhead** ..	@ 10%	... =	
		Grand Total =	

∴ **Rate per sq m = Rs....**

11-19. ANALYSIS OF RATE FOR CARRIAGE OF MATERIALS

Factors influencing the cost of transport :—Materials are usually carried at the departmental store or at the work site either by animal transport such as by Bullock carts or by mechanical transport such as by trucks. The cost of transporting materials depends upon several factors as has been shown diagramatically below.

Cost of Transport

- (1) Cost of owing
- (2) For mechanical transport the rate of fuel consumption
- (3) The capacity and loading of the vehicle.
- (4) Labour cost for loading, unloading and delay per trip.
- (5) The speed of the vehicle.
- (6) Number of trips in a day (8 hours).
- (7) The lead of materials per trip.
- (8) For mechanical transport allowance for movement of the truck from parking place to duty spot and back.

Before going further, let us explain the different factors in short.

(1) **Cost of Owing** :—This includes the cost of hire charges of the vehicle for a working period (8 hours) in a day including the cost of driver. For animal transport Bullock Cart charges of Rs. 50·00 may he considered fair and in the case of mechanical transport hire charge of a truck (diesel) of Rs. 200·00 may be considered reasonable for 8 hours in day.

(2) **For mechanical transport the rate of fuel consumption and its cost**—The rate of diesel oil consumption may be assumed at 1 litre per 5 k.m. and the rate of mobil oil consumption at a rate of 1 litre per 140 k m.

(3) **The capacity and loading of vehicle :**—The capacity of a vehicle varies for different class of materials. A chart has therefore been given below showing the carrying capacity of different materials by different transport. In some cases a diesel truck may carry more quantity of materials at their own risk but volumes can not be taken into consideration in the analysis of rate.

Sl. No.	Materials to be carried	Capacity per trip	
		By bullo cart	By diesel truck (8 tonns capacit
1.	Bricks—		
	(a) Madular or traditional 9″ × 4½″ × 3″ ...	400 nos.	2,000 nos.
	(b) Traditional 10″ × 5″ × 3″	300 nos.	1,800 nos.
2.	Sand, Lime, Surki, Mooram, etc. Earth, Ballast, Building rubbish, Boulders etc.	9·0 cu m	4·2 cu m
3.	Cement, Stoneblocks, steel or other heavy materials	1·5 tonns	8·0 tonns
4.	Timber.	1·4 cu m	3·5 cu m
5.	S. W. pipe (a) 100 mm dia.	75 r m	350 r m
	„ „ (b) 150 mm dia.	45 r m	180 r m
6.	Tar, Bitumen etc	1½ tonns	5 tonns

(4) **Labour cost for loading, unloading and delay per trip :**—The labour cost for loading and unloading a load will depend on several considerations such as the weight of the load, the size of the load, the ease of taking hold of the load and the kind of material. Beside these the cost also depends on the skill of the workman, his rate of work etc.

There is no special rule whereby the best combination of the above considerations can always be determined by one computation. However, selecting a labour gang of the right number of men those who will be along with the truck will work efficiently and economically. The number of labourers, Mazdoor (Beldar) in such a gang may be taken as 6 nos. per truck.

The time required for loading and unloading will vary on different jobs, different materials and different methods of loading. A period of $\frac{3}{4}$ hour is to be allowed for loading and unloading in each trip by animal transport and 1 hour by mechanical transport according to the recommendations of Central Public Works Department.

(5) **The speed of the vehicle :**—This depends on the lead [illegible] the lead be lesser the speed will be lower. At beginning estimator is ge[illegible]ed to estimate the average truck speed at too high a value. For a lead in 1 k[illegible] the average speed is to be considered as 10 k m per hour and for each additional lead of 1 k m over the initial lead an increase of $\frac{1}{2}$ km may be allowed according to the practice of C. P. W. D. For a Bullock cart the speed may be assumed 4 k m.

(6) **Number of trips in a working day (8 hours) :**—Number of trips in a working day depends upon the speed which itself depends upon the truck, the road, traffic and the driver.

The number of trips in a working day of 8 hours may be given by :—

$$N=\frac{8}{\frac{2L}{S}+\frac{3}{4}}.$$ This is applicable for any type of transport.

where, L = The lead in kilo metre,

S = The speed in kilo metre per hour,

$\frac{3}{4}$ hour is the time allowed for loading per trip.

(7) **The lead of materials :**—Shorter lead of materials greater is the carrying cost and vice versa. The time and cost for loading unloading are same per trip of a vehicle. Now if the lead be shorter the above rate will be higher in comparison to the rate for longer distances. For a short distance a mechanical transport can not speed up fully in comparison to the rate for a longer distances.

(8) **Allowance for movement of truck from parking place to duty spot and back :**—A distance of 6 k m may be allowed for movement of truck from parking place to duty spot and back.

11-18 Cost of materials for Different Leads by animal transport :—

For an example let us calculate the cost per trip for a lead of 3 km by a bullock cart

Number of trips N per 8 hours per day $=\frac{8}{\frac{2L}{S}+\frac{3}{4}}$

Here, L = The lead = 3 k m ; S = The speed = 4 k m/hour

$$\therefore \quad N=\frac{8}{\frac{2\times3}{4}+\frac{3}{4}}$$

Adopting a local charge of a bullock cart per day (8 hours) = Rs. 50·00

Cost per trip $=\frac{50\cdot00}{5\cdot55}$ = Rs. 14·08

Following the above procedure of calculations a table has been prepared for different leads showing the cost per trip against such leads.

Lead	1 k m	2 k m	3 k m	4 k m	5 k m	6 k m	7 k m
Number of trips per 8 hours	6·40	4·57	3·55	2·91	2·46	2·13	1·88
Cost per trip	Rs. 7·82	Rs. 10·94	Rs. 14·08	Rs. 17·18	Rs. 20·32	Rs. 23·46	Rs. 26·5[illegible]
Increase in cost over previous k m	–	Rs. 3·12	Rs. 3·14	Rs. 3·10	Rs. 3·14	Rs. 3·14	Rs. 3·12

11-19. How the Analysis of rate for carriage of materials is individually prepared ?

Analysis of rate of a material for the quantity per unit of rate can be worked out knowing the capacity of the cart per trip and the number of trips required to carry the quantity of materials. The total cost for the number of trips at the rate to the specified lead is to be calculated. Then an amount of 10% to the total cost is to be added for contractors profit to show the rate per unit of the material. Overhead charges may be excluded considering that no hand tools or operating machinery becomes necessary for carriage of the materials.

Example : Analysis of rate for carriage of materials Sand, Lime, Mooram, Earth, Ballast, Boulders, Building rubbish etc. for a lead of 5 k m by bullock cart. Unit of rate cu m

Number of trips N per hour for a lead of 5 km$=\dfrac{8}{\dfrac{2\times5}{4}+4}=2{\cdot}46$. (This has been shown in the above table.)

Adopting a local rate for hiring charge of Bullock cart @ Rs. 50·00 per day, cost per trip $=\dfrac{50{\cdot}00}{2{\cdot}46}$ = Rs. 20·32 (this has been shown in the above chart.

Volume of materials to be carried=1 cu m.
Carrying capacity per trip=0·9 cu m.

Number of trips required $=\dfrac{1}{0{\cdot}9}=1{\cdot}11$. The cost has been shown in the table as below.

Materials	Unit of rate	Quantity per trip	Number of trips	Rate per trip Rs. P.	Amount Rs. P.
Sand, Lime, Mooram. Earth, Ballast, Bolders etc. ...	cu m	0·9 cu m	1·11	20·32	22·55
Profit	@ 10%	of the	total	=	2·25
				Total	=24·80

∴ The carrying rate of 1 cu m of any one of the above mentioned material for a lead of 5 k m=Rs. 24·80 by bullock cart.

Following the same procedure Analysis of rate has been prepared for some other materials showing the carriage cost for various loads by bullock cart.

Materials	Unit of rate	Capacity per trip		1 k m Rs. P.	2 k m Rs. P.	3 k m Rs. P.	4 k m Rs. P.	5 k m Rs. P.	6 k m Rs. P.
			Cost per trip	7·82	10·94	14·08	17·18	20·32	23·46
1. Bricks (Modular or 9″×4½″×3″ size)	1000 nos.	400 nos.		19·55	27·35	35·20	42·95	50·80	58·76
			Add 10%	1·95	2·73	3·52	4·29	5·08	5·88
				21·50	30·08	38·72	47·24	55·88	64·64
2. Cement, stone blocks, steel or such other materials	Tonne	1.5tonnes		5·21	7·29	9·39	11·45	13·55	15·64
			Add 10%	·52	·73	·94	1·15	1·36	1·56
				5·73	8·02	10·33	12·60	14 91	17·20
2. S. W. pipe (a) 100mm dia.	100r m	75 r m		10·40	14·55	18·78	22·90	27·02	31·28
				1·04	1·46	1·88	2·29	2·70	3·13
				11·44	16·01	20·66	25·19	29·72	34·41
do—do— (b) 150mm dia.	100r m	45 r m		17·39	24·32	31·28	38·18	45·12	52·14
			Add 10%	1·74	1·43	3·13	3·02	4·51	5·21
				19·12	26·75	34·41	42·00	49·63	57·35

11-20 Analysis for Rates Carriage of Materials by Mechanical transport (Diesel trucks) :—

N. B.* *Cost per trip has been given in the table as worked out in the next page. For any individual item of material to be carried for a specific lead the cost per trip shall be worked out first.

Materials	Uuit of rate	Capacity per trip		1 k m Rs. P.	2 k m Rs. P.	3 k m Rs. P.	4 k m Rs. P.	5 k m Rs. P.	6 k m Rs. P.
			Cost per trip	37·64	42·00	46·30	50·39	54·35	58·10
1. Bricks Modular or 9″×4½″×3″ size	1000 nos.	2000 nos.		18·82	21·00	33·15	25·20	27·18	29·05
			Add 10%	1·88	4·10	2·32	2·52	2·72	2·90
				20·70	25·10	25·10	27·72	29·90	31·95
2. Sand, Lime Surki, Mooram, Earth, Ballast, Boulder etc.	cu m	4·2 cu m		8·96	10·00	11·02	11·99	12·94	13·83
			Add 10%	·90	1·00	1·10	1·20	1·29	1·33
				9·86	11·00	12·12	13·19	14·23	15·21
3. Cement, stone blocks, steel etc.	tonne	8 tonnes		4·71	5·25	5·78	6·29	6·79	7·26
			Add 10%	0·47	0·52	·58	·63	·68	·73
				5·18	5·77	6·36	6·92	7·47	7·99
4. S. W. pipe (a) 100mm dia.	100 rm	350 r m		10·75	12·00	13·22	14·39	15·52	16·60
			Add 10%	1·08	1·20	1·32	1·44	1·55	1·66
				11 83	13·20	14·54	15·86	17·07	18·26
—do—do— (b) 150mm dia.	100 rm	180 rm		20·91	23·33	25·72	27·99	30·19	32·27
			Add 10%	2·09	2·33	2·57	2·80	3·02	3·23
				23·00	25·66	28·29	30·27	33·21	39·50

Note : Knowing the av. increase of cost per k. m. from the table calculate the cost for successive k. m.

Analysis for Carriage of Materials per Trip by Mechanical Transport for Different Leads.

N.B. (1) *The consumption of diesel is assumed @ one litre per 5 k m.* (2) *Consumption of mobil oil is assumed @ one litre per 140 k.m.* (3) *In column 4, an allowance of 6 k.m. has been provided for movement of truck from parking place to duty spot and back. Cost of diesel Oil shall be corrected according to the current rate.*

Lead in k m	Average speed k m	Number of Trips $N=\frac{8}{\frac{2L}{S}}+1$	k m done 2NL+6	Litres of diesel oil consumed	Cost of diesel oil @Rs. 1·60 per litre	Litres of mobil oil consumed	Cost of mobil oil @ Rs. 8·70 per litre	Cost of 6 Mazdoor @Rs. 10·00 each+ hirecharge Rs. 200·00	Total cost	Cost per Trip	Increase in cost over previous k. m.
				Litre	Rs. P.	Litre	Rs. P.		Rs. P.	Rs. P.	Rs. P.
1	16	7·11	20·22	4·04	6·46	0·14	1·21	60·00+ 200·00 =260·00	267·67	37 64	—
2	17	6·48	31·92	6·38	10·20	0·23	2·00	,,	272·20	42 00	4·36
3	17·50	5·96	41·76	8·35	13·36	0·30	2 61	,,	275·97	46 00	4·30
4	18	5·51	50·32	10·05	16·08	0·36	3·13	,,	279 21	50·39	4·09
5	18·5	5·19	57·90	11·58	18·52	0·41	3·56	,,	282·08	54·35	3 96
6	19	4·90	64·80	12·96	20·73	0·46	4·00	,,	284·73	53·10	3·75
7	19·5	4·66	71·24	14·25	22·80	0·51	4·43	,,	287·23	61·63	3 53
8	20	4·44	77 03	15·40	24·64	0·55	4·78	,,	289·42	65·18	3·55
9	20·5	4·26	82·68	16·54	26·46	0·59	5·13	,,	291·59	68 44	3·26
10	21	4·10	88·00	17·60	28·16	0·63	5·48	,,	293·64	71 61	3 17
11	21·5	3·94	92·90	18 58	29·72	0·66	5·74	,,	295·46	74·98	3·37
12	22	3·82	97·91	19·58	31·32	0·70	6·09	,,	297·41	77·85	2·87
13	22·5	3·71	102·45	20·48	32·76	0·73	6·35	,,	299·11	80 62	2·77
14	23	3·60	106·80	21·36	34·17	0·76	6·61	,,	300 78	83·55	2·93
15	23·5	3·50	111·20	22·25	35·60	0·80	6 96	,,	302·56	86·44	2·89

CHAPTER XII

ESTIMATING OF QUANTITY OF MATERIALS

12-1. A Jail compound wall.—Calculate the quantities of brick, sand, cement and brick ballast that may be required to construct a Jail compound wall as shown in the fig. 12-1 for 100m in length.

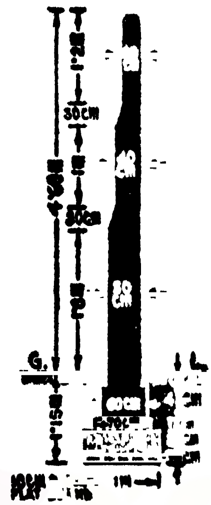


FIG. 12-1

General specification are as follows :—

Cement concrete in foundation (1 : 3 : 6) with brick ballast should be laid over a brick flat soling. Brickwork in wall should be I-class in cement mortar (1 : 4 finished smooth with 12mm thick cement plaster (1:4) all round from 15cm below G.L.

Quantity of work :—

Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1. **Brick flat soling**	1	100	1·00	—	100	100 sq m	
2. **Cement concrete** 1:3:6) in foundation	1	100	1·00	1·15	115	115 cu m	
3. **Brickwork in cement motar (1:4)**							
(a) Below G. L.—							
1st footing ...	1	100	·70	·15	10·50		
2nd footing ..	1	100	·60	·45	27·50		Chamfer is to be considered as if square
50cm layer	1	100	·50	·15	7·50		
(b) Above G. L.—							
50cm layer ...	1	100	·50	2·10	105·00		
40cm layer ...	1	100	·40	1·30	52·00		
30cm layer ..	1	100	·30	1·20	36·00		
						238·00 cu m	
4. **12mm thick cement plastering** (1:4							
Battered side ...	1	100	—	4·79	479		4·79=·15 (below G.L.)+1·8+1·0 +1·2+2×·32
Inner side	1	100	—	4·75	475		
Top ..	1	100	·30	—	30		$·32=\sqrt{(·10)^2+(·30)^2}$
						984	sq m

Quantity of Materials :—

Particulars	MATERIALS REQUIRED				
	1-class bricks	2-class bricks	Cement	Sand	Brick ballast
1. For brick flat soling, 100 sq m @ 5000 Nos. bricks (metric), 3·5 cu m sand } per 100sqm	—	5000nos.	—	3·5 cu m	—
3. For cement concrete (1 : 3 : 6) 115 cu m @ 1·6 cu m cement, 4·8 cu m sand, 9·6 cu m brick ballast } per 10 cu m	—	—	18·40 cu m	55·2 cu m	110·4 cu m
3. For brickwork in cement (1:4). 238 00 cu m @ 5000 Nos. bricks (metric), 0·50 cu m cement, 2·80 cu m sand } per 10 cu m	1190nos.	—	16·65 cu m	66·6 cu m	—
4. 12 mm thick cement plaster 984 sq m @ 0·38 cu m cement, 1·50 cu m sand } per 100 sq m	—	—	37·40 cu m	15 0 cu m	—
Total amount=	11900 Nos.	5000 Nos	72·48 cu m	140·3 cu m	110·4 cu m

12-2. R.C.C. underground Reservoir.—Find out the quantities of cement and sand required for the construction of the R C.C. underground reservoir as shown in the attached drawing. See Fig. 12-2.

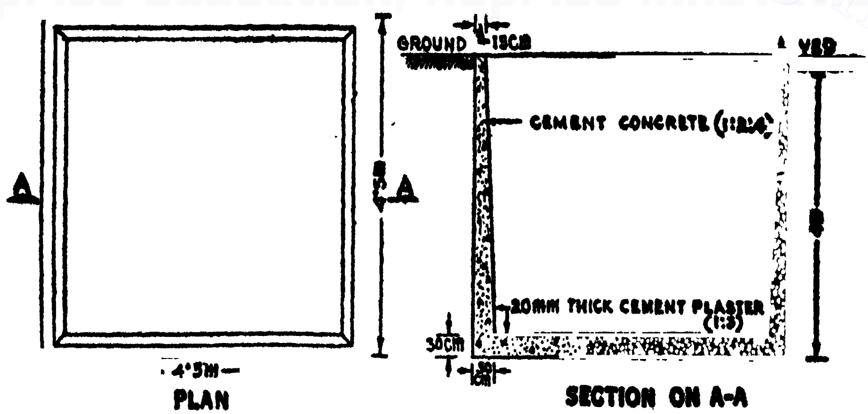


FIG. 12-2

Details of Measurement and Calculation of Quantities Art 12-2

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Cement concrete (1:2:4)							
	(a) Base slab (outer to outer)	1	4·5	4·5	·30	6·08		
	(b) Vertical slabs (considering without any tapering first)	4	$\frac{4{\cdot}5+3{\cdot}9}{2}$	·30	3·7	18·65		Av. length = $\frac{4{\cdot}5+3{\cdot}9}{2}$
	Less tapering	4	$\frac{4{\cdot}2+3{\cdot}9}{2}$	$\frac{{\cdot}15}{2}$ (av)	3·7	4·50	(-ve) 20·23 cu m	
2.	20mm thick cement plaster (1:3), for inside and top only							
	Base	1	3·9	3·9	—	15·2		Ht. of inclined side may also be calculated as 3·71m. But has been considered 3·7m.
	Sides	4	$\frac{4{\cdot}2+3{\cdot}9}{2}$	—	3·7	59·9		
	At top	4	$\frac{4{\cdot}5+4{\cdot}2}{2}$	·15	—	2·6	77·7 sq m	

Calculation and Quantity of Materials (Art. 12-2)

Particulars of items and basis of calclation of materials	MATERIALS REQUIRED: Cement	Sand	Stone chips
1. For cement concrete (1:2:4) 20·23 cu m			
@ 2·2 cu m cement, 4·4 cu m sand, 8·8 cu m stone chips } per 10 cu m	4·45 cu m	8·90 cu m	17·80 cu m
2. For 20 mm thick cement plastering (1:3) 77·7 sq m			
@ 0·82 cu m cement, 2·46 cu m sand } per 100 sq m	0·64 cu m	1·92 cu m	—
Total amount...	5·09 cu m = 152·7 bags	10·82 cu m	17·80 cu m

12-3. Counterfort Retaining wall. – Fig. 12-3 shows part elevation and section of a counterfort retaining wall, calculate the quantities of stone chips, and cement required to complete the R.C.C. work for a length of 3·7m. The proportion of concreting is 1 : 2 : 4.

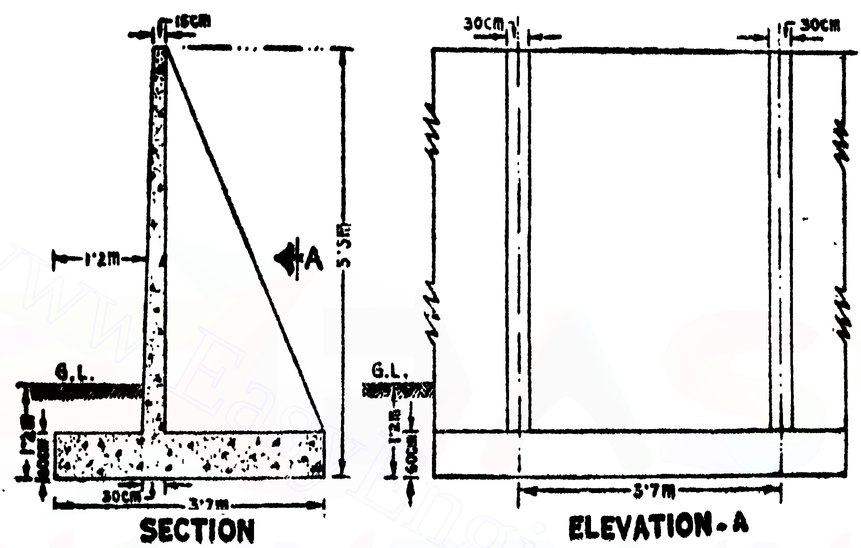


FIG. 12-3

Details of Measurement and Calculation of Quantities (Art. 12-3

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
	Cement concrete (1:2:4)							
1.	Base slab ..	1	3·7	3·7	·60	8·21		
2.	Vertical slab ..	1	3·7	$\frac{\cdot30+\cdot15}{2}$	4·9	4·08		
3.	Counterfort rib ..	1	$\frac{1}{2}$×2·2	·30	4·9	1·62	13·91	2·2=3·7–1·2–·30 cu m.

Calculation and Quantity of Materials :

For 1 : 2 : 4 mixture metarials required per 10 cu m @

Cement=2·2 cu m
Sand=4·4 cu m
Stone chips=8·8 cu m

∴ For 13·91 cu m materials required

$$\text{Cement}=\frac{2\cdot2}{10}\times13\cdot91=3\cdot06 \text{ cu m}=91\cdot8 \text{ bags}$$

Sand=3·06×2=6·12 cu m
Stone-chips=3·06×4=12·24 cu m

12.4. Surface drain—Fig. 12-4 shows the plan of outer line of a building and section of surface drain to be construced all round the building. Calculate the quantities of cement, sand, brick ballast and bricks that may be required to construct the entire work.

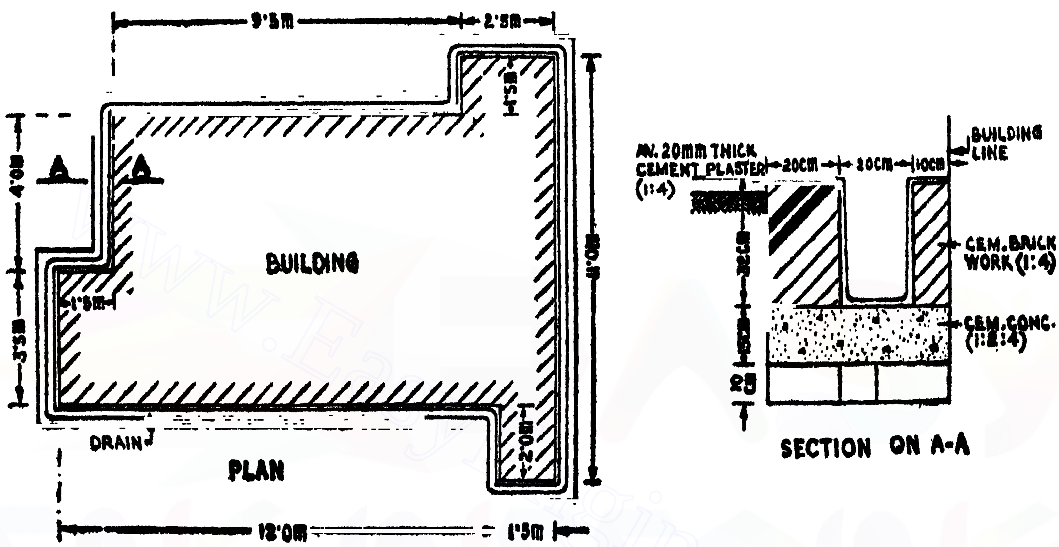


FIG. 12-4

To calculate the length of surface drains :—

Studying this closed traverse figure we reveal that entire front=entire back and also entire left hand side=entire right hand side.

(a) Centire line of drain channel, back or front $=(12m+1{\cdot}5m)+2\left(10cm+\frac{20cm}{2}\right)=13{\cdot}90m$

Entire left or rigit side .. $=11{\cdot}0m+2\left(10cm+\frac{20cm}{2}\right)$ ... $=11{\cdot}40m$

∴ Total length of drain channel $=2(13{\cdot}90+11{\cdot}40)$ ... $=50{\cdot}60m$

(b) Thus, Centre line of 10cm side of drain$=2[(13{\cdot}5+2\times5cm)+(11m+2\times5cm)]$ $=49{\cdot}4m$

(c) Centre line of 20cm side of drain

$$=2\left[\left\{13{\cdot}5+2\left(10cm+20cm+\frac{20cm}{2}\right)\right\}+\left\{11m+2\left(10cm+20cm+\frac{20cm}{2}\right)\right\}\right] \quad =52{\cdot}2m$$

(d) Centre length for concrete work and brick flat

$$=\left[\left\{13\cdot5\text{m}+2\left(\frac{10\text{cm}+20\text{cm}+20\text{cm}}{2}\right)\right\}+\left\{11\text{m}+2\left(\frac{10\text{cm}+20\text{cm}+20\text{cm}}{2}\right)\right\}\right]=51\cdot0\text{m}$$

Details of Measurement and Calculation of Quantities (Art. 12-4)

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	Brick flat soling ..	1	51·0	·50	—	25·5	25·5 sq m	
2	Cement concrete (1:2:4) with brick ballast	1	51·0	·50	·15	3·83	3·83 cu m	
3.	Brickwork (1:4) in 20cm layer	1	52·2	·20	·30	3·13	3·13 cu m	
4.	10cm thick brickwork (1:4)	1	49·4	—	·30	14·82	14·82 sq m	
5.	20mm thick cement plaster (1:4)							
	(a) Within drain	1	50·6	·80	—	40·5		80=·20+2×·30
	(b) Top of 10cm side	1	49·4	·10	—	4·9		
	(c) Top of 20cm side	1	52·2	·20	—	10·4		
							55·8 sq m	

Calculation Quantity of Materials (Art. 12-4)

Paticulars of items and basis of calculation of items		MATERIALS REQUIRED 1-class bricks	2-class bricks	Cement	Sand	Brick ballast
1. For brick flat soling, 25·5 sq m. @ 5000 nos. bricks (Metric), 3·5 cu m sand	per 100 sq m	—	1,275 nos	—	0·89 cum	
2. For cement concrete 1:2:4, 3·83 cum@ 2·25 cu m cement, 4·5 cu m sand, 9·00 cu m brick ballast	per 10 cu m	—	—	0·86 cum	1·72 cum	3·44 cu m
3. For brickwork (1:4), 3 13 cu m @ 5,000 nos. bricks (Metric), 0·7 cu m cement, 2·8 cu m sand	per 10 m	1 565 nos	—	0·22 cum	0·88 cum	—
4. For 10 cm brickwork (1:4) 14·82sq m @ 5,000 nos. bricks, 0·7 cu m cement, 2·8 cu m sand	per 100 sq m	741 nos	—	0·10 cum	0·40 cum	—
5. 20mm thick cement plaster (1:4) 55·8sq m 0·8 cu m cement, 2·4 cu m sand (0·2cum for neat cement)	per 100 sq m	—	—	0·45 cum	1·33 cum	—
Total=		2300 nos	1,275 nos	1·63 cum 48·9 bags	8·46 cum	3·[illegible] cu m

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12.5. Abutment wall—Estimate the quantities of bricks, stone chips, sand and cement as required to construct one abutment wall for a length of 10m as shown in the fig. 12·5. Bricks for soling should be 2nd class.

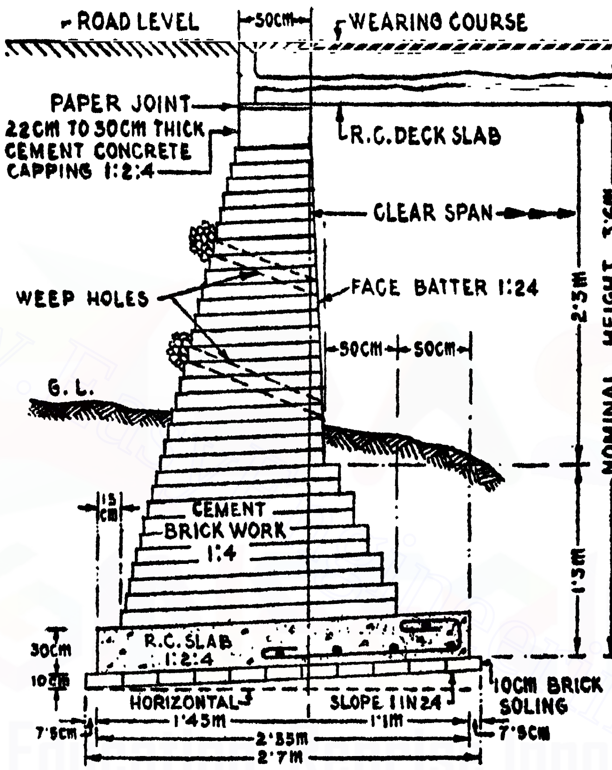

FIG. 12·5

Details of Measurement and Calculation of Materials (Art. 12·5)

Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
1.	10cm Brick flat soling	1	10·0	2·703	—	27·03	27·03 sq m	$2{\cdot}703 = \sqrt{(2{\cdot}7)^2 + ([illegible])^2}$
2.	R.C.C. work in foundation slab (1:2:4)	1	10·0	2·553	·30	7·66	7·66cu m	
3.	Cement concrete capping (1:2:4)	1	10·0	·50	$\frac{\cdot 22+\cdot 30}{2}$	1·30	1·30cu m	

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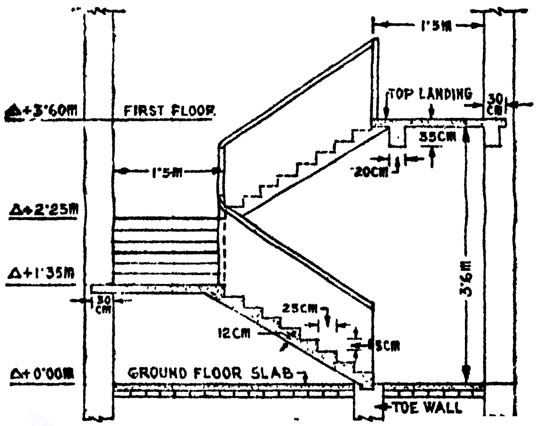
Item No.	Description	No.	L. m	B. m	H. m	Qu.	Total	Explanatory notes
4.	Brickwork in cement mortar (1:4)							
	(a) Left side trapezium portion (with top & bottom horizontal) ...	1	10·0	$\frac{\cdot 53+1\cdot 3}{2}$	·30	27·45		Capping considered 30cm throughout. Offset at left side be 3 cm.
	(b) Right side bottom trapezium (with top & bottom horizontal upto 90cm above R.C. slab) ...	1	10 0	$\frac{\cdot 60+\cdot 20}{2}$	·10	4·00		·60=1·1—·50 ·20=1·1—(·50+·50)+$\frac{\cdot 50}{5}$, 5no. of offset each $\frac{\cdot 50}{5}$.
	(c) Triangular portion above the trapezium of (b) ...	1	10·0	$\frac{\cdot 10}{2}$	2·0	1·00		2·0=2·3—·3(for capping).
	(d) Trapezium portion at base (left out when considered horizontal) ...	1	10·0	$\frac{1}{2}(\frac{\cdot 50}{54}+\frac{20}{24})$	2·40	1·45	33·90 cu m	2·4=2 55—·15

CALCULATION AND QUANTITY OF MATERIALS (Art. 12-5)

Particulars of items and basis of calculation of materials.	MATERIALS REQUIRED 1-class bricks	2-class bricks	Stone chips	Sand	Cement
1. For brick flat soling 27·03 sq m. @ 5000nos. bricks (metric), 3·5cu m sand } per 100sq m	—	1352 nos.	—	0·49cu m	
2. For R.C.C. work in foundation slab (1 : 2 :4) 7·66cu m. @ 2·2 cu m cement, 4·4 cu m sand, 8·8 cu m stone chips } per 10 cu m	—	—	6·8cu m	3·40 cu m	1·68cu m
3. Cement concrete coping (1:2:4) 1·30 cu m @ same as (2)	—	—	1·16cu m	0·58cu m	0·29cum
4. Brickwork in cement mortar (1:4) 33·90 cu m@ 5000 nos. bricks (metric), 0·7cu m cement, 2·8 cu m sand } per 10cu m	16950 nos.	—	—	9·48cu m	2·37cu m
Total=	16,950 nos.	1 352 nos.	7.96cu m	14·40cum	4·34cu m =130bags



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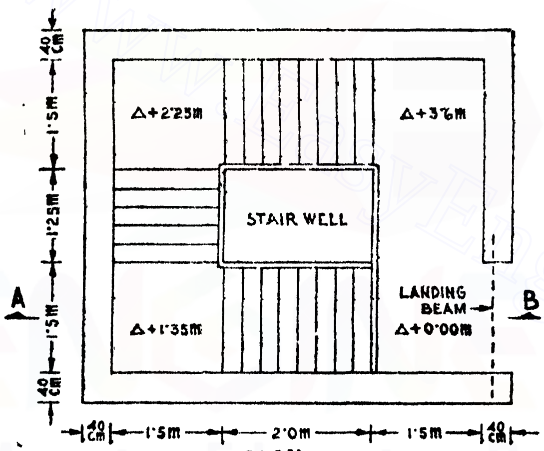

PLAN

FIG.12-6

12-6. Staircase—Plan and section of a R.C. stair supported at ends of flights has been shown in the fig. 12-6 after omitting the reinforcements. Estimate the quantities of stone-chips, sand and cement as *required for 1 : 2 : 4 proportion* to construct this portion of work. Webs of beams those have been shown in the fig. are not to be considered, but entire top landing having a length of 4·25m is to be provided in the estimate.

Volume of concrete for :—

(*a*) *12cm thick slab—*

First and last flights—

$= 2\sqrt{(2{\cdot}0m)^2 + (1{\cdot}35m - {\cdot}12m)^2} \times 1{\cdot}5\,m \times 12cm = 0{\cdot}423$ cu m

For turn landings with 30cm bearing in walls—

$= 2(1{\cdot}5m + 30cm) \times (1{\cdot}5m + 30\,cm) \times 12\,mc = 0{\cdot}778$ cu m

Entire top landings—

$1 \times 4{\cdot}25m \times (1{\cdot}5m + {\cdot}30m) \times 12cm = 0{\cdot}918$ cu m

(b) *Steps triangular in shape* (21 nos in all)

$21 \times {}^{25cm} \times 15cm \times 1{\cdot}5m$

$= 0{\cdot}589$ cu m

$\therefore$ Total Volume $= 2{\cdot}708$ cu m

Say $2{\cdot}71$ cu m

CALCULATION AND QUANTITY OF MATERIALS

	Cement required	Sand required	Stone chips required
Cement concrete 1:2:4 2·71 cu m @ 2·2 cu m cement } per 4·4 cu m sand } 10 cu m 8·8 cu m stone chips	$\frac{2{\cdot}2}{10} \times 2{\cdot}71$ $= {\cdot}060$ cu m	$0{\cdot}60 \times 2$ $= 1{\cdot}20$ cu m	$0{\cdot}60 \times 4$ $= 2{\cdot}40$ cu m

Example —1. The abstract of estimate for a certain work shows the following quantities for some of the items. Prepare the material statement for different materials required for the work.

First class brickwork in 1:6 cement mortar	=	250m³
Pointing outside of brickwork in 1:2 cement mortar ...	=	650 m²
13mm cement plastering in 1:4 cement mortar for inside brickwork	=	750m²
White-washing of plaster work—3 coats	=	750m²
R.C.C. 1:2:4) work in slabs with 1% steel ...	=	50m³ (A.M.I.E. 1981)

CALCULATION OF MATERIALS (EX.1)

Item No.	Particulars of items and basis of calculation of materials	Bricks 1—Class	Cement	Sand	Stone chips 20 mm down	Mild Steel	Stone Lime
1.	First class brickwork in (1:6) cement mortar = 250m³ @ 5000 nos. Bricks per 10³; 0·5 cu m cement, 3·0 cu m sand (dry mortar = 3·5 cu m)	$\frac{5000}{10} \times 250$ = 1,25,000 nos.	$\frac{0·5}{10} \times 250$ = 12·50 cu m	$\frac{3·0}{10} \times 250$ = 75·00 cu m (medium)	—	—	—
2.	Pointing outside of brickwork in 1:2 cement mortar = 650m² @ 0·21 cu m cement, 0·42 cu m sand per 100m² (dry mortar = 0·63 cu m)	—	$\frac{0·21}{100} \times 650$ = 1·365 cu m	$\frac{0·42}{10} \times 650$ = 2·73 cu m (medium)	—	—	—
*3.	13mm cement plastering in 1:4 cement mortar for inside brickwork = 750m² @ 0·42 cu m cement, 1 68 cu m sand per 100m² dry mortar = 2·1 cu m)	—	$\frac{0·42}{100} \times 750$ = 3.150 cu m	$\frac{1·68}{100} \times 750$ = 12·60 cu m (medium)	—	—	—
4.	White-washing of plaster work 3 coats = 750m² @ 30 kg stone lime, 0·15 kg gum per 100m²	—	—	—	—	—	$\frac{30}{100} \times 750$ = 225 kg. cum = $\frac{0·15}{100} \times 750$ = 1·12 kg
5.	R.C.C. (1:2:4) work in slab with 1% reinforcement = 50³ @ 8·8 cu m stonechips, 4·4 cu m sand, 2·2 cu m cement per 10m³	—	$\frac{2·2}{10} \times 50$ = 11·00 cu m	$\frac{4·4}{10} \times 50$ = 22 cu m (coarse)	$\frac{8·8}{10} \times 50$ = 44 cu m	$50 \times \frac{1}{100}$ = 0·50 cu m	—
	Total =	1,25,000 nos.	28·015 cu m; $\frac{28·015}{0·0347}$ = 807 bags	90·33 cu m; 22·00 (course)	44 cu m	0 50 cum = 0·50 × 7850 = 3925 kg	225 kg; gum = 1·12 kg.

Material Statement :—

1. Brick 1-Class ... 1,25,000 nos
2. Cement ... 807 bags
1. Sand (coarse) ... 22·00 cu m
4. Stand (medium) ... 90·33 cu m
5. Stone chips 20mm down ... 44 cu m
6. Mild steel ... 39·25 qu
7. Stone lime ... 225 kg
8. Gum ... 1·12 kg

* **Note:**—*For 13mm cement plastering in 1:4 cement mortar :— For 100 sqm vol. of wet mortar = 100×0·013 = 1·3 cu m. Increase 20% for filling depressions etc.* = 1·3 + 1·3 × ⅕ = 1·56 *cu m (wet). For dry volume increase the quantity by one-third* = 1·56 × ⅓, = 2·08 *say* .21 *cu m.*

CHAPTER XIII

SPECIFICATION

13-1 What is Specification ? A specification is a specific description of a particular subject. An engineering specification contains detailed description of all workmanship and materials which are required to complete an engineering project in accordance with its drawings and details. The technical drawings of a structure will show the proportions and relative positions of the various components of the structure. Many a time it is not possible to furnish the information on the drawings, regarding the quality of materials to be used and the quality of workmanship to be achieved during construction, due to shortage of space. This data regarding the materials and workmanship is conveyed in a separate contract document which is known as the "specifications" for the work. Thus the drawings with the specifications "will completely define the structure". This "specification" is furnished separately along with drawings and is an essential part of all engineering contracts.

13-2 Necessity of Specifications :—The necessity of specifications are the following :—

(i) The cost of an unit quantity of work is governed by its specification.

(ii) Specification of a work is required to specify the quality and quantity of different materials required for a construction work and is one of the essential contract documents. Thus a contractor can make a program to procure the materials required for a project as well as the owner can check the quality of materials confirming the specification avoiding dispute with the contractor.

(iii) This also specifies the workmanship and the method of doing the work. Thus specification of a work serves as a guide to the supervising staff of the contractor as well as the owner to execute the work with their satisfactions.

(iv) A work is carried out according to its specification and the contractor is paid for the same. Any change in specification changes the tendered rate.

(v) As the rate of a work is based on specification a contractor can calculate the rates of various items of works in a tender with his procurement rates of materials and labour. Thus tender paper without specifications of works is baseless.

(vi) Specification is necessary to specify the equipments, tools and plants to be engaged for a work and thus enables to procure them beforehand.

(vii) The necessity of specification is to verify and check the strength of materials for a work involved in a project.

(viii) Specification is an essential contract document and is required for Arbitration or court cases.

13-3. How to write specification ? While writing a specification endeavours should be made to express the requirements of the specifications clearly and in concised form, avoiding repetition and unusual words. Ambiguous terms such as 'suitable', 'proper' etc. should be avoided. As far as possible, the clauses should be arranged in the order in which work will be carried out. This does not mean to follow the works according to the order of arranging but it facilitates reference.

Specifications depend upon the site conditions, the nature of work and the purpose for which the work is carried out.

Students should practise drawing up clauses for imaginary work, introducing as many new clauses as possible in the specification. It is only practise by which they will acquire the necessary skill to write well phrased clauses.

13-4. Types of Specifications.—The specifications are broadly divided as two types—

(*a*) *General specifications*. (*b*) *Detailed specifications*.

(*a*) *General specifications* :—In general specifications, nature and class of works and names of materials that should be used are described. Only a brief description of that every item is given. It is useful for estimating the project. The general specifications do not form part of the contract document.

(*b*) *Detailed specifications* :—The detailed specifications form a part of the contract document. They specify the qualities, quantities and proportions of materials, and the method of preparation and execution for a particular item of works in a project. The detailed specifications of the different items of the work are prepared separately and they describe what the work should be and how they shall be executed and constructed. While writing the detailed specifications the same order of sequence as the work is to be carried out is maintained.

13-5. General Specification of a first Class Building—

(*a*) *Foundation and plinth* :—Brickwork in foundation and plinth shall be of the first class brick in cement or lime mortar over cement or lime concrete.

(*b*) *Filling* :—Foundation trenches and plinth shall be filled up with coarse sand.

(*c*) *Damp proof course* :—D.P.C. shall be 2·5 cm thick cement concrete or 2 cm thick cement mortar with 5% pudlo by weight of cement or other standard water proofing material.

(*d*) *Superstructure* :—Superstructure shall be of the first class brickwork in cement mortar.

(*e*) *Roofing* :—The roof shall be 10cm R.C.C. slab with 10 cm average lime terracing over it.

(*f*) *Flooring* :—Mosaic flooring shall be provided in drawing room, dining room, bath room and W.C. Bed room floors shall be coloured and polished. Floors of others shall be 2·5 cm cement concrete over 7·5 cm lime concrete, polished.

(g) *Finishing* :—Inside and outside shall be 12mm cement plastered. The inside of drawing, dining and bed rooms shall be distempered and the rest portions white washed three coats. The outside shall be colour washed over three coats of white wash.

(h) *Doors and windows* :—Doors and window frames shall be of seasoned teak wood and shutters of 3cm thick teak wood panelled. Brass fittings shall be provided. Doors and windows shall be varnished with French polish.

(i) *Miscellaneous* :—Rain water pipes shall be of Asbestos cement or cast iron, finished with paint. All sanitary, water-supply and electrical fittings shall be of first class materials.

13-6. General Specification of a second class Building.—

(a) *Foundation and plinth* :—The brickwork in foundation and plinth shall be of 1st class brick with lime mortar over lime concrete.

(b) *Filling* :—Foundation trenches and plinth shall be filled up with earth.

(c) *Damp proof Course* :—D.P.C. shall be 2cm thick cement mortar with 5% pudlo by weight of cement or other standard water proofing materials.

(d) *Superstructure* :—Superstructure shall be of 2nd class brickwork in mud mortar.

(e) *Roofing*:—The roofing shall be flat terraced roof or Jack arch roof or R.B. roof.

(f) *Flooring* :—The flooring shall be 2·5 cm cement concrete over 7·5 cm lime concrete.

Finishing :—The inside walls shall be plastered with lime or cement mortar, outside walls shall be pointed or plastered with lime or cement mortar. Inside shall be white washed three coats, and outside colour washed two coats over one coat of whitewash.

Doors and windows :—Door and window frames shall be of well seasoned sal wood and shutters of 4·5 cm shisham or deodar wood, panelled. They shall be fitted with iron fittings. Doors and windows shall be painted with two coats.

Miscellaneous :—Rain water pipes shall be of cast iron. Electrification, sanitary and water supply fittings may be provided.

13-7. First-class Bricks :—Bricks should be moulded from good earth free from all traces of salt-petre or other salts. They should be of uniform deep-red, cherry or copper colour, thoroughly burnt without being vetrified. They should be hard, sound and of uniform sizes and shape having each two adjacent plane surfaces at true right angles. The bricks should be free from cracks, chips, flaws, stones, or humps of any kind. They should not show any signs of efflorescence either in dry state or after soaking in water. They shall be homogeneous in texture and emit a clear ringing sound on being struck. Dry bricks should not absorb more than one-sixth of their weight when immersed in water for one hour. They should not break when two bricks in two hands are struck together or when dropped from breast height on the ground.

Bricks should be of standard dimensions as per I. S. I. (19cm×9cm×9cm) or as prescribed by the Public Works Department.

13·8. Cement:—The cement used for reinforced concrete works shall be ordinary portland cement or rapid-hardening portland cement conforming to I. S. 269-1958 or blast furnace slag cement conforming to I.S. 455-1962 or high alumina cement of approved specifications. The minimum tensile strength of ordinary portland cement as per I.S. 269 (1958) should be 175 kg/cm² after 7 days and the minimum tensile strength after 7 days should be 25 kg/cm². The initial setting time should not be less than 30 minutes and the final setting time should not be more than 10 hours.

13·9. Sand:—The fine aggregate (sand) shall conform to either I.S. 383-1963 or I.S. 515-1959. It shall be clean, sharp, heavy and gritty to touch. Sand should be free from clay, mica, vegetable and organic matter or any other foreign matter. River and pit sand should be used as this does not contain common salt in large quantities. Sand must be cleaned by screening before its use. If a sample of sand contains more than 4 to 6 percent of clay it should be washed thoroughly. Sand should be perfectly dry before it is used. Otherwise the bulking effect of sand must be taken into account.

Sand for all cement concrete works must be coarse. It should not pass through I. S. sieve No. 480 (approximately 4·75mm) and retain on No. 15 sieve (5·5mm). The fineness modulus of coarse sand shall be determined by taking 500gms. of it from a representative sample of sand and passing it successively through I.S. sieves No. 480. No. 240. No. 120. No. 60. No. 30 and No. 15.

Medium sand may be used in cement mortar for masonry, plastering, pointing etc. and bituminous works of road. Sand filling in plinth, where specified may be done with fine sand. The fineness modulus of fine sand should not be less than one.

13·10. Water :—In concrete works the water used for both mixing and curing shall be free from injurious amounts of deleterious materials. Potable waters are generally considered satisfactory for mixing and curing concrete.

13·11. Lime :—(a) *Quick lime or white lime* : This should be obtained by burning pure lime stone, chalk or sea-shells, in a kiln. The burning should be done with coal, charcoal or fire-wood as fuel, but it should not be with cow-dung. After burning the pieces of stones should be picked up to exclude ash and over or under burnt pieces. Lime which has been damaged by rain, moisture, dirt etc, shall not be used. The lime should be slaked thoroughly on a brick platform. Unslaked lime must be kept in air tight vessels. Slaked lime should be packed in gunny bags, and stored in dry places so that this may not absorb moisture from the air. All lime that has been damaged by rain or moisture or dust should be rejected. Unslaked white lime weighs 214 kg/cu m. The tensile strength of briquettes after 24 hours curing by immersion in water should be 12·8kg/sq cm.

(*b*) *Hydraulic or kankar lime* : This should be obtained by burning broken kankar or clayey lime stones 5cm gauge and free from sand grains. The burning should be done with coal, charcoal or fire wood as fuel but not with cow-dung. After burning the pieces of kankar should be picked up to exclude ash and over or underburnt pieces. Slaking should be done on a brick platform. Only just enough water should be added as excess of water will harden it and make it useless. Slaking should be done just before use and not immediately after burning. The tensile strength of briquettes after 24 hours curing by immersion in water should be 7 kg/sq. cm.

13·12. Reinforcement :—The reinforcement shall be of mild steel and medium tensile steel wire, conforming to I.S. 432—1960 or cold twisted steel bars conforming to I.S. 1786 1961 or deformed steel bars conforming I.S. 1139-1959.

All reinforcement shall be clean and free from loose mill-scales, dust, loose rust and coats of paints, oil or other coatings which may destroy or reduce bond.

Welded joints in reinforcement may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcement shall be done in accordance with the recommendations of relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction.

13·13. Storage and Handling of Materials :— (According to the recommendation of the National Building Code of India)

(a) **Cement** :—Cement bags shall be placed in stacks on raised platforms, dry and impervious to water and at least 30cm clearance from any wall. The stacks shall not be more than 12 bags high to prevent lumping of cement under pressure as also chances of injury to any workman.

Where bulk handling of cement is undertaken protective masks shall be provided for the workmen.

(b) **Lime** :—Lime shall be stored in a suitable shed to protect it from dampness. It should not be stacked against a wall of a shed.

Quick-Lime shall, as far as possible be stacked soon after it is received. Storage of unslaked fat or semi-hydraulic lime is not desirable as lime deteriorates by absorption of moisture from atmosphere.

(c) **Brick** :—Bricks shall not be dumped at site. They shall be stacked on level ground in regular tiers directly as they are unloaded to minimize breakages and counting of bricks. It is preferable to limit the height of stacks to 1·5m.

(d) **Fine Aggregate** :—Fine aggregate like Sand, Cinder and Surkhi shall preferably be stacked in regular stacks on a hard surface or platform so as to prevent the admixture of clay, vegetable and other foreign matter.

(e) **Coarse Aggregate** :—Coarse aggregates shall be stacked in regular stacks in such a way as to prevent the admixture of vegetable and other foreign matters.

(f) **Steel** :—Steel reinforcement shall be stored in a way as to prevent distoration and corrosion. Bars of different classification, sizes and lengths shall be stored separately to facilitate issues. In case of long storage or in coastal areas, reinforcement bars shall be stacked above ground level by at least 15 cm to prevent scaling and rusting.

13-14. Earthwork in excavation of foundation trenches :—

(1) Before the earthwork is started, the whole area where the work is to be done shall be cleared of grass, roots of trees and other organic matter.

(2) The excavation shall be carried out exactly in accordance with the dimensions shown on the drawings or such other dimensions as the Engineer-in-charge may decide.

(3) Sides of the trenches shall be vertical and its bottom shall be prefectly levelled, both longitudinally and transversely. Where the soil is soft, loose or slushy the trench shall be widened by allowing steps on either side or the sides sloped or shored up.

(4) During excavation if rocks or rocky soils are found it shall be levelled as far as possible and the small spaces which are difficult to level shall be filled in with concrete.

(5) If the excavation is in earth, the bottom of the trenches shall be sprinkled with a little water and rammed. Any excess digging or any patches of bad soil or hollows shall be removed by placing concrete or any other special treatment as the Engineer-in-charge decides.

(6) No material excavated from foundation trenches, shall be placed than one metre to the outer edges of the excavation.

(7) Water in trenches must be bailed or pumped out and where it is apprehended that the sides may fall down arrangement shall be made for adequate timber shoring.

(8) When it is specified that the work is to be carried out without removing pipes, cables, sewers, etc. all of them shall be temporarily shored and saved from any damages.

(9) The materials or valuables found during excavation shall be the property of the Government.

(10) The cost of all materials and labour required for fencing in and protecting against risk of accidents due to open excavation shall be provided

13-15. Brick Soling in Foundation trenches—

(1) Picked Jhama or second class bricks in dry condition shall be laid on the foundation bed as headers with frogs upwards.

(2) All bricks shall be laid closely with brake joints and the small gaps between them shall be filled up with local fine sand or dry loose earth.

(3) Brick bats which are permitted to be used only to provide brake joints, shall be placed at the edges of trenches.

13-16. Lime concrete in foundation—(*a*) *Materials* (i) Coarse aggregate shall be obtained by breaking good quality overburnt or well burnt brick bats, must not be spongy or with any signs of saltpetre or any coating of foreign materials and homogeneous in texture. The ballast shall be of more or less cubic in shape, free from dust, dirt and any other foreign matters. It shall pass through 32 mm dia ring and well graded.

(ii) Fine aggregate shall be surki (may also be sand or cinder if specially mentioned, but surki is preferred for better concrete) made from well burnt first class brick bats ground to pass through a mesh 1·5mm each way and shall be perfectly clean and free from any foreign matter.

(iii) Lime shall be freshly burnt, slaked and screaned before use. The slaking shall be done at site of work. If not otherwise specified stone lime shall be used.

Besides these the materials that are in use shall be of standard specifications.

(b) *Proportioning*—Usual proportions of coarse aggregate, surki and lime shall be 100 : 36 : 18 unless otherwise specified. While measuring the materials by boxes, shaking, ramming or hammering shall not be allowed.

(c) *Mixing*—The mixing shall be done by hand or mechanical mixer when so specified. Hand mixing shall be done on a clean solid water-tight masonry platform of sufficient size to provide ample mixing area. Brick ballast shall be well soaked with clean water for a period of not less than 3 hours before mixing and shall be stacked evenly on the platform usually not more then 30cm high at a time. Lime and surki in the specified quantities shall be mixed dry till of uniform colour and spread over the stacked ballast. The materials shall then be turned over once without adding water, then at least further three times gradually adding water so that whole surface of each ballast becomes coated with mortar and the mix becomes plastic to give a uniform concrete. Only enough clean water shall be used to render the concrete workable. The consistency of concrete shall be such that the mortar shall not tend to separate from the coarse aggregate. The volume of concrete shall be mixed for the day's work, old and stale concrete shall not be used. In case of machine mixing for large quantity of concrete brick ballast shall be placed at first in the rotating mixing drum which shall be followed by wet mortar in the specified proportion. Water at last shall be added slowly to the required quantity and the drum shall be allowed to turn at least 30 times to give a uniform concrete of workable consistancy.

(d) *Placing of concrete* : Concrete shall be laid (not thrown) in courses of not more than 20cm thick at a time and consolidated by rammers, until the layer is 15cm thick. Weight of rammers shall not be less than 4·5 kg and the area be not more than 220 sq cm. Consolidation shall not be completed until a skin of pure mortar covers surface. In hot season lime water shall be sprinkled on the surface during ramming to keep the concrete wet. No ramming shall be allowed on the next day when the mortar has started setting.

(e) *Joining of concrete* : Where joints in a layer are unavoidable, the end of the layer shall be sloped off with a long slope at an angle of 30 degree and thus the successive coarses shall be laid on it with break joint.

(f) *Test* : Two days after ramming the concrete shall be tested by digging a hole of about 7·5cm deep and 7·5cm in diameter and filled with water. Water level shall not go down to any extent if concrete is well consolidated. Safe compressive stress of concrete shall be 43 tonnes/sq m.

(g) *Curing*—Concrete shall be kept wet with moist gunny bags for at least 7 days and no masonry should be laid on it within this period.

13-17. Cement concrete in foundation or used as sub-grade for flooring—(a) *Materials* (1) Coarse aggregate—The aggregate used shall be the hardest available, such as granite, gravel or broken stone as specially mentioned and free from dust, dirt, soft material, vegetable matter etc. It shall be well graded from 2·5cm down to 10mm. 12% upto 4cm size aggregate is permitted as oversize materials. (2) Fine aggregate shall be of coarse sand, consisting of sharp and angular grains and it shall pass through a size of 5·5mm mesh sieve. It shall be clean and free from dust, dirt and organic matters. Sea sand shall not be used. These shall also follow their standard specifications. (3) Water shall be clean, free from alkali, acid and suitable for drinking purposes. Cement shall be fresh portland cement and conform to the standard specifications.

(b) *Proportioning of concrete* : Proportion of cement, sand, and coarse aggregate shall be 1:2:4 or 1:3:6 or 1:4:8 as specified. Coarse aggregate and sand shall be measured by gauge boxes of suitable size 35×25×40cm while cement shall be taken by bag weighing 50 kg or a volume of 0·035cum. If the sand contains moisture, then bulkage shall be determined at site and the extra quantity of sand so determined shall be added. No extra quantity shall be permitted unless bulkage is determined. As the bulking of sand may vary from day to day and at different parts of the day on account of varying moisture content, frequent tests for bulking shall be carried out with the sand to be used while measuring the aggregate, shaking, ramming or hammering shall not be done.

(c) *Mixing of concrete* : '*Hand mixing*' by batches shall be permitted on small works. Normally all structural concrete of proportion 1:2:4 or 1:3:6 shall be mixed in mixture machine. For small quantity when hand mixing be permitted by the Engineer in-charge extra cement upto 10% over the standard requirement of cement for machine mix shall have to be provided by the contractor at his own cost. The mixing shall be done on a clean water tight masonry, or concrete slab or steel plate platform. Dry coarse aggregate shall be stacked evenly on the platform. Sand and cement in the specified quantities at first be mixed dry till of uniform colour and spread over the stacked coarse aggregate. The materials shall then be turned over once without adding water and then at least further three times gradually and slowly adding water according to the water cement ratio to give a uniform concrete. (2) *Machine mixing* : The coarse aggregate shall be placed at first which shall be followed by sand and cement and be thoroughly mixed together dry in the specified proportion in a batch type mechanical mixer unless otherwise approved. Water will then be added gradually to the required quantity to have the desired water cement ratio. Mixing shall be continued until there is a uniform distribution of the materials and the concrete is uniform in colour and consistency, but in no case shall the mixing be done for less than two minutes after all the materials including water are kept in the drum. The mixed concrete shall be unloaded on a water tight masonry platform or on steel plate. Only such quantity as are required for immediate use are to be mixed at any one time and the entire quantity shall be removed and placed at its position before the initial setting time of cement.

(*d*) *Workability*: Workability of concrete shall be checked at frequent intervals. The slump test or where facilities exist the campaction factor test in accordance with I.S. 1919-1957 shall be adopted for this purposes.

(*e*) *Placing of concrete* : Before proceeding to place the concrete, the brick flat soling shall be well wetted and cleaned. Concrete shall not be dropped from a height or handled in a manner which will cause separation. It shall be laid gently in its permanent position and shall be levelled both transversely and longitudinally. Each layer of concrete while being placed, shall be consolidated by mechanical vibration or by punning with 16mm dia. steel rod and tamping with wooden tampers to form a dense material. All surfaces after consolidation shall be free from air holes, honey combing or any other blemishes. Any water accumulation on the surface of newly placed concrete shall be removed by approved means. Concrete shall be placed continuously till the completion of the part of work between construction joints. For thick foundations the successive layers shall be laid before the immediate lower lawer has set. Before placing new concrete against the concrete that has already set, the face of the old concrete shall be cleaned, wetted, roughened and a coating of neat cement grout (1:1) applied thereto. The interval between adding the water to the dry materials and the completion of the placing of concrete shall not exceed 25 minutes.

(*f*) *Construction joints* : For construction joints in the same layer, the concrete shall be left in a long slope at an angle of 30° and the joints of two successive layer shall be of break joints.

(*g*) *Protection and curing of concrete* : Freshly laid concrete shall be adequately protected, about 1 to 2 hours after its laying, from too rapid drying due to sunshine etc. and also from running of surface water and shocks. After about 24 hours of laying of concrete the surface shall be cured by flooding with water of minimum 25mm depth or by covering with wet absorbent materials. The curing shall be done for a minimum period of 10 days. Over the foundation concrete, the masonry work may be started after 48 hours of its laying, but the curing of cement concrete shall be continued along with the masonry work for a minimum period of 10 days.

In case of cement concrete used as sub-grade for flooring, the flooring may be commenced within 48 hours of the laying of sub-grade. Neat cement slurry at the rate of 2·75kg of cement per square metre shall be applied to the base before laying floor, and will be paid separately. The curing to be continued along with top layer of flooring for a minimum period of 10 days.

13-18. First class Brickwork—(*a*) *Materials* : (1) Brick shall be first class of standard specifications, regular in shape and size with sharp edges. They shall be of uniform deep red cherry or copper colour, free from cracks, chips, flows and lumps of any kind. Dry bricks shall not absorb more than one-sixth of their weight when immerged in water for one hour. Brick shall have a minimum crushing strength of 105 kg per sq cm. (2) For cement mortar, cement shall be fresh portland cement of standard quality. Sand shall be medium coarse, clean, sharp and free from clay, mica or other organic matter. (3) For lime mortar, lime shall be slaked and fresh stone lime screened at work site conforming its standard specification. Surkhi shall be made from first class brick having uniform colour and free from admixture of foreign matter.

(*b*) *Mortar* : The brickwork shall be done with the specified mortar (cement or lime) mixing the ingredients in the specified proportion. Sand shall be measured on the basis of its dry volume. In case of damp sand, its quantity shall be increased suitable to allow for bulkage. Materials of mortar shall be first mixed dry till of uniform colour on a solid clean water tight platform and then mixed wet at least three times by adding water gradually and evenly.

(c) *Bricks before laying* : All bricks shall be thoroughly soaked in water by submerging them in clean water for at least four hours just before use. The wetted bricks shall be staked on a clean platform of wooden planks to avoid any contact with mud.

(*d*) *Laying* : The brick shall be of English bond unless specially mentioned. The brickwork shall be true to line, plumb and solid through with joints not exceeding 6mm in thickness for cement mortar and 10 mm for lime mortar. Each coarse of brick shall be laid quite levelled and perfect in bond well beded with frogs upward and flushed in sound mortar. No bats shall be permitted except where absolutely required for obtaining the specified bond or dimensions of different courses. Brickwork shall be carried out together so as to maintain, as far as possible, uniform height of not more than 1 m at a time. All mortar joints on the surfaces of walls shall be raked to a depth of 12mm in case where the walls are to be plastered while the mortar is green and left clean and free from all loose or adherent mortar by brushing. Mortar of the proper consistency only shall be delivered on the work and subsequent shinning with water if required shall be provided. Very thick or thin mortar shall be remixed. Only fresh mortar within ½ hour for cement and 24 hours for lime mortar from the time of adding water shall be used and no old or stale mortar be allowed in brick joints even remixed. During rains no brickwork shall be carried out unless special arrangements are made to protect the brickwork from rains for 24 hours according to the direction of the Engineer-in charge.

(*e*) *Curing* :—The brickwork shall be protected from rain or sun while it is green. The brickwork shall be kept wet on all the faces for at least 10 days during construction. At the end of day's work troughts shall be formed on the tops of walls by weak cement mortar or by mud edging to a depth of 2·5 cm minimum and be kept flooded with water.

(f) *Scaffolding* :—In all first class building work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together by horizontal pieces, over which scaffolding planks shall be fixed. For other classes of work single scaffolding may be allowed.

13-19. Earthwork in filling :—Each filling of foundation trenches shall be taken up as soon as brickwork has been carried out to the plinth level. The space between the masonry and sides of the foundation trenches shall be cleared of whatever may have fallen therein and shall be filled in with earth. The earth shall be loose and free from brick bats, pieces of stones, and vegetable matters. It shall be deposited in layers not exceeding 15 cm and each layer shall be well watered and rammed before the next layer is spread over it.

13-20. Terrace flooring over brick flat—(a) *Materials*—Brick ballast that will pass through 3 cm dia. ring, surki and lime shall be of their standard specifications. The ingredients shall be mixed at first dry and then wet to the required proportion (100 : 36 : 18 as is usual).

(b) *Preparation of base* : Excess earth or sand that has been thoroughly compacted in the plinth shall be removed to a depth equal to the thickness of the floor to provide room for this. The bed shall then be dressed with required slope of the floor towards its water out let. A layer of second class or picked jhama brick as specially mentioned shall then be laid with break joints and the small gaps between them shall be filled up with local fine sand.

(c) *Placing of concrete*—The concrete shall then be laid to the specified thickness and thoroughly rammed and consolidated in position till the surface is smooth and no further impression can be made. During ramming lime water shall be sprinkled on the surface to keep the concrete wet. Corners and edges where ramming is difficult shall specially be consolidated by wooden battens according to the direction of the Engineer-in-charge. The surface shall be checked frequently with spirit level and wooden straight edge to have a true surface.

(d) *Curing*—The floor shall be kept wet for at least a week.

13-21. Artificial stone flooring—Usual thickness is 2·5 cm. The ingredients are cement, sand and stone chips in the proportion 1: 2:4 or as specified. (This is also known as patent stone flooring when crushed blast furnace slag is used as coarse aggregate).

(a) *Materials*—Coarse aggregate shall be stone chips well graded from 12mm down, free from dust, dirt etc. hard and rough. Sand shall be coarse 5mm maximum size, clean, free from dirt etc. Cement shall be fresh portland cement. All the materials as stated above and water shall comply with their respective standard specifications.

(b) *Preparation of base*—The surface of the lime concrete base shall be thoroughly cleaned and moistened in case it is green or thoroughly hacked and cripped off if it is not green to make the surface rough enough. It shall then be cleaned of all loose particles and dust and shall be saturated with water overnight. The slope desired in the floor shall be provided in the sub-grade.

(c) *Proportioning and mixing*—Usual proportion of cement, sand and coarse aggregate shall be 1 : 2 : 4 or as specially mentioned. The cement and sand shall be at first mixed dry and this dry mixture shall be further mixed with dry coarse aggregate. Required amount of water 32 litres or 7 gallons per bag of cement as per water cement ratio shall be added slowly and gradually to mix the concrete wet. The mixture shall have a slump of not more than 4 cm.

(d) *placing of forms*—Oiled wooden forms of 4 cm width and of same height as specified for the thickness of the floor 20mm minimum to 40 mm maximum shall be laid firmly dividing the whole floor into suitable sections not exceeding 3·3 sq m in area. Alternate panels shall be laid on alternate days.

(e) *Laying and finishing of concrete*—Just before the placing of the concrete the under bed shall be coated with a thin coat of neat cement and sand 1:1. The concrete shall then be placed and spread between the forms, thoroughly compacted to the required thickness. The surface shall then be smoothed with wooden floats. To remove any unevenness a mixture of fine sand and cement in the proportion 1:2 shall be laid on the top of the beaten surface and thoroughly smoothed with wooden floats. The surface shall be frequently tested with spirit level and wooden straight edge to have a true surface. Finally the surface shall be rubbed, sprinkling neat cement to have 1·5mm thick layer and smoothed and brushed to give a shining hard surface. The whole operation of mixing, placing and compacting shall be done within the initial setting time of cement. The floor shall be left undisturbed for 12 hours and after this period it shall be kept wet for at least 7 days.

13·22. Patent stone floor :—The proportion and method of construction is the same as that of the artificial stone floor. The only difference is that the course aggregate shall be of crushed blast furnace slag.

13·23. Mosaic or Terrazoo floor :—12mm thick Terrazzo finish shall be laid monolithic with the under-bed of 12mm thick layer of 1:3 cement and sand mortar. (The mosaic floor may also consist of two layers, the bottom layer or the under-bed of 2 cm thick cement concrete 1 : 2 : 4 and the upper layer of 6mm thick mosaic finish.)

(a) *Materials* : (i) For plastering—Sand shall be clean river sand, coarse, clean, free from dust, dirt and well graded. Cement shall be of portland cement of standard specification, (ii) For mosaic work—Course aggregate shall be of dry, sharp and hard marble chips 6mm down to 5·5mm and shall be free from any foreign matters. Fine aggregate shall be of marble powder and cement may be gray, white or coloured as specified following its standard specification. Water shall be of a quality fit for drinking purposes.

(b) *Proportioning and mixing*—The Terrazzo mixture shall consist of one part of cement of any desired colour $\frac{1}{4}$ part of marble powder and 2 parts of marble chips. Quantity of water shall not be more than 20 litres per bag batch. Cement and marble chips shall at first be mixed dry and this dry mixture shall be further mixed with course aggregate dry.

Required amount of water shall slowly and gradually be added and then thoroughly mixed with the concrete wet.

(c) *Preparation of under bed*—The surface of the base slab shall be cleaned of all loose particles and dust with a steel brush and shall be thoroughly wetted overnight. Just before laying the cement plaster under-bed, a cement sand grout of 1:1 mix shall be broomed into the surface. The under-bed of 12mm thick cement plaster (1:3) of stiff consistency shall then be spread, thoroughly compacted and screened uniformly with a steel brush or broom stick and left rough for the necessary key of the terrazzo finish. While the under-bed is still plastic, the floor shall be divided according to directions into rectangles by strips of brass or aluminium of about 4 cm wide. No rectangles shall exceed 1·5 sq m in area. The top of the strips shall be 12mm above the surface of the under-bed.

(d) *placing and laying*—As soon as the mortar of the under-bed has hardened sufficiently a thin coat of cement, slurry enough and having the same colour as the finish shall be brushed on the under-bed in each rectangles framed by the metal strips. Immediately the terrazzo mixture of the required colour shall be laid tamped and trowelled to an even surface. The whole operation shall be carried out within the initial setting time of the cement i.e. 30 minutes. As soon as floor has hardened to withstand damages to it, it shall be kept wet for at leat 10 days.

(e) *Grinding*—After three days the surface shall be ground down by an approved type of grinding machine or by hand with three approved grades of carbrandum course, medium, fine and finally with pumice stone to a smooth even surface. The floor shall be kept wet during grinding. Any air holes, pits and other blemishes appearing on the surface shall be filled with cement paste composed of $\frac{1}{2}$ part marble powder and 1 part cement having the same colour as has been used in the terrazzo, allowed to harden and ground again.

(f) *Cleaning and polishing*—After the final grinding the floor shall be thoroughly cleaned with warm water and soft soap and when it is absolutely dry shall be polished by rubbing oxalic acid powder with a piece of felt.

13-24. Damp proof course :—D.P.C. of cement concrete should have a mix of 1:2:4 or 1: $1\frac{1}{2}$: 3, usual thickness being 2·5cm to 4cm.

(a) *Materials*—Coarse aggregate shall be of clean, hard and dense stone chips 12mm down and shall be washed before use. Sand shall be clean, sharp and coarse of average 5mm size shall be free from dust, dirt and screened before use. Cement shall be fresh portland cement. All the materials in use including water proofiing compound shall be of their respective standard specification.

(b) *Mixing*—Coarse aggregate and sand shall be measured by volume with gauge boxes and cement by bag having a weight of 50 kg and volume of $\frac{1}{30}$ cu m. Some sample tests of cement bags shall be made at work site to ensure the specified weight and volume. The mixing shall be done on a clean solid platform. Dry coarse aggregate shall be stacked evenly on the platform. Sand and cement in the specified quantities at first be mixed dry till of uniform colour and spread over the stacked course aggregate. The materials shall then be turned over once without adding water and then at least further 3 times, adding the required quantity of water gradually and slowly to give a uniform concrete. Water proofing compound Pudlo or Cico @ 5 or 3 per cent by the weight of cement as specified shall be mixed with concrete to make it water proof.

(c) ***Preparation of base.***—The top of the walls on which damp proof coarse is to be laid shall be constructed with bricks on edge or with the frogs of the bricks down. The top of the plinth bed over which damp proof coarse is to be placed shall be thoroughly cleaned with a steel brush, washed and wetted before laying the course of concrete. Wooden straight edges shall be fixed on plinth wall having the same inner width as that the required width of the D.P.C.

(d) *Laying.*—Damp proof course may be laid to the full width of the plinth or of the superstructure as specified in the drawing or specially mentioned. It shall be laid to the specified thickness (2·5 cm or 4 cm) over the plinth wall flushing with the floor surface and shall not be carried across the doorways or such other openings. D.P.C. shall then be consolidated by tamping and levelled both longitudinally and transversely. Laying shall be completed in same day ; the joints or breaks shall be given at the door opening. The surface of the concrete shall be roughened and chequered when air dry so as to form a key for the joint with the brick wall above.

(e) *Curing.*—Damp proof course shall be kept wetted for at least 7 days after laying, if the brickwork is not ready to proceed further. But in any case no brick work shall be commenced on the freshly laid damp proof course unless the D.P.C. has been flooded with water for at least 48 hours.

[Alternatively, the damp proof course may also be of 2 cm thick layer of cement mortar (1:2) mixed with water proofing compound or with 5% of Pudlo by weight of cement. In this case only write the specifications of sand and cement as given in (a). The mixing is same as that of cement mortar for brick work. All other clauses are same as stated above.]

13-25. Reinforced cement concrete (*R.C.C.*).—(*a*) *Shuttering and Staging*—Shuttering shall be of approved dressed timber preferably of seasoned Jarool wooden boards not less than 3 cm thick. Faces in contact with concrete shall be free from adhering grout, projecting nails, spilts or such other defects. As an alternative, sufficiently rigid steel shuttering may be used. All joints of the shuttering shall be either tonged and grooved or the joints be perfectly closed and lined with craft paper or other type of approved materials so as to prevent the loss of liquid from the concrete. In case of steel shuttering the joints shall be similarly lined. Any timber that shows any tendency to wrap, shrink or twist shall be readjusted. All shuttering and framing shall be rigid, well braced and sufficiently strong to stand the pressure of wet concrete and stresses of ramming etc. upto the satisfaction of the Engineer-in-charge. If mechanical vibrators are to be used then bolts shall be applied

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in place of wire ties or nails to strengthen the frame work and to resist additional stress. All props of approved size shall be supported on double wedges and when the props shall be taken out, these wedges shall be gently eased and not knocked out. All frame work shall be removed without shock or vibration after a period of 21 days for bottom shuttering of horizontal members and 3 days for side shuttering. Faces of shuttering in contact with concrete and interior of all moulds and boxes must be thoroughly washed and an approved mould oil or other material insoluble in water shall be applied to prevent adherence of the concrete.

(*b*) *Reinforcement.*—Mild steel bars shall conform to the I. S. specification, free from rust, paint and grease or oil etc. All reinforcement bars shall be accurately placed with necessary hooks and bends etc. as described on the drawing or elsewhere. Bars at their points of intersection shall be securely wired together with 18 S. W. G. annealed black iron wire. The cover of concrete to the reinforcement shall be as described on the drawings and shall be provided by means of distance pieces of concrete block or other approved material. Bars under 25mm in size shall be bent cold by approved means producing a gradual and even motion. Bars of 25mm in size or more shall be bent hot, but shall not be heated beyond cherry-red colour and after bending it shall be allowed to cool slowly without quenching. Bends shall comply with the dimensions shown in the bending schedule.

(*c*) *Materials for concrete.*—Same as cement concrete in foundation except that the size of coarse aggregate shall be 20mm unless specially mentioned in the type of work.

(*d*) *Proportioning of concrete.*—Same as cement concrete in foundation item no 13-17(b)

(*e*) *Mixing, workability, placing and curing.*—Same as cement concrete in foundation item no. 13—17, (c), (d), (e) and (g).

13·26. Reinforced Brickwork (R. B. Work).—(*a*) *Materials*—All bricks must be of first class quality and free from soluble salts. The mortar shall consist of 1 part of fresh portland cement and 3 parts of coarse sand passing through I. S. sieve No. 480 and retain on No. 15 sieve (i.e.) between 4·75 mm to 5·5 mm. Mild steel bars shall be straight and free from rust, paint, grease etc. All materials as stated above including water shall be of standard specifications.

(*b*) *Shuttering and staging.*—Shuttering shall be of approved dressed timber like seasoned Jarool wooden boards of not less than 3 cm thick. Faces in contact with concrete shall be free from adhering grout, projecting nails, spilts or such other defects. Any timber that shows any tendency to warp, shrink or twist shall be adjusted. All shuttering and framing shall be rigid, well braced and sufficiently strong to stand the pressure of wet bricks. All props of approved size shall be supported on double wedges.

(*c*) *Laying of Bricks.*—All bricks shall be thoroughly saturated by submerging them in clear water for at least four hours before use. A line of bricks shall be first laid with frogs downward in each direction to act as a guide and to ensure that cutting of brick is avoided. In case, if a part brick has to be introduced this shall be done at about the middle of the length. The gap between two lines of bricks for the reinforced joint shall not be less than 4 cm or three times the diameter of the reinforced rods whichever is greater. For roof slabs bricks shall be arranged in such a way so that the inner edge of the wall and the reinforced joint do not lie on the same line.

(*d*) *Laying of reinforcement.*—Reinforcement rods shall then be laid exactly at the centre of the joint. The rods shall not touch the bricks at any place. Overlapping of bars shall be avoided as far as possible by using bars of the required length, but where this cannot be done a lap of 45 diameters shall be given with the necessary hooks at the ends and two rods shall be wired along the lap.

(*e*) *Laying of mortar.*—Mortar of cement and sand in the proportion 1 : 3 shall be first mixed dry on a solid, clean platform and then be mixed wet at least three times by adding clean water gradually and evenly. The mortar shall be placed into the gaps in between the bricks within 30 minutes surrounding the reinforced rods. Care shall be taken that bottom of rods in the slabs have the correct cover of mortar under them. The filling of joints by mortar shall be carried out continuously and no portion of mortar shall be allowed to start its initial set before the neighbourly mortar is in its place.

(*f*) *Curing.*—The work shall not be disturbed and be kept wet for at least 7 days.

(*g*) *Removal of centering*—The centering shall be removed after 10 days without any jerking of any kind.

13 27 **Cement plastering.**—(*a*) *Materials*—Cement shall be fresh portland cement and sand shall be medium quality, cleaned, free from organic matter or salts. All the materials including water shall be of standard specification.

(*b*) *Preparation of mortar.*—The materials shall be at first mixed dry thoroughly till uniform colour to the required proportion and then shall be mixed wet adding water slowly and gradually for at least four times to give a uniform paste. So much material shall be prepared at a time as can be used within the initial setting time (30 minutes) of cement.

(*c*) *Preparation of surface.*—The surface of the wall shall be brushed, cleaned, washed watered and wetted with water before plastering. In case of cement plaster on cement concrete the face shall be lightly roughened, cleaned, washed and wetted. To ensure uniform thickness of plaster as specified, narrow strips of about 10 cm wide plaster shall be applied first at a distance of about 1m centres and the gaps between such strips shall immediately be filled up with mortar.

(*d*) *Laying*—The plastering shall be started from the top and worked towards the ground. The whole surface shall be made flush with wooden straight edges and rubbed thoroughly with wooden floats to ensure an even surface. Rounding of corners if desired by the Engineer-in charge shall be carried out in one operation.

(*e*) *Curing.*—Plastering surface shall be kept wet by sprinkling water after 12 hours for at least 7 days and shall be protected from rain or sum.

13-28. Cement pointing.— (*a*) *Preparation of surface* : The joints of the brick work shall be racked out to a depth of at least 12mm. Raking shall be done with long nails bent at one end. The surface of wall including the racked joints shall be brushed, cleaned and washed with water and kept wet for 2 hours before pointing.

(*b*) *Mortar.*—Pointing to new brickwork shall be done while the mortar in the joints is still green. Ingredients of mortar, i.e. cement and sand shall be of their standard specifications and shall be at first mixed dry with a required proportion (1 : 2 or 1 : 3) and then wet by adding water gradually and slowly to form a stiffer mortar.

(*c*) *Pointing.—For flush pointing*—both horizontal and vertical joints shall be filled up with mortar and pressed with a pointing trowel and finished off flush with the edges of the bricks so as to produce an even appearance to the brick surface.

(*d*) *For rule pointing.*—horizontal joints shall be at first filled up with mortar and pressed to form U-shaped horizontal lines. The vertical joints shall then be filled with mortar and pressed flash with the edges of bricks.

During pointing work no mortar shall be spread over the faces of bricks and the edges of the bricks shall be clearly defined. After pointing the surface shall be kept wet for at least 7 days. During this period it shall be suitably protected from sun, rain and other damages.

13-29. Sand rubbing.—(applied mainly as an external wall finishing)—Unless specially mentioned the mortar shall be composed of 6 parts of fine sand, 2 parts of stone lime and 1 part of cement. All the ingredients shall be fresh, clean and they shall follow their respective standard specifications. Lime and sand shall be mixed at first before 12 hours and cement shall be mixed 30 minutes from the time of completion of a batch. The prepared paste shall be laid on about 1·5mm thick thoroughly smoothed, rubbed and finished off The work shall be kept wet for at least 3 days.

13-30. Lime Terracing.—(*a*) *Materials*—(i) Coarse aggregate shall be of well burnt first class brick ballast of uniform deep cherry red or copper colour. It shall be free from dust, dirt or other vegetable matters and shall pass through 25 mm dia. ring but retain on 6 mm squars mesh screen. It shall be well graded. (ii) Fine aggregate shall be of surki grounded from new first class bricks and shall pass through a screen 25 meshes per sq cm. Surki shall be of uniform colour, free from dirt, vegetable or other foreign matters. (iii) Lime shall be freshly burnt stone lime and shall be free from ash, unburnt stone particles or other foreign matters. Lime shall be screened at site of work through a seive of 3 meshes per cm. Beside these, all the materials including water shall be of standard specifications.

(*b*) *Mixing.*—The mixing shall be done on a clean solid platform. Brick aggregate shall be well soaked with clean water not less than 3 hours before mixing and it shall be stacked evenly on the platform. Lime, surki and brick aggregate shall be mixed in the proportion 2 : 2 : 7 or as specified. Lime and surki in the specified quantities shall at first be mixed dry till of uniform colour and it shall be spread over the stacked ballast. The materials shall then be turned over once without adding water and then at least further three times gradually adding water to give a uniform concrete.

(*c*) *Laying.*—The R. C. roof slab over which lime terracing is to be laid shall be at least 28 days old. The surface of the R-C. shall be cleaned and shall be moistened by sprinkling clear water before laying concrete. Concrete shall then be laid (net thrown) on the roof slab in a single layer about 20% thicker than specified for consolidation with slope (minimum 1:60) towards gutter.

(*d*) *Consolidation.*—The concrete shall then be thoroughly consolidated by beating with wooden mallets (thapies) weighing about 1kg slowly and gradually to the specified thickness 10cm to 13cm. The beating shall be systematic by lengthwise movement of two rows of labourers from two ends on the entire width of the roof. The labourers shall be sitted close to each other in a row and shall keep on moving backwards and forwards. While the beating of concrete is going on, the surface of the concrete shall be frequently sprinkled with lime water and a mixture of molasses, catechu and methi seeds for water proofing. The quantity of materials per 10sq m shall be as follows ; molasses 1·5 kg, catechu 250 grams and methi seed 250 grams. Consolidation by regular beating will be continued until the mortar shall have almost set and the wooden mallets rebound from the surface readily when struck on it which shall generally occur after 5 days. Special care must be taken not to allow the concrete to dry before its thorough consolidation.

(*e*) *Finishing.*—The surface shall be softened by sprinkling pure water and the mortar which is brought to the surface by beating shall then be rendered smooth and finished off with lime rubbed with the face of a trowal. On no account plastering shall be used on the surface but lime putty prepared from lime and surki (1:1) may be used if the floated mortar is found insufficient to fill up all the surface pores.

✓(*f*) *Curing.*—The roofing shall be kept wet for at least 10 days, intermittently spraying water on straw or old gunny bags or fine sand laid on the roof.

✓**13-31. White washing.**—(*a*) *Materials*—The wash shall be composed of 5 parts of stone lime and one part of shell lime well slaked and mixed with clean water to form a thin cream according to the direction of the Engineer in-charge. Lime water thoroughly mixed in a container shall be strained through a coarse cloth. Gum shall then be added in the proportion of 100 grams to 15 litres to the strained wash. (b) *Preparation of base*—Before any white wash is applied on the surface, the walls shall be cleaned and freed from all loose or foreign matters. Lime patty shall be used to make good all holes before white washing. (c) *Method of application.*—The white wash shall be applied with hair brushes vertically and horizontally alternately. Each coat shall be perfectly dry before the succeeding one is laid over it. The white wash shall be kept stirred in the container while using. The whitewash shall not be splashed on the floor and other surfaces and if any, it shall thoroughly be cleaned before drying. Two to three coats shall be applied as specified.

13-32 Colour washing.—The same as washing except that during adding Gum colouring pigment shall be added to in the required quantity as directed by the Engineer-in-charge and thoroughly mixed. Before application of colour washing a coat of whitewash shall be applied first.

13-33. Lime punning to walls.—(*a*) *Materials*— 1 part of shell lime with 3 parts of stone lime shall be thoroughly mixed, stirred with water and then strained through a cloth to remove gritty and foreign matters, if any. Both the limes shall be slaked and tempered by keeping under water for at least 7 days before use. After mixing the limes with water it shall be allowed to settle down for about 24 hours, after which the clean water rising to the surface shall be allowed to run off from the container and soft lime putty which has settled down at the bottom shall be taken out and used for punning.

(*b*) *Preparation of base.*—The sand plaster shall be thoroughly cleaned from any loose particles and washed with water before application of the punning.

(*c*) *Application of punning.*—Lime punning shall be applied uniformly for 1·5 mm thick and rubbed through with woodden trowel. The coat shall be finished by rubbing with a steel trowel to a shining white surface.

13-34. Distempering.—(*a*) *Materials*—The distemper shall be of the colour as specially mentioned and shall be thoroughly mixed with the quantity of water as prescribed by the manufacturer. Only the required quantity (12 kg per 100 sq m for 1st. coat and 7·5 kg for subsequent coats) shall be mixed at a time as required for the days work. It shall be well stirred before and during use to maintian an even consistency.

(*b*) *Preparation of surface.*—New plastered surface shall be thoroughly brushed free from mortar droppings and other foreign matter and sand papered smooth. Before distemparing efflorescence, if any, shall be wiped out with a clean cloth. New plasterd surface shall be allowed to dry up before any operation for distempering and the surface shall be washed over with a solution of zinc sulphate. One kg of zinc sulphate in 10 litres of water and then shall be allowed to dry up.

In the case of old work, all loose pieces, scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc. Pitting in plastering shall be made good with plaster of paris mixed with dry distemper of the colour to be used. The surface shall then be rubbed down again with a fine sand paper and made smooth. A coat of the distemper shall be applied over the patches. The prepared surface shall be allowed to dry thoroughly before application of regular coat.

(c) *Application.*—No distemper shall be applied in wet weather. Distemper shall be applied with proper distemper brushed but not with white wash brushes, first horizontally and then immediately crossed off vertically which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush marks. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which can not be completed the same day. After the day's work the brush shall be washed with hot water and kept dry.

13-35. Woodwork for door and window shutters.—Timber shall be of teak, deodar etc. as specified, well seasoned, dry, free from sap, knots, crack or any other defects or diseases. Shutters shall be either panelled, battened, venetion or glazed as specified. Thickness of shutters shall be 4 cm to 5 cm as specified. All the workmanship shall be neat and truly finished to the exact dimensions. All mortise and tenon joint shall be fixed with wooden pins and glued before fixing. Opening for panels shall have their longer dimensions vertical.

All fittings such as hinges, tower bolts, wooden blocks, wooden clear, sliding bolt for handle etc. as per standard departmental drawing shall be of an approved make. Iron screws shall be used with iron fittings and brass screws with brass fittings. Screws fixing the fittings shall be driven home with a screw driver but not by hammering.

13-36. Woodwork for door and window frames.—Timber shall be of teak, sal, deodar etc. as mentioned, well seasoned, dry, free from sap, knots, warp, crack or any other defects or diseases. All wood work shall be neatly finished to the exact dimensions shown in the drawing. The *Chowkats* shall be framed and morticed together with wooden pins. For overlaping of shutter 2·5 cm to 2 cm wide rebates shall be provided. The frames shall be placed in position truly vertical before the masonry reaches half the height of the opening with iron clamps or by wooden bricks built in the masonry as mentioned. Before placing the frames in position the surfaces of frames coming in contact with masonry shall be given a coat of red-lead paint or be tarred as directed by the Engineer in-charge.

13-37. Glazing to teak wood glazed window sashes.— The glass panes shall be bright, free from flaws specks or bubbles, scratches and of the specified manufacturer. Unless otherwise specified the thickness of glass shall be 3mm. The glass panes shall be so cut that these fit slightly loose in the rebates of sashes for allowing for expansion. Designed or frosted glass when specified the design and quality shall be approved by the Engineer-in-charge. Superior glass panes such as sheet glass, plate glass, pinched glass, shall be used, when so specified.

The glass panes shall be set in the rebates of the framework of wooden sash bars, and they shall be secured by small nails and putty, the frame shall be primed and prepared for painting before glass panes are inserted so that the wood may not draw oil out of the putty. Frosted glass panes shall be fixed with frosted face on the inside. In case of small glass panes a thin layer of putty shall be applied on the rebate of the sash bars then the glass pane shall be positioned allowing equal gaps at all four sides by a few small nails and after positioned further sufficient nails shall be fixed at regular intervals of 5cm at all sides. Further putty (front putty) shall be applied and pressed in position and finished off neatly and in such a manner that all heads of the nails are hidden up and also no putty projects beyond the rebate or leaped over the glass.

Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil to the mixture to form into a stiff paste.

In case of large glass panes shall be fixed by wooden beading having mitred joints, a thin layer of putty shall be applied between glass panes and the beading and fixed with brass or nickel screws.

13-38. Painting to new woodwork.—Painting shall be carried out at the driest season of the year. All woodwork shall be seasoned and the surface to be painted shall be dry, rubbed down smooth with medium and fine sand paper and thoroughly cleaned. Knots or holes shall be covered or filled in with a mixture of red lead and glue in equal quantities laid on hot; which is called knotting. Knots in resinous wood such as deodar, shall be painted over with hot lime and scrapped off after 24 hours and be primed with red or white lead and linseed oil. When dry they shall be rubbed with pumic stone. Nail-holes, cracks and other inequalities shall be filled with putty (made of 2 parts of whiting, 1 part of white lead mixed together in linseed oil) or with a mixture of glue and plaster of paris and levelled to the surface level, known as stopping.

All wood work shall receive at first a coat of priming composed of one part of white lead to eight parts of chalk ground and mixed together with 4 parts of double boiled linseed oil. The stopping for nail holes etc. shall then be rubbed down with a sand paper before applying paint.

Two coats of paints shall be applied over the priming coat if not otherwise specified. Ready-manufactured moist paints or ready mixed paints of the same brand as specified shall be used. The paint shall be applied with brushes, smoothly spread in a direction opposite to that final coat(in case of 3 coats same direction for 1st coat and opposite direction for 2nd coat) without any visible brush mark. Each coat shall be allowed to dry up perfectly before the succeeding coat is laid over it protecting the surface from dust or dirt. Final coat shall be applied in a perpendicular direction to that of 1st coat.

The paint in the can shall be stirred up occasionally with a stick so that the paint does not settle down. Prepared paint shall be covered with water to prevent oxidation and drying if the paint is left unused for a time in an open vessel. Guards or warning pamphlets shall be provided while the paints are wet to prevent this from unmindful visitors.

13-39. Painting to Iron Work.—All rust scales, dirt, suppliers delivery marks, oil, grease etc. shall be removed by approved means before painting. Special care shall be taken for cleaning of corners. All structural steel work shall be primed with red lead before erection except the surfaces which will be in contact with concrete. Where corrosive effect is likelyhood from sea atmosphere, a coat of raw linseed oil shall be applied on the surface immediately after cleaning and before the 1st coat of red lead. Two to three coats of approved ready-manufactured paint or ready-mixed paint shall be applied at right angles to each other after erection of the structural member. Each coat shall be allowed to dry up perfectly before succeeding coat is laid over it. Painting shall be carried out during the dry season.

13·40 Painting to plaster.—The plaster on walls shall be cleaned and primed with boiled linseed oil or glue size. The latter shall not be used if the walls have been white washed. In case of new cement plaster the priming coat shall be applied with a solution of 2 25kg of Zinc Sulphate in 5 litres of water and when it is dried up a coat of raw linseed oil be given. The first and second coat shall consist of white lead and boiled linseed oil. The third coat shall be applied with white lead only, tinted to approach the desired colour mixed with linseed oil and a small proportion of turpentine as the drier. The final coat shall consist of a larger proportion of turpentine with a little varnish to serve as a binder and it shall be applied evenly with a hard brush when the previous coat is still tacky.

13·41. Varnishing.—Knots, holes and cracks shall be stopped with putty made of whiting (ground chalk) and linseed oil. The wood work shall be rubbed down with a sand paper sufficiently smooth to remove any grain marks and it shall be cleaned beforehand. The varnish shall be applied freely being worked well in using strong, firm strokes with brushes and spread evenly. The brushed shall be well worm and perfectly cleaned. In no case sand papers shall be rubbed across the grain, which may cause the finest marks on the finished surface. Two coats of boiled linseed oil or two thin coats of glue as mentioned shall be applied and each such coat shall be allowed to dry up and rubbed down smooth with a fine sand paper. Specified quality of Copal varnish shall then be laid on the prepared surface in thin coats unless any other brand is specially mentioned. For new wood work a second coat shall be applied after the first coat of varnish has thoroughly been dried up. No varnishing shall be allowed to be undertaken in rainy days.

13-42. French polishing.—(*a*) *Materials*—Pure shallac varying from pale orange to lemon yellow colour, free from rasin of dirt shall be dissolved in methylated spirit at the rate of 1·5 kg of shallac to 1 litre of spirit. Suitable pigment shall be added to get the required shade.

(*b*) *Preparation of surface.*—Unevenness shall be rubbed down smooth with sand paper and well dusted. The surface shall be cleaned. Visible knots, if any, shall be covered with a preparation of red lead glue size laid on white hot. Holes and indentations on the surface shall be stopped with glaziers putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1·5 kg. of whiting per litre of spirit and rubbed down again with glass paper and wipped clean.

(*c*) *Application.*—The polish shall then be applied by a pad of wooden cloth covered by a fine cloth. The pad shall be moistened with the polish and rubbed hard on the wood in a series of overlapping circle applying the mixture sparingly but uniformly over the entire area to give an even level surface.

(*d*) *Finishing.*—The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth, damped with methylated spirit and rubbed lightly and quickly with circular motions.

13-43. Decorative waterproof cement coating.—(also known as Snowcem, Supercem, Aquacem, Durocem etc. This is made with a base of white portland cement and is supplied in powder form and only requires the addition of water in one stage. Available in various colour).

(*a*) *Materials.*—This is made with a base of white portland cement and is supplied in powder form and only requires the addition of water in one stage. Available in various colours. The water proof cement paint shall be of approved brand and manufactured as mentioned.

(*b*) *Preparation of surface.*—For new work, the surface shall be thoroughly cleaned of all mortar droppings, dust, dirt and other foreign matters by use of stiff wire brushing and washing. The surface shall be thoroughly wetted with clean water and water shall be allowed to run off before the waterproof coating is applied. In the case of old work, all loose pieces and scales shall be removed and the surface shall be thoroughly cleared of all dust, dirt, algae, grease etc. by stiff wire brushing and washing.

(*c*) *Mixing.*—The paint shall be mixed in such quantities as can be used up within an hour of its mixing. The contents of each fresh container shall be loosened by rolling or shaking the container before opening for first time. Waterproof cement paint shall be mixed with water as per manufacturer's instructions, for Snowcem equal volumes of clean water and snowcem shall be mixed in a clean container and shall be well stirred to get uniform consistency. The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set.

(*d*) *Application.*—The mixture shall be applied on the clean and wetted surface with good quality broad brush or spraying machine. The mixture shall be well stirred during the period of application. For hand brushing horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks.

Second or subsequent coats shall be applied after the previous coat has set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall be well wetted.

(*e*) *Curing.*—At the end of the day's work each coat shall be wetted with a fine water spray. Any painted surface shall be wetted after an interval of at least 6 to 8 hours of the application of paint.

13·44. Rain water down pipes.—Unless specially mentioned rain water pipe shall made of cast iron, zinc, Asbestos cement or G. I. sheeting as specified. The bore of the rain water pipes shall be 6·5 sq cm for each 10 sq m of roof area drained and shall be provided about 6 m apart. All vertical pipes shall be fixed to stand well clear of the wall so that no water leaked from the pipe may damage the wall. A rain water head of the shape of a funnel shall be fixed in such a way as to prevent any leakage through the walls. The bottom end or shoe of the pipes shall be fixed in such a way as can prevent the rain water to splash on the walls during discharge.

13·45 Lighting conductor.—Lighting conductor shall be of copper, aluminium or iron as specially mentioned, but it shall be made of the same material throughout including the points of terminal and the earth plate if not otherwise mentioned. The air terminal which is also called finial shall be 20mm solid rod and pointed at top (multi point type formerly in use has no advantage over one point) and shall be extended 30cm minimum above the highest point of the structure. Air terminal shall be provided about 30m apart for flat roofs. Prominent points of roofs even if it is less than 15m apart shall also be provided with an air terminal. In case the height of a structure is 36m or more air terminals shall be provided 15m apart and shall be connected with a band of the same material. The size of conductors shall be according to the recommendation of "Draft code of practice." Any metal coming within 1·2m or heavy metals even beyond 1·2m of the course of a conductor shall be connected with it. The runs of the down conductors shall preferably be along with the corners and as straight as possible following the most direct path without sharp bends or turns. The radius of bends when unavoidable shall not be less than 30cm and the change of direction not greater than 30°. Conductors shall be secured by clamps along with walls without any insulation. The lower extremity of the conductor shall be buried in permanently damp soil beyond 3m of the foundation of the structure.

13·46. Ashlar masonry.—(*a*) *Stone* :—Stone shall be of the type specified. It shall be hard, sound, durable and tough, free from cracks, decay and weathering.

(*b*) *Dressing.*—Every stone shall be cut to the required shape and size, so as to be free from any waviness and to give truly vertical and horizontal joints with the adjoining stones. The size of the stones to be laid in regular courses shall not be less than 300mm in height. Width of stones shall not be less than the height of the course. Thus the length of stones shall not be less than two times the height of the course. At all beds, joints and faces stones shall be fine chisel dressed. The faces that are to remain exposed in the final position shall be so dressed that when checked with a 60cm straight edge no point varies from it by more than 1mm. Thus, the top and bottom faces that are to form the bed joints shall not vary by more than 3mm when checked with a 60cm straight edge, and the faces which are to form the vertical joints with adjoining stones shall not vary more than 6mm. Any vertical face that is to come against backing of masonry shall not vary more than 10mm when checked with the 60cm straight edge.

(*c*) ***Mortar.***—The mortar used for jointing shall be as specified.

(*d*) ***Laying.***—All stones shall be wetted before laying. Stones shall then be floated on mortar and bedded properly in position with wooden mallets without the use of chips or under pinning of any sort. Laying of stones for walls and pillars shall be carried up truly plumb or battered as shown in the drawings. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Face stones. shall be laid headers and strechers alternatively. The header shall come under the middle portion of the strechers. In order to break the continuous vertical joints, the stones in the adjacent layers shall have a lap of more than half of the height of the course.

Stones shall be laid in regular courses, of not less than 14·5cm in height and all the courses shall be of the same height. All the connected masonry work shall be carried out together so as to maintain, as far as possible, uniform height but where breaks are unavoidable, the joint shall be made in good long steps. When necessary, jib crane or other mechanical appliances shall be used to hoist the heavy pieces of stones taking care so that the corners of the stone are not damaged. Stone shall be covered with gunny bags, before tying chain is passed over it.

(*e*) ***Curing.***—The work shall be kept constantly moist on all faces for a period of at least seven days. Green work shall be protected from rain by suitable covering.

13·47. Random Rubble Stone Masonry.—(*a*) *Materials*—(1) Stone shall be hard, sound free from decay and weathering. Stones with porous matter or with boulder skin shall be rejected. The size of stones shall not be less than 15cm in any direction. (2) Cement and sand for cement mortar or lime and surki (sand) for lime mortar shall be of standard specification.

(*b*) ***Mortar.***—The ingredients of mortar, cement and sand or lime and surki shall be first mixed dry in the specified proportion till of uniform colour on a solid clean platform and then mixed wet at least three times by adding water gradually and evenly.

(*c*) ***Laying.***—All stones shall be thoroughly wetted before laying. The stones shall be ammer dressed with wooden mallet on the bed and from all other faces to enable them to come into close proximity with each other securing close joint. The walls shall be carried up truly plumb. Face stone shall not be narrower than its height and shall tail back and bond well into the backing. The stones shall be arranged to break joint on the face for at least half the height with those of course above or below. Stones shall be so laid that all joints are quite full of mortar and the thickness of joints shall not exceed 20mm. Interstices between stones shall be wedged with stone chips and spalls to avoid thick beds of joints and mortar. In the interior thickness of the wall, bond stones at least 45 cm long shall be given one for every $\frac{1}{2}$sq m of face so as to approximately provide thorough bond of long stones. The masonry shall be carried out together so as to maintain uniform height as far as possible. If any part of a wall is required to raise in advance, toothing must be formed bygiving projections to bond to the wall to be built later.

(*d*) *Curing*.—The work shall be protected from rain or sun while it is green. At the end of the day's work the tops of walls shall be left flooded. The masonry shall be kept moist on all the faces for at least 7 days.

13·48. Coursed Rubble Masonry.—(*a*) *Materials*—Same as specified in Random Rubble Masonry.

(*b*) *Laying*.—All stones shall be thoroughly wetted before laying. Every course of stone shall be hammer dressed and laid truly horizontal and every vertical joints shall be truly vertical. Faces shall be accurately squired and each face joint shall be dressed at right angles. The face stones shall be laid alternate headers and stretchers. No pinning shall be allowed on the face. Each course shall consist of stones of even thickness not less than 3cm and not more than 23cm. No stones in face shall have less breadth than height and no stone shall tail into the wall less than its height. At least $\frac{1}{3}$rd of the face stones shall tail into the wall twice their height. The masonry shall be carried up regularly and true to plumb. The thickness of joints shall not exceed 12mm. In case plastering or pointing is not to be carried out, the joints shall be struck flush and finished at the time of laying.

(*c*) *Bond or through stones*.—Through stones going through the walls shall be well distributed providing in the whole wall by arranging them in a staggered fashion in successive courses. The intervals of through stones shall not be less than 1·5m in each course. For walls upto 60 cm thickness, a through stone shall extend from one face of the wall to other. But in case for walls of greater thickness at least 15 cm side over lapping headers forming a stone joint shall be laid from face to back.

(*d*) *Quoins*.—Corner strones or quoins shall be dressed to correct angle. The short bed of the stone shall be at least equal to height. The quoins shall be laid with header and strecher in alternative layers.

(*e*) ***Curing*** :—Same as described in Random Rubble masonry.

13·49. Galvanised Iron Roofing.—(a) Corrugated Galvanished Iron (C.G.I.) sheets shall be of the specified gauge. If the gauge is not specified, they shall be 0·63 mm thick (24 B.G.). The sheets shall be free from twist or buckle and shall have uniform corrugations, true in depth and pitch, and parallel to the sides of the sheet. The galvanizing shall be clean and uninjured in the carriage by the rubbing of zinc covering and free from ungalvanized spots or other defects.

(*b*) *Laying.*—Sheets shall be laid on wooden or steel purlins as indicated on the working drawing. The tops of all purlins shall be in one plane so that the sheets may be fixed with purlins without exerting any pressure or hammering. According to I. S. specification 277—1962 an end lap of 15cm in the lengthwise direction and side laps of two corrugations shall be provided. In ridges and hips where plain sheets are used a lap of 23cm shall be maintained. The lines of corrugations shall be parallel to the sides of the roof unless specified. The roof slope shall not be laid flatter than 1 in 4 if not otherwise specially mentioned.

Holes for hook bolts etc., shall be drilled but not punched in the ridges of the corrugations from the underside while the sheets are on the ground. A sheet shall be fixed on every purlin passing under it at least at three places at regular intervarls. Care shall be taken so that all holes, on the corrugation shall occur in the ridge of the sheet as laid. Sheets shall be fixed to the purlins by means of 8mm diameter galvanized hook bolts and nuts with a washer of bitumen, and a limpet washer in each fixation. The diameter of the holes in the washes shall be same as the G.I. bolts or hook bolts. All nuts shall be tightened from top of a sheet uniformly to give a leak proof covering.

(*c*) ***Wind Ties.***—If specified wind ties of 40mm × 12mm flat iron shall be fixed at the end laps and eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins.

13·50. Asbestos Cement Corrugated Sheet Roofing.—(*a*) *Materials*:—The sheets shall be of the specified approved quality, and shall conform in all respects to the I.S. specification No. IS 459—1962. The sheets shall be free from all cracks, chipped edges or corners and any other damages.

(*b*) ***Frame work.***— The sheets shall be laid on the purlins and battens as per working drawing. The maximum spacing of purlins under the sheets shall be 1·6m in the case of 7mm thick sheets. For 6mm thick sheets the spacing of purlins shall be 1·40m. The top bearing surfaces of all purlins and other members shall be in one plane so that the sheets can be fixed on the purlins without exerting any force.

(c) *Laying.*—The sheets shall be laid with the smooth side upwards and the first sheet shall be laid uncut starting at the eaves. The side lap shall be of half a corrugation and an end lap of 15cm minimum. Side laps should be laid on the side facing away from the prevailing monsoon winds. The free overhang of the corrugated sheets at the eaves shall not exceed 30cm. It is preferred to lay the sheets commencing from the end opposite to the direction of prevailing wind and rain.

(d) *Slope.*—The roof slope shall not be flatter than 1 vertical to 5 horizontal. Normal slope shall be usually 1 vertical to 2 horizontal or as specified.

(e) *Fixing.*—The sheets shall be fixed to purlins from top of corrugations through 9·5 mm dia. holes (1·5 mm greater than the dia. of the screws) drilled but not punched to receive 8mm dia. galvanized iron J or L hook and nuts. The grip of the J or L hook bolt on the side of the purlin shall not be less than 25mm. Each G.I. J or L hook bolt shall have a bitumen washer and a galvanised iron washer placed over the sheet before the nut is screwed down from above. At first each nut shall be screwed lightly and thus after a dozen of sheets are laid, the nuts shall be tightened to ensure a leak proof joint. Every sheet shall be secured in position at six places, two at the head, two at the bottom and two at the middle. Roof ladders or planks shall always be used during laying and fixing the sheets, to avoid damage to the sheets and to provide security of the workers.

(f) *Wind ties.*—Unless otherwise specified wind ties shall be of 40×6mm flat iron section and shall be fixed at the eave ends of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlin.

(g) *Ridges and hips.*—Ridges shall be of the type as specially mentioned such as "One piece plain angular" for a slope exactly 30° or "Serrated adjustable" or plain wing adjustable etc. as appropriate for the corrugated roof which is to be covered. Ridges and hips shall be of the same manufacture as the corrugated sheets used for the roof. The sections shall be free from cracks, chipped edges or corners. The ridge sections shall be laid as per manufacturer's instructions. The ridge shall be formed with the aid of a pair of ridge cappings each overlapping the other. These adjustable ridge cappings shall be secured to the ridge purlin by the same kind of bolts which are used for fixing sheeting.

13·51. Supplying and fixing Indian pattern water closet including flushing cistern and foot rests complete.—

All materials and fittings used in the construction shall conform to the latest aditions of the relevant Indian standard.

***Materials.*—(a) *Water closet.*—**The Indian pattern water closet pans shall be either of white glazed earthenware, while viterous China or white glazed fire clay as specified. The pan shall be either long pan pattern (size 580mm) or Orissa pattern (size 580mm) size, make, design and approved by the Engineer-in-charge. Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self draining with weephole at the flushing inlet to the pan. A pan shall be provided with a 100mm Sand Cast Iron (S.C.I.) trap "P" or "S" type with approximately 50mm water seal and 50mm dia. vent horn where required by the Engineer-in charge.

(*b*) *Flushing cistern.*—The flushing cisterns shall be manually operated (for domestic purpose) or high level as specified. The cistern may be cast iron, or porcelain as specified and shall have a removable cover which shall fit closely on it and be screwed against displacement. In the case of high level cisterns, the outlet shall be of 32mm nominal bore and in the case of low level cistern, the outlet shall be 40mm nominal bore. The discharge rate of the cistern shall be about 5 litres in 3 seconds when connected to a appropriate flush pipe, and there shall be no appreciable change in the force of flush during the period of discharge. The cistern shall have a discharge capacity of 5 or 10 litres as specified. A high level cistern shall have to operate with minimum height of 125 cm and a low level cistern with a maximum height of 30cm between the top of the pan and the underside of the cistern. The body thickness of a cast iron cistern shall not at any place, be less them 0·5 cm. The body of a pressed steel cistern shall be of seamless or welded construction of thickness not less than 1·6 mm and shall be porcelain enamelled or other wise protected against crrosion. All working parts shall be designed to operate smoothly and efficiently. Cistern shall be mosquito proof. A cistern shall be considered mosquito proof only if there is no clearance any where which would permit a 1·6mm wire to pass through in the flushing position or filling position or over flow position. The siphonic action of a flushing cistern shall be capable of being rapidly brought into action by the operating lever, but shall not self siphon or leak.

(*c*) *Fixing of pan.*—The pan shall be sunk into floor and embeded in a cushion of average 15cm cement concrete 1:5:10(1 cement : 5 sand :10 brick ballast of 40mm size) The concrete shall be left 11 5cm below the top level of the pan so as to allow for flooring and its bed concrete. The joint between the pan and the trap shall be made leak proof with cement mortar 1:1.

(*d*) *Fixing of flushing cistern.*—The cistern shall be fixed on C.I. or R.S. cantilever bracakets which shall be firmly embeded in the wall in cement mortar 1:4:(1 cement :4 fine sand) or fixed by using wooden plugs and screws. The outlet or flush pipe from the cistern shall be connected to the pan by means of cement or putty joint. The flush pipe shall be fixed to wall by using holder but clamps.

(*e*) *Foot rests.*—After laying the floor, as specified, a pair of foot rest not less than 25 × 13 × 3cm of white glazed earthenware shall be set in cement mortar (1 cement : 3 sand)

The position of foot rest from its back edge shall be 17·5 cm from the inside back edge of the pan for a 500 mm (inside) pan.

All sanitary and plumbing works shall be carried out through licensed plumbers. On completion of the work the site shall be cleaned and all rubbish be disposed off as directed by the Engineer-in charge.

13-52. European pattern (Pedestal type) water closet including flushing cistern and flush pipe complete.

(*a*) *Water closets* :—Water closets shall be either white glazed earthenware, white viterous China or white glazed fire clay as specified and shall be "wash down Type". The size, make and design shall be as specified and approved by the Engineer-in-charge. At base of each water closet there shall have 4 holes having a minimum diameter of 6·5 mm for fixing to floor. Each water closet shall have an integral trap with either "P" or "S" outlet with a least 50mm water seal. In order to enable an efficient flush the inside surface of water closets and traps shall be uniform and smooth.

(*b*) Flushing cistern and Flush pipe : Same as (b) 13-51

13-53. Providing and fixing wash hand basin including all fittings :—(*a*) *Materials* : *Wash basin*:—Wash basin shall be of white glazed earthenware, white viterous China or white glazed fire clay as specified. The size of the basin may be 630 × 450mm or 550 × 400mm flat back as specified. For angle back the size may be 600×400mm or 400×400mm as specially mentioned. Basin shall be provided with single or double tap holes as specified. The tap holes shall be square. Each basin shall have a circular waste hole to which the interior of basin shall drain. Each basin shall be provided, fitted and fixed with a non ferrous or approved brand 32mm dia. waste fitting. To discharge the waste water from a basin 32 mm dia. G.I. or P.V.C. as specified waste pipe with coupling at one end fitted with brass or alluminium nut shall be provided for a length of 60 to 105cm long as required. To receive the brackets on the underside of a wash basin stout slots not exceeding 13mm diameter 5mm high and 300mm from the back of basin to the centre of the stud shall be suitable. Each basin shall have an integral soap holder recess or recesses which shall fully drain into the bowl. All the waste fittings shall be chromium plated of grade B type conforming to IS specification 1068. The basin shall be provided with one or two 15mm chromimum plated (C.P.) brass pillar taps as specified and one C.P. stop cock on the supply line of grade B conforming IS 1068. The lead or porcelain connecting pipe as specially mentioned shall be of the specified diameter and length 30 to 45 cm with wiped solder joints

A sample of each kind of fitting shall be get approved from the Engineer-in-charge and all supplies made according to the approved samples.

(*b*) *Fixing of wash basin*—The installation shall consist of an assembly of wash basin, pillar taps, R.S. or C.I. brackets, lead or porcelain pipe, stop cock and waste pipe. The height of front edge of wash basin from floor level shall be 80cm. The basin shall be supported on a pair of R S. or C.I. cantilever brackets with two coats of approved paint in cement mortar 1 cement : 3 sand or fixed in position by means of wooden plugs and screws. The R.S. or C.I. brackets shall conform I.S. 775. If not otherwise specified, the brackets shall be 40×40×6mm angle or T iron brackets. The wall plaster on the rear shall be cut to rest over-hang the top edge of the basin. After fixing the basin, plaster shall be made good and surface finished to match with the existing one.

White glazed pedestals for wash basins shall be provided where specified. The quality and colour of the pedestal shall be exactly the same as that of the basin with which it is to be installed. It shall be capable of supporting the basin rigidly and adequately and shall be so designed as to make the height from the floor to top of the rim of basin 75 to 80cm.

All sanitary and plumbing works shall be carried out through licensed plumbers. On campletion of the work the site shall be cleaned and all rubbish disposed off as directed by the Engineer-in-charge.

13·54. Supplying and fixing shower bath with fittings complete—

All materials and fittings used in the construction shall conform to the latest editions of the relevent Indian standard. The shower rose shall be of chromium plated or white glazed fire clay or white viterous China as specified. The size of the shower rose shall be 100mm when measured across the diameter and the inlet connection shall be 15mm size. The shower rose shall be round or octagonal as specified and shall have 145 holes with a variation upto ± 10. The diameter of each hole in the shower rose shall be 1·2mm with a variation upto ± 10. The inside of the shower rose shall be uniform and smooth in order to ensure free flow of water

A stop cock of the specified size shall be provided to control the inlet supply of water to shower rose. The stop cock shall be polished bright and chromium plated of grade B type or gun metal screw down pattern as specified. The shower rose shall be fitted with the 12mm diameter G.I. pipe with a 90° bend at top. The height of the rose when fitted shall be 210cm from the floor.

13·55. Supplying, joining and fixing galvanised iron water pipes in a building:—

(*a*) *Materials* :—The pipes shall be galvanised mild steel welded pipes and seamless, screwed and socket tubes conforming to the requirements of I.S. 1239 for medium grade. They shall be of the diameter (nominal bore) specified in the description of the item.

The pipes, sockets and pipe fittings shall be cleanly finished, well galvanised in and free from cracks, surface flaws, laminations and other defects. The fittings shall be screw threads at the ends, clean and well cut. The ends shall be cut cleanly, and square with the axis of the tube. Female threads on fittings shall be parallel and male threads shall be taper.

(*b*) *Cutting, laying and jointing*:—The pipes shall be inspected before use to ascertain that they conform to the specification given above. Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be threaded conforming to the I.S. 554 with pipe dies and taps carefully in such a manner as will not result in slackness of joints when the two pieces are screwed together. The taps and dies shall not be used for turning of the threads so as to make them slack, resulting the joints are not water tight. The screw threads of pipes and fittings shall be protected from damage until they are fitted.

In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, Tee, bend with the pipe wrench. All joints shall be fitted in such a manner that they shall be water tight. In the case of underground piping shall be thickly coated with approved anticorrosive paint to prevent corrosion.

The pipes and fittings shall run on surface of the wall unless otherwise specified. The fixing shall be done by means of standard pattern holder but clamps of required shape and size so as to fit tightly keeping the pipes about 1·5cm clear of the wall. The clamps shall be embedded in brickwork in cement mortar 1 cement : 3 sand at regular intervals in straight length. The clamps shall be fixed at shorter length near bends and fittings as directed by the Engineer in-charge. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed on ducts providing sufficient space to work on the pipes with the usual tools. All pipes and fittings shall be fixed truely vertical and horizontal unless unavoidable.

(*c*) *Testing the joints* :—After laying and jointing, the pipe line shall be inspected under presure and flow of water. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost. The pipes and fittings after they are laid shall be tested to hydraulic pressure of 6 kg/cm^2 (60 metres).

13-56. Half-brick thick partition wall in cement mortar :—(*a*) *Brickwork* :—Bricks shall be first class and the proportion of cement mortar shall be 1:3 (cement 1 : 3 sand) The brickwork shall be done in the same manner as brickwork in cement mortar except that all courses shall be laid with stretchers and between the main and partition walls there shall be T junctions at each end. For T junctions alternate layers of bricks of partition wall shall be entered by half brick depth in the adjoining walls.

(*b*) *Reinforcement.*— Expanded metal mesh or black iron wire net as specified shall be provided at every alternate or third layer as required. Flat bars of section about 25mm × 2mm may be used as hoop iron reinforcement for walls where specially mentioned. In this case they shall be hooked at corners and junctions.

Before laying the iron band half the mortar for the joint shall first be laid and other half laid after the iron band is placed in position and stretched upto the full length of the wall. Care must be taken that the iron brand is fully embedded in mortar. The height of the brickwork shall not be carried out more than 1·2m height at a time.

(c) *Curing* :—The curing shall be done in the same manner as brickwork for the main walls.

13·57. Brief specification for water bound Macadam Roads—(a) *Preparation of sub-grade*:—Special attention shall be given to the compactness of the sub-grade and its drainage. The sub-grade shall be prevented from becoming so dry that it breaks up from the want of cohesion, or so wet that it forms mud. All pockets of loose or soft soil shall be removed and thoroughly filled with coarse, graded granular materials and well rammed. It shall be dressed to the specified camber (may be 1:48) before laying of soling.

(b) *Collection of materials* :—Materials for the base course or soling shall preferably be stacked outside the road formation. Quantity of material required for each furlong shall be collected within the same furlong and no collection is permitted when the work is in progress

(c) *Diversion of Traffic*.—Warning signals showing that the road is under construction shall be placed at least 75m apart.

(d) *Soling (or Base course)*.—If stone is specified, it shall be 15cm average width, 10cm thick and not more than 20cm to 40cm in length. It shall be hand packed and laid on their edges with greater side across the road way. If brick soling is specified, the bricks shall be laid flat or on edge close fine and break joints and hand packed. Bricks shall be laid at right angles to the centre line of the road. In double layers flat brick soling, the upper layer shall be laid on 2·5cm thick sand cusioning between the layers and the upper shall be laid along the axis of the road. Edging shall be made of single bricks laid on-edge and parallel to the axis of the road. Profiles shall at first be made so that the finished road surface flushes with the top of edging. Profile of the soling shall frequently be checked up.

(e) *Wearing course*.—According to I.R.C. recommendation stone shall be free from dust, flat chips and other impurities. The accepted metal shall consist of three classes in the proportion 70% passing through a screen of 45mm mesh but retained on 32mm mesh. 20% passing through a screen of 32mm mesh but not a screen of 20mm mesh. 10% passing through a screen of 20mm mesh. All metals shall be rejected which will not pass through 45mm mesh in any direction. If broken brick is used it shall pass through a ring 52mm diameter and it shall be well graded. The broken brick will be well pugged and only dark red colours shall be accepted.

(f) *Spreading of Materials*.—Spreading shall be done to specified camber and thickness but not more than 10 cm at a time. The top surface shall be dressed by hand and checked up by means of spirit level.

(g) *Dry rolling*.—After spreading and checking up of material it shall be rolled by a $4\frac{1}{2}$ tons roller to obtain perfect interlocking. Rolling shall be commenced at one edge of the road and gradually worked towards the centre in a direction parallel to the centre line of the road. Excessive rolling shall be avoided and at no time the roller shall be left on the surface of roadway.

(*h*) *Wet rolling.*—After dry rolling the metalling shall be moderately watered according to the direction of the Engineer-in-charge and be kept saturated and the rolling shall be continued with such heavy rollers as can produce pressure of 21kg to 35kg per sq cm width of the roller wheel. For field test a piece of metal as used in base course about the size of a walnut shall be put on the surface and the roller shall be passed over it ; it will be driven in if the consolidation is incomplete but if not driven in and crushed, the surface has been well compacted.

(*i*) *Spreading of Blindage* (fine gravel, mooram etc.) Approved quanity of blindage shall be spread uniformly over the surface to a thickness of 12mm to 20mm watered and rolled.

(*j*) *Finishing, Curing and opening of traffic*—The treated surface shall be covered up with a thin layer of sand. The consolidated surface shall not be opened to traffic till it is dry (preferably 4 days after).

13·58. Single coat surface dressing with bitumen on a coat of priming—(*a*) *Preparation of base.*—Newly metalled road shall be kept open to traffic at least for 4 months before surfacing. The surface of the road shall be allowed to dry up perfectly swept clean and freed from dust, dirt or other foreign matters by hand brushing with wire brushes, brass brooms and finally by fanning with gunny bags to remove all loose dust. All potholes, depressions, ruts or irregularities exceeding 12mm shall be patched or reconditioned at least one week before commencement of the surface dressing.

(*b*) *Application of Binder.*—All the bitumen drums shall be freed from water during discharging into the heaters. To obtain correct and even distribution of the paint the road surface shall be divided into rectangles as the container of one pouring can cover the area. Bitumen primer shall be heated into the heaters according to the manufacturers specification (B.O.C. Shell primer No. 2 at 100°F) and applied uniformly either under pressure or from flat spouted can, operated by hand on the road at a rate of 9kg/10 sqm and allowed to soak for 48 hours without disturbance. The bitumen shall then be brushed evenly with rubber squeeges longitudinally over the surface. The final coat (may be Mexphalte 80/100) shall similarly be applied over 1st coat at a rate of 16 kg per 10 sq.m and heated at 350° to 375F.

(*c*) *Chippings and Spreading.*—Stone chips shall be hard, tough and clean crushed. Unless specially mentioned, the size of chippings shall be of 12 mm and passing through 20mm but retained on 20mm square mesh. Within 15 minutes after the application of bitumen the blindage of stone chips shall uniformly be distributed at the rate of 1·4 cum per 100 sqm without any accumulation of surplus chippings at any point. The excess of the chippings shall be removed within 48 hours after the application. Hand brooming or light drag shall follow the application of chippings prior to rolling.

(*d*) ***Surface dressing and rolling.***—Immediately after brooming and while the bitumen is still working, a roller 8 to 10 tons according to the direction of the Engineer-in-charge (6 tons for 6 mm chipps) shall be rolled over the whole surface. Rolling shall be commenced at one edge of the road and gradually worked towards the centre in a direction parallel to the centre line of the road for 6 to 8 trips as directed by the Engineer-in-charge.

(*e*) *Opening to traffic.*—The surface of the road may be opened to traffic soon after rolling.

13-59. Laying pre-mixed chipping carpet (with bitumen or road tar) over a water bound road surface.—(*a*)*Preparation of Base.*—The surface of the road shall be swept clean and freed from dust, dirt or other foreign matters by hand brushing with wire brushes, brass brooms and finally by fanning with gunny bags to remove all loose dust. All pothols, depressions, ruts or irregularities shall be patched or reconditioned at least one week before commencement of carpeting.

(*b*) *Tack Coat.*—A tack coat of say Shelspra B.S. heated to 325° to 350° F shall be applied uniformly on the cleaned road surface at the rate of 10 kg. per 10 sq. m.

(*c*) ***Materia's for carpet.***—Stone chips shall be hard, tough, clean and crushed. The size of chippings shall depend upon the thickness of carpet specified. For 2·5 cm thick carpet standard size of chippings shall be 12 mm and for any other thickness size of chippings shall be a multiple of 12 mm to that thickness nearest to 3mm. For 100 sqm and for 2·5 cm thick quantity of stone chips shall be 30 cu m, bitumen or road tar at the rate of 64 kg per cu m of metal. For any other thickness the quantity of above indent shall be multiplied by the thickness.

(*d*) ***Mixing.***—The mixing plant shall be a double paddle type drum, where power rotary mixture is not available. In a batch the stone chips in dry condition shall at first be put into the drum with $\frac{2}{3}$rd the required quantity of binder and be heated at a temperature as specified by the manufacturer (shelspra B.S. at 225°F to 340°F). When the stone is well coated the remaining portion ($\frac{1}{3}$rd) of binder shall be added and thoroughly mixed until all the particles are well coated. The mixture shall then be conveyed to the road surface by wheel barrow or stretcher as specially mentioned.

(*e*) ***Spreading.***—The mixture placed on the prepared base shall immediately be spread evenly with rakes to the desired thickness and checked by template.

(*f*) ***Rolling.***—Rolling shall be continued with a 6 to 8 tons roller immediately after the premix has been laid for a length of 15m and when it is still hot. Rolling shall be commenced at one edge of the road and gradually worked towards the centre in a direction parallel to the centre line of the road. The roller wheels shall be moistened with water while rolling. Any unevenness of the surface found during rolling shall be removed by filling with the premix.

(*g*) ***Sand Spreading.***—The prepared surface shall be lightly dusted by spreading sand at the rate of 0·75 cu m per 100 sq m and lightly rolled before opening to traffic.

(*h*) *Seal Coat.*—If seal coat is specially mentioned over the premix chipping carpe (depending on the nature of traffic) shall be applied at the rate of 0·75 cu m of sand mixing with 3·8 kg of shelspra B.S. per 100 sq m and then rolled with 8 tons roller.

13·60. Specifications for different categories of roads :—The following specifications as recommended by the Indian Road Congress should be followed henceforth.

Description	Category of Road			
	(a) National (N.H.) and State Highway (P.H.)	(b) Major District Road (M.D.R.)	(c) Other District Road (O.D.R.)	(d) Village Road (V.R.)
1	2	3	4	5
1. Normal widths of Right of way. (This is the area of land acquired and reserved for construction and development of a road along with its alignment)				
(i) For Agricultural country or open area	30·5 m	24·4 m	12·2 m	12·2m
(ii) For Urban or Industrial area ...	24 4 m	12·2 m	9·1 m	9·1m
(iii) For Hilly area	18 m	15 m	12 m	9m
2. Roadway width or formation width or crest width. (This is the width of carriage way including traffic separator if any plus the shoulders on either side).				
(i) For plain area	12 m	10 m	8 m	7·5 m
(ii) For hilly area	8·8 m	4·75 m	4·75 m	4 00 m
3. Corriageway width or crust width				
(i) For single lane	3·8 m	3·8 m	3 8 m	3·8 m
(ii) Double lane (without raised kerbs)	7 0 m	—	—	—
4. Shoulder width (This is the portion of the roadway between the outer edges of the pavement to the edge of road formation)				
(i) For plain area	3 m (single lane)	1·8 m	1·8 m	1·2 m
(ii) For hilly area	1·5 („)	0·5 m	0·5 m	0·5 m

5. **Camber** ... ...

Kutcha roads ...	3 to 4%
Water-bound macadam ...	2·5 to 3%
Thin bituminous surface ...	2·5%
High type bituminous surface	2%

1

6. Ruling gradient				
(i) For plain area	1 in 30	1 in 30	1 in 30	1 in 30
(ii) Mountainous area (cross slope from 25 to 60 percent)	1 in 20	1 in 20	1 in 20	1 in 20
(iii) Steep area (cross slope greater than 60 percent)	1 in 16	1 in 16	1 in 16	1 in 16
7. Ruling Design speed in Km. p.h.				
(i) For plain area	100	80	65	50
(ii) For hilly area	50	40	30	25
(iii) Sleep area	40	30	25	20
8. Minimum Radii on horizontal curves (rulling)				
(i) For plain area—	335 m	244 m	152 m	91 m
(ii) For mountainous area—				
(a) Area not affected by snow ...	50 m	30 m	20 m	14 m
(b) Snow bounded area	60 m	33 m	23 m	15 m
(iii) Steep area—				
Area not affected by snow... ...	33 m	14 m	14 m	14 m
Snow bounded area	33 m	15 m	15 m	15 m
9. Location of cautionary signs in rural areas—				
(i) For plain area ...	120 m	90 m	60 m	40 m
(ii) For hilly or mountainous area	60 m	50 m	40 m	40 m

10. Side slopes ...

(i) For embankment or filling ... 2 : 1 when the height of embankment is over 0·8 m

(ii) For cutting
- Ordinary soil — 1 : 1 to $\frac{1}{2}$: 1
- Medium rock — $\frac{1}{12}$: 1 to $\frac{1}{16}$: 1

CHAPTER XIV

PROJECT ESTIMATE

14-1. Estimate for a Project :—Project means a full scheme or proposal of an undertaking a task and may consist of several types of work along with details of each work.

A project or major scheme consists generally of the following works :—

(1) Preliminary investigation, Reconnaissance survey, preliminary survey, Location survey, Traffic survey for road projects, soil testing by trial boring etc. as the case may be.

(2) Preparation of preliminary estimate to give an idea of the cost involved and obtaining administrative approval.

(3) Detailed surveying of site or alignment by traverse surveying, levelling, contouring, plaintable surveying etc. as the case may be.

(4) Plotting or drawing work, preparation of topographic map or Basic map showing the location of residential, commercial, Industrial Buildings, location of sewers, water main, railway lines, existing roads, cultivated land etc. as the case may be, preparation of longitudinal and cross-sections for a road or canal project.

(5) Selection of site or alignment on the drawing.

(6) Investigation and workings out the accomodation or requirement of plinth area, number, type and sizes of buildings of various kinds in the case of building project ; width and type of road, the type and number of cross-drainage structures for a road project ; length, basin area and capacity of canal for an irrigation project.

(7) Land acquisition—Calculation for area of land to be acquired for road or canal project, the area of Homestead and Arable land per km, and preparation of land acquisition plan.

(8) Preparation of layout plan or basic map to layout the proposed building structures, or making formation line of road or formation line of bed of canal and drawing cross sections of the road or canal etc.

(9) Structural detailed design with design data and detailed calculations.

(10) Preparation of working drawings consisting plan, sections, elevations and structural details.

(11) Preparation of site plan or Index plan for a building project and in the case of a road or Irrigation project preparation of key map, Index map, detailed location survey plan and longitudinal sections, detailed cross sections for buildings, Dak bungalows, rest houses etc.

(12) Quantity estimate of different items of works involved in the project from the working drawing.

(13) Collecting data required for preparing estimate from sponsoring Departments.

(14) Preparation of Detailed specifications for the items of works those are not provided in the departmental schedule.

(15) Calculations of quantities for road and irrigation works, the detailed calculations of earthwork is attached with the project estimate and for other type of works calculations for each item of works.

(16) Preparation of detailed estimate and abstract of cost for different sub-heads of items.

(17) Preparation of general Abstract of cost. This includes the name of the project and cost of different Sub-heads along with contingency, work charges, Tools and Plants, Operation and Maintenance during construction etc.

(18) Working out the cost benifit ratio specially for Irrigation project.

(19) Purchase of different materials and equipments. The particulars of quantities of different materials for the project as Bricks, stone chips, bitumen M.S. rounds, cement, spun pipe etc. and equipments required to be purchased and supplied departmentally to contractors.

(20) Accomodation of field staff :—This includes temporary accomodation of staff Quarters, site offices, arrangement of watersupply, sanitation electrification, approach road, etc.

(21) Project report or general report and report on estimate.

(22) Bar chart-showing the phaseing the physical and financial performance for the entire plan period of the project.

The following papers should be submitted in according to the following order as serially arranged.—(1) Report, (2) Design datas and calculations of design, (3) Specifications, (4) Detailed statement of measurements, quantities and rates, (5) An abstract showing the total estimated cost of each item, (6) The detailed estimate in specified form and (7) Plan and drawings. In case of a project consisting of several works, the report may be a single document for all works but details of measurement and abstracts of costs should be prepared for each work, supplemented by a general abstract bringing the whole together. Fraction of rupee should be omitted.

14-2. Reports on estimates :—To write a report for a building project the various points has been briefly stated in chapter—III. Reports on estimates should be prepared in a lucid form, comprehensive and understandable by all nontechnical officers to give a clear picture of the whole project.

The following sub-heads should be provided in general :—(1) **History**—(i) Particulars relating to the initiatian and reasons leading upto the proposal. (ii) General necessity of the project along with reference to previous correspondence or to the proposal.

(2) **Design** (i) A description of the original proposals and those finally adopted with regard to selection of site or selection of alignment, area of land, nature of soil, topography of the land and orientation. (ii) Reference to specifications, basis of design calculations and drawings etc.

(3) **Scope or provisions made** :—Accomodation provided and what works are covered and what works are not included by the estimates should be distinctly stated. For a big

project arrangements of labour amenities, temporary accomodation of staff and reference to what arrangements are being made for any portions which are not included in the estimate should be mentioned.

(4) **Land** :—Arrangement of land and its acuisition if necessary.

(5) **Rates** :—Basis on which the rates have been provided, giving reference to the standard schedule of rates of the locality or department, supporting analysis of rates for the items which are not covered by the schedule of rates.

(6) **The manner for execution** of the work wheather by item rate, or percentage rate or lump-sum or any other type of contract or daily labour basis etc, should be mentioned.

(7) **Total cost** :—The total cost of the project and how to be financed, Return or revenue income if any.

(8) **Establishment** :—Provision made for work-charged establishment and its rate.

(9) **Tools and Plants** :—Provision made in the estimate to purchase construction plant, tools etc. that may be necessary to execute the work with reference to specification etc.

(10) **Time of completion** :—Time of starting and time of completion.

14-3. **ESTIMATE FOR BUILDING PROJECT** :—*The estimates for building projects, when submitted should be prepared under the following heads* :—

(1) Buildings, including filtered and unfiltered water supply, sanitation, electrification and in case of furnished building the provision for furniture.

(2) Boundary walls or fences, gateways, internal roads and paths for different buildings, internal parks and trees connected with the garden layout.

(3) Approach road or main road outside the boundary walls of the building as may be necessary for the layout.

(4) Internal layout for water supply, storm water drainage and sewerage lines for different buildings and their connections with the outside main lines.

(5) Inside layout for electrical power connections, inside street lighting and service connections outside the boundary of the compounds.

(6) Miscellaneous works such as levelling the ground, soil testing, surveying, cutting trees, dismantling of old structures and other items which are not covered under the above heads.

(7) Special tools and plants which may be necessary in connection with the project.

(8) Departmental charges if any.

(9) Acquisition of land if necessary.

(10) Plan sanction fees of the local Municipality or Corporation.

14-4. **ROAD PROJECT** :—*A road project estimate essentially contains the following papers* :—(1) Abstract of cost, (2) Project report, (3) General report, (4) Reconnaissance survey work report, (5) Roller statement, (6) Analysis of rate, (7) Earth work estimate, (8) Land acquisition, (9) Turfing estimate, (10) Water way-chart, (11) Abstract of activities per km wise, (12) Abstract of cost, (13) Bar chart, (14) Different maps, drawings and road sections at suitable intervals of the existing ground level and proposed formation levels, (15) Details survey sheets.

(1) **Abstract of cost** generally contains the following :—

Name of work, length of road, total cost. Total cost is found by adding the following sub-heads :—

(a)	Land acquisition cost	=Rs.···
(b)	Earthwork, Bridges and culvert	=Rs.···
(c)	Materials including work (hard crust) ...	=Rs.···
(d)	Ancilliary works.	=Rs.···
(e)	Quality control & soil survey.	=Rs.···
(f)	W/c, Contingency and T. & P.	=Rs.···
	Total cost	=Rs···

(2) **Project report** :—The following informations should be provided in a project report.

(a) *Object and Targets* :—This includes the notes of the proposed terminal road connections and connection with other roads alongwith route facilities.

(b) *Location with reasons therefor* :—Location of route through which it passes and the reasons for such locations.

(c) *Physical aspects including broad engineering details* :—The informations of the waste and arable land with homestead areas affected should be given. Particulars of crest width, crest width, curve value, base value, metal thickness etc. i e. the details of cross section of the road including black toping should be described.

(d) *Purchase of different materials and equipments* :—This should include the particulars of the quantities of different road materials (bricks, stonechips, bitumen, M. S. rounds, cement, spun pipe etc.) and equipments required to be purchased in connection to construct the road.

(e) *Organisational aspect* :—The necessity of regular and work charged establishment require to complete the project should be informed.

(f) *Co-ordination of the other departments* :—The Co-ordination which is required with collector, L.A. department, local administration, P.W. D. etc. should be stated.

(g) *How the cost may be meet up* :—The state Government earning revenue from road tax, central aid etc. those are applicable should be mentioned.

(h) *Facilities* :—Economic condition of the locality which may improve by transporting and selling the local products. Administrative facilities and law and order situation which may be improved should be mentioned.

(3) **Report (of estimate)** :—(a) *The estimated amount* and the length of the road, crest and crust width should be stated. The specification of the road crust should be stated in detail containing the following informations :—

(i) Brick soling or brick bats consolidation thickness in different layers.

(ii) Width and thickness and name of materials to be used for shouldering.

(iii) Thickness of overburnt brick ballast consolidation.

(iv) Thickness of stone metal consolidation. (v) Surface dressing.

(b) *Reference of schedule* of rates adopted to prepare the estimate should be mentioned.

(c) *Reference of order* underwhich the estimate has been prepared and the amount put up for administrative approval and technical sanction.

(4) **Reconnaissance survey Report** :—This should include the following particulars.

(a) *Name of the project* for which report is drawn.

(b) *Authority* :—Office order nos. under which the survey work is made should be mentioned.

(c) *Introduction* :—How the proposed road scheme arises, brief description of the present condition of transport arrangement of the areas through which the proposed road alignment passes should be stated.

(d) *General description* :—The general description of obstructions and diversions, condition of land, condition of soil, the structures those are effected etc., should be stated.

(e) *Detail description per k m. wise* :—The details of alignment, bridges, culverts. canals, rivers, provision of water way, connections with other roads, names of mouzas, diversions etc. for each km should be stated separately.

(f) *Proposal* :—The physical character of the road proposed should be stated.

(5) **Roller statement** :—The number of days required for rolling earthworks, metal consolidation and surface dressing should be shown separately and the total number should be drawn up.

(6) **Analysis of rates** :—Where the rates are not adopted from departmental rates analysis of rates should be drawn up.

(7) **Earthwork estimate** :—This is a very lengthy calculation of earthwork and is shown separately per k.m. wise.

(8) **Land acquisition** :—Calculations of areas of land per k. m. wise are shown in this statement. The total area of Homestead land and Arable land per k.m. are also shown separately in this statement.

(9) **The calculations of the area of Turfing** :—Turfing required per k.m. to k.m. is shown in a separate statement.

(10) **Waterway chart** :—The details of existing waterways, the existing waterway to be retained or replaced, new proposals with the detailed description of the proposed waterways, their height of bank, span etc. are shown in a separate sheet per k.m. wise stating the distance of chainage within that k.m.

(11) **Abstract of activities per k.m. wise** :—This is a lengthy statement of all informations those are involved to construct the road and are grouped under five parts (as shown below) within a k.m. length of the road. This per k.m. to per k.m. chart of activities for the entire road length is shown in this statement as below :—

Part—I

1. Land acquisition :—
   (a) Homestead land ... ...
   (b) Arable land ... ...
2. Dug belling ... ...
3. Cement concrete boundary pillar
4. Jungle clearing ... ...
5. Compensation of houses & structures :-
   (a) Pucca structures ... ...
   (b) Kutcha structures ... ...

Part—II

1. Earthwork (compacted) :—
   (a) Ordinary earthwork ... ...
   (b) Muram or soft rock ... ...
   (c) Hard rock ... ...
2. Turfing to side slopes ... ...
3. R.C.C. K.M. post ... ...
4. R.C C. $\frac{1}{10}$ th K.M. post ... ...
5. Waterways :—
   (a) R.C.C. spun pipe culvert with single barrel, with double barrel, tripple barrel.
   (b) Cross drain.

Part—III

1. Shouldering width and thickness with metal used on both sides.
2. (a) Boulder or brick bats consolidation or brick flat soling.
   (b) 1st. layer loose and consolidated thickness.
   (c) 2nd layer—do-do-do-
3. Thickness ofme tal consolidation.

Part—IV

1. Surface dressing ...

Part—V

1. R C C. direction board ...
2. Sign board. ...
3. R C.C. guard post ...

(12) **Abstract of cost** :—The abstract of cost per k. m. wise is drawn up following the abstract of activities as in parts separately (partwise-I to V) are added up in a grand total column. *The enhancement of market price is anticipated for the plan period of work and an amount is provided in the k. m. wise estimate.* For quality control 1% and for soil survey work 1% of the estimated cost are added. For contingency 3%, workcharged, 2·5%, and for Tools and plants 0·50% are added.

The percentage cost for the following are shown separately at the end of the abstract sheet.

(1)	Land acquisition	= 10% generally of the estimate.
(2)	Earthwork & Turfing	= 10% „ „ „ „
(3)	Bridges and culverts	= 9·5% „ „ „ „
(4)	Hard crust including black topping surface	= 70% „ „ „ „
(5)	Decorative work	= 0·50% „ „ „ „
		Total = 100 percent.

13. **Barchart** :—A barchart showing the physical and financial performance for the entire plan period of the project is shown in a graph.

14·5 IRRIGATION PROJECT :—*A small irrigation project generally contains the following documents* :—(1) Project or general report, (2) Technical notes, (3) Benefit, (4) Gauge curve, (5) Design calculations, (6) Statement of (*a*) Flood damages and relief measures during the period of inundation, (*b*) Flood damages and relief measures after the completion of the scheme, (*c*) Benefit cost Ratio, (7) Report (of estimate), (8) General abstract of cost, (9) Abstract of cost of estimate, (10) List of bridges to be constructed, (11) Calculation of earthwork, (12) Analysis of rates, (13) Drawings.

(1) Project or general report :—The project report essentially should contain the following sub-heads (*a*) *Introduction* :—This includes the notes of the proposal, the previous basin area and the proposed basin area, (*b*) *Location* :—Locations of basins and their comparative levels and boundary demarcations, (*c*) *Problem* :—Inadequacy of drainge canal, growth of Industrial and Urban areas resulting increase of the run-off, Low swamp areas and water-logging if any resulting less production of khariff crops, due to prolonged water-logging the problems of communications, Sanitary conditions etc, on the other hand short supply of water to paddy etc. resulting no production or small production of pady. (*d*) *Solution* :—Construction of new canal, their length, direction, drainage area covered, outfall connection points should be stated in the report.

(2) Technical notes :—This should contain the following particulars :—The full drainage level (F. D. L.) or full supply level (F. S. L.), the division of basin area on the basis of contours and existing ridge lines of roads and railway lines should be mantioned. The run-off index for rural area and Semi-Urban areas should be stated. A stage discharge curve should be prepared giving the reference of the gauge reading. The gauge data of the proposed sluice site at chainage should be mentioned. Tide Lockage at different points should be computed from the respective tide curves.

(3) Benefit :—The following particulars are required under this head :—(*a*) Benefit during monsoon to grow more khariff by effective drainage and (*b*) Partly benefit during past monsoon with the water available from the channels to grow Rabi crop, full and part benefit areas.

Full Benefit :— Paddy = average Kg/Acre = ...M T.
Straw = —do— —do— = ... M.T.
Partial Benefit :—Paddy = —do— —do— = ··· M.T.
Straw = —do— —do— = ··· M.T.

Total product, Paddy in M.T. = ... Straw in M T = ...
Present benefit Paddy in M.T. = ... Straw in M.T. = ...

Net extra production available from the scheme, Paddy = ... M.T. Straw = ... M.T.
Value of estimated additional production after completion of the scheme.

Paddy = ... M.T. @ Rs. ... = Rs. ...
Straw = ... M.T. @ Rs. ... = Rs. ...

∴ Total valus of estimated additional out turn production = Rs. ...

Production cost :—Cost of total production (input cost) in fully benefitted area = Rs. ...

Cost of additional production from both fully and partially benefitted area of the scheme = Rs. ... Less 15% considered as present achivement.

∴ Net Additional Cost for additional production = Rs. ...

∴ *Net Additional Benefit after completion of the scheme =*

Total value of estimated out turn — net additional benefit = Rs. ...

Total estimated cost of the project = Rs. ...

Operation and Maintenance Cost of the project @ 16% of the capital cost = Rs. ...

Hence, **Benefit-cost-ratio** $= \dfrac{\text{Net additional Benefit}}{\text{Operation \& Maintenance cost}}$. **This ratio must be more than one in order to get sanction of the project.**

4. **Gauge curve** :—A gauge discharge curve for the canal should be drawn showing the average high water level (Av. H. W. L.) and (Av. L. W. L.) at out fall sluice site.

5. **Design calculations** :—This includes calculations of Full Drainage Level (F. D. L.) of the canal, calculations of discharge for the canal basin drainage, design of canal etc.

6. **Statement of** (*a*) *Flood damages* :—This includes statement of flood damages and relief measures during the period of inundation in connection with the canal, i.e., the average loss per year in Rupees. (*b*) *Flood damages and relief* measures after completion of the scheme :—This is a statement of damage value of crops and houses in Rupees after completion of the scheme.

(*c*) *Benefit cost ratio* $= \dfrac{\textit{Annual benefit of the proposed scheme in Rupees}}{\text{Operation \& maintenance cost (usuaally 16\% of the capital)}}$

This ratio must be more than one in order to get sanction of the scheme.

(7) **Report** :—This is a report written on the estimate and includes a statement of basin area, necessity of the estimate, utilisation of spoil earth, construction of necessary bridges, rates followed, total cost and how to be financed.

(8) **General Abstract of Cost** :—This includes the name of the scheme and cost of different sub-heads are added up as shown below. The detailed cost of each sub-head is not shown in the general abstract of cost.

(*a*)	**Preliminary expenses** ...	= Rs.	...
(*b*)	**Land**	= Rs.	...
(*c*)	**Regulator**	= Rs.	...
(*d*)	**Cross-Drainage**	= Rs.	...
(*e*)	**Bridges**	= Rs.	...
(*f*)	**Buildings**	= Rs.	...
(*g*)	**Earthwork**	= Rs.	...
(*h*)	**Tools and Plants**	= Rs.	...
	Total	= Rs.	...
(*i*)	**Maintenance during construction @ 1% of all except land**	= Rs.	...
(*j*)	**Contingency @ 3% on all items except land**	= Rs.	...
(*k*)	**W. C. establishment 1½% on all items except land**	= Rs.	...
	Grand Total	= Rs.	...

9. Abstract of cost of estimate :—The cost under each sub-head from the general abstract of cost is detailed in the abstract of cost as stated below.

(*a*) *Preliminary expenses* ;—(i) Cost of survey works =Rs. ...
(ii) Construction and fixing B. M.and C. S. pillars=Rs. ...

(b) *Land* :—Cost of land to be acquired to construct the canal including spoil bank.

(*c*) *Regulator* :—Construction of regulator.

(*d*) *Cross drainage structure* :—(i) Construction of pipe inlets, (ii) Construction of pipe outlets, (iii) Construction of inlet sluice.

(*e*) *Bridges* :—(i) Construction of pucca road bridges (ii) Reconstruction of pucca bridges (iii) Construction of foot bridges (iv) Dismantling of old dilapidated regulator if any.

(*f*) *Buildings* :—(i) Construction of operator sheds for sluices including cost of land, (ii) Construction of quarters for Gauge Readers, (iii) Construction and remodelling of Bungalow

(g) *Earthwork in excavation* in making embankment etc.

10. List of bridges to be constructed :—The list of bridges to be constructed or reconstructed in connection with the project should be given in a statement showing the location of the bridges, their types, total span of bridge required etc.

11 Calculation of earthwork :—The detailed calculations of earthwork should be shown separately for pre-work and post work.

12. Analysis of rates :—When rates of all items of works are adopted from the departmental schedule analysis of rates for those items are not required. But in case of non schedule items of works supporting analysis of rates are given in a separate sheet.

13. Drawings :—Detail drawings for Index map of the Basin ; Contour map of the canal basin area ; Cross section of the canal at regular intervals ; Long section of the canal from outfall chainage to 0·00 chainage ; Land acquisition plans and all other drawings in connection with the scheme are submitted.

14·6. A SMALL SEWERAGE PROJECT :—A small sewerage project generally contains the following papers (1) Project report, (2) Design critaria, (3) Technical specification, (4) Design, (5) Abstract of estimate, (6) Detailed design, (7) Detailed estimate of each unit, (8) Analysis of rate and (9) Drawings.

1. Project report :—This includes the following :—(*a*) *Introduction* :—Location and area of urban and rural area if any with the name of municipality, subzoning after analysis of the contours, the name, parts of each subzone.

(*b*) *Topographic features* :—Whether the ground is fairly flat or undulated and the average ground levels, existing river, canal if any flows by the side of the scheme.

(*c*) *Population* :—The previous census population of the area concerned and the project population for the designed year.

(*d*) *Existing facilities and problem* :—Existing sewerage system if any with present conditions of the different units. The present system of dumping of Night soils, house hold septic tanks with effluent, the drainage arrangement of the area concerned.

(*e*) *Proposed facilities and provisions made* :—Laying of new sewers, high rate filter, primary clarifier, and detailed description of the treatment plant, installations of Dumping deposits etc.

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2. **Designed critaria** :—(*a*) Sewage flow—The quantity of domestic sewerage for design purpose (normally 80% of the per capita water supply). (*b*) Peaking Factor (i e. ratio of maximum to average which varies in accordance with the Tributory population). (*c*) Industrial water to be discharged into sanitary sewers (generally 50% of the total industrial water.) (*d*) Infiltration Allowance, (*e*) Roughness co-efficient, (*f*) Min slope and velocity, (for smaller sewers the following min slopes should be adopted, 200 mm. dia. 0·004, 375 mm. dia. 0·0015, 450 mm. dia 0·0012, 525 mm. dia. 0·001 and 600 mm. dia. 0·0008).

3. **Technical specification** (Treatment plant) :—(*a*) Design capacity of sewage treatment plant, (*b*) Peak flow expected to be contineous for 4 hours at a stretch, (*c*) BOD of Raw sewage, (*d*) Effluent quality after treatment, (*e*) Dry solid in the raw sewage, (*f*) Average rainfall in the area, (*g*) Temperature variation. (*h*) Position of sereen chamber above or below G. L.

4 **Abstract of estimate** :—Cost of different sub-heads as required to complete the project are shown separately and summed up. An example is given below.

(*a*) Cost of construction of sewer line =Rs.
(*b*) Cost of Manholes and catch basins ... ... =Rs.
(*c*) Cost of road restoration ... ... =Rs.
(*d*) Cost of construction of dumping depot. ... =Rs.
(*e*) Cost of high rate filter ... ... =Rs.
(*f*) Cost of Grit chamber ... ... =Rs.
(*g*) Cost of primary clarifier ... ... =Rs.
(*h*) Cost of Secondary clarifier ... ... =Rs.
(*i*) Cost of overflow bye-pass ... ... =Rs.
(*j*) Cost of Pumping Machinery ... ... =Rs.
(*k*) Construction of office, sanitary block chlorine house, covered store etc =Rs.
(*l*) Construction of boundary wall and gates etc. ... =Rs.
(*m*) Permanent electric installations ... =Rs.
(*n*) Supply and installation of chlorinator and chlorine gas cylinder. =Rs.
(*o*) Internal development, construction of drains, roads, lighting etc. =Rs.
(*p*) Supply and installation of laboratory equipments to keep effective control over effluent quality. ... ... =Rs.
(*q*) Purchase of one Jeep car with trailor for effective maintenance. =Rs.

				Total	=Rs.
Contingency	5%	...			
W. C. Estt.	$2\frac{1}{2}$%	...	...		=Rs.
Tools and plants	3%	...	...		=Rs.
Survey & Design	3%	...	...		=Rs.
Supervision	4%	...	...		=Rs.
				Total	=Rs.
				Land Acquisition	=Rs.
				Grand Total	=Rs.

CHAPTER XV

VALUATION

15·1. What is Valuation ? Valuation is the art of assessing the present fair value of a property at a stated time. Valuation of anything is an estimate of the value of that thing in terms of money. It only attempts at suggesting the fair prices. Yet, valuation is not an arbitrary process. It is based on certain facts and indications and only after a judicious processing of such facts and indications we can suggest the value or fair price of the property.

Rises and falls of the fair price can occur in a very short space of time. It follows therefore that all valuations must clearly state the date to which the valuation relates, since time is the essence of all valuations.

15·2. Difference between Value and Cost :—Cost means the actual cost of construction where as value means the present market value or fair sale value which may not be the same to the cost of construction. Value depends on supply and demand where as cost is a constant amount requires for the construction. For an example, suppose a person has constructed a nice out-house at a desert place according to his liking at a cost of Rs. 80,000/-. But just after that he wants to sale the property which has a little value to the others choice and he gets a maximum offer of Rs. 40,000/-. The owner was about to sale his property, but just at that time a plan becomes sanctioned to develop a big industry adjoining to the area and subsequent growth of population starts. So due to demand the out-house becomes valuable and he sales at a price Rs. 1,25,000/-. So, the value of the property varies from Rs. 40,000/- to Rs. 1,25,000/- but the cost remains the same Rs. 80,000/-. Therefore, value depends on demand and supply where cost is a constant amount.

15·3. Qualifications and functions of a Valuer :—A valuer is an expert who can work-out the market value of a property based on scientific analysis and instances of sales. A good valuer is an engineer or architect who must possess sound knowledge of the following subjects : 1. Estimating and costing. 2. Surveying and levelling. 3. Planning and designing. 4. Experience in construction works. 5. Building bye-laws of the local bodies. 6. Law of easements. 7. Law of contracts. 8. Land Acquisition and Town planning Act. 9. Arbitration. 10. Fire insurance. 11. Central and local Government's taxation. 12. Money market and rate of interest. 13. Zonal importancy of land and buildings. 14. Writing reports.

The function of a valuer is to determine the market value of a property in order to help his client and also the courts when enquired for the same.

15·4. The purposes of valuation are :—

1. Purchase for investment or for occupation. 2. Tax fixation. 3. Sale. 4. Rent fixation. 5. Insurance Premium. 6. Mortgage value. 7. Compulsory Acquisition. 8. Speculation. 9. Betterment charges. 10. Auction bids. 11. Wealth tax. 12. Gift tax. 13. Probate. 14. Estate duty. 15. To determine the amount of court fee stamp.

Before going further, we would define and explain certain terms and concepts frequently used at the time of valuation.

15-5. Some common terms in Valuation :—

1. **Gross Income**—Gross income is the total income or receipts from all sources without deducting the outgoings necessary for taxes, maintenance, collection, replacement or loss of income, ground rent etc. whatever may be.

2. **Outgoings**—Outgoings are the expenses to be made by virtue of being in possession of the property and also the expenses of maintaining the property. Outgoings may be classified under the different heads of taxes, repairs, management and collection charges, insurance premiums loss of rent. It should also include sinking fund. A short description of each head of outgoings are given below :

(*a*) *Taxes*—This include Municipal taxes. The rates that are payable for Occupiers' share and for Owners' share of taxes are calculated on the basis of 'Annual Rental Value' of a property after deducting an amount for repairs etc. (usually 10% of the rent for repairs). The amount of taxes to be deducted wlll vary from place to place in accordance with the laws in force at that particular Municipality. For big properties Wealth tax and Property tax are also required as imposed by the Government.

(b) *Repairs*—An amount is provided for annual repairs of buildings to keep the same in a sound condition although actual repairs are taken in hand periodically say 3 to 5 years intervals. In average cases 10 percent of the gross rent is provided for valuation purpose. Although cost of a building should not have a direct bearing on the amount for repairs, yet there is also a method to provide 1% to $1\frac{1}{2}$% of the cost of construction for annual repairs.

(*c*) *Management and Collection Charges*—An agent collects rents for big buildings and if the state is large he will also manage the state. Usually the charges vary from 4 to 5 percent. This includes investigation of petty complains and supervising petty repairs. This figure of 4 to 5 percent does not include salaries of Liftman, Sweeper to clean staircase, common passage etc. pump attendant and Electric Charges for common lights, pump and Lift etc. with due allowance for the service charges. In order to include all such expenses at least 9 to 10 percent of the gross rent should be allowed as the management and collection charges.

For small buildings having no lift, no common pump or light etc. and the owner collects the rent himself the outgoing on account of this head is not practically considered.

(*d*) *Insurance* :—The amount of actual insurance premium is considered as an outgoing expense. A property may not be insured at all, but this does not mean no deduction should be made for insurance premium. Because market value is required to be ascertained from the view-point of a prudent perchaser who will always insure his building against fire and if the owner has failed to take this precaution, a valuer should do so, otherwise an incorrect figure will be found. Insurance premium depends on the construction of the building, the nature of Occupancy of the building, the adequacy of the water supply, the pressure of the water main and facilities for fire fighting etc.

(*e*) *Loss of Rent* :—Part of a property may remain vacant for some period and will not fetch any rent for that period. Therefore the loss of rent is considered as outgoing expenses and deducted from the calculated gross rent. The average loss of the part 3 years may be considered as a guide to calculate the yearly loss of rent.

(*f*) *Sinking Fund*—Some as described in Sl. 9.

(*g*) *Ground Rent*—When a structure is constructed on a lease hold property (lease may be 99 years or 999 years) then a specified amount in a specified period as may be agreed upon is considered as outgoing from the gross income of that property.

3. **Net Income**—Net income is the gross income less all outgoings which includes taxes, premiums, repairs, insurance, management and collection charges, loss of rent, ground rent, sinking fund etc. necessary to maintain the property in a state to command that income.

4. **Scrap Value**—Scrap value is the value of dismantled materials of a built up property at the end of its utility period and absolutely useless except for sale as scrap. When it applies to an old building which has outlived its useful span of life a certain amount can get by selling the old useful materials like, bricks, steel, wooden articles, etc. less cost of demolition of the building. The scrap value of a building is usually considered as 10 percent to the cost of construction. Thus in the case a machine which do not give useful service or becomes obsolete and can not be used again by repairing or replacement of parts, the value obtained at that time by selling the machine in one unit or cut in parts is known as scrap value. The scrap value is also known as *junk value or Demolition value*. On rare occasions scrap value may be zero or even negative if the cost of dismantling or removal becomes equal or more than the scrap value.

5. **Salvage Value**—It is the estimated value of a built up property at the end ot its useful life without being dismantled. Salvage value will be high when a building, a machine becomes useful after replacement and remodeling.

6. **Market Value**—Market value of a property is the value at which it can be sold in the open market at a particular time. In the open market means the property is offered for sale by advertise in daily News Papers and all necessary steps are adopted so that every person who desires to purchase the same can make an offer. The owner willing and not obliged to sell might reasonably expect the price from a willing purchase with whom he was bargaining for the sale. So market value must be free from forced value or sentimental value.

Values vary time to time. Factors affect the market value of a property are :—

(i) *Forces on demand and supply*—Few buyers as compaired to a number of properties available for sale in a locality will result in low prices for the property and vice-versa.

(ii) *Rise in population*—Rise in population may be due to growth of new industries or influx or by multiplication will result heavy demand for land-building properties.

(iii) *Cost of production*—The present cost of production affects the value due to rapid change of price index in comparison with the rate of depreciation.

(iv) *Purpose of purchase*—Value of a property will be more when the purchaser can reside himself even in partly vacant house or speculate to run a business by purchasing the property.

(v) *The imposition of control of prices of building materials*—This will cause violent fluctuation in the prices of building materials and the values of buildings will vary an appreciable amount from time to time.

(vi) *Rent Restriction Act*—Value of a property is calculated from its probable annual income through rent and so due to certain passing of a rent restriction act. by a Government may be the means of causing a slump in property values.

(vii) *Improvement by Public Schemes*—The taking of any public service scheme, like sewerline, waterline, means of transport etc. to an area lacking modern amenities will tend to make that area more attractive and will be closely followed by an increased in land values. Even a proposal to bring a sewerline to an unsewered area or before roads are made and services installed will cause to rise the value of property at that area.

(viii) *Interest on Schedule Banks or Government securities*—The lowering of the Schedule bank interest or Government security higher may be the interest of making more money available for investment in property and vice-versa.

(ix) *Abnormal condition*—Due to insecure conditions like riots, war trend etc. cause of values may drop and remain for a considerable period.

7. **Book Value**—Book value is defined as the value of the property shown in the account book in that particular year, i.e. the original cost less the total depreciation till that year. Thus the book value of a property gradually reduces at a constant amouut year after year upto the limit of scrap value i.e. upto its utility period. Book value is applicable on building and movable properties but not on land. This is usually required in the accounts book of a company to show the assets and also required to determine the reserved price for court sale.

Difference between market and Book Value :—

Market value	*Book value*
(*a*) The value is fixed by purchaser.	(*a*) The value is fixed by the rate of depreciation.
(*b*) The value may be higher during the subsequent years due to increase of price index.	(*b*) The value can not be higher during the subsequent years even due to increase of price index.
(*c*) The value may be constant for a period.	(*c*) The value can not be constant but there is a gradual fall.
(*d*) This is applicable for any type of property.	(*d*) This is not applicable in case of land or metal articles like Steel, Copper, Gold etc.
(*e*) Market value is considered for valuation.	(*e*) Book value is considered for Accounts book of a company.
(*f*) This depends on forces of demand and supply, development of the area etc.	(*f*) Book value is not variable due to its demand and supply or development of the area

A market value higher than the book value indicates profit for the seller. For an example the book value of a Motor Car after its useful life may show only the cost of scrap value or 10 percent of its original cost. But due to increase of price index and sound maintenance the market value of the car may be more than the book value or even more than the cost at which this was originally purchased. This is a case of profit for the seller.

8. **Assessed value** :—Assessed value is the value of a property recorded in the register of a municipality in order to determine the amount of municipal taxes to be collected from the owner of the property. Generally the assessed value is determined from the gross annual rent at which the land or building might at the time of assessment be reasonable expected to let from year to year, less in the case of building, an allowance of ten percent for the cost of repairs and for all other expenses necessary to maintain the building. In case if the gross annual rent of a property can not be easily estimated then an amount of 5 percent of the estimated cost of the property shall be considered.

9. **Sinking fund** :—Sinking fund is an amount which has to be set aside at fixed intervals of time (say annually) out of the gross income so that at the end of the useful life of the building or property the fund should accumulate to the initial cost of the property. A building a machine, a vehicle etc., becomes useless after certain years i.e. at the end of its life. Hence it is necessary to make some provision whereby the owner can accumulate to a sum required for rebuilding the premises or can replace the article. For the above purpose sinking fund is periodically collected and deposited to a bank to get highest compound interest or sinking fund insurance policy is made to the insurance company throughout the life of a building or article. In case when a building is built up or a vehicle is purchased by taking loan, a small portion of rent or income is set aside every year or at regular intervals and may be paid directly to the lender by way of instalments.

Determination of sinking fund :—

The calculation of sinking fund depends upon the life of a building and also upon the rate of interest. When the life of a building is over the owner can get back a certain amount on the sale of old building materials which is known as *scrap value*. This amount is considered as 10% of the building cost. Therefore, the calculation of sinking fund is made on 90% cost of the building.

Let S = Total amount of the sinking fund ; I = Annual instalment required ;

i = Rate of interest expressed in decimal ; n = number of years and

I_0 = Co-efficient of annual sinking fund, so that $I = I_0 \times S$.

The first annual instalment would accumulate interest for (n-1) years, the second for (n-2) years and so on. Also the annual sinking fund for redemption of Rs. 1·00 would be I_0 (as $I = I_0 \times S$ and $S = 1$).

Consequently, the first instalment would accumulate to $I_0\ (1+i)^{n-1}$, the second to $I_0\ (1+i)^{n-2}$ etc. Whence $I_0\ [(1+i)^{n-1}+(1+i)^{n-2}+\cdots\cdots+(1+i)^2+(1+i)+1]=1$

$$\text{or,}\quad I_0\frac{[(1+i)^n-1]}{(1+i)-1}=1.$$

$$\text{or,}\quad I_0=\frac{i}{(1+i)^n-1}\qquad\ldots\qquad\ldots\qquad(1)$$

$$\text{consequently,}\ I=I_0\times S=\frac{Si}{(1+i)^n-1}\qquad\ldots\qquad(2)$$

Example—1. An owner has installed an air cooler in a building at a cost of Rs. 8,000/-. If the life of the air cooler is 18 years calculate the amount which he should set aside annually as sinking fund to accumulate the above cost at 5% compound interest.

$$\text{Annual sinking fund require, } I=\frac{S\,i}{(1+i)^n-1}=\frac{8000\times0{\cdot}05}{(1+0{\cdot}05)^{18}-1}=8000\times0{\cdot}0355=\text{Rs. }284/\text{-}$$

Therefore, the owner should set aside an amount of Rs. 284/- annually and invest the same @5% compound interest for a period of 18 years in order to accumulate the total cost of Rs. 8,000/-

Example—2. A person has purchased an old building at a cost Rs. 90,000/- on the basis that the cost of land be Rs. 50,000/- and the cost of building structure be Rs. 40,000/-. Considering the future life of the building structure be 20 years workout the amount of annual sinking fund at 4% interest when scrap value be 10% to the cost of building structure.

Scrap value = 10% cost of building structure = 0·10 × 40,000 = Rs. 4000/-

∴ The total amount of sinking fund to be accumulated = 40,000 − 4,000 = Rs. 36,000/-

Annual sinking fund for re-equipment of Rs. 36,000 in 20 years.

$$I=\frac{Si}{(1+i)^n-1}=\frac{36{,}000\times0{\cdot}04}{(1+0{\cdot}04)^{20}-1}=36{,}000\times0{\cdot}0336=\text{Rs. }1{,}209{\cdot}60$$

∴ Annual instalment for sinking fund for a period of 20 years = Rs. 1,209·60.

10. Capitalised value :—The capitalised value of a property is the sum or amount, the interest on which at the highest prevailing rate would be equal to the net income out of the property.

If a property produces a net income of Rs. 4,000 per annum and a purchaser desires 8% return on his capital according to the highest prevailing rate he should pay Rs. $4{,}000\times\frac{100}{8}$ = Rs. 50,000 maximum for the property. This amount Rs. 50,000 is the capitalised value of the property. If the purchaser, pays more, he will not have 8% return on capital. If he pays less, he will obtain a greater return than 8%. Thus, higher the rate of interest lower will be the capitalised value of a property and vice-versa. But practically the capitalised value of a property does not lower down inspite of higher Bank interest due to the fact that rent goes up and so more will be the net annual return.

The multiplier of the net annual return or rent (in this case $\frac{100}{8}$) to obtain the capital value is known as the year's purchase.

∴ *Capitalised value = Net annual return X year's purchase.*

11. Year's Purchase (Y. P.) :—Year's purchase is defined as the capital sum required to be invested in order to receive a net annual income as an annuity of Re 1/- at certain rate of interest.

The terminology describes that to gain an annual income of Rs. 1 at a fixed rate of interest the capital sum should be Rs. $1 \times \frac{100}{\text{Rate of interest}}$. Thus to gain an annual income of of Rs x at a fixed rate of interest the capital sum should be $x \times \frac{100}{\text{Rate of interest}}$.

But, $\frac{100}{\text{Rate of interest}}$ is termed as year's purchase.

Therefore, the capital sum = annual income (net) × year's purchase. *The multiplier of the net annual income to determine capital value is known as the year's purchase (Y. P) and is useful to obtain capitalised value of a property.*

For an example suppose a person intends to purchase a property which produces a net return of Rs 6,000 per annum and the purchaser desires to get 8% return on his capital. In this case the capitalised value of the property which should be paid by the purchaser $=$Rs. $6{,}000 \times \frac{100}{8} =$ Rs. $6{,}000 \times 12{\cdot}5 =$ Rs. 60,000·00. The multiplier of the rent is 12·5, i.e., after 12·5 years of purchase the purchaser will get return the capital sum of Rs 60,000 in the form of annual net income of Rs. 6,000.

The multiplier of the rent in the above case *is* $12{\cdot}5 = \frac{100}{\text{Rate of interest}} = \frac{100}{8} = \frac{1}{0{\cdot}08} = \frac{1}{i_p}$

Where i_p *is* the rate of interest in decimal. For 5% rate of interest, *Y. P.* $= \frac{100}{5} = 20$; for 6% interest, *Y. P.* $= \frac{100}{6} = 16{\cdot}67$ and is similar for other rates.

A building, a machine etc. (but not land) becomes useless after certain years i.e at the end of its life. Hence, it is necessary to set aside a certain amount at fixed intervals of time (here annually) whereby the owner can accumulate to a sum required for rebuilding the property at the end of its utility period. Therefore, income of a property will provide both for the interest of the capital and accumulation of sinking fund to replace the capital.

$\therefore$ For annual income of Rs. 1 or year's purchase $= \frac{100}{\text{rate of interest} + \text{rate of sinking fund}}$

Expressing the rate of interest in decimal and rate of sinking fund also in decimal,

year's purchase $= \frac{1}{i_p + i_c}$

Where i_c is the sinking fund to replace Re 1·00 at the expiery of the term, i e. sinking fund co-efficient.

Example 1.—Work out the value of year's purchase for an old building if its future life is 15 years and the rate of interest is 7% on capital and 4% for sinking fund.

Year's Purchase, $Y.P. = \frac{1}{i_p + i_c}$,

In this case $i_p = 0{\cdot}07$ on capital and $i_c = 0{\cdot}40$ on sinking fund.

The co-efficient of sinking fund $i_c = \frac{i}{(1+i)^n - 1} = \frac{0.04}{(1+0.04)^{15} - 1} = 00.5$

$\therefore$ Year's purchase $= \frac{1}{0.07+0.05} = 8.333$

12. Depreciation :—Depreciation is the loss in the value of the property due to its use, life, wear, tear, decay and obsolescence This is an assessment of the physical wear and tear of the building or property and is naturally depend on its original condition, quality of maintenance and made of use. Thus the value of a buiding or property decreases gradually upto the utility period due to depreciation. There are different methods to calculate depreciation. Whatever method is adopted book value of a property at a particular time is the original cost less all depreciations till the time. The general annual decrease in the value of a property is known as *Annual depreciation*. Present value of an old building should be worked out on the basis of an annual rate of plysical deterioration multiplied by the building age and concluding by making a final adjustment for obsolescence.

13. Obsolescence :—This may be defined as the loss in the value of the property due to change in fashions, in designs, in structure, in adequacy to present or growing needs, necessity for replacement due to new inventions etc. An apartment which becomes increasingly difficult to rent out is said to suffer from obsolescence.

Obsolescence may be (*a*) *Internal obsolescence* :—

due to (i) Poor on eccentric original design,
(ii) Change in type of construction,
(iii) Change of kind of construction,
(iv) Change in utility demand.

(*b*) *External obsolescence are* :—

(i) Poor original location, (ii) Change in the character of the district, (iii) Specific detrimental influences, such as due to construction of factories, stackyards, proximity of public building, traffic locations and noises etc., (iv) Zoning laws.

Differentiation between Depreciation and Obsolescence :—

Depreciation	Obsolescence
1. This is the physical loss in the value of the property due to wear, tear, decay etc.	1. The loss in the value of the property is due to change of design, fashion, in structure of others, change of utility demand and also specific detrimental influences.
2. Depreciation depends on its original condition, quality of maintenance and mode of use.	2. Obsolescence depends on normal progress in the arts, inadequacy to present or growing needs etc.
3. This is variable according to the age of the property. More the age more will be the amount for depreciation.	3. This is not dependable on age of the building. A new building may suffer its usual rent due to obsolescence.
4. There are different methods by which the amount of depreciation can be calculated.	4. At peresent there is no method.

14. Amortization ;—This is accumulation of sinking fund at compound interest for payment of debt.

15. Annuity :—Annuity is the net instalment of annual or periodical payment for repayment of the capital amount invested in a property for a specified period. Annuity is either paid at the begining or at the end of the each period of instalment.

In case when the annuity is payable at the begining of each period of year and payments are *continued* for *certain fixed number of periods* it is known as **Annuity certain.**

In case when the annuity is receivable for an *indefinite period,* it is known as **Perpetual Annuity.**

In case when the annuity commences *after a few years* from the actual date of the capital amount it is known as **Deferred Annuity.**

16. Valuation Tables :—The mathematical combination of simple and compound interest for sinking fund, depreciation, interest on capital, amount receivable at the end of a given number of years at a certain rate of interest etc. are calculated through their respective formula. But these involve elaborate and tedious calculations. Valuation tables are therefore constructed based on there respective mathematical formula The tables are energy-saving devices and assist valuers to arrive at a speedy and accurate calculation These tables are in the form of ready reckoners and are very easy to use. But it is necessary for valuer to have a thorough knowledge of the construction of these tables.

15-7. Determination of Depreciation :—Depreciation is an assessment of the physical wear and tear of the property and is naturally dependent on its original condition, quality of maintenance and mode of use.

Methods of calculating depreciation :—(*a*) *Straight line method,* (*b*) *Constant percentage method* or *Declining Balance method*—(*c*) *Sinking fund method,* (*d*) *Quantity survey method.*

It should be noted that whatever method is adopted, book value of the property at a particular time should be the original cost less all depreciations till the time. Likewise book value at the expiry of the use of the property should be its scrap value or salvage value.

(*a*) *Straight line method* :—In this method the property is assumed to lose value by a constant amount every year, and thus a fixed amount of original cost is written off every year so that at the end of the term when the asset is worn out, only the scrap value remains.

Let, C = Original Cost ; Sc = Scrap value ; n = life of the property in years.

D = annual depreciation by straight line method

$$\text{Annual depreciation} = \frac{\text{Original cost—scrap value}}{\text{life in years}} \quad \text{i.e.} \quad D = \frac{C - Sc}{n} \quad \cdots (3)$$

Example—I The total cost of a new building is Rs. 1,50,000. Workout the depreciated cost of the building after 20 years by straight line method if the scrap value is Rs, 15,000 assuming the life of the building is 80 years.

Annual depreciation by straight line method

$$=\frac{\text{Original cost—scrap value}}{\text{Life in years}}=\frac{1{,}50{,}000-15{,}000}{80}=\text{Rs. } 1687{\cdot}52$$

Depreciation for 20 years $=$ Rs. $1687{\cdot}50\times20=$ Rs. $33{,}750{\cdot}00$

$\therefore$ Depreciated cost of the building after 20 years $=150{,}000-33{,}750=$ Rs. 1,16,250/-

(*b*) *Constant percentage method or Declining Balance method* :—In this method the property is assumed to lose value annually at a constant percentage of its value (or book value).

Let $p=$ percentage rate of annual depreciation for the constant percentage method expressed in decimal.

$C=$ Original cost ; $Sc=$ Scrap value ; $n=$ life of the property in years

By constant percentage method at the end of the first year the value of the property $=C(l-p)$, at the end of second year $=\{C(l-p)\}\ (l-p)=C(l-p)^2$, at the end of third year $=C(l-p)^3$ and so on.

Whence, at the end of n years value of the property becomes ultimately the scrap value $=Sc=C(l-p)^n$

Or, $p=1-\left(\frac{Sc}{C}\right)^{\frac{1}{n}}$.........(4)

The above formula does not hold good when the scrap value, Sc is zero.

Example 1. The present value of a machine is Rs. 20,000/. Workout the depreciation cost at the end of 5 years, if the salvage value is Rs. 2,000/. Assume life of the machine be 16 years.

The percentage rate of annual depreciation for the constant percentage method,

$$p=1-\left(\frac{Sc}{C}\right)^{\frac{1}{n}}=1-\left(\frac{2000}{20{,}000}\right)^{\frac{1}{n}}=1-0{\cdot}8660=0{\cdot}134.$$

$\therefore$ Value of the property at the end of 5 years $=C\,(l-p)^5=20{,}000\,(1-0{\cdot}134)^5=$ Rs. 9,741 35

(*c*) *Sinking fund method* :—In this method the depreciation is assumed to be annual sinking fund plus the interest of the accumulated sinking fund till that year.

The annual sinking fund to provide for Re 1/- in 'n' years $=\frac{\quad}{(1+y)^n-1}=x$ say (equ.—2)

Where, $i=$ rate of interest expressed in decimal at which sinking fund amount is required to be invested.

An amount of Re 1/per annum in 'n' years $=\frac{(1+i)^n-1}{i}=y$ (say)

$\therefore$ Rate of depreciation in 'n' years $=x\times y$ or $xy\%$

Example-I. The cost of construction of a new building according to present market rate is Rs. 80,000/ having a life of 70 years. But if the building is 15 years old determine the depreciated amount which should be deducted from the cost of the new building at 6% compound interest.

In this case the depreciation is assumed to be annual sinking fund plus the interest of the accumulated sinking fund.

Sinking fund co-efficient for 70 years $Ic = \frac{i}{(1+i)^n - 1} = \frac{0.06}{(1+0.06)^{70} - 1} = 00.010$

An amount of Re 1/ per annum in '*n*' years $= \frac{(1+i)^n - 1}{0.06}$

An amount of Re 1/ after 15 years $= \frac{(1+0.06)^{15} - 1}{0.06} = 23.25$

$\therefore$ Rate of depreciation in 15 years $= 0.001 \times 23.26 = 0.02326$ or 2 326%

Total depreciation in 15 years on Rs. 80,000 $= 80{,}000 \times \frac{2.326}{100} =$ Rs. 18,608/

$\therefore$ Rs. 18,608 should be deducted due to depreciation from the cost of the new building.

(*d*) *Quantity Survey Method* :—In this method the property is studied in details and extent of physical deterioration worked out in an endeavour to calculate depreciation.

Further Example. A concrete mixture was purchased at Rs. 8,000·00. Assuming salvage value to be Rs 1,000 00 after 5 years calculate depreciation for each year adopting (*a*) Straight line method, (*b*) Constant percentage method, and (*c*) Sinking fund method

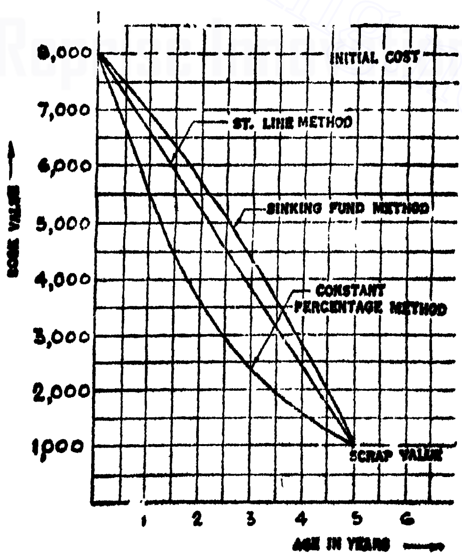
Express the results graphically, age *vs*. book value

(*a*) *Straight line method*, Annual depreciation $= D = \frac{C - Sc}{n} = \frac{800 - 100}{5} =$ Rs. 1,400.

Age in years	Depreciation for that year	Book value
0	0 00	8,000 00
1	1,400 00	6,600 00
2	1,400 00	5,200 00
3	1,400·00	3,800 00
4	1,400 00	2,400 00
5	1,400 00	1,000 00

(*b*) *Constant percentage method* : Constant percentage $= P = 1 - \left(\frac{Sc}{C}\right)^{\frac{1}{n}} = 1 - \left(\frac{1}{8}\right)^{\frac{1}{5}} = 0.34$

Age in years	Depreciation for that year	Book value
0	0·00	8,000 00
1	2,720 00	5,280·00
2	1,795 00	3,485·00
3	1,185·00	2,300 00
4	783·00	1,517 00
5	517·00	1,000·00



(*c*) *Sinking fund method*: Annual sinking fund considering 5% interest = 1

$$= \frac{(8000-1000)\times 0{\cdot}05}{(1+0{\cdot}06)^5-1} = 1240{\cdot}00 \text{ (approx.)}.$$

Age in years	Annual sinking fund	Interest on sinking fund	Depreciation	Book value
0	0·00	0·00	0·00	8,000·00
1	1240·00	0·00	1,240·00	6,760·00
2	1240·00	74·40	1,314·40	5,445·60
3	1240·00	153·20	1,393·20	4,052 40
4	1240·00	236·80	1,476·80	2,575·60
5	1240·00	335·60	1,575·60	1,000·00

15·8. Valuation and its different aspects : It is now evident that valuation is a process dependent on reasoings, facts and proper interpretation of such reasoning and facts. But the process may be a little involved when the forces of demand and supply are unstable. A plot of land bought today may cost much more than what it costs five years back and this increase may not be accounted for by the usual interest for these five years. Rate of interest may vary from time to time. Cost of materials also increases. A structure built ten years back at a cost of Rs. 35,00·000 may have present book value at Rs. 22,000 00 allowing depreciation. But according to present market value the building may sell at Rs. 30,000·00. Then what should be the reasonable valuation of the property ? How can the effect of obsolescence be considered ? What should be the basis of land valuation ? There is no single answer to all these problems, and as such different methods of valuation are existent.

15-9. Computation and valuation tables : Two more expressions, other than those already worked out, are frequently made use of for valuation purpose. These would be deduced here.

(*a*) Present value P of Rs. 1·00 receivable at the end of n years when the rate of interest. is i, expressed in decimal. This Deferred income means an income which will not commence unless a specified period has passed. Deferred income may be for the cases (i) which is recivable in perpetuity after a certain number of years (ii) which is receivable for a specified period after a certain number of years.

Rs. 1·00 accumulates to (1+i) after one year, to $(1+i)^2$ after two years and $(1+i)^n$ after n years. It follows that $\frac{1}{(1+i)}$ Accumulates to Rs. 1·00 after n years

$$\text{whence } P = \frac{1}{(1+i)^n} \quad \ldots \quad (5)$$

(*b*) **Present value V of Rs 1·00 per annum for n years allowing simple interest at i on capital and redemption of the capital at r per annum—**

Simple interest on V per year $= Vi$

Annual sinking fund to replace $V = \dfrac{V \times r}{(1+r)^n - 1}$ -(as per expression 2)

Consequently $I = Vi + \dfrac{V \times r}{(1+r)^n - 1}$ whence $V = \dfrac{1}{1 + \dfrac{r}{(1+r)^n - 1}} = \dfrac{1}{i+s}$ (6)

where, s = annual sinking fund required to replace Rs. 1·00 at the end of n years.

TABLE SHOWING TYPICAL VALUES OF Ic

n \ i	2%	3%	4%	5%
5	·1923	·1887	·1852	·1811
10	0913	·C872	·0835	·0795
15	·0578	·0538	·0501	·0463
20	·0412	·0372	·0335	·0302
25	·0312	·0274	·0241	0209
30	·0247	·0210	0179	0150
40	0166	·0133	·0106	·0083
50	·0118	·0089	·0066	·0048

The six expressions developed are frequently used for the purposes of valuations of a property. Valuation tables are available that give the values of I*c* (in expression 1), *p* (in expression 4), and P (in expression 5) and V (in expression 6) for different values of i, r, n and Sc

15-10. Different methods of valuation :—The different methods of valuation commonly adopted are (a) Rental method of valuation, (b) Initial cost based valuation, (c) Direct comparison method of valuation, (d) Profit based valuation, (e) Development method of valuation, (f) Depreciation method of valuation.

(a) Rental method of valuation :—In this method the net rental income is calculated after deducting all outgoings from the gross rent and year's purchase is calculated after adopting the current bank interest. Then valuation of a property is worked out by multiplying the net rental income by the year's purchase.

When the rent has been proved and is likely to be maintained for years to come, then the rental method of valuation should be applied to determine the market value of a property. This method is very useful for a property with a new building. The actual rent paid must be proved that the rent is the fair rent otherwise very little reliance can be placed upon it.

Capitalised value = Net rent × Year's purchase. Net rent = Gross rent — outgoings.

Year's purchase shall be worked out assuming the present rate of interest of schedule banks.

During valuation by rental method the following particulars shall be considered :

1. Land and its tenure i.e. shape of the land and whether it is a freehold or lease hold land on which building has been erected. 2. Cubic contents of the building, 3. Future life of the building. 4. Gross rent. 5. Outgoings. 6. Year's purchase. 7. Capital repairs if required. 8. Value of land form records.

Example—1. Find the capital value of a premises consisting of land and a well-built house, let out for Rs. 800/-per month inclusive of all taxes. The house is in good condition. The rent by comparison with other premises is fair and is likely to be maintained. Assume the following data :

Outgoings : 18% of the gross rent.

Expected rate of return : 8%

Future life of the building : 60 years.

Gross rent per month = Rs 800/-

∴ Gross rent per annum = 800 × 12 = Rs. 9600/-

Outgoings 18% of the gross rent = $9{,}600 \times \frac{18}{100}$ = Rs. 1,728·00

Net rent = Gross rent — Outgoings = Rs. 9,600 — Rs. 1,728 = Rs. 7872/-

The life of the building being 60 years the income is considered perpetual.

$$\text{Year's purchase} = \frac{100}{\text{rate of interest}} = \frac{100}{8} = 12{\cdot}5$$

Capital value by rental method of valuation = Net rent per year × Year's purchase

= Rs. 7,872 × 12·5 = Rs. 98,400/-

Example—2. Work out the value of a premises consisting of land and a house in a poor condition, to let for Rs. 600·00 per month inclusive of all taxes. The house is in such a condition that the effective life cannot be more than 20 years and after that the house shall have to be rebuilt by an estimated cost of Rs, 25000/-, The rent by comparison with other premises is fair and likely to be maintained provided yearly repairs are constantly executed. Assume the following data :

Cost of annual repairs : 8% of the gross rent

Year's purchase for 20 years @ 7% allowing for redemption of estimated cost to rebuild the house @ 4%. Other outgoings 18%.

Gross rent per month = Rs. 600/- $\therefore$ Gross rent per year = 600×12 = Rs. 7,200/-

Outgoings—

Repairs ...	... 8%
Other outgoings	.. 18%

Total = 26% of the gross rent = Rs. $7{,}200 \times \frac{26}{100}$ = Rs 1,872/-

Cost of rebuilding structure = Rs. 25,000/-

Considering 1 year rent shall have to be lost due to rebuilding ... = Rs. 7,200/-

Total = Rs. 32,200/- This amount shall have to be set aside for redemption @ 4% interest in the form of annul sinking fund premium.

$\therefore$ Annual sinking fund for 20 years $= \frac{Si}{(1+i)^n - 1} = \frac{32{,}200 \times 0{\cdot}04}{(1+0{\cdot}04)^{20} - 1} = 32{,}200 \times 0{\cdot}0325$ = Rs. 1,079/-

Net rent = Gross rent − Outgoings = 7,200 − 1,872 − 1,079 = Rs. 4,249.

Year's Purchase $= \frac{100}{\text{rate of interest}} = \frac{100}{7} = 14{\cdot}286$

$\therefore$ Capital value = Net rent per year $\times$ Year's purchase = Rs. $4{,}249 \times 14{\cdot}286$ = Rs. 60,701.

$\therefore$ Value of the premises = Rs. 60,701/-

(b) Initial cost based valuation :—By this method the valuation is taken to be Initial or Prime cost less depreciation. It should be noted that the rate of depreciation and life span of a building depend on quality of maintenance and quality of material used. The point obsolescence should be considered during the initial cost.

The following are the few methods which can be adopted to determine the initial cost, (1) Estimated cost from accounts, (2) Cost from detailed items, (3) Estimate from plinth area basis, (4) Estimate from unit rate, (5) Cube rate estimate.

(1) Estimated cost from accounts : This method is suitable where works are done by inviting tenders and gives most accurate cost of construction. This method is mostly applicable for buildings constructed by Govt. or local bodies. The payment records are called for to verify the actual cost. In case when owner supplies materials and works are done by labour contract the owner should submit the detailed accounts for all payments made by him. Such accounts may be fictitious and 10% of the estimated cost may be added to arrive at the net amount.

(2) Cost from detailed items : In this method detailed measurements of the building must be made and a schedule of quantities for all the items used in the construction is prepared. Multiplying the items of works by the current P.W.D. rates the cost of the building may be determined. This is the best method to determine the estimated cost but a very laborious task.

(3) **Estimate from plinth area basis :** In this method measure the plinth area of a building and multiply the same by the current plinth area rate. To determine the plinth area rate the quality of materials used in a building including all sanitary and watersupply fittings, electric wiring shall be noted.

(4) **Cubic rate estimate :** In this method the cubic contents of a building is measured and multiply the same by the current cubic rate. This method is more accurate than plinth area basis as the height of a building is involved in the calculation.

After ascertaining the prime cost of a building the present day value is required. This is found by making a deduction to represent the depreciation of the building. To calculate depreciation the present age of the building should be carefully investigated by searching the municipal assessment records, or examining the sanctioned plan and other relevant authentic documents which are likely to give the correct age of the building.

For depreciation a percentage cost of the building may be deducted. In this method of percentage deduction, no deduction shall be made for a 5 year-old building and after that the rate of deduction shall be for the following slabs.

Consider the life of the building is 80 years and 10% being scrap value.

Age in years		Rate of depreciation per year		Total depreciation
Ist Slab : 0 to 5	...	Nil	...	Nil
2nd Slab : 5 to 10	...	$\frac{1}{2}\%$	...	2·5% for 2nd Slab
3rd Slab : 10 to 20	...	$\frac{3}{4}\%$	...	7·5% for 3rd Slab
4th Slab : 20 to 40	...	1%	...	20% for 4th Slab
5th Slab : 40 to 80	...	$1\frac{1}{2}\%$	...	60% for 5th Slab
Balance......=10% for scrap				Grand total=90% for 80 years

Example-1. A person has purchased an old two storied building in vacant position on a land measuring 170 sq m having total plinth area 110 sq m by an amount Rs. 1,10,000/-. From records it is proved that the age of the building is 45 years. If the present value of land is Rs. 30 per sq m and present plinth area rate to construct such a building considering the point obsolescence be Rs. 900/-per sq m including the cost of water supply, sanitation and electric connections, work out your valuation to compare the above purchase value with the above datas.

Prime cost of building = plinth area × plinth area rate = 1100 × 900 = Rs. 99,000

Considering the life of such a new building being 80 years and 10% for scrap value

Depreciation for first 5 years...		...	...	= nil
,,	,,	5 to 10 years	$=\frac{1}{2}\%\times 5$	= 2·5%
,,	,,	10 to 20 years	$=\frac{3}{4}\%\times 10$	= 7·5%
,,	,,	20 to 40 years	$=1\%\times 20$	= 20·0%
,,	,,	40 to 45 years	$=1\frac{1}{2}\%\times 5$	= 7·5%
			For total age 45 years	= 37·5%

∴ **Amount of depreciation = Rs. 99,000 × 37·5 = Rs. 37,125/-**

∴ Depreciated cost = prime cost—value of depreciation
= 99,000—37,125 = Rs. 61,875.
Cost of land = 170 × 320 ...... = Rs. 54,400

Total value = Rs. 1,16,275

As the person has purchased the property by an amount of Rs 1,10,000/- he has made a gain by 1,16,275—1,10,000 = Rs. 6,275/-

Note that if the above old building requires immediate major repairs due to its poor structural condition then an amount should be deducted due to such urgent repairs.

(c) **Direct comparison method** : This method consists of ascertaining the capitalised value of a property by direct comparison with capitalised value of a few adjoining properties. This method is adopted when the particulars of sale of a few adjoining properties are available. The properties should be similar, transactions are to be new and normal, details of each property is known.

This method is suitable where it is not possible to know the fair rent like owner occupied properties, Schools, Clubs, Out-houses etc.

Example 1. An owner has decided to sell his vacant property with a 30 years-old single storied building having a total plinth area of 110 sq. m. The cost of land is Rs. 30,000/- as compared with the adjoining areas. There is no comparable instances of letting values available in the locality but the present plinth area rate to construct such a new building has been determined from current sale price which is Rs. 550 per sq. m. What should be the sale price of the property having a total life of 80 years and when the rate of annual sinking fund interest is 5%.

Prime cost of the building only = 110 × 550 = Rs. 60,500/-

Sinking fund co-efficient for 80 years, $Ic = \frac{i}{(1+i)^n - 1} = \frac{0.05}{(1+0.05)^{80} - 1} = 0.0010$

An amount of Re 1/- per annum in n years $= \frac{(1+i)^n - 1}{i}$

An amount of Re 1/- after 30 years $= \frac{(1+0.05)^{30} - 1}{0.05} = 66.22$.

∴ Rate of depreciation in 30 years = 0.001 × 66.22 = 0.06622 or 6.622%

Total depreciation in 30 years = Rs. $60500 \times \frac{6.622}{100}$ = Rs. 4,006/-

∴ Depreciated cost of building = Rs. 60,500 — Rs. 4,006 = Rs. 56,494

∴ Sale price of the property should be (1) Value of land ... = Rs. 30,000/-
(2) Depreciated cost of building = Rs. 56,494/-

Total = Rs. 86,494/-

(d) Profit based valuation :—This is very much similar to the rental method of valuation and is most applicable in case of valuation of hotels, cinemas, shops etc. In this method net profit is worked out after deducting all possible outgoings including interest of capital investment and also remuneration of labour rendered by owner. This net profit can reasonably be realised in the form of rent and is multiplied by year's purchase to determine the capitalised value.

Example 1. Workout the valuation of a cinema house with the following data ! Cost of land for life-time period of the house (i.e. deferred value)=Rs. 1,20,000/-. Gross income per year=7,50,000/-. Expenses required per year :—(*a*) To run the cinema including staff salary, electric charges, municipal taxes including licence fees, stationery and printing etc. is 30% of the gross income. (*b*) For repairs and maintenance of machineries, plants, equipments, furnitures etc. @5% of their capital cost of Rs. 9,50,000. (*c*) Sinking fund for the machineries as in (*b*) whose life is 25 years @4% after allowing 10% scrap value. (d) Insurance premium is Rs. 10,000/- per year. Assume year's purchase for 60 years @8% and redemption of capital@4%, annual repair of the house @ 2% on gross income.

Gross income per year ... ... Rs. 7,50,000/-

Outgoings—

(*a*) Staff salary, electric, and printing charges @30% of gross income =Rs. 2,25,000/-

(*b*) For repairs and maintenance of machineries etc. @ 5% of Rs. 9,50,000/- =Rs. 47,500/-

(*c*) Sinking fund for machineries etc. with 25 years life @4% on Rs. $9,50,000 \times \frac{9}{10}$ = on Rs. 8,55,000/-

Sinking fund co-efficient for machineries $= \dfrac{0{\cdot}04}{(1+0{\cdot}04)^{25}-1} = 0{\cdot}024.$

∴ Sinking fund on Rs. 8,55,000 = Rs. $8{,}55{,}000 \times 0{\cdot}024$ ... =Rs. 20,520/

(*d*) Insurance premium per year ... ... =Rs. 10,000/

(*e*) Yearly charge for cinema building repair @ 2% on gross income =Rs. 15,000/

Net income =Rs. 4,31,980/-

Year's purchase for 60 years @8% and redemption of capital @4% $= \dfrac{1}{ip+Ic}$

Co-efficient of sinking fund for 60 years, $Ic = \dfrac{0{\cdot}04}{(1+0{\cdot}04)^{60}-1} = 0{\cdot}0042$

$$\therefore \quad \frac{1}{ip+Ic} = \frac{1}{0{\cdot}08+0{\cdot}0042} = 11{\cdot}88.$$

∴ Capital value = Rs. $4{,}31{,}980 \times 11{\cdot}88$ = Rs. 51,31,922/-

Total valuation = Capital value of house + value of land for 60 years
= Rs. 51,31,922 + Rs. 1,20,000 = Rs. 52,51,922/-

(e) **Development method of valuation** :—At times some undeveloped or under-developed property is bought, developed and then offered for sale. The valuation in that case would depend on initial investment, development cost and expected profit.

The development method of valuation is sub-divided into two parts :

(1) **"Development of Building Estates"** i e., Plotting Scheme. In this method an estate is developed with all the essential amenities and sold out in small plots with most advantageous manner so that the state be worth more. When a city continues to expand then the land becomes known as "Ripe for building."

(2) **Hypothetical Building Scheme** :—In this method a plot is developed by laying out buildings thereon with all essential amenities for more worth.

(1) **Valuation by Development of Building Estates**=Present value—total outgoings.

Procedure of valuation :—

(i) First find out : Net area of land=Total area—area of land required for essential amenities like roads, parks, water supply pumping stations etc. which may be considered 30% of the total area.

(ii) Calculate Gross income=Net area of land available for sale by plotting×average sale price.

(iii) From Gross income find out present value.

Since all the plots of land are not sold at a time therefore, the Gross income is deferred by half of the period that is likely to escape before all the plots are sold. If a period of 4 years is required to sell all the plots then the Gross income will be multiplied by the present value of Re. 1 in 2 years at the rate 8 percent (say) ; if the period is 6 years, the Gross income will be multiplied by the present value of Re. 1 for an average period of 3 years at 8 percent.

From the present value deduct the following outgoings :—

(*1*) *Cost of development* :—This item consists of all expenses for construction of roads, footpaths, sewerlines, filtered and unfiltered water mains, lighting of the streets etc. and all such similar development expenses. The whole expenditure for the above work is not required to be paid at a time, therefore the total development cost should be deferred half the period they are likely to be computed.

(*2*) *Payment for the easement rights* :—This is the capital sum which may have to be paid to the adjoining owner to provide an access within his land or to be paid to extinguish any easement rights. The full amount when required shall be treated as outgoings because the amount will have to be paid immediately.

(*3*) *Engineering and supervision charges* :—In order to prepare plans, estimate and competent supervision for the development works an expenditure varying from 4% to 7½% of the deferred cost of development should be allocated.

(*4*) *Stamp cost and incidental charges* :—This item will include legal charges, brokerage, stamps, advertisement etc. and is usually 10% of the present value as in (iii) (i.e. the deferred value of gross income).

(5) *Developer's Profit*—The developer not only deserves to derive interest on his capital but there should be good margin for profit owing to the risks that he is taking. This profit should be from 15% to 20% of the present value i.e. the deferred value of gross income. But 15% profit should be taken as the absolute minimum.

Example—1. Workout the cost of a plot of land measuring 60,000 sq metre which is now ripe for building development when the average market rate for small building plots is Rs. 50/- per sq metre and the cost of development for roadways, water supply, sewerage system, electricity and all other engineering works is Rs. 4·00 per sq m.

Area of the plot ... ... =60,000 sq m

Less area of the land required for road, parks etc. =30% of the area of plot ... ... =18,000 sq m

Net area=42,000 sq m

Gross income=Net area of land×average sale price=42,000×50=Rs. 21,00,000

Assuming that the last plot will be sold after 4 years from the date of purchase, the present value shall be for average period of 2 years @8%.

Present value P of Rs. 1·00 receivable at the end of 'n' years @8%

$$P=\frac{1}{(1+i)^n}=\frac{1}{(1+\cdot 08)^2}=0\cdot 8573.$$

∴ Present value of Rs. 21,00,000/- payable for average period of 2 years @8%

=Rs. 21,00,000×0·8573=Rs, 18,00,330/-

Outgoings :—(a) Cost of development=60,000 sq m×Rs. 4·00 per sq m=Rs. 2,40,000 Considering the development period be 2 years, the present value of development is deferred by one year @8=0-8573×2,40,000 ... ... =Rs. 2,05,752

(b) Engineering and supervision charges in instalments @ 5% on the present value of development ... ... $=2,05,752\times\frac{5}{100}$=Rs. 10,288/-

(c) Stamp cost and incidental charges @ 10% of the present value=$18,00330\times\frac{10}{100}$

=Rs. 1.80,033/-

(d) Developer's profit @15% of the present value $=18,00,330\times\frac{15}{100}$=Rs. 2,70,050

∴ Total outgoings=$(a)+(b)+(c)+(d)$=Rs. 6,66,123/-

∴ Cost of the plot i.e. the value of land before development

=Gross value—Outgoings

=21,00,000—6,66,123=Rs. 14,33.877.

Value of land per sq m$=\frac{14,33,877}{60,000}$=Rs. 23·90

(f) Depreciation method of valuation :—According to this method the depreciated value of a building is calculated directly with the help of the formula, $D=\frac{P(100-rd)^n}{100}$

Where, D = the depreciated value of a building structure after n years

P = cost of the building at present market rate as if new

rd = fixed percentage of depreciation.

(where, r = rate, d = depreciation)

n = the number of years the building had been constructed

The value of rd for different life of a building is as below :—

Building having a life		value of rd
100 years	...	1·0
75 years	...	1·3
50 years	...	2·0
25 years	...	4·0
20 years	...	5·0

By depreciation method of valuation the value of building structures only may be determined. To calculate valuation of a property the cost of land as per present market rate, cost of water supply, sanitation and electrification shall be added to the valuation of building structure.

Example-1. What is the present value of a property having a land area of 270 sq m with a 25 years old 1st class building with a plinth area of 200 sq m. The building is provided with first class water-supply, sanitary and electric fittings. Consider present plinth area rate with water supply, sanitary and electric fittings = Rs. 400 per sq m.

New cost of the building including all fittings at present = 200 × 400 = Rs. 80,000/-

Depreciated value of a building $D=\frac{P(100-rd)^n}{100}$

Assuming the life of the building = 100 years, rd = 1.0 and n in this case = 25

$$\therefore\ D=80{,}000\frac{(100-1)^{25}}{100}=80{,}000\times\left(\tfrac{99}{100}\right)^{25}=\text{Rs. } 62{,}240/-$$

Assuming cost of land = Rs. 150 per sq. m, total cost of land = 270 × 150 = Rs. 40,500/-

∴ Valuation of the property = 62,240/- + Rs. 40,500/- = Rs. 1,02,740/-

15-11. Fixation of standard Rent :—Standard rent is the rent which may be charged to a tenent under the law.

The rent is determined from the value of a property. Greater the value of a property, the greater is the rent. The method of fixation of rent is just reverse the rental method of valuation of a property.

Procedure to determine the standard rent :—

(1) Standard rent or gross rent = Net return or Net rent + Outgoings

(2) Calculate annual net return = Summation of the following :—

(a) A certain annual interest on the cost of construction of the building including the costs for water supply and sanitary works, electric installations etc. The cost of construction also includes the expenses due to subsequent additions and alterations and also any expenditure made on the land. Although the rate of interest may reasonably be 12% for investment on building but the allowable rate of interest under law for Govt. house building loan may be 6% or as specified.

(b) A certain annual interest on the cost of land. The rate of interest on land may be same or a bit less than the rate of interest for the cost of construction.

(c) Outgoings :—This is same as explained in the rental method of valuation.

Example—1. A person has invested Rs 80,000·00 in land and building expecting 6% return. The plot of land costs Rs. 20,000·00. Assuming cost of annual repair to be Rs. 200·00, management charges at Rs. 1,000·00 per annum and other outgoings at 20% of the gross rent calculate the reasonable monthly rent if annual sinking fund co-efficient be 0·01.

Net income expected $= 80{,}000 \times \frac{6}{100} =$ Rs. 4,800·00 per annum.

Let, Gross rent per annum $= x$

Outgoings :—

Repairs	= Rs. 200·00
Management charges	= Rs. 1000·00
Other outgoings	$= 0{\cdot}2x$
Sinking fund	$= 0{\cdot}01 \times 60{,}000 =$ Rs 600·00

Whence, net rent $= x - (0{\cdot}2x + 1800{\cdot}00)$ per annum

$\therefore \quad 0{\cdot}8x + 1{,}800 = 4{,}800$

or, $0{\cdot}8x = 6{,}600$

$\therefore \quad x = 8{,}250$

or, monthly rent $= \dfrac{8250}{12} = 687{\cdot}50$

Example—2. A person has purchased a plot of land costing Rs. 80,000/-and has constructed a building thereon at a total cost of Rs. 1,20,000/- including water supply, sanitary and electrical installations etc. Allowing a net return 7 percent on the cost of constraction and 6 percent net return on the cost of land, workout the standard rent of the property with the following data.

(i) Sinking fund on 4% basis for the future life of 75 years = 0·22%.

(ii) Annual maintenance ½% of the cost of construction.

(iii) Municipal taxes and other outgoings 28·5% of the gross rent.

Standard rent or gross rent = Net rent i.e. net return + outgoings

Net return per annum :—

(*a*) On the cost of construction of Rs. 1,20,000 @ 7% = Rs. 8,400/-
(*b*) On the cost of land of Rs. 80,000/- @6% = Rs. 4,000/-

Total net return per annum = Rs. 12,400/-

Outgoings :—

(*c*) Sinking fund on 4% basis for future life of 75 years on 90% of building cost (scrap value considered 10%) $= 1,20,000 \times \frac{90}{100} \times \frac{0.22}{100}$ = Rs. 237·60

(*d*) Annual maintenance ½% of the cost of construction $= 1,20,000 \times \frac{0.5}{100}$ = Rs. 600·00

(*e*) Municipal taxes and other outgoings 28·5% of the gross rent.
Let this standard rent be x. ∴ Municipal taxes and other outgoings $= 0.285x$

Total outgoings = Rs. $837.6 + 0.285x$

Standard rent = net return + outgoings

or, $x = 12,400 + 837.6 + 0.285x$ or, $x = \frac{13237}{0.715}$ = Rs. 18,513·29

∴ Standard rent per annum = Rs. 18,513·29. Standard rent per month $= \frac{18,513.29}{12}$ = Rs. 1542·77

LEASE-MORTGAGE

In a wider sense there are two types of property namely :—

15-13. A Freehold property :—A freehold property is in absolute possession of its owner for a period of indefinite duration who has the right to use the property at his free will subject only to the laws of land. The owner may sell the property, divide it, develop it, donate or grant it on lease at his sweet will.

15-14. A Leasehold property :—A leasehold property is in physical possession of the *lessee* (or lease hold er) for a definite period under terms and conditions specified in the lease document. The absolute owner of the property, granting lease, known as *lessor*, specifies such terms and conditions as the duration of lease, type of use the property would be subject to, the annual payment to be made by the lessee, whether *sub-lease* would be permitted and if permitted under what conditions etc. The duration of the lease period is normally fixed at 21, 50, 99 or 999 years with different terms and conditions. When the lease is granted for a period of 99 years, it is known as a *long term lease* and when it is for 999 years it is said to be *lease in perpetuity or for endless duration.* The lease is as good as freehold except that there may be some restrictive mutual agreements regarding the built-up area, number of floors, user etc.

In case of short term and long term lease the lessor gets back absolute possession of the property at the expiry of the lease.

Broadly speaking there are two types of leases, namely :—

(1) Building lease and (2) Occupation lease.

(1) *Building lease*—In this case the owner of a freehold open plot of land lets out his land on lease to some person called lessee on an agreed amount of premium or ground rent or a combination of both. The lease holder can erect a building there on to a specified amount in a specified period and he maintains the property and can reside or earn income through such property. Since the lease holder has to spend sufficient money for the construction purpose and as such building lease is generally granted for a long period of 50,99 or 999 years. At the termination of the lease, the lessor becomes the full owner of the land and all buildings erected thereon.

The rent which is paid by the lease holder for the use of land usually for the purpose and the privilege of building on another man's land is known as *ground rent.*

(2) *Occupation lease.*—In this case, lease is granted against premium or rent or a combination of the two by an owner of a property consisting of land and buildings or other structures for occupancy for a fixed period to another person. The lease holder does not require to spend money to construct building and as such lease is generally granted for short term as 7, 14 or 21 years. The lease holder may maintain the property according to the terms and conditions of the lease.

If the rent that is received by the lessee for land and building is the full annual value of the property, it is known as *Rack Rent.*—

15-15. Mortgage :—The owner of a property can raise loan on interest against the security of his property. Such advancement of money against any form of security is called as *Mortgage*. The transactions, the security and the conditions of loan are entered in a document known as *Mortgage deed*. The person advancing money is called as *Mortgagee* and the person borrowing the money is known as *Mortgagor*. The mortgagor remains in possession of his property and receives income therefrom. He can sell the property. So the mortgagee is not a legal owner of the property. The mortgagor or owner borrows money putting up his property as security for the loan. In case if the mortgagor fails to repay the loan with interest or fails to instalments within a specified period as agreed in the Mortgage deed the Mortgagee can sell the property to recover the loan, interest and other dues.

15-16. Equity of Redemption :—It is the legal right of a mortgagor whereby he can free his property from the mortgagee after repaying the full amount of loan together with interest.

15-17 Basis of valuation for the purpose of mortgage :—The basis of valuation of a property for advancing loan against the security of the property should be the rental method of valuation and depending on the proper rate of interest for the purpose of capitalisation according to the present money market. The following points should be guarded for determining the amount of loan :—

(1) Not more than 50% of the value of the property shall be considered for advancing the amount of loan.

(2) To determine the value of the property all outgoings and other factors such as obsolescence etc. shall be carefully considered.

(3) The property shall be such that the same can be sold at any time, comfortably even at the unfavourable time.

(4) Mortgage should be for a short time and value of the property should be ascertained, considering the property will depreciate and more repairs may crop up if the mortgagor neglects to maintain the property.

(5) Net rent from the property should be at least equal to or favourably more than the interest that a mortgagor will be required to pay on the loan amount.

Example 1. A R.C.C. framed structure 8 storied building having a cubic contents of 14,000 cum constructed 15 years back on a free hold tenure land to measure about 1100 sqm. The building fetches a rent of Rs. 14,000 p. m. What amount you will recommend for advancing a loan on the property against mortgage if the rate of land in the neighbourhood = Rs 800/- per sq. m, insurance premium = Rs. 900/- p.a. and Municipal takes = 30% of the gross rent. Assume future life of the building be 60 years. Rate of interest as 8% and for redemption of capital 5%.

	Gross annual rent = Rs. 14,000 × 12	= Rs.	1,68,000/-
Deduct :—(1)	Municipal tax @ 30% on Rs. 1,68,000 ...	= Rs.	50,400/-
(2)	Management and collection charges @ 8% on Rs. 1,68,000	= Rs.	13,440/-
(3)	Repairs @ 8% of gross rent	= Rs.	13,440/-
(4)	Insurance premium	= Rs.	900/-
	∴ Net annual return = gross annual rent—all deductions	= Rs.	89,820/-

Assuming future life of the building be 60 years, the co-efficient of sinking fund

$$I = \frac{i}{(1+i)^n - 1} = \frac{0{\cdot}05}{(1+0{\cdot}05)^{60} - 1} = 0{\cdot}0028$$

$$\therefore \text{ Year's purchase} = \frac{1}{i_p + i_c} = \frac{1}{0{\cdot}080 + 0{\cdot}0028} = 12{\cdot}077$$

∴ Capital value = Net annual return × year's purchase
= Rs. 89,820 × 12·077 = Rs. 10,34,756·10 say Rs. 10,84,756/-

Land value Reversion :—

Value of land @ Rs. 500 per sq m. = 11,00 × 500 = Rs. 5,50,000/-

Now, when Rs. 1/- be deferred for 60 years 5% interest, $= \frac{1}{(1+i)^n} = \frac{1}{(1+0{\cdot}05)^{60}} = 0{\cdot}0535$

∴ Deferred land value Rs. 5,50,000/- for 60 years at 5% interest
= 0·0535 × Rs. 5,50,000/- = Rs. 29,425·00

∴ Total value of the property = value of structure + Reversion value of land
= Rs. 10,84,756 + Rs. 29,425 = Rs. 11, 14, 181/-

For advancing loan against first legal mortgage of the property the maximum amount can be recommended is 50% of Rs. 11, 14, 181 = Rs. 5,57,090/-

15-18. Easement :—An easement may be defined as the privilege or right without profit, which the owner of one property has to enjoy in respect of that property in or over the property of another person.

When a property has enjoyed a privilege from time immemorial it is said to have acquired a prescriptive right, and an easement right may be created when the property have had uninterrupted enjoyment of the privilege for a period of not less than 20 years.

The property which enjoys the right is known as the "*Dominant Tenement*" and the property over which the right is enjoyed is known as the "*Servient Tenement,*".

Some examples of easements are :—

(i) Right to enjoy air and light from the owner of the adjoining land.

(ii) Right of access through the adjoining owners land.

(iii) Right to run and maintain electric and telephone lines, pipe lines for water supply, sewer and gas etc. from the owner of the adjoining land.

(iv) Right of flow of storm water, surface drains over others land.

(v) Right to hold or support metre boxes, main gates etc. on or from the structure of others owner.

(vi) Right to provide supports for an old building from the adjoining owners land (for an example supports against erosion from neighbours land).

15-19. Valuation and Rent fixation of Government Building.

Valuation.—The value of a Government building to be used for residential purposes of government employee is determined considering the following expenses :—(*a*) First cost or capital cost of construction of the building including water supply, sanitation and electrification. (*b*) Expenditure due to ; (i) raising, levelling and dressing sites. (ii) storm drainage and (iii) approach roads and paths within the compound. The cost of land for the purpose of construction of the building or the expenditure on community lawns or gardens are not taken into account during valuation of a Government building. The valuation may be workedout by Initial cost based valuation.

Cost of the building and services are workedout under the following conditions :—

(i) When a residential building is newly constructed, the value can be normaly known from estimated cost from accounts i.e., from the final bill paid and from the other expenditures incurred to complete the building. The present value may be determined after deducting the calculated amount for depreciation. (ii) The expenditures which are made for additions and alterations at a cost more than 5% of the capital cost are added with the capital cost at the time of valuation. (iii) When whole or part of a building or other nonresidential building is to be used for residential purpose.

15-20. Calculation of the standard Rent of a building for residence purpose of Government employee Owned by Government

Method I. ***Individual percentage basis*** :—The yearly rent of a Government building is fixed up after adding the following amounts :—

(1) Interest of capital cost per annum of the building excluding the cost of land. The interest on capital is favourably considered and is usually taken as 6% per annum. The capital cost includes all such cost as mention the above valuation.

(2) Cost of maintenance and repairs of the residence including sanitary water-supply and electric installations and fittings. For annual repairs of building 1½% for sanitary works 1%; for watersupply 1%, electric installations 1½% of their respective capital cost are allowed (this is variable at different States) or as specified by the competent authority (not below the rank of Executive Engineer).

(3) The amount of the rates or taxes in the nature of house or property tax payable in respect of the residence under any law or custom to a municipality or other local body.

If no such estimate has been made for (2) and (3) above a percentage of the capital cost of the residence to be fixed by the competent authority and based on the average proportion which the amounts actually charged for such taxes, maintenance and repairs in respect of buildings of similar design and with similar conveniences in the same locality bear to the capital cost of such buildings.

The competent authority may at any time revise the amount estimate or percentage fixed under (2) and (3) and shall so revise it if no revision has taken place for five years.

For (2) cost of repairs shall include (i) ordinary repairs executed annually or periodically, (ii) special repairs executed at long intervals for renewal of floors, roofs and replacement. The probable cost of repairs necessiated by the occurrence of fire, flood, earthquake, abnormal storm or natural calamity shall not be taken into consideration.

Method 2. *Overall percentage basis* :—According to this method the annual standard rent is considered as 6% of the capital cost of construction of all structures (as mentioned in valuation).

Method 3. According to this method allotment for accommodation for residence of a Government employee is provided according to 1/10th. of his basic pay. In addition he has to pay the electric bill, sweeping charge etc.

Chargable monthly house rent of a government employee for a Government building shall be minimum amount from the above three methods. But now-a-days cost of construction of a building becomes so high in comparison to the basic pay that the chargable house rent becomes minimum as per method 3.

Rent statement :—In order to deduct house rent for a Government employee possessing a Government building from his salary or to allot a Government residence a statement is prepared which is known as *Rent statement*. The statement is usually prepared according to the proforma as shown below ;—

Average Salary of the tenent	Cost of the building	Cost of Services	Total Cost	Rent @ 6% interest	Rent @ 10% of pay	Rent to be Charged

Average pay means by averaging monthly basic pay at the begining and end of a pay scale.

Example 1. A government employee having a pay of Rs. 700 per month, occupies a quarter having a plinth area of 120 square metre. The prevailing rate per square metre of plinth area is Rs. 400. Calculate and suggest the amount of monthly house rent payable by the employee. (A.M. I E. 1979)

Cost of building for 120 square metre @ Rs. 400 per sq m=Rs. 48,0001. This is assumed that the above cost includes the cost of water supply, sanitation and electrification.

Rent per annum on overall percentage the basis 6% interest per annum on the capital cost=Rs. 48,000$\times\frac{6}{100}$=Rs. 2880 $\therefore$ per month=Rs, 2401

But Rent per month on the basis of 10% of pay=Rs. $\frac{700\times10}{100}$=Rs. 70·00 Chargable rent is the minimum of the above two=Rs.=70·00 per month.

Example 2. Calculate the standard rent of a Government residential building newly constructed at the cost of Rs. 7,500 00.

Datas given : (i) Cost of sanitary and water supply works=10% of the building cost.
(ii) Cost of electric installation=8% of the building cost.
(iii) Cost of internal roads and compound wall=Rs. 10,000·00
(iv) Municipal and all other taxes.=Rs. 300 per annum.

To Calculate Capital Cost :—(1) Cost of building =Rs, 75,000·00

(2) Cost of sanitary and water supply$=\frac{75,000\times10}{100}$=Rs. 7,500 00

(3) Cost of electric installation $=\frac{75,000\times8}{100}$=Rs. 6,000·00

(4) Cost of internal roads and compound wall =Rs. 10,000·00

Total=Rs. 98,500 00

To calculate the standard rent the cost of land has not been included.

Overall percentage basis :—

Standdard rent per annum with 6% interest on Capital Cost=Rs. 98,500$\times\frac{6}{100}$

=Rs. 5,910·00

Beside this the occupants are to bear the municipal taxes per annum =Rs. 300

Total=Rs. 6,210·00

$\therefore$ Standard rent per month=Rs. 6,210·00÷12=Rs. 517·50

Individual percentage basis :—

Interest on total capital cost @ 6%=Rs. 93,500$\times\frac{6}{100}$ =Rs. 5,910·00

Annual maintenance charge for :—

(i) Building, roads and compound wall @ 1·5%=Rs. 85,000$\times\frac{1\cdot5}{100}$= Rs. 1,275·00

(ii) Sanitary and water-supply works @ 1% =Rs. 7,500$\times\frac{1}{100}$=Rs. 75·00

(iii) Electric installations @ $1\frac{1}{2}$% =Rs. 6,000$\times\frac{1\cdot5}{100}$=Rs. 90·00

(iv) Principal and all other taxes =Rs. 300 00

Total rent per annum=Rs. 7,650 00

$\therefore$ Standard rent per month=Rs. $\frac{7,650}{12}$=Rs. 637·50

The chargable standard rent is the minimum from the above two methods =Rs. 517·00 p. m.

15·21. Fixation of proportionate rent of a building used for office-cum residence purposes :— When a portion of a building is used for residential purpose beside office the fixation of proportional rent may be findout in the following way—

Let A = Total plinth area of the building, A_1 = plinth area for office purpose

A_2 = plinth area of residential portion, R = rent of the building.

Proportional rent for residential portion $= R \times \frac{A - A_1}{A}$

15·22. Valuation of Land

Plots of land are valued as per sq. metre or Katha or per sft. Road side plots fetch more value than other. Front belt l and is the land, bounded by unobstructed sight lines, front belt line and the road. Generally, it is taken that second belt depth = $1\frac{1}{2}$ × front belt depth, and third belt depth = $1\frac{1}{2}$ × second belt depth. Value of recess land = $\frac{2}{3}$ × value of land in that particular belt of land. Tank filled land is valued at half the rate of the particular belt in which it falls if the tank is not too deep. If, however, this land has special amenities, this rule does not hold good. The front belt depth is generally taken as 18 metres, to 25 metres, The figure 15-2 for example may be seen for the idea of different belts of land and recess lands.

The factors, on which value of land depends, are : (i) Situation, (ii) Size, (iii) Shape, (iv) Frontages and depth, (v) Return frontages, (vi) Width of roadway, (vii) Vistas, (viii) Nature of soil and tanks.

(i) *Situation* : The earning capacity of the building erected on the plot determines its value. Building erected at the city centre fetch more rent than those in suburbs, and the value of land will thus be more in city centre than elsewhere. Orientation of the plot is also important. Thus South facing plots will fetch more value than Northfacing ones.

(ii) *Size* : Medium sized plots will be most costly, because those will have much demand with middle class people.

(iii) *Shape* : Lands of awkward or odd or irregular shape will fetch less value, because here much of space is wasted in constructing the building. Lands of good shape (say, rectangular) are costlier.

(iv) *Frontage and depth* : Neither the frontage, not the depth should be too small for good plots. Frontage : depth should be 1 : $1\frac{1}{2}$ or 1 : 2 for good plots. 12 metres frontage with 18 metres to 24 metres depth is ideal for residential plots.

(v) *Return frontage* : A plot at the junction of two roads is said to have a return ontage. Wider of the two roads, and in case the roads are of equal width the more portant of the two roads should be taken as at the front of the plot.

(vi) *Width of the roadway* : Plots on wider roads generally fetch more value. However, important business centres, plots on narrow roads also fetch high value.

(vii) *Vistas* : When a plot is such that it faces a road, which meets the road on which said plot is situated, it fetches more value.

(viii) *Nature of soil and tanks* **:** Value of shallow tanks is taken as half the value of solid land generally. Full value of land is reached from 0·5 to 1 in course of 10 years generally, and from this idea, the value of land after a particular period after filling can be calculated.

Example 1. A property consists of a South facing plot of land, having South-East and North sides in due directions, which measures 60 m, 180 m and 80 m respectively. It consists of an old two storied building, having a total cubical content of 2840 cubic metres. Assuming prime cost of construction of the building as Rs. 500/- per cubic metre and allowing old material's value only for the building, what would you recommend as the fair value of the property, if the front belt land (depth of front belt being 25 m) be estimated at Rs. 90/- per sq m

Plot	Area in Sq m	Area in Terms of F. B. Units
1 F B	$60 \times 25 = 1500$	1500
2 S B	$60 \times 375 = 2250$	$\frac{2}{3} \times 2250 = 1500$
3 T B	$60 \times 117{\cdot}5 = 7050$	$\frac{1}{2} \times 7050 = 3525$
4 F B R	$\frac{1}{2} \times 25 \times 2{\cdot}8 = 35$	$\frac{3}{4} \times 35 = 26{\cdot}25$
5 S B R	$\frac{1}{2} \times (2{\cdot}8 + 7) \times 37{\cdot}5 = 183{\cdot}75$	$183\ 75 \times \frac{3}{4} \times \frac{2}{3} = 91{\cdot}87$
6 T B R	$\frac{1}{2}(7 + 20) \times 117{\cdot}5 = 1586$	$1586 \times \frac{3}{4} \times \frac{1}{2} = 594{\cdot}75$
		Total $= 7237\ 87$

$\therefore$ Value of the plot

$= 7237{\cdot}87 \times 90 =$ Rs. 6,51,403/-

Prime cost of construction of the building

$= 500 \times 2840 =$ Rs 14,20,000-

Old materials value $= 10\% \times 1{,}42{,}0000$-

$=$ Rs. 142000

$\therefore$ Value of the property $=$

value of plot $+$ value of building

$= 6{,}51{,}408/- + 1{,}42{,}000/-$

$=$ Rs. 7,93,4081-

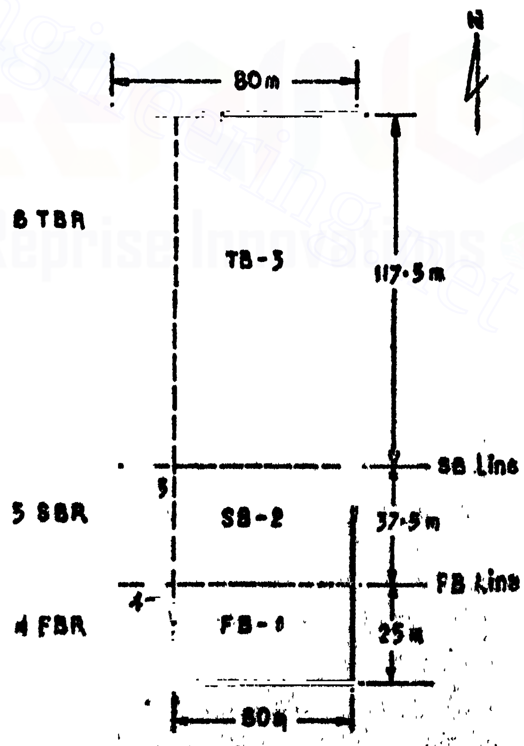


FIG. 15·2

Example 2. A property is proposed to be developed on a South facing plot of land on a 30 m wide road in Calcutta, having a frontage of 30 m and a depth of 60 m. The front belt may be taken up to 25 m with the value fixed at Rs. 400 per sq m for the front belt land. An eight-storied building having a ovarall height of 30m above the ground is proposed to be constructed with 5 m space on the east, 1·3 m on the west and 12 m on the north. If the cost of construction is Rs 70 per cubic m and rentable area is 60% of covered area, find the average rent to be realised per sq m of rentable area, for investment to yield @$8\frac{1}{2}$% gross.

PLOT	AREA IN SQM	AREA IN TERMS OF F.B UNITS	
1—FB	$30 \times 25 = 750$		$= 750$
2—SB	$35 \times 30 = 1050$	$1050 \times \frac{2}{3}$	$= 700$
		Total	$= 1450$ sq m

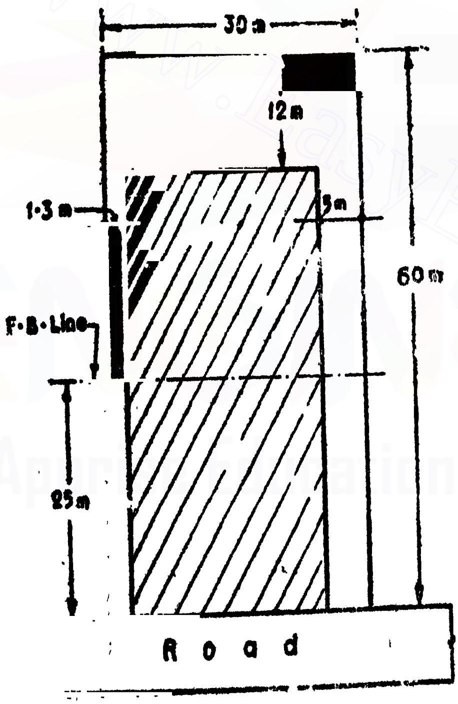


FIG. 15-3

Value of the plot $= 1450 \times 400 =$ Rs. 5,80,000

Now, floor area of the building $= 48 \times 23.7$
$= 1137{\cdot}6$ sq m

and volume of the building $= 1137{\cdot}6 \times 30$
$= 34128$ cu m

Prime cost $= 70 \times 34128$/-
$=$ Rs. 23,88,960/-

Investment in land and building
23,88,960 + 5,80,000/- = Rs. 29,68,960

Rent to be realised for $8\frac{1}{2}$% gross return

$$= 29{,}68{,}960 \times \frac{8\frac{1}{2}}{10} = 2{,}17{,}439/-$$

But, rentable area $= 1137{\cdot}60 \times 60 = 6826$ sq m

Rent to be realised per sq m $= 2{,}17{,}429 \div 682{\cdot}6$
$=$ Rs. 320·27/-

Example 3. Find the value of the plot of land A B C D E F G H J K L M N P Q R, of which the lengths of different sides are given in the figure 15-4. Assume the following :

(i) On 12 M wide road, the front belt depth is 24 M and the value of front belt land is Rs. 60/- sq. metre.

(ii) On 6 M wide road, the front belt depth is 18 M and the value of front belt land is Rs. 40/- per square metre.

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AB=18M	JK=24M
BC=9M	KL= 9M
CD=60M	LM=27M
DE=6M	MN= 9M
EF=24M	NP=42M
FG=9M	PQ= 6M
GH=18M	QR=27M
HJ=36M	AR=30M

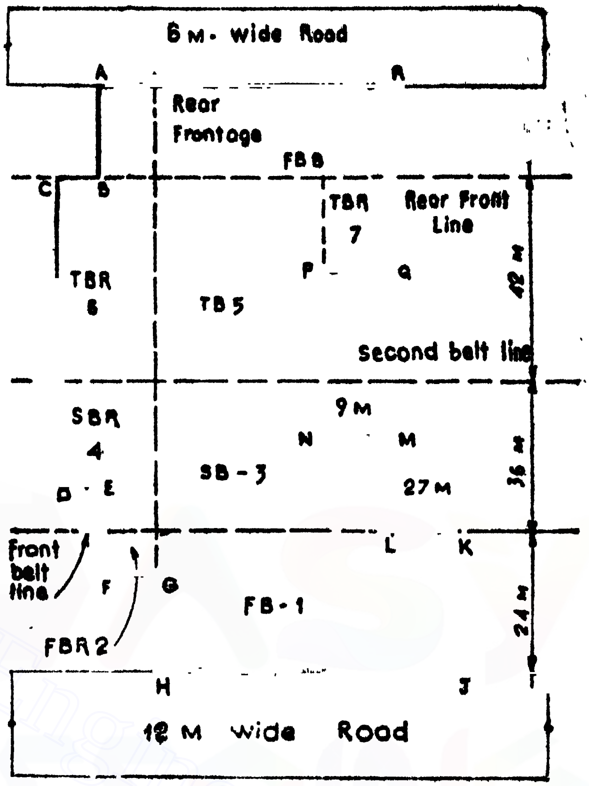


FIG. 15-4

Ans. Considering 12M wide road frontage, third belt land value = Rs. ½×60 = Rs. 30 per sq. metre. Considering 6m wide road frontage (rear), value of second belt land ⅔×40/- = Rs. 26·67/- per sqm which is less than Rs. 30/-. But front belt land value per sq m. 40/- which is more than Rs. 30/-. (Third belt land value for 12m wide road) In such cases consider the maximum value of land.

Plot	Area in sq. m		Area in terms of front belt units	
F B—1	36×24	=864		=864
F B R—2	9×6	= 54	¾×54	=40·51
S B—3	27×27+9×18	=891	⅔×891	=594
S B R—4	18×9+15×18	=432	⅔×¾×432	=216
T B—5	42×18	=756	½×756	=373
T B R—6	42×15	=630	½×¾×630	=236·25
T B R—7	6×9	= 54	⅜×54	= 20·25
			Total	=2349·0

Value=Rs. 60×2349·00=Rs. 1,40,940 Rear front belt area=18×30=540 sq m

Value of rear front belt land=540×Rs. 40=Rs. 21,600/-

∴ Total Value of land=Rs. 1,40,940+Rs. 21,600/-=Rs. 1,62,940/-

Further Example—1. A person resides in a two storied building constructed 30 years ago on a land measuring 200 sqm. The total plinth area of the building is 130 sqm. For good maintenance the future life of the building is estimated to be 50 years. The owner now desires to sell the property and has received an offer of Rs 3,50,000 with vacant possession. On the other hand he has received an offer of monthly rent of Rs. 4,000 for the entire property. As a valuer advice the owner whether he will sell the property or give it on a rental basis.

Assume the following data.—(i) Value of land for similar plots at that area = Rs. 590 per sqm; (ii) Annual sinking fund for the redumption of Re 1 at 6% in 80 years = 0.0006; (iii) Interest on capital = 10%; (iv) Outgoings 28% of the gross rent; (v) Present cost of such a two storied building = Rs. 2,000 per sqm.

Present cost of the building = 130 × Rs. 2,000 = Rs. 2,60,000

Calculation of depreciation by sinking fund method :—

Sinking fund co-efficient for 80 years at 6% = 0·0006

An amount Re 1 after 30 years $= \dfrac{(1+0{\cdot}06)^{80-1}}{0{\cdot}06} = 79\ 058$

∴ Rate of depreciation for 30 years = 0·0006 × 79·058 = 0·04743 i.e. 4 743%,

Total depreciation in 30 years on Rs. 2,60,000 = 2,60,000 × 0·04743 = Rs. 12,332

∴ Depreciated cost = Rs. 2,60,000 — Rs. 12,332 = Rs. 2,47,668

(1) Value of the property on land and building method :—

Value of 200 sqm land = 200 × Rs. 500	= Rs. 1,00,000
Depreciated cost of building	= Rs. 2,47668
Total value =	Rs 3,47668

(2) Value of the property on rental basis :—

Rent per year = Rs. 4,000 × 12 ...	Rs. 48,000
Deduct outgoings @ 28%	Rs. 13,446
Net return =	Rs. 34,560

Year's purchase with 10% interest on capital and 6% on sinking fund

$$\text{Y. P.} = \frac{1}{0{\cdot}10+0{\cdot}06} = 6{\cdot}25.$$

∴ Capital value = Rs. 34,560 × 6·28 = Rs. 2,16,000

To calculate deffered value of land :—

When Rs. 1 be deffered for 50 years with 10% interest $= \dfrac{1}{(1+1)^n} = \dfrac{1}{(1+0{\cdot}10)^{50}} = 0{\cdot}0085$

∴ Deferred value = Rs. 1,00,000 × 0·0085 = Rs. 850

Total value = Rs, 2,16,000 + Rs. 850 = Rs. 2,16,850·00

Value of the property by land and building method = Rs. 3,47,668

Value of the property by rental basis = Rs. 2,16,850·00. The owner gets an offer of Rs. 3,50,000 which exceeds the property value, therefore the owner is adviced to sell his property.

Valuation for Rating purpose :—Rate has been defined as a public charges equally assessed on property and are applicable to local purposes of a public nature. This is charged on the basis of an assessment in respect of the yearly value of property.

Methods of Assessing the rateable value of a property are :—(1) Rental method, (2) Comparison method, (3) Capital value (structural method), (4) Profit based.

(1) **Rental method**—In this method the actual rents paid by the tenants are adopted and is the best and most direct method for assessing the rateable annual value of a property.

Ten percent statutory deduction :—The owner is allowed 10% deduction from the gross rent for repairs, insurance etc. The statutory deduction does not include special services rendered by the owner.

Calculation of municipal taxes as percentage of gross rent :—

Consider the annual rent is Rs. 100 including tenants tax. Deduct the statutory deduction of 10%. Rateable value, Rs. 100−Rs. 10=Rs. 90

∴ When rateable value is Rs. 90 the rent=Rs. 100

„ „ „ is Rs. 100 „ „ $=\text{Rs. } \frac{100}{90}\times 100=\text{Rs. } 111{\cdot}11$ Say Rs. 111

Therefore, when the rent is Rs. 111 p.a. rateable value=Rs. 100

Considering the tenants tax be 8% his rent (this is fixed up by the local municipality)

The total ammount of rent is required by the owner=Rs. 111+Rs. 8=Rs. 119.

Now, for gross rent of Rs. 119 Tenant's portion tax=Rs. 8·00

„ „ „ „ Rs. 100 „ „ „ $=\frac{8\times 100}{119}=\text{Rs. } 6{\cdot}72.$

Therefore after deducting the municipal tax for the tenant the Gross rateable value =Rs. 100−Rs. 6·72=Rs. 93·28.

∴ Net raeable value=Gross rateable value−10% statutory deduction
=Rs. 93·28−Rs. 9·33=Rs. 83·95

In case when the Municipal tax is 32¾% of the net rented value (This is fixed up by the local Municipality) Tax $=\frac{83{\cdot}95}{100}\times 32{\cdot}75=\text{Rs. } 27{\cdot}49.$

Therefore for a gross rent of Rs. 100 per annum and with 32·75% tax, the payable tax per annum=Rs. 27 49

(2) **Comparison Method** :—This method is used when a building is erected by the owner and not for letting purposes and not ordinarily let, the rate of letting of comparable premises are applied to premises in question so as to arrive at the annual value. This requires skilled consideration and sound knowledge in order to calculate what are comparable premises which is the basis of this method.

In some of the Municipalities the annual value is deemed to be five percent on the estimated present value of the property.

(3) **Capital Value method** :—As in the case of comparison method five percent of the value of the property is generally charged as the annual valuation of the property. Over this annual value the percentage of tax is applied to calculate the annual taxation of the property.

(4) **Profit based** :—This method is adopted when it is not possible to calculate the rent by any of the other methods. This method is usually applicable for cinemas, theatres, hotels, race course etc.

EXERCISES

1. A machine is estimated to last for 10 years and its scrap value is estimated to be Rs. 3000. The owner desires to install a new machine by replacing the old one after 10 years. Calculate the amount of 'sinking fund' to be provided by the owner every year, if the new machine is going to cost Rs. 35,000. Assume the rate of interest as 6%.

2. A 15-years old building constructed at a cost of Rs. 70,000 is priced at Rs. 65,000 in the market to-day. As a valuer, advise the purchaser whether he will be in gain or loss. The future life of the building is estimated as 55 years and the prevailing rate of interest is 6% on sinking fund. (A.M.I.E. 1981s)

3. A landlord possesses a building which fetches a gross rent of Rs. 350/- per month. The out goings amount to 25% of the gross rent. The estimated future life of the building is 25 years, but it is expected to last by another 40 years if structural and other repairs are immediately carried out at an estimated cost of Rs. 7,500/-. Suggest by valuation process, whether it is economical to renovate the building or not. Assume rate of interest as 10% on capital and 6% on sinking fund. (A.M.I.E. 1981s)

4. The owner of a vacant plot of land constructs a building on it to-day at a cost of Rs. 40,000/-. The land was purchased 5 years ago at the investment of Rs. 9,000/-. If the expected returns are 7% on present cost of land and 9% on the cost of construction of the building, fix the standard rent from the property per month assuming suitable percentages of outgoings. Assume the life of building as 60 years and the rate of interest on sinking fund as 5%. (A.M.I.E. 1980w)

5. A R.C.C, building fetches a monthly rent of Rs. 250/-. It is a freehold property constructed 20 years ago, and is expected to last for 80 years more. It is estimated to cost Rs. 50,000/- for rebuilding at the end of its useful life and to yield Rs. 3,000/- as scrap value.

The municipal taxes are 6½% of rental income, water charges Rs. 12/- for each of the four connections in the building, and sanitary charges are Rs. 81·50/- all per annum. The insurance charges are Rs. 105 per annum. The rent is likely to be maintained if repairs are executed constantly at a rate of 1% of the structure every year.

If the rate of interest for capitalisation is 6% and that of sinking fund 4%, work out the value of the building for perpetual income. (A.M.I.E. 1980s)

6. A doctor possesses a building admeasuring about 167 sq. m with open space to sky as 2·4 m×2·7 m. It consists of a ground floor part of which is rented fetching monthly rent of Rs. 95/- and the upper three floors which are used by the owner. On second floor there is an additional open area of 3·6 m×2·7 m. On the third floor there is only a bed room measuring (outside to outside) 3·9 m×4·0 m. The building is 60 years old with old type of construction. The structure is in quite a good condition with an estimated future life of 40 years. The owner pays Rs. 1,840/- as outgoings. The equivalent rent for the portions of building occupied by the owner can be taken as Rs. 600/- per month. It is a freehold property. The value of land may be assumed steady and rate of interest as 7½%. Estimate the value of the property by two relevant methods and compare the values. (A.M.I.E 1980w)

7. Work out the valuation of a cinema, theatre and find the value per seat with the following details :

Number of seats : 1,700

Gross annual income from cinema shows : Rs. 5,40,00/-

Income from slide advertisement : Rs. 30,000/-

Staff salary, electricity bill stationery, taxes etc. : 40% of gross income

Repairs and maintenance of machinery : 5% of capital cost

Capital cost of machinery : Rs. 10,00.000/-

Sinking fund on machinery : Rs. 20,000/-

Annual insurance premium : Rs. 10 000/-

Repairs to building : 2% of gross income.

Assume years purchase for 35 years at 8% and redemption of capital at 5%.

Deferred value of land ; Rs. 1,50,000/- (A.M.I.E. 1981w)

8. What are the different methods of depreciation ? Describe each method briefly.

9. What are the different methods of valuation ? What are the purposes of different methods ?

10. What is Obsolescence ? What are (a) internal obsolescence ? (b) external obsolescence ?

CHAPTER XVI

ACCOUNTS

16-1. Introduction :—*What Accounts are ?*
Why it is necessary to maintain ?
What is the relation of Accounts to Public Works Project ?

Account is that method of book-keeping by means of which the cost of the service or undertaking may be accurately known. To have adequate financial control over the works it is necessary to maintain accounts in the method suitable to each type of business. Of the many process in vogue, the system followed in Public Works Department of the Central and State Governments is known as Public Works system of accounts. It essentially follows the actual execution of works or Projects on Public sector.

16-2. Functions of the Public Works Department :—Of the manifold functions of the Public Works Department the services commonly undertaken are indicated below :—

PUBLIC WORKS DEPARTMENT

- Civil Works
- Works entrusted by other Govt. or Deptt. such as P. & T., Railways. M.E.S., Defence.
- Deposit Works of private or local bodies

These works mainly relate to Construction or Maintenance of—

(i) Building (ii) Roads, Bridges, Runways (iii) Water supply and sanitation (iv) Irrigation, Navigation, Embankment, Drainage (v) Electrical and Airconditioning (vi) Mechanical and Transport (vii) Furniture and Fixture.

At times, the P. W. D. is entrusted with Famine Relief Works.

16-3. Organisation.—The analytical diagram below will provide an idea of the P. W. Organisation in relation to works in brief :—

Building Project.

- Labour
  - Engaged by Contractor
  - Departmental
    - Work Charged Staff
    - Muster Roll Labour & Casual Labour
- Material
  - Supplied by Contractor or Supplier
  - Manufactured by the Department
- Overheads
  - C.E./A.C.E
  - S.E.
  - D.O.[E.E]
  - S.D.O.[A.E.]
  - Overseer [S.O./S.A.E.]

The designations of the officers of the P.W.D. have been abbreviated as S.O. for Sectional Officer, S.D.O. for Sub-Divisional Officer, A.E. for assistant Engineer. D.O. for Divisonal Officer, E.E. for Executive Engineer, S.E. for Superintending Engineer. C.E. for Chief Engineer and A.C.E. for Additional Chief Engineer.

16-4. Stages in execution of works.—(*a*) It is essential to keep in mind that the normal work shall be commenced or liability incurred in connection with it unless the formalities shown in the sketch below have been completed

PROJECT

(i) Administrative approval | (ii) Expenditure sanction | (iii) Technical sanction | (iv) Appropriation or Allotment of fund

(i) & (ii) **Administrative Approval and Expenditure Sanction** are formal Approval and concurrence given by an administrative Department of the Govt. for a work or project for which preliminary estimate has been framed by the P. W. D. to meet the needs of Department requiring the work. This is, in effect, an order on the P.W D. to execute the proposed work within the amount so sanctioned.

(iii) **Technical Sanction** is the term which denotes the order of the competent authority of the P.W D. sanctioning a proper detailed estimate of a work or project. It amounts to no more than a guarantee that the estimate is accurately framed and structurally sound.

(iv) **Appropriation or allotment of fund** represents the amount available for expenditure on a work during a particular financial year *i e.* from April to March

In case of excess of more than 10% over the amount of administrative approval or technical sanction and 5% over the Expenditure sanction a revised administrative approval, Expenditure sanction or technical sanction, as the case may be, is required to be obtained from authorities concerned before incuring the liability.

(*b*) In cases of emergency such as breach, or a flood or calamity like Earthquake and so on, one or more of the above stages may be obviated as per direction of the S.E. or higher authority. The audit officer concerned should be kept informed about the liability incurred in anticipation of formal sanction.

16-5. Main Divisions of Accounts :—Govt. Accounts are maintained in the following *three parts* :—(i) Consolidated Fund of India or the State concerned (ii) Contingency Fund of India or State (iii) Public Account of India or State.

In part (i) There are *three main Divisions, viz.*

(*a*) Revenue, (*b*) Capital, (*c*) Debt (Public Debt, and loans and advances).

In part (ii) There is no Division.

In part (iii) There are *two main Divisions viz.*

(*a*) Debt, and Deposits [other than those in Part (i) above], (*b*) Remittances.

The Revenue (Division) deals with the proceeds of taxation and other receipts classified as revenue and expenditure therefrom. The Capital (Division) deals with expenditure met usually from borrowed funds with the object of increasing specific assets or for reducing recurring liabilites'. The Debt (Division) comprises of loan raised by Govt. and the Remittance Division consists of all merely adjusting heads *i.e.* remittances of each between treasuries and transfer transactions between different accounting circles.

The transactions of Public Works Officers *are grouped under the heads*

I—Expenditure Heads, II—Revenue Heads. III—Remittance Heads.
IV—Debt and Deposit Heads.

16-6. Classification of the Operation of the Public Works Department :—Of the four groups *viz.* I—Expenditure, II—Revenue etc. mentioned above the main unit of classification against group I and II is known as Major Head which is divided into minor heads, each of which has a number of sub-heads generally known as detailed heads. Instances are.—

	Major Head	Minor Head	Detailed Head
1.	XXXVII—Public Works	Miscellaneous	Rents of lands
2.	50—Public Works	[A—Orgl. Works-Buildings General Administration.]	1. Purchase 2. Stock 3. Misc. P. W. Advances
3.	50—Public Works	Suspense	4. Workshop Suspense

As there are large number of Major Heads, they have been listed and each has been assigned a serial number. The Revenue Major Heads are denoted by Roman numeral *viz*. I—Customs, II—Union Excise Duties, III—Corporation Tax, XXXIV—Irrigation, Navigation, Embankment and drainage works, XXXVII—Public Works etc. Similarly Expenditure Major Heads are denoted by Arabic numerals thus :—I—Custom. 2—Union Excise Duties. 20—Audit, 50—Public Works. 64—Famine Relief and so on.

16-7. System of P.W. Accounts :—The main feature of the system of P.W. Accounts are :—

(*a*) Divisional Officer (E.E.) is the cheque drawing and disbursing officer of the Division which is the executive and accounting unit. The overseer (Sectional Officer) is the primary element in it who is also the keeper of important initial accounts records such as M. Bs., Materials at Site Accounts [M.A.S. A/cs.], stores and Tools and Plant (T. & P.) accounts on the bases of which the Sub-Divisional records and returns are complied.

(*b*) The Divisional Officer is placed in accounts with Treasury or Reserve Bank/State Bank of India by the Accountant General [A.G.] on which he draws Cheques to meet payment for works and office contingencies. He deposits in it the departmental receipts by Treasury Challans.

(*c*) The Divisional Officer maintains accounts of all stores received and issued in the forms prescribed by the A.G. as per returns submitted by the Sub-Divisional offier.

(*d*) The accounts of receipts, payments and issues of cash and stores including the transaction of Sub Divisional Officers, are got complied by the Divisional Accountant monthly and submitted to the A. G. concerned for audit and incorporation in the General Accounts of the Govt.

(*e*) Payment to Regular Establishment of the Division and Sub-Division is made on bills presented and encashed at the Treasury and therefore does not appear in the Divisional Monthly Account complied by Divisional Accountant.

In the above context, the two fold functions of the Overseer (S.O.) are very important in Public Works set-up. He is responsible both for execution of works and maintenance of accounts with which he is concerned. The record of a transaction of a receipt or expenditure in the initial account books by the Overseer (S.O.) is producible as convincing evidence of facts in a Court of Law. All transactions involving the giving or taking of cash, stores, other properties, which have money values should therefore, be brought to account in a clear, explicit and self contained manner. It is however not sufficient that an Officer's accounts are correct to his own satisfaction but he has to satisfy the audit by a clear and complete proof.

16.8. Divisional Accountant :—To assist Divisional Officers in the discharge of their responsibilities the Accountant General will post a Divisional Accountant to each divisional office. The functions of the Divisional Accountant are three fold :—

(*a*) as the compiler of the accounts of the division with the prescribed rules and form the data furnished to him,

(*b*) as internal checker charged with the responsibility of applying certain preliminary checks to the internal accounts, vouchers etc.

(*c*) as financial assistant and adviser to the Divisional Officer in all matters relating to the accounts and budget estimates.

In the discharge of the above duties the Divisional Accountant is expected to keep himself conversant with all sanctions and orders, passing through the office and with other proceedings of the Divisional Officer. He should advise the Divisional Officer on the financial effect of all proposals for expenditure.

The Divisional Officer should see that he is given the fullest opportunity of becoming conversant with these sanctions, orders and proceedings. The Divisional Accountant is expected to see that the rules and orders in force are observed in respect of all the transactions of the division which come within his sphere of duties. If he considers that any transaction or order affecting receipts or expenditure is such as would be challenged by the Accountant General if the internal check entrusted to the Accountant were applied by the former, it is his duty to bring this fact to the notice of the Divisional Officer with a statement of his reasons, and to obtain the orders of that officer. It will then be his duty to comply with the orders of the Divisional officer, but if he has been overruled and is not satisfied with the decision, he should at the same time make a brief note of the case in the Register.

The Divisional Accountant is responsible for the arrangements for checking i.e. for seeing that satisfactory and efficient arrangements are made for checking. He should see that the comparative statement correctly incorporates the totals as checked on the individual tenders.

16·9. CASH :—(*A*) *Receipts* (*B*) *Payments* (*C*) *Cash Book*
(*D*) *Subsidiary Cash Book* (*E*) *Imprest* (*F*) *Temporary Advance*

The term cash includes legal tender coins, notes, cheques, Deposit-at-Call Receipts of Scheduled Banks, Demand drafts & Revenue Stamps, but does not cover Govt. Securities, Deposit receipts of banks other than those mentioned above, National Savings Certificates, Postal Cash Certificates, Treasury Savings Deposit Certificates etc. which are sometimes received as Security as Deposit and are treated in Accounts as Interest-bearing Securities

(A) Receipts : In the discharge of duties, the Divisional or Sub-Divisional Officers are required to realise money on Govt. account which they should promptly bring in his books and remit it to the Treasury or Bank duly supported by a memorandum or Challan in Form T. R.-6. A cash receipt in Form 3 must invariably be granted in each case of realisation of money. These receipts should not be utilised for current Govt. expenditure except under special circumstances when the drawing officer would send a cheque to Treasury/Bank for the amount taus utilised drawn in his favour with an endorsement or "received payment by transfer credit to P.W. Department". For all Deposits in Treasury, Challan Forms specially marked for (Central) or (State) as required should be obtained. The columns indicating—'By whom Deposited'. 'on whose behalf deposited,' particulars of deposits, amount and classification of the deposit with signature of Departmental Officer should be properly filled in and sent to Treasury in duplicate with the remittance. A copy duly received should be obtained and kept on record as a proof of remittance.

Private cash or account of officer or any member of the Departments should, in no case, be mixed up with public cash or account. If an officer who is not in-charge of cash book receives money on behalf of Govt. he should not mix it up with his Imprest or any other cash in his charge but pay or remit it at his earliest opportunity to the nearest officer having a cash book or direct into a Treasury.

(B) **Payments** : Except payment to the staff or payments of claims less than Rs. 10/- (ten), all other payments are made by the Divisional or Sub-Divisional Officer (where authorised) by cheques. Self-cheque is drawn to meet claims of W.C. Staff and contingent expenses. The currency of all cheques issued expires, if not presented for payment within three months after the month of its issue. No cheque should, as a rule, be drawn until it is intended to be paid away. *It is serious irregularity to draw cheques and keep them in chest at the close of the financial year with the idea of showing the full amount of grant as utilised.*

Against each payment made, the disbursing officer must have a voucher on his record as a proof of payment setting forth full particulars of claim, quantity, rate, unit and amount duly acknowledged by the claimant or his representative holding legally valid power of attorney.

(C) **Cash Book** : The cash book is one of the most important account records of the Division. It is maintained in Form—1 for all cash transaction taking place from day to day strictly in order of occurrence. The detailed instructions are available in the fly leaf of the cash book. The columns provided in the Books are shown below :—

FORM—1 CASH BOOK

Receipt side					Payment side						
								Payment			
								Cash	Bank or Try.		
Date of receipt	No. of Vr. of receipt	From whom received etc.	Amount (Cash)	Classification of receipts	Date of payment	No. of Vr.	To whom paid etc.		No. of Ch/ Ch.Book	Amount	Classification of charges
1	2	3	4	5	6	7	8	9	10	11	12

As indicated above, all receipts in cash are entered in Receipt side of the book: Deductions from bills for Security Deposit etc. and self-cheque drawn are also entered in the Receipt side by contra entries from payment side. In other words such amount appears on both sides of the Cash Book

All payments made are entered either in cash or cheque Col. according to the mode of payment. (1) Cheques drawn to replenish the cash chest is shown in Col. 11 and simultaneously in Col. 4 (2) Deductions from bills for security deposit etc. are shown in Col. 9 with a per contra entry in Col. 4. (3) When a cheque is cancelled, a minus entry is made in Col. 11 giving counter reference against original entry in the book. (4) Issue of a new cheque in lieu of a time barred or lost cheque is shown in red ink in Col. 8 without any entry in Col. 9 or 11. A note is kept against original entry at the same time. (5) Entries in respect of Imprest and Temporary Advances are made in red ink in Col. 8. The amounts of payment are not shown in Col. 9 or 11 as they form part of the cash balance of the officer making advance, till the accounts rendered are accepted and adjusted, finally in Cash Book.

The cash book of the Division is closed on the last working day of the month. The Sub-Divisional cash book is closed earlier to enable Divisional Officer to incorporate the transactions in his monthly cash account.

After the cash book is closed and physical counting of cash is done by the Divisional Officer a cash balance report is made out. A certificate of the count of cash is recorded by him in the cash book showing details of closing balance under (*a*) *Temporary Advances*, (*b*) *Imprest*, and (*c*) *Cash in chest*.

In case actual balance is found surplus, a receipt entry is made to tally the book and classified under P.W. Deposit. Similarly, if cash is found short a payment entry is made to set right the book by debit to Misc. P.W. Advances.

(D) Subsidiary Cash Book :—Beside the above cash book, the Divisional Officer has to maintain another cash account known as *Subsidary Cash Book* to record transactions of recipts and payments relating to pay, allowances etc. of his regular establishment for whom he draws money from Treasury by presentation of bills. The cash and account books in both cases must be kept separately.

(E) Imprest :—An Imprest is a standing advance of a fixed sum of money given to Sub-Divisional Officer and Overseers (S.O.) to enable them to make day to day petty payments for proper discharge of their duties.

The account of the Imprest is kept in duplicate in Form-2 by the Imprest holder. The original Form with supporting vouchers is submitted to the Divisional Officer by him from time to time for recoupment. The imprest holder is responsible for the safe custody of the money either in cash or in form of vouchers.

FORM—2 IMPREST CASH ACCOUNT

Month Date	Vr. No.	Transaction	Amount of payment	Total	Head of account
1	2	3	4	5	6

(F) Temporary Advance :—Temporary Advances are granted to S.D.O. or Overseer (S.O.) for making specific payments on bills or Muster Rolls etc. already passed for payment by the Divisional Officer.

The account is maintained and submitted in Form 2 as in the case of Imprest.

From the above it follows that :—

(*a*) Temporary Advance is granted only on passed bills while Imprest is granted without such bills.

(*b*) Imprest is recouped while Temporary Advance is never recouped.

16-10. STORES :—

(*A*) *Introductory* (*B*) *Class of Stores* (*C*) *Reserve Stock Limit* (*D*) *Procurement and issues* (*E*) *Stock taking* (*F*) *Value Accounts*.

(A) Introductory :—Sometimes in the interest of work or Project, it is found desirable to retain in the hands of Govt. the supply of certain class of materials or to build up a reserve of essential items not easily available in the market. Thus the stores in P.W.D. grow up. The accounts of stores are based on fundamental principle that the cost is debitable to the final Head of Acconnt or work for which these are procured. If it cannot be determined at once, it should be kept in accounts for unclassified item known as *suspense account* pending clearance, as the materials are actually issued. The transactions of receipts and issues should therefore be recorded strictly in order of occurrence and as soon as they take place. Fictitious Stock adjusments are prohibited.

(B) Class or Stores :—The following four classes of stores in the P.W.D. can be distinctly grouped in two categories :—

(*1*) *Stores debited to final heads*—(i) Tools and Plant (ii) Road Metal (iii) Materials charged to works. (*2*) *Stores debited to suspense*—(iv) Stock.

(C) Reserve Stock Limit :—To avoid locking up of capital a financial limit known as Reserve Stock Limit is fixed by the Govt. The C.E./A.C.E. redistributes the amount for each Stock to restrict the aquisition of stores including the balance in hand within that maximum limit. For instance, a Reserve Stock Limit of Rs 2 lacks is fixed for a stock under "A"—Division for the year 1981-82. The value of Stock held by this Division shall not exceed Rs. 2 lacks at any time between April 1981 to end of March 1982.

(D) (i) Procurement of Stores :—Stores are procured from the following sources :—

(*a*) Manufacture

(*b*) Local purchases from the suppliers (normally up to Rs. 2,000/- per item at a time).

(*c*) Bulk purchases through Director General of Supplies and Disposal.

(*d*) Other Division or Department.

Goods Received Sheet :—

All materials received are examined, counted, or weighed and entered in Measurment Book as well as in the Goods Received Sheet (Form-8-A), the total number or quantity being entered in the *Bin Card* (*Form-8*) immediately. Payments for all stock received are made on the basis of entries recorded in **Goods Received Sheet (GRS)** and these are therefore treated as very important account records. The G.R.S. is prepared in triplicate by carbon process in copying pencil. One Copy is retained by the Store Keeper or Overseer (S.O.). The other two are sent to Sub-Divisional Office. One copy is passed on to the supplier by the S.D O. and the other to the Divisional Officer for posting the Priced Stores Ledger and making payments to the party concerned.

Materials obtained by manufacture are regulated by the estimate approved by the competent authority for the purpose. Except certain categories of materials such as, food stuff, Medical stores, Road metal, Bricks, Stones, Lime, Wooden and Cane furniture etc. other purchase of value of more than Rs. 2,000/- at a time are made through Director General Supplies and Disposals (D.G.S. & D.) by placing indents in his prescribed form. In no circumstances should the payment for such supplies through D.G S. & D. be made direct to the suppliers. The suppliers get payment from the Pay and Accounts Officer of the D.G.S & D. on the authority of the consignees receipt certificate. The cost of the materials thus supplied is finally adjusted in Public Works Accounts by book transfer through the Accountant General concerned.

(D) (ii) **Railway Consignment :**—When the materials are received form outside by Rail, the consignee is responsible for verifying at the time of taking delivery that the stores have been received in tact without loss or damage. If the despatch is a full wagon load, he ascertains that the seals on the wagon are in perfect condition. If there is evidence of loss or damage he arranges to secure necessary certificates from the appropriate Railway Official before taking delivery and on the authority of the same he prefers a formal claim against the carrying Railway for compensation for the loss or damage. In case the goods are insured, a claim, for the loss is lodged with the Insurer at once.

Indemnity Bond :—

He arranges for taking delivery at the earliest opportunity to avoid payment of demurrage and wharfage charges for delay and blocking up of Railway space. In case Rail-Receipt (R/R) is not received in time an **Indeminity Bond** is signed by him and the delivery is obtained. For this, he should keep himself in constant touch with Railway authorities to know whether the goods have arrived.

Credit Note :—

Payment for freight etc. to Railway is made by **Credit Note** on the basis of which the book adjustment is made between Railway and Public Works Department through the Accountant General concerned. Credit notes being important documents should be preserved very carefully.

(D) (iii) Issues : Materials are issued from stock for the following purposes as indicated below :—(a) For use on works by issue to contractor or direct (b) For supply to other Division or Department (c) For sale to contractor, members of the Department, other persons or local Bodies for which sanction of the competent authority is required.

Issue of materials from stock should be made only on receipt of an Indent (Form-7) in quadruplicate signed by Divisional or Sub-Divisional Officer. An entry of the quantity of stores issued is made in all the copies of Indents received over the signature of the store keeper or S.O. and a corresponding entry is made in the Bin Card simultaneously. One copy of the Indent is retained by the Store-Keeper or S.O., the second being returned at once to the Indenting Officer, the third and the fourth copies are sent to Divisional officer for value accounting.

Adequate care must be taken to obtain acknowledgement of the person taking delivery of materials on the body of the Indent in the space provided for it. When the materials are sent outside by Rail, the booking of the goods is made according to the despatch and packing instructions of the consignee. Goods are not insured against loss or damage without prior sanction. The Railway receipt is promptly to be sent to the consignee.

(D) (iv) Bin Cards :—Bin Cards constitute the basic quantity record maintained chronologically of stock transactions at the place where the materials are stored. These Cards are posted from the Goods Received Sheet and the Stores Indents. Proper maintenance and safe custody of these cards should be ensured. As soon as a Bin Card is completed is should be returned to Divisional Office after carrying over the balance to the new Card for verification and record.

(E) (v) Priced Vocabulary of Stores :—It is a list of materials in stock with correct description and indentifying (Code) number adopted by the Department (to be used uniformally) on the basis of an up-to-date classification of stores to facilitate the preparation and valuation of Indents and correct posting of all transactions. The prescribed sub-heads of the stock accounts are :—(i) Building materials (ii) Timber (iii) Metals (iv) Fuel (v) Painters stores (vi) House fittings (vii) Small stores (viii) Miscellaneous (ix) Land kilns and (x) Manufacture.

(E) (vi) Physical verification of stock taking :—Divisional Officers are required to have all stores under them physically verified at least once a year. Important stores should be counted by S.D.O. himself. The results of verification should be reported to the Divisional Officer for orders but as soon as discrepancy is found out, the book balance must be set right by the verifying officer treating a surplus as a receipt and deficit as an Issue with suitable remark.

The value of stores found surplus is credited as a revenue receipt and that of a deficit is kept under Misc. P. W. advances pending recovery or adjustment as the competent authority may decide. When the loss is declared to be irrecoverable and its write-off ordered, the amount is withdrawn by a Transfer Entry from Misc. P. W. Advance and charged to the work concerned or to the general Head "Losses in Stock".

(F) Value Accounts : All payments for stock received from sources other than D.G.S.&. D. are made by Cheque on bills received from suppliers or on Cash Settlement suspense accounts rendered by other P. W. Divisions. Payment to D.G.S & D. is made by book adjustment through the Accountant General.

All recoveries and adjustment of the value of stock issued are made by Divisional Officer on the valuation of Quantity account. For this purpose an issue rate is assigned to each article brought on stock.

F (a) Issue rate : This rate is fixed for each article at the beginning if they are (as far as possible within the prevailing market rates) on the principle that the cost to be charged to works should approximately be the actual cost of the stores and there is no ultimate profit or loss in stock accounts. The rate includes original price paid, carriage, other incidental charges connected with its handling, and storage charges ; and remains constant throughout the year unless sudden heavy fluctuation necessitates its revision.

If the issue rate of an article of stock happens to be appreciably less the prevailing market rate at any time, sales to private bodies or issues outside the Divn, should be restricted. Issues to contractors of such materials if not stipulated in the contracts and unavoidable sales should only be made at prevailing market rates. Issues to other Division or department may be made at a rate higher than the Issue Rate.

F (b) Storage Charges : These charges form part of the issue rate and are added to it on percentage basis. Such a percentage is fixed annually on the principle that the total annual cost of establishment employed on handling (after acquisition) and keeping intial accounts, on the custody of stores, and maintenance of the store godown or yards, is recovered from the anticipated issues from stock during the year.

F (c) Handling Charges : Similarly, a suitable percentage to cover carriage and other incidental charges is fixed annually to be added to Issue rates towards Handling Charges on the principle indicated for fixation of storage charges.

F (d) Supervision Charges :—When stock materials are sold to the Public or to other Department additional charges on account of supervision and contingencies at *ten percent* are realised on the value of stock including storage charges. These charges may however, be waived by the officer empowered to sanction the sale in the case of surplus stock which would otherwise be unsaleable.

G (a) Monthly Summaries of Stock Receipt of Issue : For the purpose of adjustment of value in the monthly accounts of the Divn. the receipt and issue transactions are abstracted in the summary of stock receipts (Form-9) and summary of Indents (Form-10) and verified with the corresponding monthly totals of Priced stores ledger (Form-12) in Divisional Office.

G (b) Priced Stores Ledger : All items of receipts and issues are entered in the ledger in Divisional Office from the G.R.S and Indents received daily from the sub-divisions in pages set apart for each article. At the end of day's postings, the balance under each article is drawn in respect of quantities as well as values. The ledger is closed each month with an abstract of value at the end of the ledger pertaining to each article of stock. The abstract should tally with monthly summaries of stock receipts and issues.

(H) Adjustment of Profit or Loss on Stock : At the end of each financial year the amount of excess or short fall representing the difference in values due to revision of rates etc. is drawn up in a proforma and credited to "Revenue" or debited to "losses on stock" as the case may be.

(I) Sales and Write off of Stores : Articles of stock (not T. & P.) which are not likely to be used during the following twelve months should he treated as surplus to requirements and reported to Divisional Officer for orders for disposal. Stores of any kind becoming unserviceable should be survey reported (in Form-18) immediately. All losses of stock should be investigated promptly and steps taken to obtain sanction of competent authority to their write off or recovery of cost. No stores should be sold out otherwise than by Public auction.

16-11. Tools and Plants :

(i) The Tools & plants of a Division are of two categories :—

(a) Ordinary T. P. *i.e.* those required for the general use of the Division, the cost of which is charged to minor head "Tools and Plant".

(b) Special T. & P. *i.e.* those required for a specific work, the cost of which is borne by the work concerned.

The prescribed sub-heads in which the T. & P. articles are grouped are :—

(i) Tools. (ii) Plant and Machinery. (iii) Scientific instruments and drawing materials. (iv) Navigation Plant. (v) Camp equipage. (vi) Live stock.

The Office furniture is also borne on T. & P. account as a separate section. Account of furniture in residences of High Officials is maintained separately outside the scope of Divisional T. & P. account.

Articles comprised within the head T. & P. can only be purchased or manufactured against sanctioned estimates except in cases of petty purchases within Rs. 500.

(ii) T. & P. Ledger : The record of numerical account of the receipt issues and balances of T. & P. is maintained in Sub-Divisional Office in Tools and Plant ledger (Form-15) which is posted from the T. & P. Received sheet (From-13) and T. & P. indent (Form-14) as and when a transaction takes place.

T. & P. ledger is kept in the following three parts :—

Part I—For articles in hand grouped under the prescribed sub-heads.

Part II—For articles temporarily lent or sent out for repairs etc.

Part III—For shortage awaiting adjustment by recovery or write off.

Form 13 and 14 are prepared by the sectional officer in triplicate by carbon process. One copy is retained by him and the other two are sent to Sub-Divisional office of which one copy is forwarded by the A. E. to Divisional office and other kept by him for posting the ledger. Except in the case of cash sales unstamped but dated acknowledgement must be obtained in support of all issues. Receipt for articles lent to contractor should set forth the valuation also.

T. & P. ledger (Form-15) is closed annually on the 30th September by the Sub-Divisional Officer after physical verification and submitted to Divisional Officer for local audit by Accountant General.

(iii) Physical verification :—The Tools and Plants are required to be physically verified by the S.O., S.D.O. by actual counting every year for the period ending September.

The articles found surplus on verification are treated as Receipts in Form-13 and 15. A note regarding articles found deficient is kept in red ink in T. & P. ledger (Form-15) without making any entry in quantity column until the loss is adjusted by recovery of cost or written off under sanction from competent authority. A corresponding entry is made in part—III of the ledger to watch clearance. When the cost is recovered or write-off sanctioned, on the survey report (Form-18) the articles are shown as issued in the Form 14 as well as in part-I and III of the T. &. P. ledger (Form-15).

(iv) Sales and Transfer of T. & P. :—Articles are made on value adjustments except in cases where it is decided otherwise. Recoveries of hire charges etc. are made when T. & P. are lent to local bodies, contractors or others.

(v) Comparative Study of Stock and T. & P. Accounts :

STOCK	T. & P.
1. Both Quantity and value accounts are maintained.	1. Only Quantity accounts are kept.
2. Value of Stock materials is charged to *suspense head*—Stock.	2. Value of T. & P. articles is charged to *final head* "T. & P." or work.
3. Value of Stock found deficient is shown issued and charged to Misc. P. W. Advance immediately.	3. T. & P. articles found short continue to be shown in the account until written off.
4. Value of stock found surplus is credited to revenue.	4. No such value adjustment is made for article found surplus.
5. The stock account is closed annually in March.	5. The T. & P. Account is closed annually in September.

16-12. Road Metal :—

For construction of new roads or for maintaining existing roads, road metal is collected at the road side before being laid. A quantity account showing km by km, the receipt, disposal & balance of each kind *viz.* stone, kankar etc. is maintained in the Sub-Division in (Form-16)—*viz.* "Statement of Receipts, Issues and Balance of road metal". This Account is rendered monthly to Divisional office. Physical verification is conducted at least once a year. Metal found surplus is atonce taken as receipt. But deficit is bought to account only on receipt of sanction to write off etc.

16-13 (a) Transfer Entries :—

Entries intended to transfer an item of receipt or charge from one work or head of account to another head work or account are known as Transfer Entries. These Transfer Entry Orders (T. E. Os) are drawn up in Form-53 and adjusted in Divisional accounts as when the necessity arises—

(a) To correct an error of classification in the original accounts.

(b) To adjust, by debit or credit to the proper head of account, an item outstanding in a suspense account or under a debt head.

(c) To bring to account certain classes of transactions which do not pass through the cash or stock account e g.—

(i) for credit to "Purchages" on account of materials received for works from sources other than stock ;

(ii) for credit to "Public Works Deposits" on account of balances due to contractors on closed account ;

(iii) for credit to Revenue heads on account of revenue not recovered in cash ;

(iv) for original debits or credits to Remittance heads based on transaction not appearing in cash ;

(v) for transfer of Tools and Plants to another division, department or Government when the value is recoverable from them ;

(vi) for those on account of supervision (when not recovered in cash), establishment, tools and plant and workshop charges.

(d) To respond to a remittance transactions advised by the Accountant General or direct by the Division or department concerned if the corresponding debit or credit to the remittance head has not appeared already in the account ;

(e) To relieve the account of a work in progress of—

(i) items which have ceased to be debitable to the estimate for the work ;

(ii) accounts of any contractor or of the work itself are to be closed, or when any recoveries to be made (otherwise than in cash) have become due.

(b) **Omnibus Transfer Entry Orders** (O.T.E.O.) are detailed T.E.O. Specially used for affording credit to "Purchases" on account of materials received for work from sources other than Stock.

T.E.Os and O.T.Os are generally initiated by the Sectional Officer or Sub-Divisional Officer. But at times T.E.O. is made in Divisional Office too. All these are registered in Transfer Entry Book (Form-54) in the Division for taking them in monthly accounts.

16-14. Revenue Receipts :—The Divisional Officer is required to assess and realise Public Works Revenue under hischarge and to keep proper records to show the assessement made, the progress of recovery and the outstanding debts due to Govt. Rent of Building is one such item.

The recovery of rent from Govt servant is normally limited to 10% of his assessable emoluments *i e.* Pay, Dearness allowance, (D.A), City compensatory allowance (C.C.A.) etc. If Standard Rent (S.R.) of the Building is less, the S.R. is recovered. For all rented buildings, the Divisional Officer sends a demand in Form 48,—"Statement of rents recoverable" to the Treasury or Disbursing Officer monthly for recovery. On the authority of certificates furnished by them he makes necessary posting in Register of Rents (Form-49).

16-15 Works Accounts :—The units of classification adopted in the general accounts of the Govt. for booking of expenditure are certain heads of account and not individual estimates. It is therefore necessary to maintain separate accounts in Sub-Divisional and Divisional levels for recording (i) the expenditure on individual works estimatewise and (ii) for working out the transactions of individual contractors against each of them. These are known as work accounts.

The objects of maintenance of such accounts are :—

(i) To exhibit the actual cost of works done.

(ii) To satisfy the needs for statistical information and for analysis of the comparative cost of various classes of works and types of Buildings.

(iii) To exercise efficient financial control over the recorded transaction of the cost of work or construction which is a prolonged one.

(A) **Cash Charges** usually booked on works are for payments (i) to daily labourers and members of the work-charged establishment of their wages (ii) to contractors and suppliers and others for works done, supplies made or other services rendered.

(i) **Departmental Labour :**

(a) *Work charged* (*W.C.*) Establishment whose pay and allowance are drawn by charge to specific work on W.C. Monthly Pay bill form are industrial workers employed upon the actual execution as distinct from the general supervision.

(b) The wages of other day labourers are drawn on *Muster Rolls* (*M.R.*) (Form-21) and charged to the work's estimate on which they are employed.

Muster Roll (M.R.) forms provides columns for recording attendance for a month but the roll may be closed for payment earlier or on completion of the job. Payment is made by the official of highest standing available at spot and proper acknowledgement obtained on the Roll. Unpaid items are recorded in the Unpaid Wages Register for subsequent payment on Hand Receipt.

(c) *Casual Labour Roll.* In exceptional or urgent cases such as flood, earthquake or closing of breaches, labourers are employed casually for short period on Casual Labour Roll (Form-22). The names of labourers are not given on this Roll. The payment in such cases is to be made by a Gazetted Officer. Payment of daily Labour through a contractor is not permissible. But in case of emergency it is done. If no possible rate could be determined for the finished work in such cases, the payment is made to contractor on the basis of No. of labours employed day by day with his profit or commission. The use of M.R. or M.B. is not permissible in such cases.

(ii) **Payments to Suppliers and Contractors**

(a) Payment for all work done and supplies obtained for specific works are made in terms of contracts of work/supply orders on the basis of measurements recorded in *Measurement Books* (*M.B.*) (Form-23). The M.B. is therefore considered as very important account records. This is serially numbered and registered in Divisional Office and is issued to Sub-Division for use by S.O. or A.E. himself.

(b) To facilitate preparation of estimates for periodical repairs and for the purpose of preparing contractor's bill for such works, another set of measurement books known as *Standard Measurement Books* (*S.M.B.*) numbered alphabetically and for which entries and abstracts are certified as correct by the Divisional officer is maintained in Sub-Divisional office. This books are got examined by the Divisional Officers annually.

Bills and Vouchers :—

Bill is a detailed account of claim for works done or supplies made indicating quantities, rates and amount due. The bill after payment becomes *Voucher* and is kept on record as a legal proof of payment. The departmental forms of bills in vogue are :—

(*a*) First and Final Bill (Form-24), (*b*) Running Account Bill (Form-26).

(*c*) Hand Receipt (Form-28).

Form-24 is used when a single payment is made for a job or contract on its completion. *Form-26* is used for all running and final payments including cases where Advance payments are made. Forms printed on yellow paper are used for final bills only. When secured advance is made, account of secured advance (*Form-26 A*) is attached to the bill *Form-28* is a simple form of voucher meant for all miscellaneous payments and advances and for which the detailed Forms 24 and 26 are not suitable. This is used for refund of Earnest Money and Security Deposit to contractors, unpaid wages to labour and W.C. staff, Advances from Provident Fund etc. etc.

Apart from the bill forms mentioned above ; special *Form 27-A* and *Form 27-B* are used for intermediate and Final Payments respectively against *lump-sum-contracts.*

On Account Payment or Payment On Account :—This means a payment on running account for works done or supplies made and duly measured. It may or may not be for full value of work or supplies.

Running Account :—Payment made for works at convenient intervals to contractor subject to final settlement of the account is termed Running Account (R/A) or Intermediate payment.

(iv) **Financial Aid to Contractor** :—It is necessary sometimes in the interest of work to make payments to contractors by way of advance. A few of them are ;—

(*a*) *Advance payment*—Such payment is made on a running account to contractor for work done by them but not measured. Certificate to printed on R/A bill is to be signed by the Sub Divisional Officer. The lump-sum amount to be paid on account of the several items is specified against item 2 of Part III of the bill. The advance is adjusted through subsequent bill in which the actual measurements have been taken.

(*b*) *Secured Advance* ; This is an advance made on the Security of materials brought to site of work, to a contractor whose contract is for completed item of work. These materials should be of imperishable nature and an Indenture in Form-31 is to be signed by the contractor before an advance (not exceeding 75% of the assessed value) can be sanctioned by the Divisional Officer. Detailed account of advance is kept in From 26-A and is attached to the R/A Bill. No record is kept in M. B. of the quantities of materials. The certificates printed on From 26-A are however to be signed by S.D.O/D.O. As the materials are consumed in work and measured for payment, the recovery is effected through the R/A Bills.

(c) On an application of the contractor for financial Aid, the Divisional Officer may sanction 75% of the net amount of the bill which is under check in Divisional Office as *lump sum advance* on Hand Receipt (Form-28) to avoid delay subject to adjustment being made against the same bill subsequently.

(B) **Issue of Materials :** Issues of materials to works from any of the sources viz, from stock or by purchases, transfer of manufacture are distinctly classified as below :—

(i) Issue to contractor :—(ii) Issue direct to works—

(*a*) *The issue of materials to contractors* who have contracted for completed items of works is regulated as per stipulation made in their agreement with the Department. As soon as the materials are made over an unstamped but dated acknowledgement showing particulars of materials, rates and values chargeable is atonce taken from the contractor. On the authority of it the adjustment is made in the accounts of works under snb-head "*Contractors-Other-Transaction*". A corresponding entry is also made in the personal account of the contractor maintained in the form of *Contractors Ledger Form-43*) in the Divisional office to indicate payments, recoveries, adjustment etc etc. against each work. This ledger is closed and balanced monthly to watch the outstanding amount against the contractors in connection with the works entrusted to each of them.

For issue of materials not stipulated in the contract, the highest of the "Three rates" (viz., Stock issue rate, Market rate and Rate as per analysis of rate for item of work on which it would be used) is charged.

For *bonafide* use on works, issues of stock materials are exempted from 10% supervision charges, A numerical account in Form-35A is maintained in sub-divisional offices to regulate the issues of materials to contractors within the estimated requirement of his contract.

Recoveries of the cost of materials are made from contractor's bills either in lump or on basis of the quantity actually consumed on the work and billed for.

The contractors are required to return surplus materials if any, on completion of work to Govt. of which the price allowed to them is worked out on the basis of the stipulated rate in contract less element of storage charge or prevailing market rate, whichever is less.

(*b*) When *materials are issued direct to work.* the cost is debited to Sub-Head "Materials" in the works account if it is a Major estimate (i,e., exceeding Rs. 1,00,000/-). In other cases it is treated as "final charge",

Materials of site Account (M.A.S.) :—

A detailed account of principal items costing more than Rs. 2,000/- each is maintained in Form-35 known as *Materials at site Account* (*M.A.S*) in terms of quantity and value to watch the receipts, issues and balances against the estimated requirements.

A simple numerical account in Form-35 may however be maintained at the discretion of the Divisional Officer in cases of minor estimates and repair works.

All surplus materials in M.A.S A/c. should be transferred to other works in progress or to stock or disposed of under sanction from competent authority.

Unused balances of materials are to be physically verified at least once a year and a report submitted to the Divisional Office.

After completion of a work theoretical calculation of the principal items of materials consumed on each sub-head is made in the Register showing the Clearance of Suspense head "Material', (Form-38). It is then compared with the quantities issued as per Form-35, and adjustment of value made between the sub-heads of works. Any difference in the value as shown in Form-35 is debited to sub-head—"Additional Charges" in the Works accounts. Thus the suspense head, "Materials" is finally cleared

(C) Major and Minor estimates : lapse of sanction—Works Abstracts and petty works requisition form,—Register of Works.

(i) **Major Estimate :** is an estimate for a work in which the sanctioned amount of the works expenditure exceeds Rs. 1,00,000/-. The rest is known as *Minor Estimate.*

(ii) **(ii) Lapse of Sanction :** The approval or sanction to an estimate for original work ceases to operate after five years unless such work has been commenced.

(iii) For each Major Estimate executed departmentally detailed form of *Works Abstract* —A (*Form-35*) is prepared by Sub-Division Office to consolidate all cash, stock or other transactions during a month showing expenditure on various Sub-Heads costing more than Rs. 7,500/ each, others being lumped together.

For each Major estimate executed by contract and for each Minor estimate simple Form of *Works Abstract—B* (*Form-34*) is used. These works Abstract Forms are sent monthly to Divisional Office for completion and posting in the Register of Works.

The estimate, account and completion certificate of works costing less than Rs. 5,000/- is prepared by the Sub-Divisional Office on a Single form *Petty Works Requisition and account* (*Form-32*) and sent to Divisional Office alongwith other documents and returns for record

(iv) The Divisional Office maintains a permanent and collective record of expenditure incurred in the Division during a year and each work to cost more than Rs. 5,000/- in the *Register of Works*. Works Abstract Form-33 and 34 after being completed in respect of entries of T.E. and Stock booked in Divisional Office are posted in the corresponding Repister of Works in Form 40 and 41 respectively. Posting of Form-32 in the Register is not necessary.

(D) Closing of Works Accounts :—It is of great importance to close the accounts of works soon after the actual work of construction is completed. Formal handing over is made by the Divisional Officer to the Department for whom the work was carried out.

(E) Completion Report and Statement are prepared in Form-44 and 45 respectively to explain the excess of expenditure over the technically sanctioned estimate for regularisation. Completion Report need only be prepared in respect of works on whieh the expenditure has been recorded by sub-heads—viz., Major Estimates.

(F) Schedule of Rates :—For facility of preparation of estimate uniformly in the Divisions and for settling rates in connection with contracts, *Schedule of Rates* for each kind of work commonly executed is prescribed by the A. C. E. on the basis of rates prevailing in each locality duly supported by analysis.

16-16. Suspense Accounts :—These accounts are meant for the temporary passage of all such transactions and must atonce be taken into the account of the works of grant concerned but cannot be cleared finally because the relevant payment, recovery or adjustment is awaited. These are sub-divided into four heads viz., (i) Purchases, (ii) Stock, (iii) Misc. P. W. Advance, (iv) Workshop suspense.

(i) *Purchases* : Materials purchased for specific work are credited to Purchases immediately on their receipt by per contra debit to the work. Materials received for stock is similarly credited to Purchases by debit to Sotck to secure agreement between the quantity and value accounts.

(ii) *Stock* : This account head is debited with all expenditure connected with acquisition of stock materials and manufacture operations and credited with value of materials issued to works, sold or transferred. The procedure of maintaining accounts has been described in section 16-10.

(iii) *Miscellaneous P.W. Advances* : Transactions booked under this head are divided into four categories :—(a) Sales on Credit, (b) Expenditure incurred on Deposit works in excess of deposit received, (c) Losses, retrenchments, errors etc., which include deficiencies in cash or stock, errors in accounts awaiting adjustment etc., (d) Other items consisting of debits, of which classification cannot be determined at once, recoverable debits not pertaining to the accounts of a work etc. This head is meant for all debits connected with the above transactions with a view to watch their ultimate recovery or write off. The Account is kept in Suspense Register (Form-67).

(iv) *Work Shop Suspense* ; Where a workshop is run by the P. W. Division, all expenditure incurred direct on jobs executed and on other operations of the workshop is passed through this suspense head. The suspence is cleared only by an adjustment against the deposit received or by transfer of debits against the service or other head concerned.

16-17. Cancelled, Lost or Lapsed Cheques :—If a cheque which has been drawn and entered in the Cash Book, has to be cancelled subsequently, the amount of it should be accounted for the creditor side as a "cancelled cheque" the cancelled cheque being treated as a voucher.

If the cancelled cheque is replaced immediately by a fresh cheque : The fresh cheque should be drawn as a "Forest Remittance", the amount and a date of the cheque in lieu of which it is drawn being quoted in the entry.

If the cancelled cheque is not replaced immediately ! The expenditure in payment of which it was drawn should be written-back by making an entry of the cancelled cheque on the debtor side as for a chash recovery of a service payment.

A lost cheque should be treated in all respects like a canselled cheque, the treasury certificate of nonpayment being regarded as a voucher in support of the entry of cancellation in the creditor side of the Cash Book.

A lapsed or time-expired cheque, if renewed, should be treated as a cancelled cheque and the fresh cheque issued in its place entered in the Cash Book.

CHAPTER XVII

CONTRACTS

17-1. What is Contract ? -The Contractors and their qualification—Authorities competent to enter into contracts for Public Works.

(A) **What is Contract ?** An agreement enforceable by law is Contract. The contract invariably follows a proposal from one party and its acceptance by the other. In absence of any of the above elements of a contract it becomes void, i.e. without a legal effect or voidable, i.e., which can be avoided by any of the parties to it.

The term contract, so far as Public Works Department is concerned, means a written undertaking for execution of works or supply of materials or for the performance of any service connected therewith duly accepted and registered by the competent authority on behalf of the Union or State Govt.

(B) **Contractors and their Qualifications**—In the above context, the term Contractors mean Private individuals Partnership firm, Public or Private Limited concerns who have made such an undertaking for the execution of works, supply of materials or for services concerned therewith with the respective Govt.

In relation to Public Works the following Categories of contractors are generally enlisted—(a) For Building and Roads (B & R), (b) For Sanitary installations and Water Supply, (c) For Electrical and Airconditioning, (d) For Furniture.

Each of these categories of contractors should have an engineering organisation competent to deal with works entrusted to them. Contractors at (b) and (c), must possess valid Plumbing and Electrical Licences respectively. Each of them is expected to have the machinary and equipment required for the job. Their qualifications are further adjudged from (i) their professional ability to understand and implement the contractual obligations and subsidiary instructions given by the Engineer-in-charge of the Department, (ii) their financial resources, (iii) their capacity to control labour, particularly by way of regular payment of fair wages and observance of Labour Regulations, (iv) and their zeal for maintaining reputation and integrity.

(C) **Authorities competent to enter into contracts for Public Works :—**

(i) Articles 229 (1) of the Constitution authorises officers of the Public Works Department to execute a contract for on behalf of "The President of India" or "The Governor of the State" as the case may be. The Divisional or Sub-Divisional Officers (i.e., Executive Engineer or Assistant Engineer-in-charge) derives delegated powers to enter into contracts for the Govt. within their financial limits.

(ii) Powers of the officers of the central Public Works Department to accept tender for contract are as below—

Additional Chief Engineer : (with the approval of Central) Works Advisory Board where necessary)	... ...	Full
Superintending Engineers	... .. upto	Rs. 10,00,000/-
Executive Engineers	... . upto	Rs. 50,000/-
-Do- -Do- (in upgraded Division)	... .	Rs. 1,00,000/-
Assistant Engineers	... .. upto	Rs. 5,000/-

For the purpose of determining the authority competent to accept the tender the net amount of the tender excluding the cost of materials to be supplied by the Department, if any is the decisive factor.

17-2. Essentials of Contracts : Essentials of Contracts are the following particulars by those all agreements must be made in order to constitute a valid contract ;

1. That the contract shall be made by parties competent to contract ;
2. That the contract shall be made by free consent of the parties ;
3. That shere shall be a definite proposal and its acceptance ;
4. That the contract shall be made so that the considerations and objects are lawful.
5. That the meaning shall be certain.

The above clauses are described briefly as below :—

1. **Parties Competent to Contract** :—A person is competent to contract provided (a) He is of the age of majority according to the law to which he is subject. A person who is not a major according to law can break an agreement. No contracts hall be made by a subordinate authority who has not been directed or authorised to do so.

(b) He is of sound mind :—A person is said to be sound mind for the purpose of making contract provided he is capable of understanding it and of forming a rational judgement as to its effect upon his interest at the time when he performs the contract.

(c) He is not disqualified from contracting by any law to which he is subject.

2. **Free Consent of the parties** :—Two or more persons are said to consent when they agreed upon the same thing in the same sense. Consent is said free when

(a) It is not caused by under influence. The relations between the two parties performing a contract are not such that one of the parties is in a position to dominate the will of the other and uses that position to obtain an unfair advantage over the other.

(b) It is not caused by committing or threatening to commit any act forbidden by the Indian penal code, or the unlawful detaining or threatening to detain any person to enter into an agreement.

(c) It is not caused by fraud.

(d) It is not caused by misrepresentation.

(e) It is not caused by mistake. Where both the parties to an agreement are under a mistake, the agreement is avoidable.

3. **Definite proposal and its acceptance** :—Terms of contract must be precise and difinite and there must be no room for ambiguity or misconstruction therein. When one person signifies to another his willingness to do anything (here contract), he is said to make a proposal. The communication of a proposal is complete, when it comes to the knowledge of the person to whom it is made. The acceptance must be absolute, unqualified be expressed in some usual and reasonable manner. Acceptance is made by performing conditions or receiving conditions.

4. **The consideration or objects are lawful** :—The consideration or object of an agreement is said to be unlawful if forbidden by law or fraudulent or of such nature that, if permitted it would defeat the provisions of any law or involves or implies injury to the person or property of another or opposed by public policy or regards as immoral by the court.

5. **That the meaning shall be certain** :- -Agreement, the meaning of which shall be certain or capable of being made certain.

17-3. Types of Engineering Contract, their advantages and disadvantages :

Following are the different types of contracts for execution of civil Engineering Works.

1. Item rate contract,
2. Percentage rate contract,
3. Lump-Sum contract,
4. Labour contract,
5. Materials supply contract,
6. Piece Work Agreement,
7. Cost plus percentage rate contract,
8. Cost plus fixed fee contract,
9. Cost plus sliding or fluctuating fee-Scale contract.
10. Target contract.

1. **Item rate contract is also known as Unit-price contract or schedule contract**: For item rate contracts, contractors are required to quote rates for individual items of work on the basis of schedule of quantities furnished by the department. This schedule indicates full nomenclature of the items as per sanctioned estimate, estimated quantities and unit therein. While filling up the rates the contractors are required to express the amount in figures and words and also to work out the cost against each item. The final total of the amount tendered for the work is also drawn up by them. This type of contract is followed by Central Public works and Railway departments.

Advantages of item-rate contract :—

(i) This form of contract ensures a more detailed analysis of cost by the contractor and as such is more scientific. The departmental officers are to work out the schedule of quantities against each item of work and the contractors are to work out the rates against each item. The element of uncertainty and guess which is inherent in the use of percentage rate contract is altogether absent in item-rate contract and the authority competent to accept the tender can easily check the rates with reference to his own calculations and decide which of the tender is favourable.

(ii) Since the contractors are to write of their individual rates of individual items in figures as well as in words, it is not easy to form a ring during submission of tender and to allot a work to one of the contractors without competition.

(iii) The contractors work out the rates of all items of the schedule in order to put it in the tender. Thus, unworkable rated tender may be avoided which leads smooth progress and timely completion of a work.

Disadvanges of item rate contract :—

(i) The basis of this type of contract is the item wise rate offered by a contractor. But the itemwise amount which is calculated by the contractor by multiplying the quantity of each item with the rate may be incorrect. Sometimes such incorrectness may be provided by a contractor for his own interest. Thus the lowest position of a tender can not be known after opening the tender in presence of all other contractors. Contractors may also quote some item rates in words excluding paisa intentionally in order to tamper in rates. Thus there is a loop hole for a contractor to correct a rate in order to be a lowest tenderer.

(ii) As the quantities may be increased or decreased, a contract of this nature requires careful consideration by the Engineer before it is entered into, as by wise anticipation or perhaps outside information a contractor may quote high prices for items that are likely to be required in increased quantities and low prices for items likely to be decreased or required in small quantities. In that case the department would stand lose heavily due to ***unbalanced tender***.

(iii) During filling up the tender by the contractors by quoting their rates in figures as well as in words against each item of the schedule there are possibilities of overwritings. Erased rates and rates not shown in words are liable to be rejected. In case of discrepancy in rates as shown in figures, and words the accepting authority may at his descretion accept the lower of the two.

(iv) Comparative statement of item rate tenders is more elaborate and comprehensive and intelligent scrutiny is required. A mistake in it may lead to the work being awarded to a contractor who is not lowest.

2. Percentage rate contract :—In this form of the contract department draw up the schedule of items according to the description of items sanctioned in the estimate with quantities, rates unit and amount shown therein. Thus the department fixup the item rates of the tender (so called as "item rate tender"). The contractors are required to offer to carry out the work at per with the rates shown in the specific price shedule or percentage above or below the rates indicated in the schedule of items of work attached to the tender. The percentage above or below or at per tendered by the contractor apply on the overall amount of quantities.

Advantages of percentage rate contract :

(i) This type of contract is convenient in so far as the lowest rate and comperative position amongst the contractors are readily known just on the opening of the tender.

(ii) As there is no provision to quote contractors own rate for an individual item, benifit due to increased quantity with a benificial rate cannot be availed by a contractor. Thus there is no possibility of unbalanced tender.

(iii) Comparative statement can be prepared quickly and their is no possibility to tamper the rates by a contractor in order to be a lowest tenderer.

(iv) As contractors are not required to quote their rates for individual items the overwritings, and erasing rate etc. can be avoided. Thus a tender (may be lowest) is not liable to rejection due to the above causes.

Disadvantages of pencentage rate contracts :—

(i) In this type of contract contractors compete the tender by quoting their percentage rates. To write down the quantum of percentage in order to be the lowest tenderer contractors mostly depend on guess the quantum of percentage to his competitors without analysing the workable rates of the individual items. Thus an uncertain or unworkable rated tender may be the lowest. Much time, considerations and approval of higher authority are required to cancel the lowest tender. On the other hand if such a tender is accepted considering the keen competition there are uncertainty for quality, smooth progress and completion of the work.

(ii) Since the contractors are to write down only the percentage above or at per or below it is very easy to write such a rate in few minuites before the time of submission of the tender. Also the correction of the percentage rate is only at one place. Thus the tenderers can easily form a ring even upto the time of submission tender in order to allot the work to a particular contractor at a high rate without actual competition. This leads drainage of Government money.

(iii) By negotiation among the contractors two or more of them may quote the same rate in order to get a part of the work at a high rate. If the tender is acceptable there is administrative difficulty to allot the whole work to any one of the contractors. There may be also technical difficulty to divide the work at equal amount among the contractors. If the work is distributed more labour is required to make entry of the measurements, to issue materials, to prepare and check the bills of the contractors individually.

3. **Lump-Sum Contract** :—In this form of contract (P. W. D. Form 12) the contractors are required to quote a fixed sum for execution of a work complete in all respect i.e. according to the drawing, designs and specifications supplied to them with the tender within the specified time.

The departmental schedule of rates for various items of work are also provided which regulates the payment to the contractor in respect of the items of works involved for any additions and alterations not covered by the original work.

Advantages of Lump-Sum Contract :—

(i) It has the advantage that the owner knows before hand exactly what the work will cost.

(ii) Detailed measurements of the work done are not required to be recorded except in respect of additions and alterations.

(iii) Since the complete picture of the work from detailed drawings and also total cost of work are known beforehand, excellent planning and efficient management for execution of work is more convinient.

Disadvantages of Lump-Sum Contract :—

(i) Under such a contract it is essential that the work be accurately and completely shown on the drawings and described in the specifications and that full informations as to site conditions should be available, otherwise disputes can easily arise.

(ii) Difficulty arises to make any intermediate payment, generally a certificate is given by a responsible officer to the effect that, by superficial or general measurement, he has satisfied himself that the value of the work is not less than a specified amount in conformity with contract agreement.

(iii) Although often used in conjunction with a schedule of prices it is not a suitable form of contract where considerable additions or variations are expected or contemplated.

4. **Labour contract** :—This is a contract where the contractor quotes rates for item work exclusive of the element of materials where are supplied by the Department free of cost.

Advantages of Labour Contract :—

(i) The materials stored by the Government are thus utilised.

(ii) The increase in the cost of the work is checked inspite of any rise in the prices of such materials in the market.

(iii) Difficulty in obtaining certain materials in the open market can be avoided and thus better progress with standard quality of materials can be mentioned.

Disadvantages of Labour Contract :—(i) There may be delay in obtaining the materials by the department subsequently the contractor is required to keep himself in touch with the day to day position regarding the supply of materials from the department.

(ii) A large storage area is required to store the different kinds of materials and constant guarding, etc. are essential. Beside these constant accounting of materials by employing additional staff is necessary. For all such expenditure the ultimate cost of materials may be higher than the cost of materials procured directly by a contractor from open market.

(iii) Thefting from store, shortage of materials, difficulty during handing over storage charge accounting all materials are constant troubles for a department.

(iv) Refund of surplus departmental materials by a contractor in a good condition, wastage, damarage etc. are also involved in this type of contract.

5. **Materials supply contract or contracts for the supply of materials** :—In this form the contractors have to offer their rates for supply of the required quantity of materials of inclusive of all local taxes, carriage and delivery to the specified stores within the time fixed in the tender. This form of contract is generally used when purchase of materials, viz., Bricks, stone chips, furniture, pipes and specials etc. are involved. All materials received should be examined and counted or measured, as the case may be when delivery is taken.

Advantages of materials supply contract :—(i) Payment of this type of contract can be made promptly, and so the contractors try to take the supply order even at less profit, resulting low cost of the materials.

(ii) As the supply of materials is taken through a contractor, the department receiving the supply of materials does not worried due to loss of materials, breakage, damarage charges during transit.

Disadvantages of materials supply contract :—(i) Constant control for quality of materials to be received at several batches at different times is required.

(ii) During submission of tender intending contractors may form a ring to get the supply order at a higher rate at different turns.

6. **Price Work Agreement** :—As the name signifies, the Piece Work Agreement is that for which only a rate is agreed upon without reference to the total quantity of work to be done or the quantity of work to be done within a given period. In case of petty work valued up to Rs. 10,000/—each inclusive of cost of meterials may be carried out through contractors by Piece Work Agreement. In this type of agreement detailed specifications and the total cost of the whole work to be done are mentioned. It is terminable from either side at any time and can not be called a contract in true sense. Work may be executed in simple "work order" agreement form, there is no security money and penalty clause.

Advantages of Piece Work Agreement :—(i) Urgent small work may be taken up for execution without inviting tender and a reasonable time is saved.

(ii) If a contractor delays to execute the work or uses inferior quality of materials or leaves the work partially complete separate contractor may be engaged at any time.

Disadvantages of Piece Work Agreement :—For this type of Small Work approved contractors find a little interest and as such work becomes in hand of petty contractors having little management system and adequate knowledge to carry out the work following departmental procedures.

7. **Cost Plus percentage rate contract :**—In tendering for work on a "Cost plus" basis the contractor is paid the actual cost of the work, plus an agreed percentage addition to allow for profit. This type of contract is generally adopted when conditions are such that labour and materials rates are liable to fluctuate. In adopting this system of tendering no "Bill of Quantities" or "Schedule of Rates" has to be priced but the owner or the Department should carefully define the actual cost and record exactly what is permissible in the cost of the work.

Advantages of cost plus percentage rate contract :—(i) It has the merit that contracts can quickly be drawn up and agreed and also work of an urgent nature put in hand without delay. It is for this reason, useful to a large extent during war period when urgency prevails and work is required to be started at short notice.

(ii) This type of contract is suitable when work can not be executed by other type of contracts at a competative rate due to uncertainty and fluctuation in the market rates of labour and materials.

Disadvantages of cost plus percentage rate contract :—

(i) Close supervision and checking of delivery notes and invoices which it involves, makes it unsuitable for works where the necessary staff is not available.

(ii) It is to the contractor's advantage to make the cost as high as possible by wasting material and employing inefficient workmen, as the contractor takes little risk and his profit is assured. This form of tender is not popular with contractors, despite the fact that they can not lose on it, for it tends to spoil the pushing qualities of those carrying out the work.

8. **Cost Plus fixed fee contract :**—In this type of contract the contractor is paid by the owner an agreed fixed lump sum amount over and above the actual cost of the work. This fixed fee shall cover overheads and profit to the contractor The fee does not vary with the actual cost of the work as in the case of cost plus percentage rate contract.

Advantages of cost plus fixed fee contract :—

(i) Since the fixed fee cover the contractor's overhead charges and profit the contractor shall naturally try to complete the work speedily in order to earn his fee as soon as possible.

Disadvantages of cost plus fixed fee contract :—

(i) This form of tender is not popular with contractors, despite the fact that they can not lose on it. The contractor shall try to complete the work as early as possible even by purchasing materials at higher rate and engaging labour at high charges and thus the owner may lose a reasonable amount to carry out the work by this type of contract.

9. **Cost plus sliding or fluctuating Fee scale contract** :—In this type of contract the contractor is paid by the owner the actual cost of construction plus an amount of fee inversely variable according to the increase or decrease the estimated cost agreed first by both the parties. Thus higher the actual cost lower will be the value of fee and vice versa.

Advantage :—In this case a contractor shall not try to increase the actual cost as in the case of "cost plus percentage rate" or shall not be indiferent as in the case of "cost plus fixed fee contract" Because interest of a contractor is totally involved with the variation of the actual cost. Thus is the actual cost lower both the owner and the contractor will be benifited. This is the best of the cost plus type contract.

Disadvantage :—The estimated cost must be very accurately determined. In case if the estimate is very higher than the actual cost due to inefficiency of the estimator a contractor will get more amount on the basis of savings and vice versa.

10 **Target contract** :—This is the type of contract where the contractor is paid on a cost-plus percentage basis for work performed under this contract, and in addition he receives a percentage plus or minus on savings or excess effected against either a prior agreed estimate of total cost or a target value arrived at by measuring the work on completion and valuing prior agreed rates.

Advantages of Target Contract :—The contractor is encouraged to use his skill and experience in keeping the cost as low as possible. This type of contract is profitable to both the contractor as well as to the owner.

Disadvantages of Target Contract :—The contractor may show higher cost of construction and thus he gains more amount even covering the penalty due to excess expenditure.

11. **Measured Contract or Schedule Contracts** :—Except lump-sum contract all other types of contracts are measured contract In this case the total cost of a work is worked out by detailed measurement of different items of work after it's completion A bill is then prepared by multiplying the measured quantities by their respective rates. Examples of measured contract are item rate contract, percentage contract, cost-plus type contract, material supply contract etc. but not Lump-Sum contract.

12 **Negotiated Contract** :—When work is awarded on contract by mutual negotiation between the parties without call of tenders, it is said to be a negotiated contract. It may be in any of the forms mentioned in 1, 2, 3, and 5 of 17-3. In the Public Works Department the contracts are negotiated only in special circumstances with a view—

(i) to obtain reasonable rates, or

(ii) to meet the situation arising out of emergency, viz. construction of shelters for displaced persons, or strengthening Runway for national defence etc. at short notice.

Advantages of this system are that it brings some economy in expenditure. The parties selected being always reliable and financially sound, ensure uninterrupted work with less chances of dispute.

17-4. What is tender ? Tender is a written offer submitted by the contractors in pursuance of the notification given, to execute certain work or supply of some specified articles or transport of materials at certain rates with the terms and conditions laid down in the tender documents. The form in which it is to be submitted is supplied by the department to eligible contractors on usual payment of cost. The tender duly filled in placed in the Tender Box with locking arrangements kept in the room of the Officer inviting tender on or before the specified hours and date notified through the tender notice (P. W. D. Form 6.).

17-5. Tender Form :—Tender form is a printed standard form of contract giving standard conditions of contract, general rules and directions for guidance of contractors There is also a memorandum for giving (i) General description of work, (ii) Estimated cost, (iii) Earnest money, (iv) Security deposit, (v) Time allowed for the work from date of written order to commence and (vi) Columns for signature of contractor before submission of tender, signature of witness to contractor's signature and signature of the officer by whom accepted. This is a part of tender document. The price of the tender form is given on the form. This printed form and other documents are to be purchased on cash payment from the office inviting the tender during office hours on all working days.

17-6. Tender documents :—The various terms and conditions of contract which are to be formulated while inviting tender for a Civil Engineering work are :—

(i) The Notice Inviting Tenders (N. I. T.) is a standard approved form of a department ;

(ii) Tender form with standard conditons of contract ;

(iii) Schedule of quantities of works to be done and materials, Tools and Plants to be supplied by the department if any ;

(iv) Special terms and conditions ;

(v) Complete specification of the work to be executed ; (Generally departmental specifications is referred)

(vi) Special specification and additional condition of contract ;

(vii) One set of approved drawings where necessary.

Before tenders for a work are invited a detailed estimate showing the quantities, rates and amount of the various items of work also the specifications to be adopted shall be prepared and sanctioned.

Sub-heads (ii), (iii), (iv), (v), (vi) and (vii) has been described under contract document. (Art. 17-19)

17-7. Tender notice :—The notice inviting tender papers is a very important document on which tenders and subsequent agreements with the contractors are based. Tender notice should stipulate reasonable time for completion of work ; in an urgent case the authority which is competent to approve N. I. T. in that particular tender might curtail the period but the period should be realistic period. All tender notices should be in the standard form of the department. It is displayed in the notice board of the division and also circulated to the related sub-divisions and other divisions of the department. For wide publicity of major work the tender notice is required to be published in two daily local News Papers. In order to minimise the heavy advertisement charges short tender notice should be given in tabular form which contains essential informations as below :—

(i) Name of the authority inviting tender ; (ii) Particulars of contractors eligible to submit tenders ; (iii) Name of work and its location ; (iv) Estimated cost of work ; (v) Price of tender form and other tender documents ; (vi) Earnest money to be deposited ; (vii) Time of completion ; (viii) Last date of sell of tender paper, last date of permission ; (ix) Last date, time limit and place of receipt of tender and also time of opening tender ; (x) Accepting authority.

Besides the above, it contains general directions, brief terms and conditions of acceptance and validity of tender etc.

Draft specimen of Tender Notice (for press)

Notice Inviting Tender

Tender No.......

1. Sealed Tenders are invited for the following works from experienced bonafied and resourceful outside contractors for the under mentioned works by the Executive Engineer......

	Name of work	Estimated cost	Price of tender form and schedule	Earnest money	Time of completion	Accepting authority
(a)	...	...	...	...	...	...
(b)	...	...	...	...	...	...

2. Tender form and other documents will be issued to the contractors from the office of the Executive Engineer/Assistant Engineer......upto...on all working days between 11 a.m. and 4 p.m. and on saterday between 11 a.m. and 1 p.m. on production of valid Sale Tax and Income Tax clearance certificates. Outside tenderers will have to obtain permission from Superintending Engineer...on production of credential for works more than one lakh.

3. Tender will be received in the tender box by the Executive Engineer...upto...p.m. on the...and will be opened at...on the same day.

Further clauses should be added in the Notice Inviting Tender (NIT) along with the tender form are :—

4. *Earnest money* :—Earnest money noted above should be deposited by a tenderer in any of the following forms, Cheques or tokens or any forms of earnest money other than those specified below, will not be accepted as valid.

(a) Deposit the amount with Reserve Bank of India or Treasury in the account of the... ...under the head Revenue Deposit. In such a case the Reserve Bank or the Treasury challan must be affixed with the tender.

(b) In the form of National Savings Certificate, National Deposit Certificate, National Planning Certificate, Govt. Security or Post Office Savings Bank account held in the name of the tenderer and duly pledged in favour of the.......

(c) Crossed Bank draft or Fixed Deposit receipt of a scheduled Bank guaranted by Reserve Bank of India held in the name of the tenderer and duly pledged in favour of ......

5. *Tender without earnest money* :—Tenders unaccompanied by full earnest money in requisite form will under no circumstances, be entertained and will summarily be rejected without further reference to the tenderers. No reference to previous diposit of earnest money and security for adjustment against the present tender will be accepted neither any request for recovery from any outstanding bills for earnest money against the present tender will be entertained.

6. *Deposit of additional earnest money for successful tenderer* :—In respect of the successful tenderers who have deposited earnest money as noted para I above the earnest money, on acceptance of the tender will be converted as a part of the security money and additional amount as security shall be deducted from the progressive bills as will amount (i) in the case of works costing upto Rs. 1,00,000 to 10% of the estimated cost of the work put to tender, (ii) in the case of works costing more than Rs. 1,00,000/- and upto Rs. 2,00,000/-, 10% on the first Rs. 1,00,000/- and 7½% on the balance, (iii) in the case of works more than Rs. 2,00,000/- 10% on the first Rs. 1,00,000/-, 7½% on the next Rs. 1,00,000/- and 5% on the balance, subject to a maximum of Rs. 1,00,000/- only.

7. *Refund of earnest money to unsuccessful tenderers* :—The earnest money of all the tenderers other than the three lowest tenders shall be returned on application and after the comparative statement is prepared and checked. Earnest money of 2nd and 3rd lowest tenderers could be returned after receipt of final decision of the accepting authority concerned towards acceptance or otherwise.

8. *Notice in the Newspaper* :—The notice appears in the Newspaper will also be treated as part and parcel of the tender in prescribed form.

9. *Time of completion* :—The time allowed for completion of the work as mentioned in clause (1) is from the date of work order. This is the essence of contract.

10. *Submission of contract documents* :—The contractor whose tender is accepted shall within seven days of issue of letter of acceptance by the accepting authority obtain contract documents in duplicate on payment of usual charges from the Executive Engineer......and enter into an agreement producing the registered documents of the company or of the firm. Failure to do so within the specified time, acceptance of the tender will be considered as automatically cancelled and deposited earnest money forfeited.

11. Period of validity of rates quoted by the tenderer :—A tenderer shall be eligible to withdraw his tender only if he fails to receive acceptance and work order within 90 days from the date of opening of tender. If a tenderer withdraws his tender within this period of 90 days without giving justifiable reasons for such withdrawls to the satisfaction of the authority accepting the tender his security money as in clause 7 shall be forfeited

12. Canvassing :—Canvassing in connection with tender is strictly prohibited and the tender submitted by the contractor who resort to canvassing will be liable to summery rejection.

13. Quotation of Rates :—(*i*) *For Priced item of works* :—A tenderer shall quote in figures as well as in words his rates at per or percentage above or below the rates shown in the schedule of items with rates and probable quantities. The said quotations is to be written in any of the forms (a), (b) or (c) below. The quantities of the aforsaid schedule may vary to any extent during execution of works, for which no claim will be entertained.

(*a*) I/We agree to carry out the work mentioned in the memorandum at per with the rates shown in the specific price schedule of probable items with approximate quantities.

(*b*) I/We agree to carry out the work mentioned in the memorandum at......% (......) percent above the rates shown in the price schedule items with approximate quantities.

(*c*) I/We agree to carry out the work mentioned in the memorandum......%(......) percent below the rates shown in the price schedule items with approximate quantities.

The said quotation in the exact wording of any of the form (a), (b) or (c) above must be written on page-2 only of the printed tender form and no where else. The quotations shall be clearly and legibly written in the tender and with the same pen and ink. Erasing or overwritting shall not be allowed. If corrections become unavoidable, the entire quotation (and not a portion only) shall be scored out and signed (not simply initialed) by the tenderer and then the same is considered as cancelled.

(*ii*) *Quotation of Rates for unpriced item of works* :—The tenderer is to quote under the column of rate in figures as well as in words his rates against each item of work as detailed with the schedule of quantities of works. Special care shall be taken to write the rates in figures as well as in words, and the amounts in figures only in such a way that interpolation is not possible. The amount for all items of works at the end of each page of the schedule shall be totalled and carried over to the next page of the schedule thus striking the total amount of the tender at the last page. The total amount shall be written both in figures and in words. While quoting the rate in schedule of quantities, the word 'only' shall be written closely following the amount.

14. Signing of tender papers :—In the event of tender being submitted by a firm, it must be signed by a member or members of the firm having legal authority to do so, and if called for, legal documents in support thereof must be produced for inspection and same in the case of a firm carried out by one member of a joint family, it must disclose that the firm is duly registered under the Indian Partnership Act. Certified copy of the legal documents must be submitted by the tenderer whose tender is finally accepted.

For priced item of works the said quotation in the exact wording of any one of the form (a), (b) or (c) as in clause 13(i) above must be written on page 2 only of the printed tender form and no where else. For this purpose the various columns in page-2 of the printed tender form shall be ignored and the quotations in the specified form should be written across the full width of the page. The quotations shall be clearly and legibly written in the tender and with the same pen and ink. Erasing or overwritting shall not be allowed.

The signature on page 3 of the printed tender form must be properly witnessed in the alloted space for the purpose. All the pages of the printed tender form, tender documents correction slips etc. shall bear the full signature of the contractor at the foot of every page on the right hand corner. Any tender not bearing signature on all the documents accompanying the tender is liable to be rejected.

If the tenderer signs a tender in any language other than English, the rate quoted by him shall be written in English by his authorised representative. In addition he shall furnish a certificate to the effect that all the stipulations of the tender documents have been fully and clearly explained to him and understood by him. The person who explained the stiputations shall also furnish a certificate to the effect that the stipulations have been fully and clearly explained by him to the tenderer.

15. *Site inspection before submission of tender* :—Before tendering the intending tenderers should thoroughly accquaint himself with the proposed work by local inspection of the sites and take into consideration of the difficulties likely to be involved in the execution of the work, communication facilities, climatic condition, nature of soil, availability of local labour and rates prevailing in the locality, removal of surplus materials etc. All these factors should be taken into consideration before quoting rates, as no claim whatsoever will be entertained by any of these accounts afterwords and for works even during night time.

16. *Near relative of a contractor* :—The contractor shall not be permitted to tender for works in the circle of the Superintending Engineer in which his near relative is posted as Divisional Accountant or as an officer in any capacity between the grades of Chief Engineer to Assistant Engineer (both inclusive). He shall also intimate the names of persons who are working with him in any capacity or are subsequently employed by him and who are near relatives to any gazetted officer in the Department.

17 *Exempting from payment of earnest money* :—A tenderer who holds the requisite fixed security (Rs. 50,000/-) with the department will not however be required to pay the earnest money. In such case, the tenderer must clearly state in the memorandum of page-2 of the printed form that he holds such a fixed security

18. *Submission list of work in hand* :—The contractor shall submit list of works are in hand (progress) giving the particulars of (i) Name of work, (ii) Name and particulars of Division where work is being executed, (iii) Amount of work (iv) Portion of work in progress.

19. Submission of tender :—Complete tender documents are to be placed in a cover and duly sealed, superscribing on the cover the name of work and the name and address of the tenderer. The sealed cover containing the tender documents is to be submitted within the specified date and time and this shall be done by inserting the same in the tender box.

Each section should be tendered for individually and separately and one sealed cover must not contain more than one tender.

20. List of machinery :—The tenderer shall furnish along with the tender a list of machinery including road rollers, tools and plants that he possesses and which he will utilise in the work.

21. Opening of tenders :—Tenders will be opened in public at...on...in the office of the ......and rates will be read out in presence of such tenderers or their authorised representative as are present but if they fail to attend during opening of the tenders on the schedule time and date tenders will be opened in their absence and no subsequent objections would be entertained under any circumstances whatsoever.

22. Acceptance of tender :—Acceptance of the tender will rest with the......who does not bind himself to accept the lowest tender and reserves the right to reject any or all the tenders received without assigning any reason thereof. The accepting authority also reserves the right to distribute the work to more than one tenderers at the rates accepted by him and the successful tenderer shall not have any claim for curtailment of works pertaining to his tender.

23. Rates to include all taxes :—The rates quoted should be for completed items of work and inclusive of sales tax, Octori, royalty and all other central or local taxes existing or that may be imposed in future.

24. Books of reference :—Except where specifically stated, otherwise, in these instructions and special conditions of contract attached herewith, the current department schedule and specification in vogue at the time of tender shall govern the work and shall be binding on the contractor. The book may be had from the Office of...on payment of Rs ...to the Divisional cashier.

25. Source and specification of materials :—Materials to be supplied by the contractor shall conform to the departmental standard conditions and specifications. If called upon the tenderer shall state the actual source of supply of any materials to be supplied by him and submit samples of bricks, ballast, stone chips, sand, timber etc. for approval of the Engineer-in-charge of the work. During the execution of work, all materials brought to site by the contractor must be offered for passing by the Engineer-in-charge or his representative, before being used in the work.

26. Change of address :—The tenderers must keep the department informed of any change of address during currency of Tender or of work, in his own interest and obtain an acknowledgement there of.

27. *Commencement of works* :—The contractor shall have to start the work within 10 days from the date of issue of work order to commence the work,

28. *Part recovery of Income Tax* :—Income tax @ 2% of the gross amount will be recovered from all bills of the contractor in terms of Section 194(c) of the Income Tax Act 1961 of Govt. of India.

17·8. Time limits for Tender Notice :—Since advertisements are sent to press through the publicity organization and they also take some time in actually sending the advertisement to the Newspapers and the press also requires some time to display the same (specially on Sunday) it is essential that the margin between the date of call for tenders and the date of opening tenders should be fixed so that the contractor gets a clear notice for the period as mentioned below to calculate his competative rates.

The following time limits between the date of call for tenders and the date of opening of the tenders are followed by the Central Public Works Department. This time limit as laid down may be varied at the discretion of the officer competent to accept the tender.

10 days in the case of works costing upto Rs. 1 Lakh.

2 weeks in the case of works costing upto Rs. 1 Lakh to 10 Lakhs.

3 weeks in the case of works costing more then 10 Lakhs.

The above time limits will not apply to global tenders.

17·9. Global Tender :—For big and specialised job or design and manufacture, global tenders are sometimes invited by the authority concerned throughout the Globe to get competetative offers from various Specialised Firms or reputed manufacturers throughout the world. The particulars of contents of the tender notice is same as that of ordinary tender notice. Only the Global tender notice is written on the heading of the notice inviting tender. It is circulated through reputed News Papers which covers the outside countries. Beside this is also circulated through the Ambassador's offices located at different important countries throughout the Globe.

17·10. Sale of Tender Papers :—Tender forms are sold only to enlisted contractors of appropriate class on their written applications and on payment of cost fixed for each set of tender documents. For specialized jobs tenders are sold to reputed parties or firms dealing with such works on the approval of the Addl. Chief Engineer. The tender papers are to be kept ready for sale as soon as the Notice inviting tender is issued.

Every set of tender documents sold is enfaced with a rubber stamp to make provision to show the name of the contractor with registered address, date on which application made for issue of tender and the actual date of issue over the signature of the Divisional or Sub-Divisional Officer. At the same time, corresponding entries are made in the Register of Sale of Tender maintained for the purpose of accounting of these priced forms and keeping record of the sale. This register is considered as a Subsidiary Cash Book and closed monthly after physical verification of the stock of forms in hand.

When tender papers are sold without plan and drawings, adequate facilities are to be given to the contractors to inspect the same in Divisional or Sub-Divisional offices before tendering.

When the tender is recalled the cost of tender papers is charged at half the original price From those who had tendered in the first call.

17-11. Submission of tender and deposit of Earnest Money : According to the directions contained in the Notice inviting tenders the contractors are required to submit their tender on or before the date and hour fixed for the same duly filled in, signed and witnessed. Before that he has to deposit the Earnest Money (usually 2½% of the estimated cost put to tender) in the manner prescribed in the P.W D. Form-6.

17-12. Opening of tenders : The sealed tenders received are to be opened in the presence of the contractors or their representatives tendering for the work at the time and place already notified. The Divisional Accountant should also be requested to be present on such occasion wherever possible. The officer opening the tenders has to read out the rates offered in case of Item rate and percentage rate tenders and amount in the case of Lump Sum tenders for information of all those present.

To avoid tampering in rates etc. in the original tenders before a comparative statement is made out and put up to him by the office he has to attest the corrections. Overwriting etc. in red ink, number them, and put his initial at the foot of each page and documents attached to the tenders. Tenders containing unauthorized corrections, and mutilations are liable for rejection.

The tenders which are not received in proper form duly filled in and signed are not supported by the requisite Earnest Money are to be summarily rejected and a record of such cases to be kept in the Register of tenders received.

17-13. Comparative Statement of Tenders : Comparative statements of Percentage rates and Lump Sum tenders are made out by the Officer opening the tender in form P.W.D. 13 himself. It contains informations regarding the name of the contractor, date of receipt of tenders, percentage above or below the rates entered in the tender documents, amount in the case of Lump Sum tenders. The recommendation or orders regarding acceptance or rejection of the tender is recorded on it.

Comparative statement of Item rate tenders is more elaborated and comprehensive and is drawn up by the office in P.W.D. Form-14 after thorough computation and check under supervision of the Divisional Accountant. On the basis of the comparative statement, the Divisional Officer has to make an intelligent scrutiny himself. The comparative statement must correctly incorporate the rates and amount and the totals drawn up and checked on the individual tenders. A mistake in it may lead to the work being awarded to a contractor who is not lowest.

If the acceptance of a particular tender does not rest with the Divisional Officer, he has to forward the tenders along with comparative statement and tender documents with his recommendation or observations to the next higher authority for consideration and orders in a sealed confidential cover.

17-14. What is informal tender ? A tender is said to be informal—(*a*) When it is not submitted in the form sold by the Department or by the due date and time notified through P. W. D. Form—6 (Notice Inviting tenders).

(*b*) When it is not supported by the requisite Earnest Money specified on the tender in the manner prescribed for the purpose in P. W. D. Form—6.

In the central P. W. D., the recognised form of Earnest Money deposit is by cash Treasury Challan or Deposit at Call Receipt of a scheduled Bank duly guaranted by the Reserve Bank of India. Cheques drawn on Banks tendered as Earnest Money is not acceptable.

(*c*) When the tender is not properly filled in or signed by the contractor or his authorized representative holding power of attorney and witnessed by a third party.

(*d*) When the tender is qualified or is made conditional by way of adding indefinite and uncertain liabilities of unusual character to it or by infringement of the standard rules and orders of the Govt. and local bodies.

The tender containing any of the above defects is liable for summary rejection.

17-15. Unbalanced Tender :— For item rate tender contractors quote their rates for the quantities of each and every individual item. But on the basis of shrewd anticipation or from outside information a contractor may quote high prices for the items of works which are likely to be increased and low prices for those item of works which are likely to be decreased. If the contractor's anticipation proves to be correct the tender becomes unbalanced and thus the department loose heavily. On the other hand for reverse case the contractor would stand to lose. For item rate tenders unbalanced tender may occur.

For a practical conception an example of unbalanced tender is set as below.

Example. An item wise rate tender amounting Rs. 2,75,000/- has been invited for earthwork of a road by a Government department having schedule of quantities without rate. Three contractors A, B and C have participated in the tender and offered their respective rates as below. After execution of the work the bills with their respective rates has also been shown below to compare their cost.

SL. no.	Description of item	Quantity cu m	Rates of contractors & tender amount			Quantity of work done cu m	Value of work		
			A	B	C		A	B	C
			Rs.	Rs.	Rs.		Rs.	Rs.	Rs.
1.	Earthwork in excavation with initial lead of 30m and lift of 1.5m	50,000	215% cu m 1,07,500	210% cu m 1,05,000	240% cu m 1,20,000	60,000	1,29,000/	1,26,000/	1,44,000/
1*a*.	For each additional lead of 15m beyond the initial lead of 30m upto 90m (i.e. 6 units)	50,000	23% cu m 69,000	22% cu m 66,000	30% cu m 90,000	56,000 (upto 90 m)	77,280/-	73,920/-	1,00,800/
1*b*.	For each additional lead of 15m between 90m and 210m (i.e. 8 units)	50,000	24% cu m 96,000	24% cu m 96,000	10% cu m 40,000 (upto	30,000 120 m)	14,400/-	14,400/-	6,000/-
		Total	2,72,500	2,67,000	2,50,000		2,20,680	2,14,320	2,50,800
		Relative position	third lowest	second lowest	First lowest	Excess amount of lowest tenderer to be paid than the 2nd lowest =			2,50,800 2,14,320 36,480

After comparison it is clear that contractor '*C*' has received the work being a lowest total tender amount Rs. 2,50,000/- with a difference of Rs. 267,000 − 2,50,000 = Rs. 17,000/- to his nearest tender *B*. But after execution of the work the bill amount of *C* is excess over Rs. 36,480 (as above) than contractor *B* who was not awarded the work. Due to such unbalanced tender the department has to lose Rs. 36,480/-.

During preparation of comparative statement an intelligent scrutiny must be made and the unbalancnd tender shall be rejected for unbalanced rates.

17-16. Acceptance of Tender :—After investigating the comparative statement the lowest tender shall be accepted as a rule by the competent authority. If for any reason, economical or otherwise, the lowest tender is not accepted reasons should be recorded confidentially and reference shall be made to the tender committee or next higher authority for order as to which of the contractors the work should be given. When a big work worth above Rs. one Lakh in value is divided into component parts for the sake of quick execution of the work and for other administrative reasons, the tender for each section should be treated as part of the tender for the whole work.

No tender can be accepted or the circumstances under which lowest tender may be rejected.—

(i) When the tender is informal.

(ii) Unless technically sanctioned and not exceed the sanctioned amount for the work.

(iii) Which involves liabilities exceeding the amount of the expenditure sanctioned.

(iv) or any uncertainty or any condition of an unusal character.

(v) Which exceeds the amount upto which he is empowered to accept tenders.

(vi) Any, provision which infringes any standard rule or order of higher authority.

(vii) Unless adequate competition and fair rate are received.

(viii) In respect if a contractor has quoted abnormally low rates, analysis of rates may be asked from the contractor and through investigation with necessary remarks and recommendations the tender should be forwarded to the next higher authority for his approval. The lowest tender in such a case may or may not be accepted.

Note that the soundness and credentials of a contractor is varified before issuing him any tender paper, so the lowest offer of a contractor can not be rejected on the plea regarding his soundness in finance, experience, reputation, manpower and equipment etc.

In case when a single tender is received this should not be opened and accepted. The powers of various officers of a department have been restricted to some extent with regard to acceptance of Single Tender. But if the tender amount is within the power of accepting authority as laid down in the departmental mannual single tender only then can be accepted.

After a decision to accept a tender has been arrived at, a letter communicating such acceptance on behalf of the President of India or the Governor of State is to be issued to the contractor at the earliest possible opportunity to complete the formalities of contract. This letter carries further directions to the contractors to execute and complete the formal contract. The letter of acceptance remains operative till the formal agreement is executed and signed by the contractor and the departmental authority after which the letter of acceptance will merge in the said formal agreement.

A copy of the letter should also be endorsed to the following in addition to the departmental officers and the concerned branches :—

(i) Regional Labour Commissioner.
(ii) Income Tax Officer.
(iii) Labour Officer.

17-17. Specimen form of letter accepting the Tender .—

By Registered Post

From : The Superintending Engineer/Executive Engineer.
To : (Name and address of the contractor)
Memo No..........Dated the............
Subject :—Tender No............Name of work.......................

Dear Sir(s)

Your tender for the above mentioned work has been accepted by the undersigned on behalf of the President/Governor/Authority at your tendered percentage of below/above the estimated cost, tender amount of Rs................

You are requested to attend the office of......to complete the formal agreement within seven days of the receipt of this letter. You are also directed to start the work at once. Please note that the time allowed for carrying out the work as entered in the tender, shall be reckoned from the 15th day after the date of this order to commence work.

Yours faithfully,
Sd/- Superintending Engineer,
Executive Engineer.

17-18. Work Order. In cases letter of acceptance is issued first to a contractor intimating that his rate has been accepted and to perform a formal agreement within a specified days (as stated in the specimen form above after omitting the last two sentences).

After the formal agreement is performed for the contract a letter is issued to the contractor known as Work Order to take up the work and the date of completion is treated from the date of issue of this letter. This is an order of commencement for a work and is issued to a contractor by the Executive Engineer Concerned.

17-19. Contract Documents :—When a work other than a petty work to be executed under the "Work Order" system is proposed to be given out on contract the Engineer-in-Charge (on behalf of the owner) prepare "Contract documents." Both the parties entering into a contract must put their signatures at each page of the contract documents and, in the case of sealed contracts, their seals under each signature. Special care shall be taken to see that all corrections, additions alterations, omissions, over-writings or slips attached to the agreements are duly signed or initialled by the contractor and the accepting authority. In cases if contractor fails to sign the above particulars mayresult dispute and disregarding claims of the Departmant. Engineering contract documents usually contain the following :—

(1) **Title Page**—This is the front page of the set of the decuments having the name of work, contract agreement number, estimated amount put to tender etc.

(2) **Index**—Showing contents and page references.

(3) **Tender Notice**—The tender notice or Notice Inviting Tender (NIT) papers are very important documents on which call of tenders and subsequent agreement's with the contractors are based. It contains essential informations in a standard printed form such as name of the work and its location, estimated cost of works, earnest money to be deposited, last date of sell of tender papers, last date, time and place of receipt of tender paper etc., time of completion, accepting authority etc.

4. **Letter of acceptance of tender and written order to commence work !**—In order to avoid legal complications, it is essential that the date of accepting of tender and the date of written order to commence work forms part of the agreement. But the date on which the agreement is finalised shall not be considered at all.

5. **Any letter giving by the Contractor with the tender** in clarification of rate or terms therein.

6. **Tender form** :—Printed form giving general directions for guidance of contractors, general description of work, estimated cost, earnest money, security deposit, time of completion and conditions of contract etc. There are columns in the tender form for signature of contractor, signature of witness to contractor's signature and of the officer by whom accepting. These columns are signed and sealed by the respective persons to enter into a formal agreement.

7. **Conditions of Contract** :—There are several clauses in the condition of contract to govern the character of the work to be carried out. Governments have their own standard conditions of contract provided in the printed tender form (as mentioned in 6 above). The conditions specify mainly the following clauses :—(1) Amount of security deposit, (2) Compensation for delay, (3) Action when whole of security deposit is forfieted, (4) Contractor remains liable to pay compensation, (5) Extension of time, (6) Final Certificate, (7) Payment on certificate, (8) Monthly bill. (9) Payment of bill, (10) Departmental materials, (11) Execution of work in accordance with specifications, (12) Alteration in designs and specifications, (13) No compensation for alteration, (14) Compensation in case of bad work, (15) Works to be opened for inspection, (16) Presence of contractor, (17) Maintenance period, (18) Care of departmental Tools and Plants, (19) Labour, (20) Work on Sunday, (21) Contract may rescinded, (22) Sum payable by way of compensation by the cantractor, (23) Changes in constitution, (24) Supervision by higher officers etc.

8. **Additional condition** :—Additional conditions are inserted in the condition of contract according to the character of the work to be carried out viz., **Insurance, Lighting and watching, etc.**

9. Schedule of items of Works with quantities and units (and with rates and amounts in the case of percentage rate contract only) gives brief descriptions of completed items of works involved and the approximate quantities are to be executed with their units of rates (and rates with amounts in the case of percentage rate contract) under this contract. For item rate contract a contractor gives his item wise rate in the schedule. But for percentage rate contract the unit rates, amount of each item and the total amount are given in the schedule. A contractor puts his overall percentage rate above or below or at per in the tender form at the last page of the schedule. This schedule is the basis of financial aspect of the contract, and preparation of bills. Payment against a contract is made according to this agreed schedule of rates by both the parties under a contract.

10. General and additional specifications :—Each engineering departmant have their own printed standard detailed specifications for the general types of works commonly involved. Unless otherwise mentioned all works under a contract are to be carried out in accordance with the general specification of the department. (Note that the general specifications mean the detailed specifications of all items of works generally involved but not the general specification of a work).

Additional specifications are provided to carry out the items of works those are not covered by the departmental printed general specification. These are specially written and provided after the printed specification for a particular contract.

11. Schedule of issue of materials and Tools & Plants ;—Giving the list of departmental materials, T. & P, to be issued departmentally, their issue rates or hire charges and place of delivery etc., terms and conditions for recovery their costs etc. Departmental materials, as specified in the tenders is issued to a contractor from time to time as required in the opinion of the Engineer-in-Charge to maintain the work program. The contractor remains solely responsible for carriage and safe custody of such materials, T. & P. including all necessary loading and unloading. No claim on account of transportation, handling or storage of any such materials is admissible. The contractor remains solely liable for any loss or damage to such materials until these are used up in works and the works are taken over by the department. Excess quantity of materials are to be returned back by the contractor. If the contractor fails to return any excess quantity of departmental materials in good condition to the departmental stores the cost of such materials is recovered at a penal rate as specified in the contract.

12. Schedule of fair wages : Labour regulations and safety code where these are not incorporated in standard form of condition of contract.

13. A complete set of drawings including plans, sections and elevations :—Gives a list of the drawing forming part of the contract and refer to them by number or title. Further drawings may be issued from time to time at the discretion of the Engineer-in-charge as need arises.

17-20. Earnest Money :—Earnest money is an assurance or guarantee in the form of cash on the part of the contractor to keep open the offer for consideration and to confirm his intension to take up the work for execution accepted in his favour as per terms and conditions in the tender. In cases where a tenderer fails to commence the work awarded to him, the earnest money is forfeited to Government. No interest is payable upon earnest money to the contractors.

If the amount of the earnest money is not large (i. e. not exceeding Rs. 250/-) it may be deposited in cash in Divisional or Sub-Divisional Office. In other cases the contractor has to deposit the same in the Treasury/Bank and to produce the receipted challan with the tender. The contractor may also deposit the same in the form of Deposit at call Receipt of a scheduled Bank duly guaranted by the Reserve Bank of India, if so desired. The amount of the earnest money which a contractor should deposit with the tender is regulated by the department and generally for works up to the of Rs. 5 Lakhs @2½% of the estimated cost subject to a maximum of Rs 10,000/-, for works above 5 Lakhs @ 2% of the estimated cost subject to a maximum of Rs. 20,000/- Enlisted contractors of a department mostly deposit a fixed permanent security according to their classification and departmental rules in order to enable them to secure exemption from payment of earnest money.

Earnest money given by all the contractors except the three lowest tenderer should be returned within a week from the date of receipt the tenders. Earnest money of the second lowest and third lowest tenderers should be returned within 15 days of the acceptance of the tender, if their offers are not considered, The earnest money of the lowest tender whose tender is normally accepted is retained by the Department as a part of the security deposit for due performance of the contract.

17-21. Security Deposit :— Security deposit is an amount of money which shall be deposited by the contractor whose tender has been accepted in order to render himself liable to the department to pay compensation amounting to the part or whole of his security deposit if the work is not carried out according to the specification, time limit and conditions of contract.

After acceptance of the tender of a contractor the earnest money which he has deposited at the time of tender is treated as part of the security money and additional amount of security money is deducted from the progressive bills so that the total amount thus constitute is 10% on the first lakh and 7½% on the balance. In case of works costing more than Rs 2 lakhs, 10% on the first one lakh, 7½% on the next one lakh and 5% on the balance, subject to a maximum of Rs 1 lakh only (The rates as mentioned here is followed by C.P.W.D.)

The security deposit is refundable to a contractor after the prescribed maintenance period is over. In order to afford relief to the contractor a percentage (normally 50%) of the security money is refunded for the portion of the work which has been completed and whose maintenance period is over.

17-22. Retention money :—Whenever any claim or claims for payment of a sum of money arises out of or under the contract against the contractor, the Engineer in-charge is entitled to withhold and also lien to retain such sum or sums in whole or in part from the security till finalisation or adjustment of any such claim. In the event if the security amount being insufficient to cover the claimed amount the Engineer-in-charge is entitled to withhold and have lien to retain to the extent of such claimed amount referred to above, from any sum or sum found payable to the contractor under the same contract or any other contract with the Engineer-in-charge pending finalisation or adjustment of any such claim.

Differences between 'security deposit' and Retention money :—

Security deposit	Retention money
1. This is compulsory to be deposited before entering a contract.	1. This is not compulsory and very rairly arises out.
2. The amount depends on the tendered amount.	2. It has no relation with the tendered amount but depends on the amount of claim against a contractor.
3. This is refundable after the maintenance period is over.	3. This has no relation with the maintenance period and can only be released after finalisation or adjustment of the claim.
4. The amount can not be collected from any other contract even under the same Engineer-in-charge.	4. The amount can be withhold from any other contract under the same Engineer-in-charge.
5. This is meant for nonfulfillment of the conditions of contract against a tender.	5. This is meant for fulfillment of any claim against this tender or other tender under the Engineer-in-charge.
6. This is a compulsory clause of the condition of contract.	6. This is not a compulsory clause and provided in some tenders as an Additional clause.

17-23. Liquidated damage :—Liquidated damage is an amount of compensation payable by a contractor to the owner or Government due to delayed construction having no relationship with real damage. If the contractor shall fail to complete the works within the time prescribed in the tender then the contractor shall pay to the owner or Government the sum stated in the tender as liquidated damages for such default and not as a penalty for every day for the excess period taken between the date of completion specified in the tender or the extended time as the case may be and the date of actual completion of the work. The payment or deduction of such damages shall not relieve the contractor from his obligations and liabilities under the contract. If before the completion of the whole works any part of the works occupied or used by the Owner or Government and duly certified by the Engineer-in charge the liquidated damages for delay shall be reduced in the proportion which the value of the part so certified bears to the value of the whole of the works.

17-24. Unliquidated damage :—This is known as ordinary damage having relation with the actual damage done. When a contract has been broken, the party who suffers by such breach is entitled to receive, from the party who has broken the contract.

17-25. Compensation for delay in Completion :—When a work alloted to a contractor remains uncommenced or unfinished beyond the time allowed for carrying out the work or if the progress of the work is not proportioned to the time escaped, then the contractor shall pay as compensation to the Owner or Government an amount equal to one percent of the tender amount or such similar amount as the competent authority may decide. The limit of compensation may be upto the full amount of security deposit.

17-26. Conditions of Contract :—The terms of contract shall be precise and definite and there shall be no room for ambiguity or misconstruction therein. In Central and State Government Engineering departments use Standard printed contract forms to avoid this contingency. To State the conditions of contract these standard forms have been followed.

Definitions :—

1. The '*President*' means the President of India and his successors. The 'Governor' means the Governor of the state and his successors Government means the president of India or Governor of the state as the case may be.

2. The '*Engineer*-in charge' means the Divisional Officer or the Executive Engineer for the time being of the Division.

3. The *Contractor* shall mean the individual or firm or company whose tender has been accepted by the President/Governor and shall include the legal personal representative or such individual or the persons composing such firm or company, successors, and permitted assignees.

4. The *site* shall mean the land and other places on, into or through which work is to be carried out or any land, path or street through which work is to be carried out under the contract or any other places provided by the Engineer-in-charge for the purpose of carring out the contract.

5. Words importing the singular number only include the plural number and vice versa.

Clause 1. Security Deposit :—The person or persons whose tender may be accepted (hereinafter called the contractor) shall permit Government to collect from the running bills of the contractor by way of security deposit such sum as along with the sum of earnest money already deposited during submitting tender will amount to 10% of the estimated cost put to tender for works costing upto Rs. 1,00000/- ; for works costing more than Rs. 1,00,000- and upto Rs. 2,00,000/- to 10% on the first Rs. 1,00,000/- and 7½% on the balance. In the case of works costing more than Rs. 2,00,000/- the amount of security deposit along with the sum of earnest money will amount to 10% on the first Rs. 1,00,000/-, 7½% on the next Rs. 1 lakh and 5% on the balance, subject to a maximum of Rs. 1,00,000/- only.

All compensations or, other sums of money payable by the contractor to Government under the terms of this contract may be deducted from, or paid by the sale of a sufficient part of his security deposit. In the event of his security deposit being reduced by reason of any such deduction or sale as aforesaid the contractor shall make good the deficit in cash or guarantee bonds duly endorsed in favour of the Government within 10 days.

Clause 2. Compensation for delay :—The time allowed for carrying out the work as entered in the tender shall be started from the 15th day after the date of giving order for its commencement or any other date specified and shall be strictly observed by the contractor. Time allowed in the tender for completion of the work is essence of the contract on the part of the contractor. When the work alloted to the contractor remains uncommenced or for delay in the completion of the work or if the progress of the work is not proportional to the time escaped, then the contractor shall pay as compensation an amount equal to 1% or such smaller amount as the Superintending Engineer may decide for each day of delay subject to the maximum of 10% of the tendered amount of the whole work. The decision of Superintending Engineer in writing as the quantum of compensation to be levied shall be final.

Clause 3. Action when whole of security deposit is forfeited :—When the contractor has made himself to pay compensation amounting to the whole of his security deposit (due to taking action of clause 2) the Engineer-in-charge, on behalf of the President/Governor shall have power to adopt any of the following courses, as he may think best suited to the interests of Government—

(*a*) To rescind the contract with a written rescission notice of the Engineer-in-charge provided the security deposit of the contractor shall stand forfeited and shall be absolutely at the disposal of Government without prejudice to Governments right to recover losses under clause 3(*b*) and 3(*c*).

(*b*) To employ labour paid by the department and to supply materials to carry out the unfinished work, or any part of the work for and on behalf of the contractor. The costs of the labours and prices of the materials certificates of the Engineer-in-charge shall be final and conclusive against the contractor.

(*c*) To measure up the work of the contractor, and to take such part thereof as shall be uncommenced out of his hand and to allot it to another contractor for its execution at the risk and cost of the original contractor.

The extra expenditure if any under clause (3*b*) or (3*c*) shall be borne by the contractor and shall be deducted by the Engineer-in-charge from the security deposit. If the extra expenditure exceeds the forfeited amount of security deposit, the difference between the extra expenditure and the security deposit shall be recovered from any money due to the contracto under the contract or otherwise.

If the Engineer-in-charge adopts any of the above clauses then the contractor shall have no clain to compensation for any loss sustained by him due to any reason whatsoever. On the other hand if the unfinished work is executed at a lesser cost, then the contractor shall have no right to claim the amount saved.

Clause 4. Contractor remains liable to pay compensation and power to take possession or disposal of contractor's plant :—If there be any delay or no action is taken to exercise clause 3 the same shall not be constitute a waiver of any of the conditions thereof and the contractor shall remain liable to pay compensation. In the event of the Engineer-in-charge putting in force the powers of clause (3*a*) or (3*c*) vested on him under the preceding clause he may, if he requires to take possession (after serving a written notice to the contractor) of all or any tool, plants, materials and stores in or upon the works and can sale them by auction on account of the contractor. The certificate of the Engineer-in-charge as to the expense of any such removal and the amount of the proceeds and expense of any such sale shall be final and binding.

Clause-5. Extension of time :—If the contractor cannot complete the work due to having been unavoidable hindered in its execution or any other ground ; the contractor-shall give an immediate report of such hindrance to the Engineer-in-charge he can apply for extension of time in writing to the Engineer-in-charge within 7 days of the date of completion. The Engineer-in-charge may grant such extension of time on reasonable grounds.

Clause-6. Completion certificate :—On completion of the work including removal of surplus materials, site godown or any other materials in connection with the work the work the contractor shall be furnished with a completion certificate by the Engineer-in-charge. The date of completion shall be noted in the Measurement-book according to the date as certified in the certificate. In case if the contractor fails to remove the above mentioned materials before the date fixed for completion the Engineer-in-charge may remove those at the expense of the contractor.

Clause-7. Payment on certificate :—The contractor shall be entitled to receive monthly payment on bills submitted by him to cost more than Rs. 5,000/- and duly approved and passed by the Engineer-in-charge, whose certificate of the sum so payable shall be final and conclusive. But all such intermediate payment shall be regarded as advance against the final payment and not as payments for work actually done. Such work may be regarded as bad, unsound and unskillful.

Clause-8. Monthly payment on bills :—Monthly bill shall be submitted by the contractor on or before the date fixed by the Engineer-in-charge for all works executed in the previous month. The Engineer-in-charge or his authorised representative shall check the measurements for its admissible payment within 10 days from the date of submission of the bill. If the contractor does not submit the monthly bill, the Engineer-in-charge may depute a sub-ordinate to measure up the said work in the presence of the contractor who will countersign the bill in order to receive his payment.

Clause-8A. Objection to the measurement recorded by Deptt :—Before taking up any measurement of any work by the departmental staff the Engineer-in-charge shall give a notice to the contractor to attain at the measurements. If the contractor fails to attend at the measurements or fails to countersign or to record the difference within a week from the date of measurements, then in any such event the measurement taken by the Engineer-in-charge or by the subordinate deputed by him as the case may be shall be final and binding on the contractor.

Clause-9. Bills to be on printed form :—The contractor shall submit all bills on printed forms supplied by the department on payment at the specified rate.

Clause 9A. Payment of contractor's bills to banks :—If a contractor desires and furnishes legal authorization as well as his own acceptance to the Engineer-in-charge payment may be made to his Bank instead of direct to him.

Clause 10A. Materials and Stores supplied by Government :—When departmental materials are issued to a contractor time to time for the purpose of the contract only at a fixed issue rate as provided in the tender, the value of the full quantity of materials and stores so supplied may be deducted from sums then due or there after to become due to the contractor under the contract or from the security deposit. All materials supplied to the contractor shall remain the absolute property of Government and shall not on any account be removed from the site of the work, and shall at all times be opened to inspection by the Engineer-in-charge or his authorised persons.

On completion of the work excess quantity of materials in perfectly good condition can be returned by the contractor to the departmental store if so required by the Engineer-in-charge. But without the consent of the Engineer-in-charge the contractor shall not be entitled to return any such materials and shall have no claim for compensation on any account of any such materials so supplied and unused by him. The Government shall not be responsible for any loss, wastage or damage to any such materials.

Clause 10B. Secured advance :—Under this sub-clause the contractor shall be entitled to get 75% advance payment against the estimated value of any materials which have been brought on the site in connection with the work during its progress and which are in the opinion of the Engineer-in-charge securedly stored and protected from any damage. Any such above mentioned material shall not be used in the works at the time of advance payment. To get such advance payment the contractor shall sign an indenture in the form to be specified by the Engineer-in-charge. When materials on account of which on advance payment has been made are used in the work the full amount shall be deducted from the next payment made under this contract.

Clause 11. Drawings and Specifications :—All works shall be carried out in the most workmanlike manner faithfully and truly in accordance with the design, drawings and specifications and written in the specification. All materials and otherwise in every respect shall be in strict accordance with the specifications. The contractor shall be entitled to have access for the purpose of inspection during office hours of all such drawings and specifications. If he so requires, be entitled at his own expense to make copies of the specifications, and of all such designs, drawings as aforesaid.

Clause-12. Alteration in specifications and designs :—The Engineer-in-charge reserves the right to make any change in, omission from, and aditions to or substitutions for, the original designs, drawings, specifications and instructions as are necessary in the opinion of the Engineer-in-charge during progress of the work and which may be given to him in writing and signed by the Engineer-in-charge. Such changes, omissions, additions or substitutions shall be deemed to have formed as work included in the original tender and the contractor shall be bound to carry out the work. The time of completion shall be extended proportionately by the Engineer-in-charge due to above reasons.

The rates for such additions, alterations or substituted work shall be worked out with the following provisions : (i) Same rates if any may be specified in the tender, if not (ii) the departmental schedule of rates at the time of the acceptance of the contract with the contractual percentage, if none of the above. (iii) by analysis worked out from the basic rates of materials and labour provided in the current schedule of rates and if the basic rates are not in the schedule then from current market rates without appilcation of the said contractual percentage. In the event on any dispute regarding rates, the decision of Superintending Engineer of the circle shall be final and binding.

Clause 12A. Revision of the rates :—In the case of any altered, additional or substitute work involves the employment of additional materials and equipments, the contractor may claim revision of the rates specified in the tender for the main work within 7 days from the receipt of the order. The Engineer-in-charge may revise such rates having regard to the increase in the market prices of such materials. In the event of a dispute the decision of the superintending Engineer of the circle shall be final and binding. But under no circumstances the contractor shall suspend the work on the ground of non-settlement of rates of items.

Clause 13. No Compensation for restriction or alteration of work :—The contractor shall have no claim to any payment or compensation for (i) any curtailment of the work as specified in the tender due to any reason whatsoever on account of profit or advantage from the execution of the original work infull or for (ii) any alterations in the original drawings, designs, specifications and instructions which may cause any curtailment of the original work.

Clause 14. Action and compensation payable in case of bad work :—If any work is found has been executed by the contractor with unsound, imperfect or unskillful workmanship, or with materials of any inferior description or is not in accordance with the contract, the contractor shall make good the defects in work at his own expense and remove the materials or articles complained in writing by the Engineer-in-charge. If the contractor fails to do so within a period as specified by the Engineer-in-charge the contractor shall be liable to pay compensation of the rate of one percent per day upto a maximum limit of ten percent the amount of the estimate. Even so the contractor fails to rectify the defects or remove and replace the defective materials the same may be done at risk and cost of the contractor.

Clause 15. Works to be opened to inspection :—All work at all times shall be opened to the inspection and supervision of the Engineer-in-charge or his subordinate. The contractor or his authorised responsible agent shall be present at all times during the usual working hours or all other times as previously informed to receive orders and instructions.

Clause 16. Notice to be given before the work is covered up :—The contractor shall not cover up or place beyond the reach of measurement any work of the tender without seven days notice in writing to the Engineer-in-charge or his subordinate in charge of the work or without consent obtained from the Engineer-in-charge. Unless otherwise, the said work shall be uncovered by the contractor at his own expense, or in default there of no payment or allowance shall be made for such work or the materials with which the same was executed.

Clause 17. Maintenance period :—The contractor shall be liable for any damage done or any defects noticed within the prescribed maintenance period of 3 months (6 months in case of road work). The work shall at or as soon as practicable after the expiration of the period of maintenance be handed over to the Engineer-in-charge in as good and perfect condition. If any damage, defects, imperfections or other faults become apparent in it from the agreed date of commencement until the end of the maintenance period the contractor shall make good the same at his own expense or in defaults, the Engineer-in-charge shall be entitled to carry out such work by other workmen and deduct the expense from any sums that be due to the contractor or from his security deposit.

The security deposit of the contractor shall not be refunded before the expiry of maintenance period or till the final bill has been prepared and passed whichever is later. However, if in the opinion of the Engineer-in-charge, half of the security deposit may be refunded after 3 months from the date of completion in order to afford relief to the contractor in the matter of early refund of the security deposit against the contract. For asphaltic work the maintenance period shall be one year from the date of the completion work and the contractor shall be responsible for rectifying the defects within this period. The security deposit relating to the asphaltic work shall be refunded after the expiry of the above mentioned period.

Clause—18. Contractor to supply tools and plants :—The contractor shall supply at his own cost materials (except such materials if any, in accordance with the contract be supplied from the departmental stores), tools, plant, appliances, implements, ladders, scaffolding etc for the proper execution of the work. The contractor shall also supply without charge the requisite number of persons, with the necessary means and materials in order to setting out works, assisting in the measurements of the work or materials. The contractor shall also provide all necessary fencing, lighting in order to protect the endanger from accident. The contractor shall be bound to bear all legal expenses and to pay damages and costs owing to neglect of the above precautionary measures.

Clause—18A. Care of departmental Tools and Plants :—The contractor shall be responsible for and shall take proper care and caution in respect of all departmental rollers, tools, machinery etc. issued to the contractor in connection with the work, and shall be liable for any loss of and damages by any reason whatsoever during the period the same are in the possession of the contractor.

Clause—18B. Workmen's Compensation :—By virtue of the Workmen's Compensation Act, 1923 of section 12, sub-section (1). The Government is obliged to pay compensation to a workman employed by the contractor, in execution of the works and as such Government will recover the amount of compensation so paid from the contractor. Government shall not be bound to contest any claim against in under section 12, sub-section (1) of the said Act, except on the written request of the contractor.

Clause—19. Labour :—No labour beyond the age of fifteen years shall be employed on the work. The contractor shall obtain a valid license under the contract labour Act and Rules before commencement of the work and shall continue till the completion of the work. The minimum wages and amenities of the labourers shall be maintained according to the provisions of labour and wages Acts.

Clause—20. Work on Sundays :—No work shall be done on Sundays without written permission of the Engineer-in-charge.

Clause—21. Subletting of works and contract may be rescinded :—The contractor shall not assign or sublet the contract or any work of the contract in whole or in part without the written permission from the Engineer-in-charge. The Engineer-in-charge shall have power to rescind the contract and to adopt any of the courses specified in clause (3) if the contractor shall—(i) assign or sublet his contract or attempt to do so (ii) become insolvent or make any composition with his creditors etc, (iii) if any bribe, loan, gift, reward or advantage, gratuity, perquisite, pecuniary or otherwise shall either directly or indirectly be given, promised or offered by the contractor or his servants to any officer or person of Government in any way connected in the contract.

Clause—22. Sums payable by way of compensation :—Under any of these conditions shall be considered as reasonable compensation without reference to actual loss,

Clause—23. Changes in constitution of firm :—The previous approval in writing of the Engineer-in-charge shall be obtained before any change is made in the constitution of the firm specially before an individual or family business contractor enters into any partnership agreement or any change is made in the constitution of the partnership firm. Unless otherwise the contract shall be deemed to have been assigned in contravention of Clause 21 thereof and the contract shall be resinded and the security deposit shall be forfeited.

Clause—24. Direction of work :—All works under the contract shall be executed under the direction and subject to the approval in all respects of the Engineer-in-charge or of the superintending Engineer of the circle for the time being who shall be entitled to direct at what point or points and in what manner the works are to be commenced and carried out.

Clause—25. Arbitration :—Except where otherwise provided in the contract all questions, disputes, meaning claim arising out of or relating to the contract, estimates, specifications, designs drawings, quality of workmanship or materials used on the work, instructions, orders or these conditions or otherwise concerning the works or the execution or failure to execute the same arising at any stage shall be referred to the sole arbitration of the Chief Engineer of the department (or if there be no Chief Engineer the administrative head of the department). If the Chief Engineer be unwilling to act as such arbitrator he shall appoint a person as an Arbitrator and such appointment shall be valid. It is also a term of this contract that no person other than a person appointed by the such Chief-Engineer shall act as arbitrator. The person thus appointed shall be the sole arbitrator and his award shall be final and binding on all parties to the contract, unless it is set aside by the Court.

The contractor invoking arbitration shall specify the dispute or disputes to be referred to arbitration together with the amount of claim. The prayer of the contractor for arbitration shall not be time barred, in accordance with the provisions of Limitation Acts 1908 or 1963 as the case may be.

Clause 26. Potent Rights :—In the event of any action, claim or proceeding relating to infringement or use of any patent or design rights etc. the contractor shall fully indemnify the Government provided the same is not the direct result of an order passed by the Engineer-in-charge.

Clause 27. Lump sum in estimates :—Whenever there are lump sum items, sum items in the estimate on which the tender is made and it is proposed to make any intermediate payment, the contractor shall be entitled to payment in respect of the items of works involved at the same rates as are payable under this contract for such items. But if in the opinion of the Engineer-in-charge the work in question is not capable of measurement payment shall be made on a certificate given by the Engineer-in-charge to the effect that by superficial measurement the value of the work done is not less than the specified amount. The certified amount shall be final and conclusive against the contract.

Clause 28. Action where no specification :—For any work for which specification do not exist, such work shall be carried out in accordance with the distinct specification and in absence of distinct specification the work shall be carriedout in accordance with the instructions of the Engineer-in-charge.

Clause 29. Withholding and lien in respect of sums claimed i.e. Retention money :—Whenever any claim, or claims for payment of a sum of money arises out of or under the contract against the contractor, the Engineer-in-charge or the Government shall be entitled to withhold and also have a lien to retain such sum or sums in whole or part of the security deposit pending finalisation of such claim. In the event if the security being insufficient to cover the claimed amount or amounts the Engineer-in-charge or the Government shall be entitled to withhold and have a lien to retain such claimed amount from any sum or sums found payable or which at any time thereafter may become payable to the contractor under the same contract or any other contract with the Engineer-in-charge or the Government. The account in respect of such withholding or retained under the line till the claim arising out of or under the contract is determined by the Arbitrator or by the competent court, as the case may be.

Clause 30. Employment of labour :—The contractor shall not employ coal mining or controlled area labour falling under any category whatsoever on or in connection with the work.

No labour should be imported from any district other than where works are to be executed without prior consent of the Engineer-in-charge. Imported labour can only be engaged with permission of the Engineer-in-charge when the progress of work so demands. 70% of the skilled labour shall have to be recruited locally.

Clause 31. Supply of water :—The contractor (*S*) shall make his/their own arrangements for such water as shall fit for construction purpose to the satisfaction of the Engineer-in-charge required for the work and nothing extra will be paid for the same. The Engineer-in-charge shall make alternative arrangements for supply of water at the risk and cost of contractor (*S*) if the arrangements made by the contractor (*S*) for procurement of water are in the opinion of the Engineer-in-charge, unsatisfactory. In case where there is no piped water supply arrangement the contractor shall be allowed to draw water from Government hand pumps and wells without any charge. The contractor shall be allowed to construct temporary tube wells or wells on Government land for taking water for construction purpose only without any charge.

Clause 32. Labour camp :—The contractor (*S*) shall at his/their own cost be allowed to provide his/their labour camp on the approved site and shall make arrangements for conservency, sanitation and water supply in the labour camp to the satisfaction of the local Public Health and Medical Authority at his/their own expenses whatsoever may be.

Clause 33. Engagement of Technical personnel :—The contractor shall employ the following technical personnels during the execution of this work :—

(i) When the cost of work to be executed is more than Rs. 2 lakhs but less than Rs. 5 lakhs one qualified diploma holder in the specific branch.

(ii) When the cost of work to be executed is more than 5 lakhs one graduate Engineer in the specific branch.

The technical staff should be available at site, whenever required by Engineer-in-charge to take instructions.

In case if the contractor fails to employ the technical staff as aforesaid he shall be liable to pay a reasonable amount not exceeding a sum of Rs. 2,000/- for each month of default in the case of graduate Engineer and Rs. 1,000/- for each month of default in the case of diploma holder.

17-27. Special terms and conditions :—Special terms and conditions mostly depend on the nature of work and are specially written by a department those are not covered by the departmental General conditions and specification in vogue at the time of tender. However, the most common special terms and conditions are as below :—

1. *Site Order Book* :—The contractor shall within ten days of the receipt of the

written order to take up work, supply at his own cost, one site order book to the sub-Divisional Officer / Assistant Engineer concerned. The site order book shall be machine numbered pages in triplicate and will be initiated by the Assistant-Engineer-in-charge. The site order book shall be kept at the site of work under the custody of the Assistant Engineer or his authorised representative. Directions or instructions from departmental officers to be issued to the contractor, will be entered in the site order book (except when such directions or instructions are given by separate letters. The contractor or his authorised representative shall regularly note the entries in the site order book and may take any of the duplicate page of the site order book for his own record.

Cases of supplementary items of claims shall not be entertained unless supported by entries in the site order book or any written order The site order book shall be enclosed along with the final bill to varify the supplimentary claims.

2. *Work program* :—The contractor shall have to submit within three days from the written order to commence the work to the Engineer-in-charge a fully detailed program showing the methods of construction, plant and temporary works he proposes to employ for the construction of the works together with specified sequence of operation for the purpose and time schedule of each such operation in which the several portions of the work shall be completed. The work program shall be approved by the Engineer-in-charge. The work program shall not violate the provision of clause—2 of the printed condition of contract and the contractor must maintain the progress of work with the work program.

3. *Precaution and co-operation with other contractors* :—All precautions must be taken to guard against chances of injury or accident to the occupants, users or workers. The contractor must protect and support all utility services like water pipe line, electric or telephone cable lines, gas line etc. fouling within his work as per direction of the Engineer-in-charge. The contractor must also keep close contract with public agencies for safety or shifting of their pipes, cable, mains etc.

All works or supply of materials at work site are to be carried with due regard to the convenience of the occupants of any, and in close co-operation with other contractors that may be working in the areas of work.

All these shall be done at the cost and expense of the contractor and deemed to have been covered by rates of the different items of work.

4. *Idle Labour* :—No claim for idle labour would be entertained under any circumstances.

5. *Arrangement of land for storing or stacking of materials and Spoils* :—The contractor should make his own arrangement for stocking and storing space within the project site for materials in connection with the work. The contractor will not be entitled to any payment or any other incidental charges caused due to such arrangement.

6. *Tools and plant* :—The contractor should entirely responsible and liable to procure and use all machinery, tools and plant and their spare parts that are required for execution of the work methodically. Delay in procurement of such items due to their non-availability or any other causes whatsoever, will not be taken as excuse for slow or non-performance of work.

17·28. Execution of civil Engineering works :—The following procedure should be followed for execution of civil engineering works :

(a) Preliminaries :—

1. Administrative approval will be obtatned before commencement of any work or liability incurred in connection with it.

2. Technical sanction will be accorded on a detailed estimate designed properly.

3. Expenditure sanction will be accorded and allotment of funds be made.

4. With receipt of administrative approval to the estimate, collection of scarce materials like cement, steel, Bitumen, stone chips etc. and arrangement for special tools and plants if required in connection with the work will be started.

5. With receipt of technical sanction to the estimate, action will be immediately initiated for taking possession of the land acquired by the Government.

6. If there is any involvement with other departments such as Traffic Police, Roads, Electrical, Gas, Telephone, local bodies like Municipality or Corporation etc. the concerned units in respect of the scheme work, will be immediately informed along with copies of the relative portions of plans and drawings for co-ordination and to take precautionary measures.

7. Preparation of draft notice inviting tender (NIT) will be taken in hand and widely published. On receipt of tenders work-order will be issued to acceptable tender after performing contract agreements with the contractor.

8. Before any work is began the Executive Engineer will see that the assistant or subordinate in charge has, for his guidance, fully detailed instructions and proper working drawings, and that he understands them.

(b) Execution of Work :—

(1) *Supervision*—Superintending Engineer, Executive Engineer, Assistant Engineers connected with the work will inspect the work frequently to ensure that the works are being executed according to drawings and specifications as provided in the contract document. The Assistant Engineer will make adequate check to ensure that measurements of work are correctly entering in the measurement book by his sub-ordinate staff designated as Sub-Assistant Engineer/sectional Officer/Overseer.

(2) *Site Order book* :—Site Order book will be maintained and whenever any Senior Officer gives instructions and orders to his Junior Officer at the site of work ; it is necessary that he will confirm such instructions and orders in writing on the site Order book. Though verbal orders should be confirmed in all cases, but implementation of these verbal orders should not be delayed for want of confirmation. S.A.E/sectional Officers will also record his observations in the Site Order Book if he finds any defective work going on or the contractor not complying with the terms of contract.

(3) *Issue of materials* :—Departmental materials, as specified in the tender will be issued to the contractor from time to time on indent as required in the opinion of the Engineer-in-charge to maintain the progress of the work. The value of all such materials issued to

the contractor will be recovered from the progressive bills payable to the contractor at the departmental issue rates. An account of materials supplied to the contractor will be properly maintained. In addition to the materials issued to the contractor they will be allowed to use of plant and Machinery of the department at fixed hire rate as provided in the tender.

(4) *Scope of Sanction* :—During execution of a work no material deviation and material structural alterations will be made without sanction of the authority, which respectively accord the administrative approval and sanctioned the estimate technically even though no additional expenditure may be involved due to such alterations. Savings due to the abandonment of a substantial section of any project sanctioned by any authority will not be considered as available for work on other sections without the further sanction of that authority. Any development of a project considered necessary while a work is in progress, must be covered by a supplementary estimate. The provisions for contingencies in a work estimate may, however, be diverted to new work not contemplated in the original project.

(5) *Progress report* :—Every officer or sub-ordinate in charge of a work will furnish a progress report of the work at the begining of each month to his next higher authority.

(6) *Materials at site account* :—The departmental materials issued to the contractor (as per items of contract) will be submitted monthy to the divisional officer by the concerned Assistant Engineer.

(7) *Payment* :—Monthly or interim payment as per term of contract will be paid to the contractor after preparing the bill on the recorded measurements duly signed by the contractor and after checking by the Assistant Engineer and test checking by the Executive Engineer the cost of materials and higher charges of Tools and plants if issued will be recovered from the bill. The divisional accountant with the help of accounts clerk will further check up the arithmatic calculations, rates and any other irregularities if any in accordance with the tender and put up the bill to the Executive Engineer for payment. The Executive Engineer will finally give payment to the contractor by crossed cheque. Thus final payment will be made to the contractor after satisfactory completion of the work and recovering all costs payable by the contractor to the department. The site must be left cleaned as per specification.

8. Excess over quantity :—In case if any item of work becomes excess over the schedule quantity of tender the excess quantity shall be passed by the accepting authority of the tender before payment of the bill even though the total cost of work remains within the sanctioned estimate.

9. Excess over estimates :—In case if any excesses over the sanctioned estimate is anticipated during execution of the work, revised estimate shall have to be prepared and sanctioned must be obtained before execution of the excess work.

17-29. Measurement and Payment for works done by Contract :—(a) *Intermediate or running payment*, (b) *Final payment*, (c) *Payment for extra work or for additional or substituted items*.

(a) **Intermediate or running payment** :—Under the terms of contract the contractor is to be paid monthly for works-in progress These payments in intermediate stage of the work are made by way of advances adjustable in the final bill which is drawn only after completion of work in all respects.

For this purpose the contractor is required to submit a bill to the Department in the prescribed form by a fixed date. If he fails to do so, the Department through their employees, viz. Sectional officer and Asstt. Engineer get the works measured and billed for which the contractor has to accept. Provisional or part rates in such bills may be allowed by the Engineer-in-charge where the various operations involved in items of work had not been completed by the time the work was last measured.

A proportionate recovery of cost of materials and hire charges of T. & P. supplied by the department and utilised in the work is also made from the running account bills.

(b) **Final Payment** :—Final payment is to be made within three months from the date of issue of certificate of final completion. The above procedure is followed in the case of final payment to contractor also. The points which are specially to be looked into before final payment are as below :—

(i) The work is complete as per specification and the site has been left clean. No damage has been caused to other properties and no defect is apparent. A certificate of physical completion has been recorded in the relevent measurment Book by the Sub-Divisional or Divisional Officer.

(ii) The measurements recorded are in accordance with the method prescribed in the contract. viz., dimensions recorded are as per drawings, deductions for voids etc. have been made, serviceable dismantled materials have been deposited by the Contractor in good conditions, limitation of the quantities for the purpose of payment specified in the contract has been duly observed etc. The measurements recorded and abstract of the bill in measurement Book drawn have been accepted and signed by the contractor in token of such acceptance.

(iii) The bill is drawn in the prescribed form printed on yellow paper. The rates for items of work, actually done and measured are not in excess of those provided for in the contract. All the formalities, viz, sanction of extension of time, rates of additional or substituted items etc. have been accorded by the competent authority. Test check of measurements, and various other tests prescribed in each Type of work have been conducted by the authorities and found in order.

(c) **Payment of extra works or additional or for substituted items** : Except in the case of abnormally high or low rated items where the quantity deviations are restricted within 5% by the authority accepting the tender, other variations, in quantities of work actually done are measured and paid at the contract rates in the usual manner. For abnormally high or low rate items prior sanction is required from the competent authorities before executing the extra quantity of works beyond 5%.

17-30. Measurements for completed works : The contracts provide for supply of requisite number of persons with means and materials required to assit in the measurements for works done by the Departmental officers free of cost. It is in the contractor's own interest that he should provide adequate facility for detailed measurements for works done (Except in lump-sum contract) on the basis of which only the payment can be made to him. It is always expected that he or his authorised representative will remain present at the time of recording each set of final measurements and will confirm the same by his acceptance to end with all disputes leading to arbitration. The method of measurments are prescribed in the departmental book of specifications of which a reference is made in each contract and which serves as a guide to contractors as well as the Departmental office. If the method is not laid down in any particular case the code of practice adopted by local bodies or reputed concerns for such item of work is followed with the approval of Engineer-in-charge. The I. S. method of measurement may also be followed.

If the contractor remains absent when the final measurement is recorded even after receipt of written notice from the Department, the measurements so recorded by the Departmental officers become binding on him.

17.31. Measurement Book (*M.B.*) : Measurement for all works done and supplies received in connection with a sanctioned estimate are recorded in a special type of Note Book (usually of size 15 cm × 10 cm) known as Measurement Book (*M.B.*). It contains, besides instructions how to write up, the columns for particulars, details of actual measurements in terms of number, length, breadth, and depth, and the contents of area. The pages are machine numbered. Each book is provided with extra leaves for index, for review by the Divisional Accountant and for review by the Executive officers.

As this book is the basis of all account of quantities for work done for which payment is made to contractors and others ; it is one of the very important initial records of the Department and is preserved carefully. Its movement between officers and persons is also watched cautiously till its final record.

The entries in M.B. are made in continuous chain in a chronological order ; no blank page being left or torn out. At the end of each set of measurements, the officer recording them has to certify—"measured by me" and to put his full signature with date.

Entries recorded by the sectional officer are always subject to test check by the Sub-Divisional officer to the extent of 50% by their money value. Similarly the Divisional officer is required to test check at least 10% of the measurements, for works costing more than Rs. 40,000/- recorded by his subordinates and to accept responsibility for general correctness of the bill as a whole.

After completion of the detailed measurements, an abstract of quantities are drawn up in *M.B.*

On completion of the abstract, the *M.B.* is sent to the Sub-Divisional officer for entering the rates of items of the bill by the Assistant Engineer, and for arithmetical and othe check by the Sub-Divisional clerk. The bill thereafter is typed out in the prescribed form and made ready for payment and submitted to Divisional office for further check and payment. Any correction to or calculations rates needed is made in red ink by the Sub Divisional or Divisional officer. In case of final bill the corrections should be got confirmed by the person making the original entries before authorising payment.

The bill after scrutiny is endorsed with a "Pay order" both on M. B. and Bill forms and signed by the Divisional officer Executive Engineer or Engineer-in-charge).

The bill having been accepted and receipted by the contractor, a crossed cheque for the net amount is drawn and handed over to the payee by the Disbursing officer.

Standard Measurement Books (S. M. B.) : A set of M. B, containing detailed measurements of payment buildings and structures maintained by each Sub-Division is kept to facilitate framing of annual repairs estimates and for payment to contractors for jobs connected therewith. Their M. Bs. are known as *Standard Measurement Books* (*S. M. B.*) The S. M. Bs. saves time and labour of the Departmental officers from repeated work of taking detailed measurements of the same building again and again.

Loss of Measurement Books : The loss of *M.B.* or *S.M.B.* which is initial accounts document is a serious matter and should be guarded in all possible manner. If, however, a book is lost, the facts of case should be reported immediately to the next higher authority for orders and for sanction to its write off. The Chief Engineer is authorized to sanction the write off after detailed investigation.

17.32. Determination of a Contract : A contract is discharged or determined by due performance of its various terms and conditions or substantial part of them. The construction work entrusted to a contractor when handed over to the Department complete in all respects, even with minor changes done under direction of the Engineer-in-charge, is treated as contract determined.

17-33. Termination of a Contract ; *Termination of Contract* either arises out of breach of provisions by one party or due to operation of the provisions of law, or due to impossibility of performance. Termination is also made by agreement.

17-34. Maintenance Period of a Contract : On the completion or determination of the contract the contractor is entitled to get a certificate of completion from the Engineer-in-Charge. But his responsibility about the quality of work done does not cease there. He is to ensure that the work executed by him is able to stand the test of time. Any imperfection which comes to the notice within a period specified in the contract has to be made good at his cost and the specified period is known as maintenance period. The Security Deposit retained with the Department is a guarantee for it. The maintenance period for works depends upon their nature ; usually the period is 3 months for works costing less than Rs. 20,000/-. The refund of the Security Deposit is only authorised after expiry of the maintenance period only.

17-35. Refund of Security Deposit : The Security Deposit is not refundable except in accordance with the terms and conditions of the contract. Each contract specifies the period of maintenance required. The question of refund arises only after expiry of this period.

The refund of Security Deposit is the last payment for due fulfilment of the contract and therefore should be allowed after finalisation of the accounts of the contractor in respect of the particular work and after obtaining a certificate to the effect that no defect has been noticed during maintenance period from the Sub-Divisional Officer.

The claim for a refund of Security Deposit deducted from bills becomes time-barred after a lapse of six years from the date of its maturity for refund.

17-36. Works carried out otherwise than by contracts : In certain cases due to its situation or nature or due to its being no susceptible of measurements the work cannot be carried out by contract. The work in such cases got done by Departmental labour and supply of materials usually the day to day maintenance work is attended to by the work-charged establishment. The works done by them are not measured. They are monthly paid staff employed more or less on the same footing as those of Regular establishment except that their pay and allowances are charged direct to the work.

Muster Roll : The categories of skilled and unskilled workers employed on works are daily rated Muster Roll labour whose daily attendance and outturn are recorded for the purpose of payment. The work is executed under direct supervision of the sectional officer or Sub-Divisional Officer concerned and may be inspected by higher officers, viz. Executive Engineer and Superintending Engineer, depending on its importance.

The attendance of the labourers employed is recorded daily in Muster Roll (M. R.) [Form-21] issued by the Divisional Officer in Part I and the quantity or works executed on M. R. is indicated in Part II of the Roll. A sketch is given in the next page :—

PART—I

Category of Labour	Sl. No.	Name & Address	Fathers Name	Date															Rate	Amount	Payees Acknowledgement	Date initial of officer making payment	Remarks
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total					
			Daily Total																				
			Initial of officer making attendance																				
			Remarks by Inspecting officer																				

PART—II

Description of works done vide M. B.—page—	Total Quantity measured	Deduct Quantity done in previous M. R. if any	Balance	Rate of Cost	Remarks

The Muster Roll being the initial record of employment and payment is dealt with and preserved carefully at all level. On receipt of a requisition from the Sub-Divisional Officer, the Divisional Officer after considering the necessity and urgency of the work and strength of labour required, issues a blank form duly registered and numbered in his office indicating the period, the maximum number of labourers to be employed and their corresponding daily wages on it. The receipt back of M. R. is watched through the Register of Muster Roll.

The Sub-Divisional Officer on receipt of the Roll, endorses it to the Sectional Officer concerned. The employment of labour recruited is made by the Sub-Divisional Officer by issue of a formal letter of appointment against each person.

The daily attendances and absences of labourers are recorded by the sectional officer or Sub-Divisional Officer concerned in Part—I daily at site of work. Erasing, overwriting and interpolation are forbidden. Any correction necessary is to be made neatly with dated initial of the officer making it. Tampering with entries and unauthorised additions and alterations in M, R. are severely dealt with. The inspecting officers are at liberty to check the attendance of the labour at any time and the works got done by them and measured in M. B. are subjected to similar test check as those prescribed for works done by the contractor.

CHAPTER XVIII

PLANNING OF BUILDING

18-1 Orientation of Building :—In housing, orientation is the placing of buildings in such a position that the maximum number of dwelling units and of their principal rooms may enjoy the specific advantages of the direction they face or avoid the disadvantages of some other direction. The principal physical elements which will affect the orientation are the following :—

1. **Sunlight** : Plan should be arranged to permit the maximum of sunlight to enter the rooms, especially in winter, or should rooms by preferencc face away from the sun because of unbearable summer heat. A south facade has the advantage of receiving much larger solar radiation during winter than that of during summer. The sun does not shine directly on the north facade, except during early mornings or late afternoons in summer for the most parts of India. The eastern and western facades receive nearly equal amounts of daily solar radiation throughout the year.

The best orientation from a solar point of view requires that the building, as a whole, should receive the maximum solar radiation in winter and the minimum in summer. The Central Building Research Institute (C.B.R.I.) recommends the following orientations for :—(a) **Hot-Arid zones or Hot-Dry zones:**—

(i) Delhi proper—the longer side makes an angle of $22\frac{1}{2}°$ on the East West line towards East south.
(ii) Northern India like Punjab—Orient along the direction East and West facing North.
(iii) Central India—Orient along E-SE and W-NW, facing N-NE.

(b) **Hot-Humid zones:**—

(i) Bengal—The best orientation is considered to be along East and West facing south.
(ii) West Coast Regions (like Bombay)—Orient along the direction S-E and N-W facing S-W.
(iii) East coast Regions (like Madras)—Orient along S-E and N-W facing N-W.

(c) **For Hill stations:**—The orientation should be such that living rooms are open on the South and West sides of the Sun.

(d) **Prevailing Winds** :— Plan can be arranged to take advantage of cooling summer breezes.

2. **Views** :—If a housing site enjoys a particularly desirable outlook in one or more directions, the layout of the site plan may capitalize this advantage, be it a distant view afforded by sloping topography, a more restricted view over an adjacent public park, or even an outlook over the centre fieled fence of the ball park.

3. **Airborne Noise** :—If a housing site is completely surrounded by noisy streets, the effort will be to face most rooms towards the interior of the property and give some measure of protection to those on the perimeter. If there is a single direction of objectionable noise the dwelling units will be crowded away from the source and the sound waves muffled as much as possible.

4. **Existing Street Pattern** :—Frequently the architect must deal with a layout of streets or roads which can not be modified because of existing rights or unwillingness of local authorities to change the prevailing pattern or permit the vacation of streets. Especially with narrow blocks, this makes the problem of securing adequate open space, light and circulation of air difficult and often well-nigh impossible.

5. **Size and shape of Plots** :—What can be done with the small property specially if comparatively narrow and deep ? What can be done if a long strip facing a street is to be developed with separable buildings intended for sale.

A given site will very rarely be well favoured with respect to all the desirable objectives of orientation. The architect must then size up what he can do with it, decide which of its potentialities is of pre dominent importance and make this the keynote of his site planning even though his plan may be less desirable from other points of view.

18-2. General Planning Factors—Whether it is "general housing" or "industrial housing" or any other variation of housing, certain general planning factors must be given very careful consideration. These are :-

(a) aspect, (b) daylighting, (c) site-dimensions, (d) number of dwelling in a block, (e) general grouping (f) access, (g) heights of blocks, (h) ventilation, (i) colour and materials, (j) aesthetic in the whole complex, and, lastly, (k) people and their needs.

Plans should be designed to meet the functions of the several parts and round the main units of furniture needed in each room to insure the fullest comfort and amenity. Circulations between parts of the house or even within the walls of individual rooms must also receive full attention, and circulation spaces must be kept to the minimum consistent with good planning.

(a) Aspect

Main living rooms should have sunshine for at least part of the day, whether they are designed to be used as living rooms only or as kitchen-living rooms. Kitchen, toilets and drying area should have west or east aspect. And sleeping spaces should be designed and planned so that the rooms get breeze and cross-ventilation, and sunshine for at least some parts of the day.

In the design of smaller blocks of flats where number of dwellings in a block is very few, it is not at all impossible to design, plan and orient the blocks in such a manner that all rooms get sunshine for some time during the day, whereas, in the design of larger blocks of flats it is generally desirable to plan with the main axis of the block from north to south, so that sunshine reaches all rooms at some time during the day.

(b) Daylighting

The important consideration in the provision of adequate daylighting is not only the size of windows, but also site planning, with such spacing apart of rows of houses or blocks of flats to insure that sunshine is not cut off in the winter time.

The greatest problem in daylighting affecting the planning of individual houses is that of the terrace house where two sides only obtain light ; it is therefore, most desirable that frontages should not be too short, since longer frontages mean reduction of depths in rooms.

Staircases, in all types of plans, should get light from any of the four sides (north, south, east and west). But in some cases, it has been found that the most troublesome lighting matter is the staircase whereas in most of the cases this difficulty is easily solved.

(c) Site-dimensions

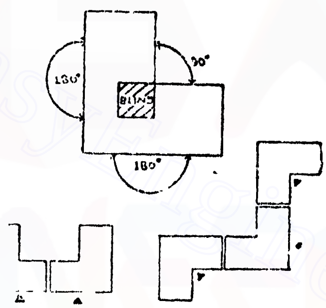
It should be realised that narrow frontage layout, although more economical in length of roads, paths and main services, is not necessarily the most econmic development of every site, since deep sites may be wasteful of land. It is desirable that sizes of garden vary throughout a housing scheme, as some tenants prefer small gardens and other large gardens. Some allotments should be available reasonably near all houses for keen gardeners and also for the use of tenants of flats.

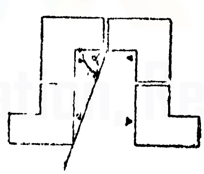
(d) Number of dwellings in a block.

Houses may be built singly, in pair, and in blocks of four to as many as ten or even more in terraces. Depending upon the needs, available space, etc., there are different types of blocks of houses having varying number of dwellings in a block.

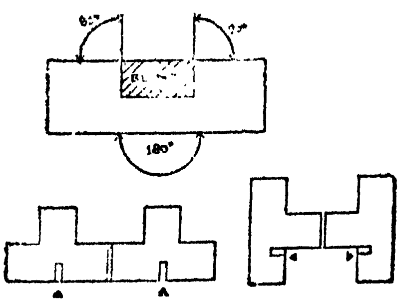
Blocks of houses having varying number of dwellings can be of the following types :—

(A) Assembly of "ELL" Units at two ends, Blind space occupies one quarter of the 'intersection.'



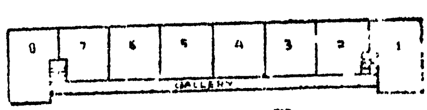


(B) Alternate assembly of 'ELL' Units Angle ∝ should not exceed 60° unless the court width is 1·25 times the building height.

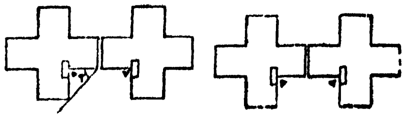


(C) Assembly of "TEE" units. In the assembly at three ends, the blind space occupies half of the intersection.

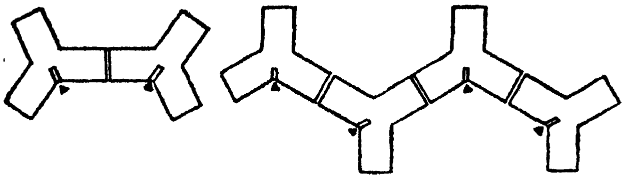
(D)

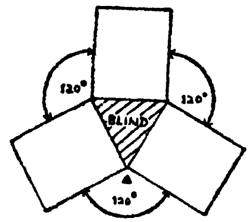


WALK-UP GALLERY UNITS



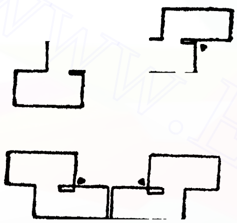
(E) Straight cross. Angle ∢ should not exceed 60° unless y equals or exceeds the building height.



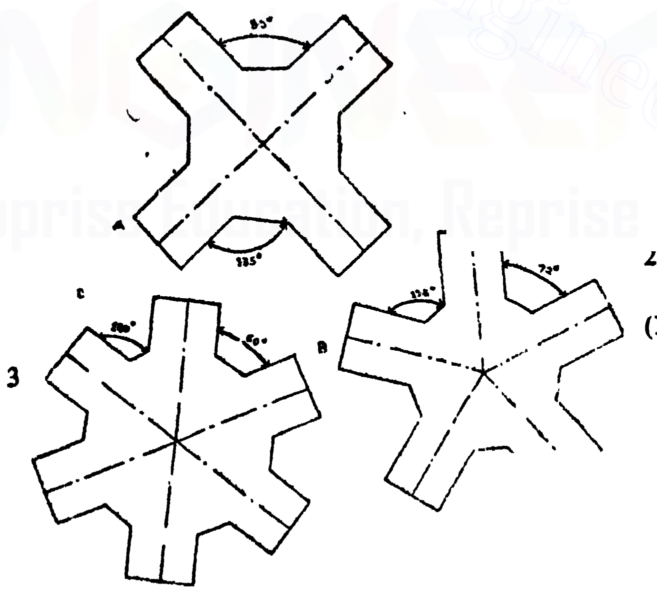


F) Different assembly of y units

(G) Assembly of y units Assemble is possible at the three end walls.



Assembly of ZEE units. Blind space equals half the rectangular inter section. Assemble is possible at two ends.



(H) Assembly of Radial Units

1. Square
2. Pentagon
3. Hexagon

But, in all cases, it must be noticed that all the blocks fit properly into their respective sites with proper orientation and having good ventilation between two blocks. The blocks should be neither too long nor too short, not even too high or too low. The blocks should be planned with their heights, lengths and widths such that an interesting visual pattern is formed and thereby enhancing the aesthetic value of the entire complex.

(e) Grouping

While considering the grouping of blocks of houses, there seems no doubt that detached houses are the most advantageous due to the increase in privacy provided, but the cost is greater due to increased lengths of roads, sewers and services, and to the increased amount of external wall. Detached houses have advantages to the planner as well, since all external walls are available for windows and access to the back door may also be on any of three walls or even on the main frontage.

Not only is privacy increased in detached houses, but noise is reduced, specially between adjoining houses, although effective steps can now be taken with constructional developments to reduce sound penetration between semi-detached or terrace houses, and assistance may be gained by avoiding the planning of living rooms adjoining one another. Sometimes, the staircase and hall may be used to act as a cut-off buffer between living rooms, whereas in some cases, the living rooms are separated only by party-wall, which even if of special construction, will only partially control the passage of sound between two dwellings, unless costly construction is indulged in. It is important in the planning of flats to avoid placing the living room of one flat adjoining bedrooms of another, maisonettes or duplex-types are similar to houses, having living rooms and bedrooms on different floor levels, and may therefore be easier to plan with protection from noise than in the case with flats.

Rural housing, where land is less costly and larger-gardens are desirable and generally preferred, may be more widely spaced, and it is consequently doubtful that blocks greater than four houses are desirable, in fact, semi-detached and detached houses are to be preferred in rural areas.

(f) Access

Every dwelling on the ground floor should have direct access from the private roads. These private roads or residential roads should be connected with the major town roads which should not directly open into the residential area. And, access from the private or residential roads should be in the form of loops or cul-de-sacs. Access to other dwellings within a block should also be planned properly and circulation spaces must be kept to the minimum consistent with good planning.

(g) Heights of blocks

Heights of different blocks should be regulated such that it does not create a drab and monotonous appearance in the entire complex. Heights should be rasied up or lowered down wherever necessary and with the varied heights of different blocks the layout or grouping should be such that it forms an interesting visual pattern in the complex.

(h) Ventilation

Apart from the ventilation in different rooms of a dwelling there should be ventilation between blocks of dwellings. Hence, the layout or the grouping of blocks of dwellings should be such that it helps in having ventilation between the blocks. Therefore, the blocks should be staggered wherever necessary, and also proper spacing between the blocks should be kept. (Usually twice the height of the front block when placed parallel and in the same axis and against the wind direction). Where a number of similar blocks is to be raised fairly close to each other, it will be more advantageous to have alternate blocks perpendicular to each other than all in a parallel formation.

(i) Colour and materials

Colour of different blocks of dwellings should be such that it creates not only an interesting visual pattern in the entire complex, but also it goes nicely with its surrounding and with the landscape. Colour should also be such that it is easily maintained and cost is within a reasonable limit.

(j) Aesthetic in the whole complex

Care should be taken regarding the general aesthetic of the complex and planning and designing should be done accordingly. Varied blocks of different heights should be created so as to form in interesting visual pattern, proper spacing between the blocks, general grouping of different blocks of dwellings should be nicely done with interesting landscape and there by enhancing the aesthetic value of the entire complex.

(k) People and their needs

In any type of housing project, general or industrial, it should be borne in mind that proper facilities and various amenities have been provided for the people for whom the housing project will be built. It must be seen that the people's needs are satisfied to the maximum extent in a particular project. Depending upon the size, the projects should be provided with different shopping centres, cinema-halls, theatres, and other recreational facilities, schools, hospitals, parks, etc. so that the people who are living in a project can satisfy their needs.

18·3. How the cost of a building may be lowered without omitting main requirements :

To meet up the growing demands of houses for middle class, and low middle class, there is extreme urgency to find some new techniques so that the cost of construction of such houses may be restricted to the minimum requirements. The Planning Commission of the Government of India emphasizes the fact in the Second Five Years Plan Report that there is considerable need for research in building materials and techniques to specify the standard of construction with due regard to the availability of local materials and the economic use of scarce materials to construct low-cost houses.

The general economy in the construction of a house is three-fold viz.

(a) Economic planning and layout. (b) Reduction of structural cost. (c) Economy in using building materials.

A brief discussion of each point shall help us.

(a) Economic planning layout may be divided into the following heads :—

(1) Shape of the house—The shape of the house has an important bearing on its cost because this effects the outside wall area as required to enclose the given amount of space. A square building is most economical in shape since it provides the maximum amount of

floor area with least amount of wall area. For example a square building measuring 10m × 10m has an area of 100sqm and the length of perimeter wall is 40rm. But a rectangular plot measuring 5m × 20m has the same area of 100 sq m but the total length is 50 r m and thus it is uneconomic due to its shape.
Minimum offsets should be provided to satisfy architectural and other practical considerations because the cost of construction for corner walls is comparatively more than straight walls. Extra expenditure is required to form the corners by joining two walls. Curved or such other walls should be omitted as the cost of these will be more in comparison to the straight walls. Economy in construction can also be effected by using as many common walls as possible by arranging two rooms side by side. For three or more roomed houses it is not desirable to construct more than two together for considerations of privacy, light and ventilation of the different rooms. Detached building costs more in comparison to that of a semidetached one. In case where a number of rooms are required it is desirable to provide bed rooms in the upper storey with advantage of more air and light. Cost of land to construct such rooms may thus be avoided and over and above only 85% cost is required to construct upper stories.

(ii) **Planning on a modular basis**—Sizes of bricks when considered as 20cm × 10cm × 10cm (with mortar) dimensions of all rooms, doors and window openings, wall between two openings etc., should be multiples of 10 for saving in the cost of meterials extra labour required to cut and patch the blocks. In the planning of large buildings, architects have always concentrated on using dimensions which were multiples of the available bricks sizes Such planning, resulting in the repetition of the same modular component found acceptance because it facilitates the preparation of designs and leads to the purchases of components on a large scale bringing about substantial economy.

(iii) **Sizes of rooms**—The Committee of Experts for Building Works has recommended that the minimum size of living rooms should be 11 sq m. Considering the positions of doors, windows and furniture a greater economy can be effected by reducing the sizes of rooms without the effect of crowding.

(iv) **Free space area**—A certain amount of free space area for corridor and verandah is required to provide independent access to different rooms and seating space etc. To lower the cost of a building such common space should be reduced to the minimum. An amount of 15% of the whole area of Building serves the purpose comfortably.

(v) **Plinth and floor heights**—A definite saving in cost of a building can be achieved by reducing the plinth height. For high areas the plinth height should be taken as 30 cm instead of 60cm and reducing its cost of construction nearly by 2% of the total cost of the structure.

Thus providing adequate ventilators just below the ceiling to create greater circulations of air, the height of roof may be reduced to even 3m (10ft). The Committee of Experts for Building Works have recommended 2·75m to 3m (9ft to 10ft) height of roof for general requirements in India.

(vi) **Doors and windows**—The cost for doors and windows becomes about ⅕th the total cost of a building structure. Therefore the number and sizes for the same should be minimum after providing for calculated amount of light and ventilation. In some cases windows placed by the side of a corridor or passage, remains closed due to privacy of the room. Such provisions of windows or doors should be strictly omitted considering their cost of construction.

(*b*) ***Reducing structural cost***—The foundation and other construction should not be designed to be unnecessarily strong by assuming large volume of loads and low values for the working stresses. When footings are required in a foundation to distribute the load on a wider area, depth of each footing should be minimum and of two layers of bricks Section of partition walls should not be considered as a load-bearing wall.

(*c*) ***Economy in using building materials*** :—Local materials should be used in the construction as much as possible. For instance, economy in woodwork may be achieved by using best quality of local wood instead of using other valuable woods (Teak. Sal. etc.,) imported from outside areas. According to the Report of the Expert Committee of National Building Organisation, economy in the use of cement in a building construction may be effected by using lime of a good quality instead of cement mainly for concrete work in foundation and floor, masonry work in foundation and superstructure.

18·4. Requirement of floor and cubic space per capita:–

Type of Building	Floor area per capita		Cubic space per capita		Verandah and in percentage to that at floor area
	M.K.S sq m	F.P.S. sq. ft	M.K.S. cu m	F.P.S. cft	
Residential Building	2·5 to 3·0	25 to 30	8·5	300	15%
Hostal Building ...	5·5 to 7·5	60 to 80	22·5	800	25%
School Building ...	1·5 to 2·0	15 to 20	5·5	200	20%
Hospital Building ...	7·5 to 11·0	80 to 120	34·0	1200	25%
Factory Building ...	2·0 to 2·5	20 to 50	7·0	250	10%

18·5. General principles of Window Design—Generally while taller windows give greater penetration, broader windows give better distribution of light. Proper planning and layout of buildings can add appreciably to the daylight illumination inside. For a given penetration, a number of small windows properly positioned along the same, adjacent or opposite walls will give better distribution of illumination than a single large window. The effective depth of a room shall not be more than 2 to $2\frac{1}{2}$ times the distance from the floor to the top of the window.

19-6 Floor Area Ratio (FAR). The quotient obtained by dividing the total covered area (plinth area) on all floors and 100 by the area of the plot

$$FAR = \frac{\text{Total covered area of all floors} \times 100}{\text{Plot area.}}$$

The FAR regulates the number of floors of a building. The different municipality or corporations have their own regulations for FAR.

The ratio among FAR's may vary between different occupancies and types of construction and the Authority shall select a basic FAR for one occupancy and a type of construction and arrive at the FAR values for other combinations taking into accounts the following local factors (a) Occupancy class, (b) Types of construction, (c) Width of street fronting the building and traffic load, (d) Locality where the building is proposed and the density, (e) Parking facilities, and (f) Local fire fighting facilities.

19-7. Building Bye Laws (Based on IS—1256)

1. Thickness of walls——The strength of masonry walls depends on the quality of bricks, mortar, method of bonding, unsupported height and length, excentricity in loading, the position and amount of openings in the wall, the location of longitudinal and cross wall etc. The minimum allowable thickness of load bearing brick masonry wall shall be as below in cm.

Storeys	1	2	3	4
1	20	—	—	—
2	20	20	—	—
3	20	20	20	—
4	30	20	20	20

2. Height Regulations:—Height shall be measured from the surface of the floor to the ceiling (or bottom of slab). The height shall not be less than for :—

(a) Habitable rooms ...2·75m (b) Bathrooms, Water-Closets and Stores 2·4m

(c) Kitchen......2·75m

3. Size of rooms :—

(*a*) ***Habitable Rooms***—9·5 sqm for only one roomed and for two roomed house one of these shall not be less then 9·5 sqm and the other be not less than 7·5 sqm with a minimum width of 2·4m

(*b*) ***Bathrooms and Water-Closet***—The size of a bathroom shall not be less than 1·5×1·2m or 1·8 sq m; if it is combined bath and water-closet, its floor area shall not be less than 2·8 sqm. The minimum floor area of W.C. shall be 1·1 sq m.

(*c*) ***Kitchen***—Every kitchen shall have a floor area of not less then 5·5 sqm with minimum width of 1·8m. Where there is a separate store, the floor area of the kitchen may be 4·5 sqm. For combined kitchen and dining the floor shall not be less then 9·5 sqm with a minimum width of 2·4m.

(*d*) *Mezzanine Floor*—The minimum size of the mezzanine floor, if it is to be used as a living room, shall not be less than 9·5 sqm.

4. Lighting and Ventilation :—

(*a*) *Habitable rooms*—Every habitable room shall have opening directly to the external air or into an open verandah, one or more windows and of an aggregate area, inclusive of frames of not less than :—

(i) One-tenth of floor area excluding doors for dry hot climate, and

(ii) One-sixth of the floor area excluding doors, for wet hot climate. Cross ventilation by means of windows or ventilators or both shall be effected in at least one living room of a tenement either by means of windows in opposite walls or if this not possible or advisable, then atleast in the adjoining walls.

(*b*) *Bathrooms and Water-Closets*—For natural light and permanent ventilation one of the following means shall be provided.

(i) Windows having an area of not less than 10% of the floor area and located in an exterior wall facing a street alley or yard.

(ii) Skylights, the construction of which shall provide light and ventilation as required in (i).

(iii) Ventilation ducts, provided such ducts have 130 sq cm of area for each sq m of floor area with a minimum total area of 300 sq cm and a least dimension of 9cm.

(*c*) *Kitchen*—Every kitchen shall be ventilated similarly as prescribed for habitable rooms near the ceiling as far as possible.

(*d*) *Staircase*—Openings for light and ventilation shall not be less than 1 sq m per floor height. Every staircase shall be lighted and ventilated from an open airspase.

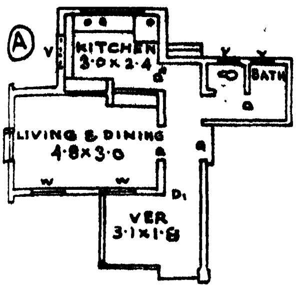
(*e*) *Stores, Back Rooms etc.*—These will have at least half of the ventilation required for living rooms.

5. Other requirements for—

Staircases—	Minimum clear width	Maximum Riser	Minimum Tread width
(i) Residential Building	1m	19cm	25cm
(ii) Public Building	1·2m	15cm	30cm

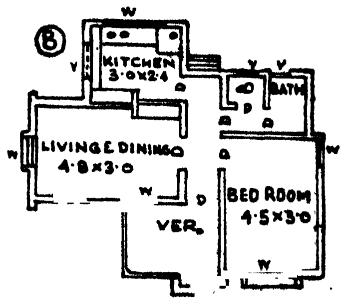
6. Plinth Regulations— No plinth or any part of a building shall be less than 30cm above the determined level of—(i) The central part of the abutting street, (ii) the footpath of the abutting street, (iii) the highest part of a service lane which determines the drainage of the premises, (iv) undulating or sloping land 1·2m above the drainage or country water-level (v) any portion of the ground within 3m distance of such a building.

19-8. Plans Of Different Types of Residential Buildings With Short Notes.



ALL DIMENSIONS ARE IN METRE.

BUILDING 'A' HAS BEEN PLANNED IN SUCH A WAY THAT IT CAN BE DEVELOPED TO TWO ROOMED (AS 'B') TO THREE (AS 'C') TO FOUR ROOMED (AS 'D') BUILDING IN FITURE.



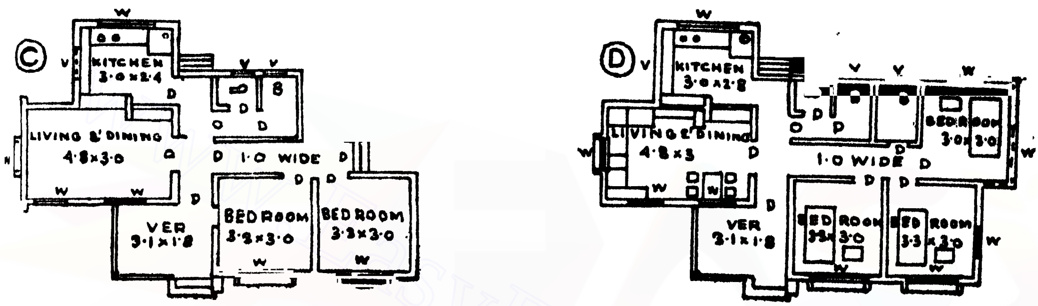


FIG. 19-1A TO 19-1D.

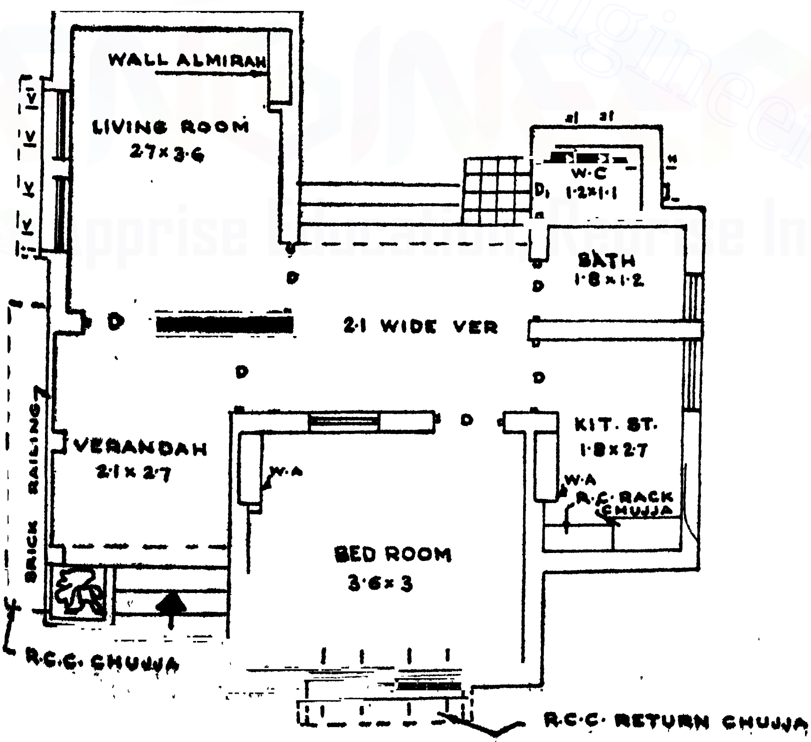


FIG. 19-2, A TWO ROOMED BUILDING PROPOSED FOR STAFF QUARTERS.

ALL DIMENSIONS ARE IN METRE.

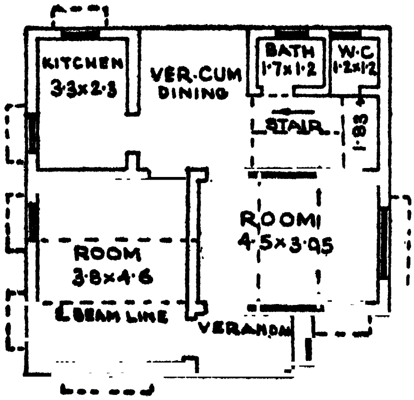


FIG. 19·3. TWO ROOMED (COMPACT PLAN) WITH PROVISION FOR STAFF CASE FOR LOW-INCOME GROUP L.I.G.)

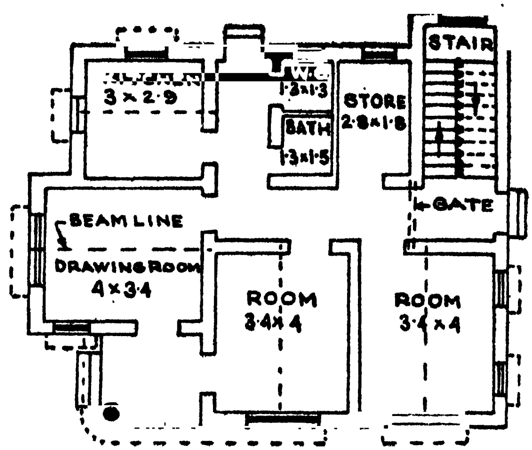


FIG. 19·4. THREE ROOMED FOR (L.I.G.)

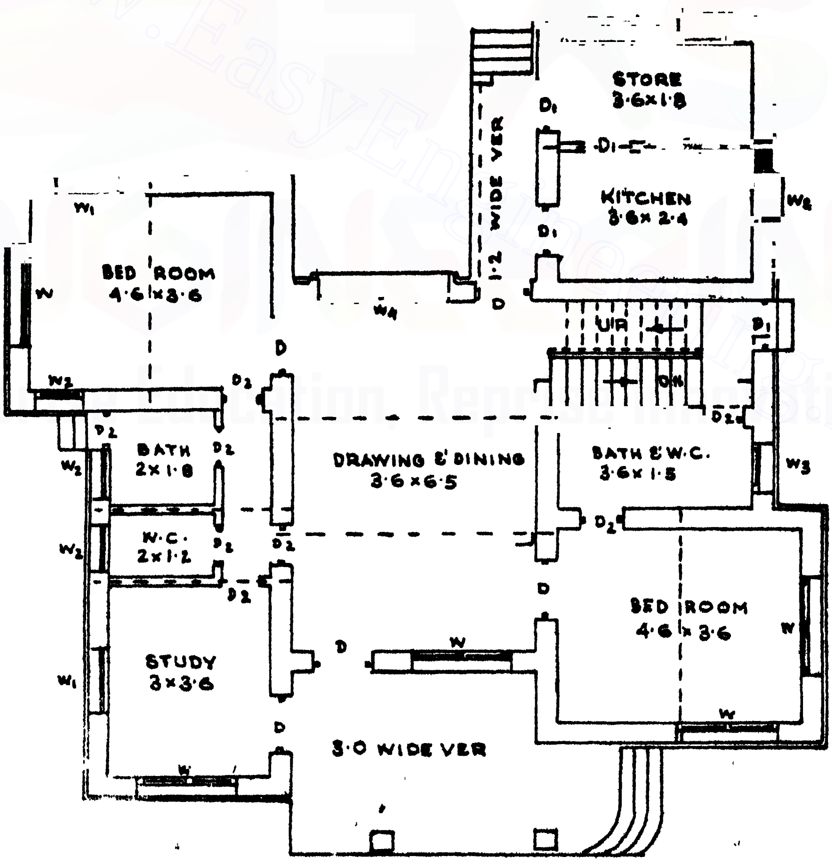


FIG. 19·5 THREE ROOMED WITH ATTACHED BATH AND W. C. FOR OFFICERS RESIDENCE FOR UPPER INCOME GROUP (U.I.G.)

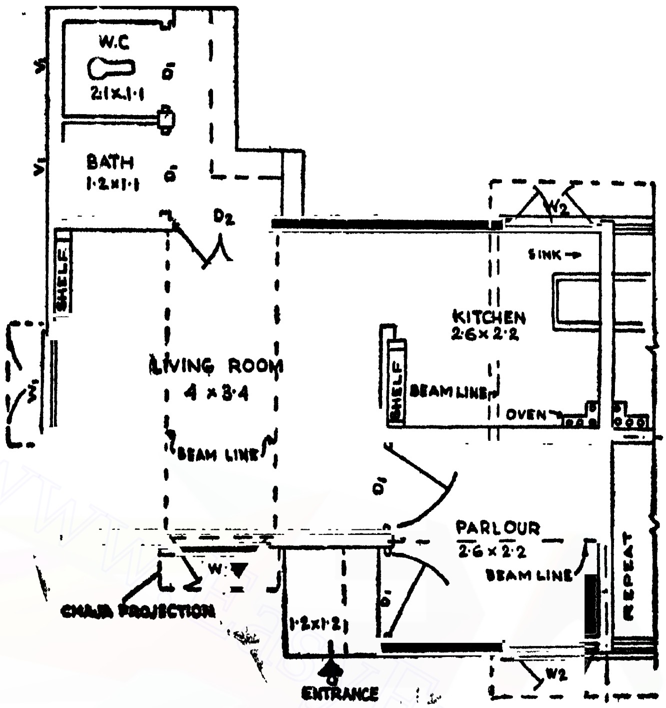


FIG. 19.6. TWO ROOMED STAFF QUARTERS.

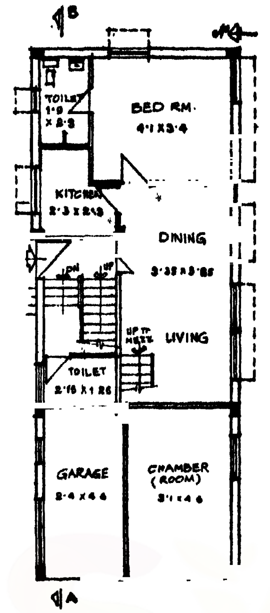
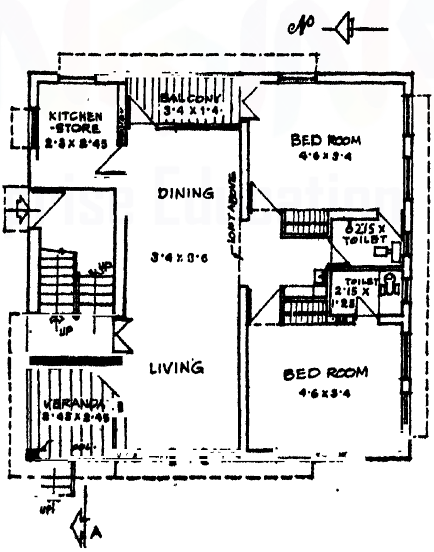
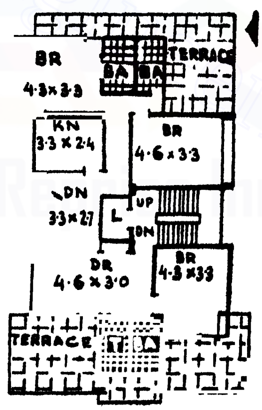
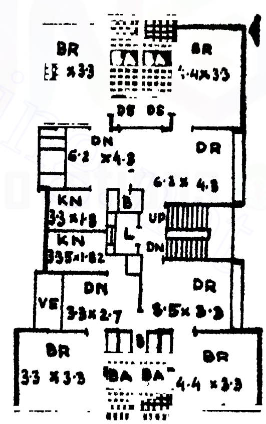


FIG 19.7. THREE ROOMED STORIED WITH GARAGE HAVING SMALL FRONT WITH ATTACHED TOILET FOR (L.I.G.)





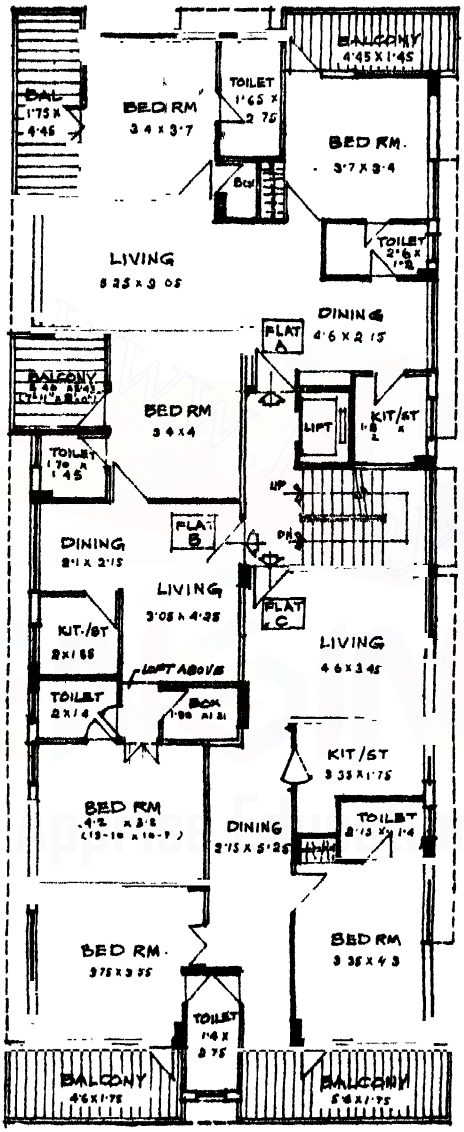


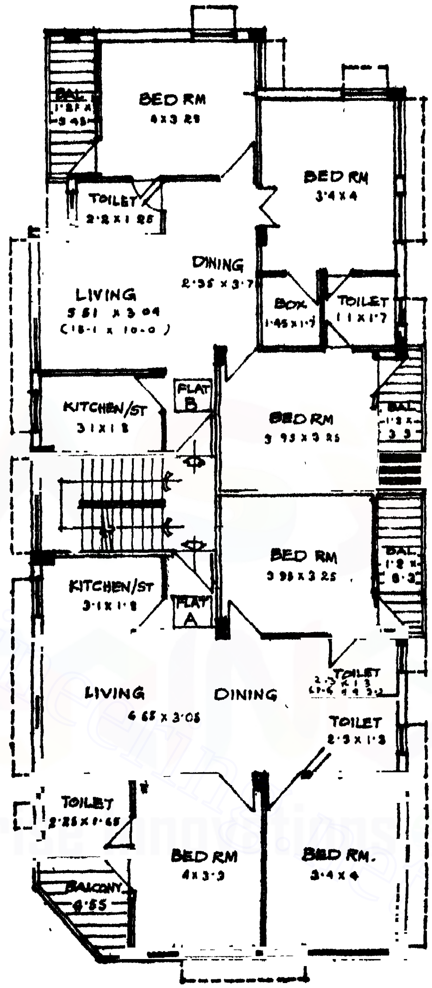
F.G. 19.8. STOREYED BUILDING ON SQUARE LAND WITH ATTACHED TOILET FOR (M.I.G.)

FIG. 19.9, THREE BED ROOMED STORIED BUILDING.

FIG. 18.1. TWO- 2 BED ROOMED FLATS PER FLOOR MULTI STORIED BUILDING.

TYPICAL FLOOR PLAN OF MULTISTORIED APPARTMENT HOUSES.





ALL DIMENSIONS ARE IN METRE

FIG. 19-11. MULTI-STORIED BUILDING WITH THREE 2 BED ROOMED FLATS PER FLOOR.

FIG. 19-12. TYPICAL FLOOR PLAN OF A MULTI-STORIED BUILDING WITH TWO BED 3-ROOMED FLATS PER FLOOR.

To form the basis for calculation of materials and labour C.B.R.I has recommended the forllowing formulae after a study of the specifications have been selected for this analysis. The tables as given below are for buildings of different shapes and plinth areas varying from 30 to 300 sq m. These are the average constant. These informations are useful for preparation of building cost index, preplanning of materials and labour requirement in a building project.

Equations for Materials Requirement (as recommended by C.B.R.I.) A=Plinth area in sqm

Name of material	Equations for Single storey	Equations for Double storey	Four Story (Super Structure R.C.C. Framed)
Bricks (% Nos)	2·26A+66·8	2·154+63	—26·2+2·56A—0·0069A^2
Cement (Tonne)	0·150A+0·57	0 145A+0·54	0·182A—0·35
Steel (kg)	21·3A—314	21·97A—305	—1491+92·0A—0·36A^2
Sand (cum)	0·47A—7	0·376A—5·6	0·361A—0·38
Coarse aggregate (cum)			
(i) 20mm and down	0·176A—0·21	0·178A—0·21	0·295A—0·75
(ii) 40mm and down (cum)	0·145A+1·5	0·075A+0·78	0·45+0·0027A+0·0001A$_2$
Brick Aggregate (cum)	0·113A—0·83	0·056A—0·42	0·021A+0·01
Lime (quintal)	0·145A—0·35	0·073—0·17	0·063A—0·08
Surkhi (cum)	0·052A—0·37	0·026A—0·18	0·01A
Timber frames and Shutters (cum)	0·019A+0·23	0·019A+0·23	0·02A+0·11
Primer (Lt)	0·068A	0·068A	0·061A+0·56
Paint (Lt)	0·108A+0·27	0·108+0·27	0·085A+1·93

Equations for Labour Requirement. A=Plinth area in sq m

Labour (in days)	Equations for Single storey	Equations for Double storey	Four storey (Super structure R.C C. frumed
Mason	1·335A+28	1·355A+26	1·67A−2
Carpenter	1·184A—9	1·194A—9	1·61A
Painter	0·089A	0·089A	0·09A
Blacksmith	0·269A—4	0·274A—4	—16+1·01A—0·004A^2
Mazdoor	4·769A+32	4·91 A+33	5·49A—9·2

Equations for Materials and labour Requirement for structure in Four-story (*R.C.C. framed*) *Building. A—Plinth are in sq m.*

Materials	Equation	Labaur (indays)	Equation
Cement (tonne) ...	0·0204A—0·01A	Mason	0·023A
Sand (cu m) ...	0·036A	Carpenter	0·054A
Coarse aggregate 20mm and down (cu m)	0·071A—0·01	Blacksmith	—1·6+0·1A—0·0003A^2
Steel (kg) ...	—171+10·46A—0·0412A^2	Mazdoor	0·343A

(*A*) ***For Single and Double storey Construction***

Specification Adopted— (*1*) ***Foundation.***—Cement concrete 1:5:10 (15cm thick), brickwork in cement mortar 1:6, 38mm thick DPC consisting of cement concret 1:2:4.

(*2*) ***Walling*** :—Brickwork in cement mortar 1 : 5 (23 cm thick load bearing and 11cm thick partitions), R.C.C. work in lintels, beams, and chajjas 1 : 2 : 4. (*3*) ***Flooring.***—38 mm thick cement concrete 1 : 2 : 4 laid over cement concrete (11·5cm thick) 1 : 5 : 10. (*4*) ***Roof.***—R.C.C. slab with lime concrete terrace (av. 11cm thick)

(*B*) ***Four storey R.C.C. framed building*** :—(a) Foundation Excavation 2m deep, R.C.C. in column footings 1 : 2 : 4 with bed concrete 1 : 4 : 8.

19-9. Cost Index :—The cost Index varies place to place and time to time. Cost Index for some of the cities those informations are available are given below.

Based on Delhi Plinth Area Rate as base 100

Name of the city	Cost Index	Name of the city	Cost Index
1. Agartala ...	333	22. Jamshedpur ...	196
2. Asansol ...	258	23. Mazafforpur ...	242
3. Alipurduar ...	152	24. Krishnanagar ...	234
4. Berhampur ...	208	25. Patna ...	203
5. Bhubaneswar ...	231	26. Port Blair ...	285
6. Bhagalpur ...	148	27. Puri ...	273
7 Bhilai ...	102	28. Ranchi ...	230
8. Calcutta ...	237	29. Rourkella ...	175
9. Cooch Behar ...	206	30. Santiniketan ...	196
10. Cattack ...	201	31. Sambalpur ...	179
11. Cochin ...	150	32. Shillong ...	246
12. Dhanbad ...	233	33. Siliguri ...	175
13. Dibrugarh ...	269	34. Tezpur ...	226
14. Durgapur ...	248	35. Trichry ...	136
15. Gangtok ...	229	36. Tuticorin ...	147
16. Gauhati ...	218	37. Vishakhapatnam ...	118
17. Gaya ...	176	38. Varanasi ...	114
18. Hazaribagh ...	230	39. Vijoyawade (CA) ...	135
19. Imphal ...	318	40. —do— Town ...	129
20. Jhansi ...	130	41. Vellore ...	132
21. Jharsugoda ...	91		

CHAPTER XIX

C. P. M. NETWORK

19-1. Introduction :— Today Network Analysis techniques form the basis of most of the project control techniques for planning, scheduling, controlling large and complex projects comprising a number of different types of works. This techniques has already acquired a number of names as CPM (Critical Path Method), PERT (Program Evaluation and Review Techniques), LESS (Least Cost Estimating and Scheduling) etc. The designation "Critical Path Method is most satisfactory because there are no limitations implied in its use and admirably suited to construct industry. The network technique created sensation after the 2nd World War and particularly since 1957. Of late, there has been a growing awareness amongst the engineers and planners in our country about the advantages of adopting these techniques in project planning and scheduling. Efforts are always made to find new ways and means to effect economy in construction. When economy shows a trend towards inflation, one of the effective steps towards reducing construction cost would be to curtail the construction period. To this end timely implementation of the project by a modern planning and scheduling techniques and thus subdividing a project into small work-elements or activities with the introduction of network planning. The technique of network analysis can be either manual or computer based.

19-2. Basic concept of Network :— In a typical project some jobs can run concurrently, while others must necessarily be done in sequence. For example, in building construction, the foundation must be laid before the columns can be erected. However at a later stage many finishing operations may go on in parallel.

The network planning lies in the fact that any project having a definite start and finish can be broken into a number of activities each of which must be completed before the project is considered to be completed. Each of the activities can thus be represented by an arrow, the tail of the arrow represents the start and the head i.e. the end with arrow head representing the finish of the activity. To facilitate designation of each activity, two circles are put, one at the tail and the other at the head end of each activity and these circles are numbered. The circles are called events and the number inside each circle is called the event number. An activity is thus represented by the event numbers at the tail and head ends of that activity as shown in fig. 19-1.

Thus, Events are represented by circle while activities are denoted by arrows—

FIG. 19-1

arrow heads pointing the complition of the activities Length, orientation or shape of the arrow have no significance while drawing networks, it is assumed that (a) time flows from left to right and (b) head events have a number higher than that of the tail.

An Event is the start or completion of task, is a significant point in project and does not consume time or resources.

An activity is the actual performance of the task, consumes time and resources The work content required to be achieved to accomplish an event is called *activity*. Each activity is independent and must have a definite start and finish. The complete project is made up of individual activities which are joined together by events. In the above fig. 19-1 activity 1-2 means that 2 is succeeding event which is completed by the activity starting from the preceding event 1. By joining activities together using the arrow and circle representation a network of activities can be built up which represent graphically the project under consideration.

19-3. The Basic Essentials to draw a CPM diagram :— The basic essentials to draw a CPM diagram are the following steps :— (a) Planning ; (b) Analysing and scheduling ; (c) Controlling ; Although, for convenience, the above three essentials are grouped separately, but they are not independent. Thus, initial planning of a project requires change if the subsequent analysis show that the original plan is unacceptable. The above three essentials are explained below.

(*a*) ***Planning*** :— This includes (1) defining the objectives of a project. (2) Developing work-Break-Down structure in order to establish work elements i. e. a project becomes divided by a number of indpendent parts of work or works activity, (3) Determining the quantity of work involved in each item of work, i, e. determining the quantity of work for individual work elements.

(*b*) ***Analysing and scheduling*** :— This involves (1) determination of precedence relationship between activities i. e. determining an order of precedence for those jobs involved in the project. We must see which job have to be completed before others can be started. (2) To determine the interdependency of events, i. e., what works can be independently carryout. (3) Scheduling the flow path of activities. The time requires for the co mpletion of each activity in order to complete the whole project. Time duration for each activity shall be fixed with reference to general availability of men, materials, equipments and past experience for similar types of project. The total project time is the summation of duration times of all activities oriented from the initial starting point of work to finishing point of work through the longest time consuming route of interrelated chain of activities. *The path of the longest duration is defined as the critical path and the activities laying in this path are called critical activities.* If a project is required to be completed within the time schedule by the critical path there shall not be any delay of the critical Activities.

(c) *Controlling* :— This includes (1) Assessing the progress of work. Assessment of the actual performance comparing with the plan, whether the overall project is going to be achieved or not. (2) Precise evaluation of actual time and cost performance against schedule. (3) A frame-work for improved scheduling of man-power, cash, equipment, supplies and other resources. Periodical checks are made regarding the expected schedule and actual time spent for different stages of construction, sometimes unavoidable cause of delay may be found and the next work may be found suitable revised accordingly. The revised net work for the uncompleted portion of the project is known as up-dating.

19-4. Drawing the network :— To draw an arrow diagram of a project firstly indentify fairly the major events as wall as activities. These should be approximately located in their correct positions related to each other from the starting to finishing events on a large sheet of paper. Identify the events by numbers. Prepare a list of events and activities descriptions to corresponding to these numbers (as shown in the example). It is more convenient to write the description on the diagram itself.

Example : The work break-down structure to erect a steel rolling mill has been graphically shown below illustrating the events, activities and precedence relationship between activities. Further Sub-divisions such as survey of site procurement of materials etc. can be made.

(a) *Planning the network* :— At this stage the project has been separated into independent jobs or activities and determined an order of presedence for these jobs.

Activity Symbol	Description of activity	Activity Symbol	Description of activity
A	Preliminary investigation	G	Installation of mill stands
B	Design and engineering	H	Installation of electrical drive equipments
C	Building foundation	I	Purchase and delivery of equipments
D	Equipment foundation		
E	Erection of building super structure	J	Installation of wiring and control equipments
F	Laying underground pipes, conduits and other utilities.	K	Final checking and testing

* R. . Rao 'Network Management Techniques' (India) Vol. 46, No. I.

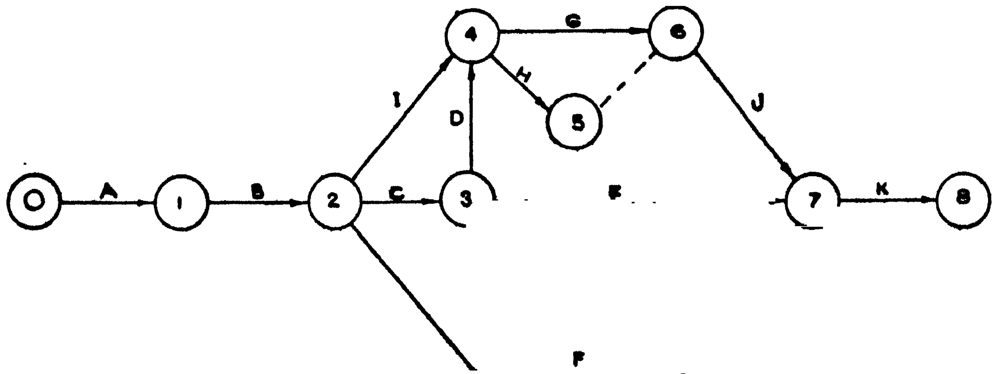


FIG. 19-2

Investigating the diagram the following points may be observed :— (i) The project has a definite start from event 0 and finished at event 8. (ii) The project has been broken down into a number of activities A, B, C, D, E, F, G, H, I, J and K. Each of the activities has been represented by an arrow, the tail of the arrow representing the start and the head i.e. the end with arrow head representing the finish of the work. (iii) Events are represented by circles. (iv) No activity can be started till the preceding event is reached. In this example event 4 can not be started until activities A, B, C, D and I are completed.

(b) ***Analysing***—The time schedule for each of the activities has analysed and alloted below and are written on the net work diagram.

Event No.	Activity symbol	Description of activity	Activity time (weeks)
0-1 ...	A ...	Preliminary investigation	6
1-2 ...	B ...	Design and engineering	12
2-3 ...	C ...	Building foundation	10
2-4 ...	I ...	Purchase and delivery of equipment	36
2-7 ...	F ...	Laying underground pipes and other utilities	6
3-4 ...	D ...	Equipment foundation	8
3-7 ...	E ...	Erection of building structure ...	10
4-5 ...	H ...	Installation of electrical drive equipments	14
4-6 ...	G ...	Installation of mill stands	16
5-6 ...	Dummy ...	No work	0
6-7 ...	J ...	Installations of wiring and control equipments	12
7-8 ...	K ...	Final checking and testing	8

Main terms those are involved in the network are explained below with the help of the diagram.

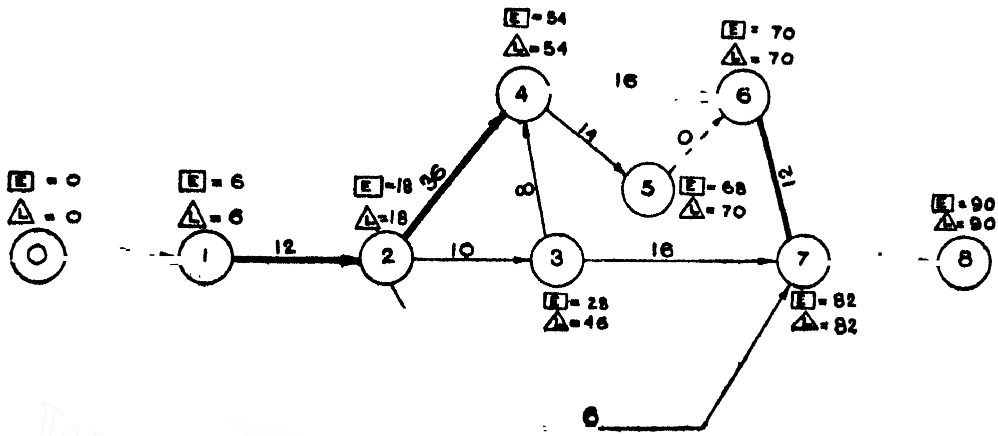


FIG. 19-3

(1) Completion period or Total project time:—The work starts at O event and completes at event no. 8 as shown in the network. Investigating the diagram it reveals that to reach at event no 8 from 0 event there are the following routes or paths or chains and time required for each path is calculated against them.

Path No.	chain			Time schedule (weeks)		Total time (weeks)
(i)	0—1—2—4—6—7—8	...	=	6+12+36+16+12+8	=...	90
(ii)	0—1—2—3—4—6—7—8	...	=	6+12+10+8+16+12+8	=...	72
(iii)	0—1—2—3—7—8	...	=	6+12+10+16+8 ...	=...	52
(iv)	0—1—2—3—4—5—6—7—8	...	=	6+12+10+8+14+0+12+8	=...	70
(v)	0—1—2—4—5—6—7—8	...	=	6+12+36+14+0+12+8	=...	88
(vi)	0—1—2—7—8	...	=	6+12+6+8	=...	32

The least total time to complete all the works those are fall on path(vi) requires 32 weeks. But works of other routes cannot be completed by this 32 weeks. The maximum total duration is for path no(i) 90 weeks. By 90 weeks all the works which fall along any other paths can be completed. ***Hence total project time is 90 days which has a maximum duration among all other paths. Therefore, the total project time may be defined as the maximum time among all the paths requires for passing from initial starting point or event upto the completion point or event.***

(2) Critical path.—As explained above, the total project time is the completion period of all works located along the path which requires maximum time and this path is named as critical path. The name critical in the sense, beause, any delay of any part of work along this path delays the total project time. On the other hand, the total project period may be reduced by reducing the time period of any activity on the critical path or by further planning to carry out two activities on the critical path at a time which is known **Crashing a Network** for reducing the project cost.

Hence the path of the longest duration is defined as the ***Critical path*** and the activities laying in this path are called ***Critical Activities***.

(3) **Noncritical Activities**.—In the diagram activities symbolised by C and D jointly require a total time of 10+8—18 weeks to reach from event 2 to event 4. On the other hand activity symbolised by I requires 36 weeks which is a critical activity. In this case of the works of C and D are delayed upto 36 weeks there is no effect on the completion period of the work. Such activities are known as non-critical Activity. Thus the activities which do not lie on the critical path are called as ***non critical Activities***

Dummy or Rebundant Activity.—Occationally two parallel activities have the same tail and head. In order to facilitate to draw the diagram and also to avoid confusion, a dummy activity is introduced. In the diagram 5-6 is the dummy activity which requires no time and the additional event no 5 is there only to replace event no. 6 separately. The direction of the dummy activity is to be decided upon by considering the interdependency of proceeding and succeeding events.

Float.—The non-critical activities have spare time to complete the portion of work. That is non-critical activity is flexible. The amount of such flexibility for an activity without affecting the completion period of the project is called ***Float***.

Earliest Event Time:—An event time signifies the time when an activity can begin or end. The earliest start time is the earliest possible time at which an activity can start. Earliest event time may be defined as the earliest time by which an event can be completed without affecting the total project time.

Studying the diagram the earliest time of event I can be completed is 6 weeks. Earliest time the event 2 can be completed is 6+12—18 weeks. Earliest time of event 3+6+12+10+28 weeks. Now, event 4 is connected by two paths those are 2—3—4 and 2—4.

Total time for path 0—1—2—4=6+12+(10+8)=36 weeks
„ „ „ „ 0—1—2—4=6+12+36 =54 weeks.

Now, following the 1st path 0—1—2—3—4 the event time is 36 weeks. But by 36 weeks on path 0—1—2—4 can not be completed but this requires 54 weeks. Therefore, the earliest event time is obtained by adding the time required for completing the activity which takes longest time. In the diagram earliest event times are shown within square.

Latest Event Time :—An event which does not lie on the critical path has spare time than as is scheduled by its earliest time of completion. For example, consider event 3, its earliest time is 6+12+10=28. But by backward calculation of scheduled event time 4 i.e. deducting the activity time of D which is 8 we find the event time of D=54—8=46. So, Event 3 can be completed by 46 weeks instead of 28 weeks. The time 46 weeks is called latest event time as shown in triangle by the side of event 3 of the diagram (and 28 weeks is called earliest event time as shown in rectangles by the side of event 3 of the diagram). In other words event 3 can be completed enjoying more time 46—28=18 weeks instead of its schedule time without affecting the completion period (This is called as **FLOAT**).

But the event time of all the events those are on the critical path can not be varied because such variation effects the scheduled completion period. ***Therefore, the earliest and latest event time of each event which is on the critical path remains same. In the*** diagram the latest event times are shown in triangles.

The analysis of network and calculated results are shown in the table as below :—

Event No.	Activity Symbol	Activity time (weeks)	Earliest Event time (weeks)	Latest Event time (weeks)	Critical path schedule (weeks)
0—1	A	6	6	6	6
1—2	B	12	18	18	18
2—3	C	10	28	46	Non-critical (float=18)
2—4	I	36	54	54	24
2—7	F	6	24	82	Non-critcal (float=58)
3-4	D	8	36	54	Non-critical (float=18)
3—7	E	10	38	82	Non-critical (float=44)
4—5	H	14	68	70	Non-critical (float=2)
4—6	G	16	70	70	0
5—6	Dummy	0	68	70	Noncritical (float=2)
6—7	J	12	82	82	82
7—8	K	8	90	90	90

Time of Completion = Maximum duration = 90 weeks.

19·5 Advantages of CPM :— This is useful at several stages and some of these are :—

1. Various alternative programs or procedures can be considered when time and resourses schedules are laid out. In the operational phase can be used as a control device to measure actual versus planned progress.

2. The management may quickly realise from, the net-work how a portion of the project is affected by the other parts of the project.

3. The different parts of the Net-work diagram are straightforward in concept and quickly explainable to a layman having no background in net-work theory.

4. Pinpointed attention to the relatively small subject of activities in a project can be drawn which are critical to its computation.

5. Action can be focused on exceptional problems contributing more relative planning and more effective control.

6. Total costs for various completion dates can be reasonbly estimated.

7. This is applicable for different types of projects.

8. Bottlenecks can be anticipated in advance and cash program can study more quickly.

CHAPTER XX

PREVALENT SCHEDULE OF RATES

The rates are variable place to place and time to time even within a same State but as a general guidance the following rates are given for capital and industrial towns. For district towns decrease the rates by 5 percent and for metropolitan towns increase upto 5 percent. The rates as mentioned below includes 10% contractors profit.

Sl. No.	Description of item	Rate Rs. P.	
	Building (A) Earthwork		
1.	Earthwork in excavation of foundation trenches or drains, in ordinary soil including removing the soil within a lead of 75m and including levelling dressing and ramming the bottom, bailing out water etc.		
	(a) Depth of excavation not exceeding 1·5m	300·00	cu m
	(b) Depth of excavation for additional depth beyond 1·5m and upto 3·0m but not requiring shoring	340·00	,,
2.	Earthwork in filling in foundation trenches or plinth	245·00	,,
3.	Sand filling in foundation trenches or plinth including cost of sand	3700·00	,,
4.	Cinder filling in foundation, compound or plinth (obtained a lead of 10km)	3600·00	,,
5.	Hire and labour charges for shoring work (a) depth upto 2·0m	13·00	,,
	(b) depth beyond 2m & upto 3m	16·50	,,
	(B) Brickwork, Concrete work		
1.	Single brick flat soling of over burnt bricks	22·70	,,
2.	Lime concrete with over burnt ballast (25 to 30mm size) Surki and stone lime (100 : 36 : 18) excluding shuttering	200·00	cu m
3.	Cement concrete with grade over burnt brick ballast (30mm size), excluding shuttering in ground floor		
	(a) proportion 1 : 3 : 6	323·00	,,
	(b) —do— 1 : 4 : 8	293·00	,,
	(c) —do— 1 : 7 : 12	242·00	,,
	(d) —do— 1 : 8 : 16	221·00	,,
4.	Cement concrete with graded stone chips (20mm size) excluding shuttering and reinforcement if any in Ground floor (a) 1: 2: 4	425·00	,,
5.	Cement concrete with graded stone ballast (40mm size) excluding shuttering in Ground floor (a) 1 : 3 : 6	320·00	,,
	(b) 1 : 4 : 8	297·00	,,
6.	Add extra for each additional storey above ground floor over the rates for cement as in item 2 to 5	6·00	,,

Sl. No.	Description of Item	Rate Rs. P.
7.	Hire and labour charges for shuttering with centering and necessary staging upto 4m using stout props and 25mm thick wooden shuttering (upto roof of Ground floor). Note : 40% to be reduced where staging is not necessary ...	15·00 sq m
	(a) Extra for works beyond the roof of ground floor	1·05 sq m
8.	Hire and labour charges for shuttering with hard wood for precast R. C. slab, curver or straight and striking out the same including fitting, fixing the precast slab in position	5·00
9.	Reinforcement for reinforced concrete work including supply of rods, cutting to requisite length, and binding and placing in position	
	(a) For works upto Gr. floor, (i) Mild steel	555·00 Quin.
	(ii) Tor steel	563·00 ,,
	(b) Extra for works beyond the roof of Gr. floor per addl. floor	2·00 ,,
10.	Brickwork in lime and surki mortar	
	(a) In foundation and plinth (1:2)	297·00 cu m
	,, ,, (1:3)	282·00 ,,
	(b) For superstructure Ground floor over the rate 10(a)	6·00 ,,
11.	Brickwork in cement mortar (a) foundation and plinth (1:3)	293·00 ,,
	,, ,, ,, (1·4)	280·00 ,,
	,, ,, ,, (1:6)	252·00 ,,
	(b) In Superstructure, Gr. floor (1:3)	299·00 ,,
	,, ,, ,, (1·4)	286·00 ,,
	,, ,, ,, (1:6) ...	258·00 ,,
12.	Brickwork in composite mortar with cement, lime and sand (a) Prop. (1:1:6)	
	(i) In foundation and plinth	265·00 cu m
	(ii) In superstructure, Gr. floor ...	271·00 ,,
	,, ,, ,, ,, (b) proportion (1:2:9)	
	(i) In foundation and plinth ...	256·00 ,,
	(ii) In superstructure, Gr. floor ...	262·00 ,,
13.	Add extra for each additional story over the rate for Gr. floor on item (10) to (12) (For using modular brick the rate will be enhanched by 12·5% over the rate item 10 to 12) ...	6·25 ,,
14.	Mud brickwork with any class of burnt bricks (a) In foundation & plinth ...	160·00 ,,
	(b) In superstructure Gr. floor	166·00 ,,
15.	Extra over rate of corresponding items for brickworks in arches including hire and labour for shuttering, centering etc.	
	(a) Clear span not exceeding 1500 mm ...	7·35 ,,
	(b) ,, ,, exceeding 1500 mm but not 2400 mm ...	8·40 ,,

No.	Description of Item	Rate Rs. P.
16.	125 mm thick brickwork in cement mortar (1:4) Gr. floor	... 33·00 sq m
17.	125 mm thick brickwork in cement mortar (1:4) with H.B. netting in every third layer in Gr. floor	... 38·00 ,,
18.	100mm thick brickwork with 1st class Modular brick (1:4) in Gr. floor	... 32·00 ,,
19.	100mm thick brickwork with 1st class Modular brick (1:4) with H. B. netting in every third layer in Gr. floor	... 35·00 ,,
20.	75 mm thick brickwork set in cement mortar (1:4) in Ground floor	... 22·00 ,,
21.	75mm thick brickwork set in cement mortar (1:4) with H.B. netting in every alternate layers in Ground floor	... 23·00 ,,
22.	Jaffri brickwork 125 mm thick in cement mortar (1:4) including 12mm thick cement plaster (1:4) in all faces in ground floor	... 36·00 ,,
23.	200mm thick cement cinder Hollow brickwork set in cement sand mortar (1:4) including raking out joints curing, scaffolding etc. complete	
	(a) In groundfl oor	... 52·50 ,,
	(b) Add extra for each addl. floor	... 0·90 ,,

(C) FLOORING

No.	Description of Item	Rate Rs. P.
1.	Terraced flooring of lime concrete with lime, surki and overburnt brick ballast (1½:2:7) (a) 7·5 cm thick	... 24·00 ,,
	(b) 10 cm thick	... 30·00 ,,
2.	Brick on edge floor or pavement with bricks set close in cement mortar (1:6) with a cushion on sand below the bricks and including ruled or flush pointing with cement mortar (1:4) on top	... 38·00 ,,
3.	Grey artificial stone in floor, dado, staircase etc. with cement concrete (1:2:4) with stone chips laid in panels including necessary levelling course with cement concrete (1:3:6) with stone chips or cement mortar (1:6) as necessary with topping made with ordinary cement in ground floor (addl. extra @ 1·5% for each addl. floor)	
	(a) 3mm thick Topping (high polishing, grinding is not permitted]	
	(i) 20mm thick	... 12·00 sq
	(ii) 25mm thick	... 15·25 ,,
	(b) 6mm thick Topping (finished thickness after final grinding and high polishing will be 3mm thick)	
	(i) 20 mm thick	... 18·25 ,,
	(ii) 25 mm thick	... 21·50 ,,
4.	25mm thick (finished) Terrazzo work, cast in situ, in floor and 20mm thick in dado, staircase etc. underlay of cement concrete (1:2:4) with stone chips including high polishing etc. (add 1·5% extra for each additional story)	

6.

Sl. No.	Description of Item	Rate Rs. P.
	(a) 9mm thick terrazzo topping finished to 6 mm	
	(i) In ordinary grey colour ...	41·00
	(ii) In Red colour ...	47·00 ,,
	(iii) In silver grey colour ...	51·00 ,,
	(iv) In Pink, Green, Yellow colour ...	54·00 ,,
	(v) In Light Green colour ...	57·00 ,,
	(b) 12mm thick Terrazzo topping finished to 9mm thick	
	(i) In ordinary Grey colour .	43·00 ,,
	(ii) In Red colour .	50·00 ,,
	(iii) In Silver Grey colour ..	53·00 ,,
	(iv) In Pink, Green, Yellow colour ..	56·00 ,,
	(v) In Light Green colour ..	59·00 ,,
5.	20mm thick (finished) Terrazzo work with precast tiles set in lime mortar (1:3) and sides with admixture of pigment and white cement in floor, dado, skirting, staircase etc. including levelling and high polishing etc.	
	(a) 9mm thick Terrazzo topping and finished to 6mm thick	
	(i) In ordinary Grey colour ...	41·00 sqm
	(ii) In Red colour ...	47·00 ,,
	(iii) In Silver Grey colour ...	51·00 ,,
	(iv) In Pink, Cream, Yellow colour ...	54·00 ,,
	(v) In Light Green colour ...	57·00 ,,
	(b) 12 thick Terrazzo topping and finished to 9mm thick	
	(i) In ordinary Grey colour ...	43·00 ,,
	(ii) In Red colour ...	50·00 ,,
	(iii) In Silver Grey colour ...	53·00 ,,
	(iv) In Pink, Cream, Yellow colour ...	56·00 ,,
	(v) In Light Green colour ...	59·00 ,,
6.	(c) Supplying dividing strip 3mm thick fitted and fixed with cement mortar (1:3) in Terrazzo or patent floor, dado etc. complete.	
	(i) Glass (a) 20mm wide strip ...	1·15m
	(b) 25 mm wide strip ...	1·45m
	(ii) Aluminium.—25 mm wide strip ...	7·00m
7.	Supplying chequered tile laid in pavements, footpath etc. including necessary under lay complete in all respects with all labour and materials.	
	(i) 25mm thick ...	37·00 sqm
	(ii) 30mm thick (red varity) ...	77·00 ,,

Sl. No.	Description of Item	Rate Rs.	P.
8.	Marbalite work in floor dado, skirting etc. including cost of tiles and high polishing complete 25mm thick in floor and 20mm thick in dado, skirting etc.		
	In ground floor (add extra 1·5% for each addl floor)	... 81·00	,,
9.	Damp-proof course with stone chips (1:2:4) double chequered 25mm thick...	9·00	,,
10.	Supplying, fitting and fixing porcelain tiles including border in wall or floor set in cement mortar (1:4) (i) White	...125·00	,,
	(ii) Other than white	...146·00	,,
11.	Marble flooring or dado 22 to 25mm thick tiles set in lime motar (1:2), ordinary (i) Area of each tile upto 0·1 sqm	...230·00	,,
	(ii) Area of each tile exceeding 0·1 sqm to 0·25 sqm	225·00	,,
	(D) Roofing and Sheet Walling		
1.	Lime terracing on roof with lime concrete (2:2:7) including rounding edges (i) 7·5 cm average thickness	... 34·00	,,
	(ii) 10 cm average thickness	... 40·00	,,
2.	Half terracing old terraced roof, removing rubbish and making good the damages to parapet and wall 5 cm thickness of new terracing	... 32·00	,,
3.	Roofing of Ranigunge pattern tiles (excluding supporting framework) jointed with cement mortar (1:3)	... 20·50	,,
4.	Asbestos corrugated sheet (6mm thick) work (excluding the supporting frame work) fitted and fixed with 9·5mm dia. J or L hooks bolts and nuts, limpet and bitumen washers and putty complete (a) In roof	... 45·00	sqm
	(b) In wall	... 44·00	sqm
5.	Galvanised corrugated iron sheet work (excluding the supporting frame work) fitted and fixed with 10mm dia. J or L hook bolts and nuts, sheet bolt, limpet and bitumen washers and putty with 150mm end lap and one corrugation minimum side lap. In roof (a) with 24 gauge sheets	... 59·00	sqm
	In wall (b) with —do—	... 58·00	,,
6.	Asbestos ridging fitted and fixed with necessary hooks, bolts, nuts etc.	... 45·00	mtr.
7.	Galvanised ironsheet ridging 2·5mm lap each way fitted and fixed etc. 24 gauge.	... 41·00	,,
8.	4 mm thick plain A.C. ceiling (excluding the supporting frame work)	... 30·00	sqm
	(E) Structural Steel work, Grills, Gates etc.		
1.	M.S. structural works, in columns beams etc. with joists, channels etc., weighing not less than 22·5 kg/r m including fitting, and fixters, fabrication, hoisting and erection riveted or welded complete	... 635·00	quin

Sl. No.	Description of Item		Rate Rs. P.
2.	M. S. structural works in roof trusses etc. with angles, Tees, flats etc. weighing less than 22·5kg/r m including fitting, fixers and fabrication, hoisting and erection complete.	...	655·00
3.	M.S. round or square gratings of windows fitted and fixed in holes of window frame with intermediate flat bar stiffener in ground floor (add 1% for each additional floor)	..	670·00 quin
4.	M S. or W.I. Ornamental grill of approved design joints continuosly welded with M.S. or W.I. flats and bars for windows, railing etc. fitted and fixed		
	(i) Grill weighing upto 12 kg/sq m	...	122·00 per sqm
	(ii) —do—do—above 12 kg/sqm and upto 14 kg/sq m	...	136·00 ,,
	(iii) —do—do—above 14 kg/sq m and upto 16 kg/sq m	...	142·00 ,,
5.	Extra for work in grill gate		
	(i) For hanging and locking arrangements. 10% extra		
	(ii) For supplying and fitting, fixing, bottom rails 5% ,,		
6.	Supplying, fitting and fixing in position rails on any surface	...	6·00 per kg
7.	Supplying 1·5mm thick M.S. sheet fitted and fixed on the face of M.S. /W. I gate etc. with point welding at not more than 150mm apart	...	73·00 per sqm
8.	Supplying, fitting and fixing steel rolling shutter profile type with 18 B.G., steel lathe section 75mm wide, fitted with coil wire spring to necessitate the fitting of required No. of C. I. Pulley on heavy duty type solid drawn seamless steel tube complete with locking arragements	...	314·00 ,,
9.	Collapsible gate with 40mm × 40mm × 6mm Tee as top and bottom guide rail, 20mm × 10mm × 2mm vertical channels 100mm apart in fully stretched position 20mm × 5mm M.S. flats as collapsible bracings	...	225·00 per sqm

(F) Carpenters and Timber Works

1.	Wood work in door and window frames including fitting, fixing for		
	(a) 1st class best Indian Teak	...	5893·00 cu m
	(b) Sal	...	3812·00 ,,
	(c) Sishu, Badam, Piasal, Panisal	...	3852·00 ,,
2.	Wood work in posts, rafters, battens, purlins, trusses beams, burghas fitted and fixed (a) Sal	...	3750·00 ,,
3.	Wooden Sash Bar 50 mm × 35 mm and upto 120 cm length with coach screws and flat iron clamp (40 × 5mm) fitted and fixed		
	(a) 1st class best Indian Teak		15·00 each
	(b) Sal		10·00 ,,
4.	M.S. clamp for fixing door and window frames made of 40mm × 6mm flat and 350mm long including fitting with cement concrete (1:2:4)		7·50 ,,

No.	Description of item	Rate Rs. P.
5.	Anodised aluminium But hinges including fitting and fixing with cadmium plated screws (i) 75×45×3·2 mm	... 3·95 each
	(ii) 100×60×3·2 mm	... 5·80 ,,
6.	Iron Butt Hinges including fitting and fixing with steel screws	
	(i) 75×50mm×10G.	... 1·80 ,,
	(ii) 100×62mm×10G	... 2·75 ,,
7.	Anodised aluminium barrel/tower/socket bolt conforming to I. S 204/74 and bearing I. S. mark fixed with cadmium plated screw	
	(i) 100 mm long × 10mm dia bolt	... 4·60 each
	(ii) 150—do— × 10—do—	... 5·70 ,,
	(iii) 150—do— × 12 —do—	... 10·35 ,,
	(iv) 200—do— × 10—do—	... 7·50 ,,
8.	Anodised aluminium aldrop/sliding bolts conforming to I. S. 2681/66 and bearing I. S. mark fitted and fixed complete—	
	(i) 250 mm × 16 mm dia bolt	... 32·00 ,,
	(ii) 250 ,, × 18—do—	... 46·25 ,,
9.	Magic eye of approved quality fitted and fixed	... 5·00 ,,
10.	Panel shutters of door and window as per design (each panel consisting of single plank without joint) including fitting and fixing but excluding the cost of hinges and other fittings.	
	(a) 25 mm thick shutters with 12 mm thick panel—	
	(i) Ist class Indian teak	...178·00 sq m
	(ii) Sishu, Badam, Bijasal, Panisal	...104·00 ,,
	(b) 35 mm thick shutters with 19 mm thick panel—	
	(i) Ist. class Indian teak	...250·00 ,,
	(ii) Sishu, Badam, Bijasal, panisay	...146·00 ,,
	(c) 40 mm thick shutters with 25 mm thick panel—	
	(i) Ist Class Indian teak	...287·00 ,,
	(ii) Sishu, Badam, Bijasal. Panisay	...167·00 ,,
11.	Venetion shutters of doors and windows with valves fixed to valve rod with plated hooks including cost of hooks and fitting	
	(a) 50 mm thick shutters with 19 mm thick valve—	
	(i) Ist class Indian teak	...390·00
	(b) 35 mm thick shutters with 12mm thick valve	
	(i) Ist class Indian teak	...290·00 ,,
	(ii) Sishu, Badam, Bijasal, Panisay	...174·00

Sl. No.	Description of Item	Rate Rs. P.	
12.	Fixed louver shutters of doors and windows including fitting and fixing but excluding the cost of hinges and other fittings		
	(a) 25 mm thick shutters with 12 mm thick valve—		
	(i) 1st class Indian teak	...170·00	sqm
	(ii) Sishu, Badam, Bijasal, Panisay	...103 00	,,
	(b) 35 mm thick shutters with 12mm thick valve—		
	(i) 1st class Indian teak	...248·00	,,
	(ii) Sishu, Badam, Bijasal, panisal	...142·00	,,
	(c) 40 mm thick shutters with 12mm thick valve—		
	(i) 1st class Indian teak	...285·00	,,
	(ii) Sishu, Badam, Bijasal, Panisal	...160·00	,,
13.	Glazed shutters of doors, windows, fan light clerestory window (with ordinary glass of 7·4 kg/sq m, 3mm thick) fitted with putty bed and nails including fitting and fixing but excluding the cost of hinges etc.		
	(a) 25 mm thick shutters—		
	(i) 1st class Indian teak	...140·00	,,
	(ii) Sishu, Badam, Bijasal, panisay	... 87·00	,,
	(b) 35 mm thick shutters—		
	(i) 1st class Indian teak	...185·00	,,
	(ii) Sishu, Badam, Bijasal, Panisal	...123·00	,,
	(c) 40 mm thick shutters—		
	(i) 1st class Indian teak	...210·00	,,
	(ii) Sishu, Badam, Bijasal, Panisal	...141·00	,,
14.	Z-batten shutters of doors and windows including fitting and fixing in position but excluding the cost of hinges and other fittings.		
	(i) 25mm thick planks, 19mm thick battons (a) Indian Teak	...259·00	,,
	(b) Sishu, Badam, Bijasal	...140·00	,,
	(c) Haldi	...110·00	,,
	(ii) 19mm thick planks and 12mm thick battons (a) Indian Teak	...189·00	,,
	(b) Sishu, Badam, Bijasal	...108 00	,,
	(c) Haldi	... 88·00	,,
15.	⅓rd panelled ⅔rd glazed door and window shutters (each panel consisting of single plank without joint and with ordinary glass of 7·4 kg per sq m or 3 mm thick) including fitting and fixing but excluding the cost of hinges and other fittings.		
	(i) 25 mm thick shutters with 12 mm thick panel (a) Indian Teak	...152·00	,,
	(b) Sishu, Badam, Bijasal	... 95·00	,,
	(ii) 40 mm thick shutters with 19 mm thick panel		
	(a) Indian Teak	...235·00	,,
	(b) Sishu, Badam, Bijasal	...150·00	,,

Sl. No.	Description of Item	Rate Rs. P.	
16.	⅔rd panelled ⅓rd glazed door and window shutters—do—do—		
	(i) 25 mm thick shutters with 12 mm thick panel		
	(a) Indian Teak	. 165·00	,,
	(b) Sishu, Badam, Bijasal	... 98·00	,,
	(ii) 40 mm thick shutters with 19 mm thick panel		
	(a) Indian Teak	...261·00	,,
	(b) Sishu, Badam, Bijasal	...158·00	,,
17.	Supplying solid flush type doors of commercial quality, the battons placed both ways in order to make the door of solid core etc. with garian or similar wood veneers.		
	(a) 35 mm thick shutters (single leaf)	182·00	sq m
	(b) 25 mm —do— —do—	...170·00	,,
18.	Supplying solid flush type doors of deluxe decorative (both sides) quality —do—do— internal tipping with teak mahogony of rose approved decorative wood Veneers.		
	(a) 35 mm thick shutters (single leaf)	294 00	,,
	(b) 25 —do———do——do	280·00	,,
19.	Supplying foctory made panel doors commercial hard wood having panel made of 12mm thick commercial veneered (both sides) teak wood etc.		
	(a) 35 mm thick shutters—		
	(i) Single leaf	...190·00	,,
	(ii) Double leaf	...202·00	,,
	(b) 25 mm thick shutters—		
	(i) Single leaf	...175·00	,,

(G) Plastering, pointing etc.

Sl. No.	Description of Item		Rate Rs. P.	
1.	Plaster to wall, floor, etc. with cement and sand mortar 12mm thick with proportion	(a) 1:6 ...	5·65	sq m
		(b) 1:4 ...	6·60	,,
		(c) 1:3 ...	6·70	,,
		(d) 1:2 ...	8·70	,,
2.	Plaster to wall, floor, with cement and sand mortar 20mm thick with prop.	(a) 1:6 ...	7·65	,,
		(b) 1:4 ...	8·80	,,
		(c) 1:3 ...	9·85	,,
3.	Plaster to ceiling with cement and sand mortar 6mm thick including roughening concrete surface with proportion	(a) 1:4 ...	4·90	,,
		(b) 1:2 ...	6·15	,,
4.	Neat cement punning in wall, dado, window sills, floor, drain etc. about 1·5 mm thick	...	1·80	,,

Sl. No.	Description of work	Rate Rs. P.
5.	Lime punning about 3mm thick with shell lime and stone lime (1:2)...	4·25 sq m
6.	Rule pointing to brickwork, in cement mortar (1:4) ...	3·35 ,,
7.	Flush pointing to brickwork, in cement mortar (1:4) ...	2·90 ,,
8.	Tuck pointing to brickwork, in cement mortar (1:3) ...	9·00 ,,
	(H) Whitewash, Colourwash, Distemper	
1.	White washing including clearing surface (i) One coat ...	32·00%sq m
	(ii) Two coats ...	54·00 ,,
	(iii) Three coats ...	76·00 ,,
2.	Colour washing with pigments of any shade with a coat of white wash priming including cleaning surface	
	(i) One coat of colour wash ...	65·00 ,,
	(ii) Two coats of colour wash (on new work only) ...	86·00 ,,
	(iii) Extra for addl. storey in external walls only ...	7·50 ,,
3.	Colour washing of any shade including cleaning surface	
	(i) One coat ...	42·50 ,,
	(ii) Two coats ...	64·00 ,,
	(iii) Extra for addl. storey in external walls only ...	7·50 ,,
4.	Dry distempering with a coat of priming including cleaning surface	225·00 ,,
5.	Bordering (upto 75mm wide) in distemper ...	17 00%metr
6.	Decorating cement based point after preparing bed in ground floor	
	(i) One coat ...	2·00 sq me
	(ii) Two coats ...	3·75 ,,
	(iii) Extra for addl. storey in external walls only ...	0·15 ,,
	I Painting and Varnishing	
1.	Priming one coat on timber, plastered or on steel or other metal surface with synthetic enamel or oil bound primer including smoothening surface ...	2·90
2.	Painting with best quality synthetic enamel paint on	
	(a) Timber or plastered surface with super gloss	
	(i) Two coats (white in shade) ...	7·50 sqm
	(ii) One coat with any shade except white ...	3·30 ,,
	(iii) Two coats —do— —do— ...	6·00 ,,
	(b) Timber or plastered surface with normal gloss	
	(i) Two coats (white in shade) ...	6·00 ,,
	(ii) Two coats with any shade except white ...	5·90 ,,

Sl. No.	Description of Item		Rate Rs. P.	
	(c) Steel or other metal surface with super gloss			
	(i) One coat (white in shade)	...	4·00	sq m
	(ii) Two —do— —do—	...	7·75	,,
	(iii) One coat (with any shade except white)	...	3·00	,,
	(iv) Two coats (—do— —do—)	...	5·75	,,
	(d) Steel or other metal surface with normal gloss—			
	(i) One coat (white in shade)	...	3·00	,,
	(ii) Two coats (—do— —do—)	...	5·75	,,
	(iii) One coat (with any shade except white)	...	2·90	,,
	(iv) Two coats (—do— —do —)	...	5·75	,,
3.	Painting with superior quality aluminium paint including smoothening surface (i) One coat	...	3·30	sq m
	(ii) Two coats	...	6·25	,,
4.	Applying plastic emulsion paint on the walls and ceiling including sand papering in intermediate coats including putty (i) One coat	...	5·50	,,
	(ii) Two coats	...	9·00	,,
5.	Painting with ready mixed red lead paint of approved make and brand (a) One coat	...	4·50	,,
	(b) Two coats	...	6·50	,,
6.	Painting with ready mixed Black Japan (a) One coat ...	...	2·20	,,
	(b) Two coats ...	...	3·10	,,
7.	Coal tarring ... (i) One coat ...	...	1·00	,,
	(ii) Two coats ...	...	1·40	,,
8.	Solignum or creasote treatment to wood work (a) One coat...	...	1·20	,,
	(b) Two coats...	...	1·80	,,
9.	Copal varnish on new wood work (a) One coat...	...	2·50	,,
	(b) Two coats...	...	3·50	,,
10.	French polishing to wood work (a) on new wood work	...	13·00	,,
	(b) on old French polished surface		13·50	,,
11.	Wax polishing to wood work (a) on new wood work ...	...	2·70	,,
	(b) on old wax polished surface	...	3·00	,,
12.	Oil bound distemper (synthetic) to interior wall, ceiling	...	5·25	,,

(J) Water supply works

1.	Supplying, fitting and fixing G. I. pipes including cost of clamps etc. as necessary, including cutting pipes, making threads, fitting, fixing etc. complete		
	(a) For above ground level—		
	(i) 12 mm dia. I. T. C. make medium quality	20·00	rm

Sl. No.	Description of Item	Rate Rs. P.	
	(ii) 20 mm dia —do— —do—	24·00	rm
	(iii) 25 mm dia.	26·00	
	(iv) 32 mm dia.—do— —do—	38·00	
2.	Supplying G.I. tank with Galvd. Iron sheet with 450mm dia. C.I. raised locking cover and 50 mm cleaning flange and plug		
	(a) With 14 gauge G. I. sheet—		
	(i) 1812 litres capacity	2380·00	Each
	(ii) 1364 —do—	1960·00	,,
	(b) With 16 gauge G. I. sheet—		
	(i) 908 litres capacity ...	1850·00	,,
	(ii) 540 —do— ...	1160·00	,,
3.	Supplying, fitting and fixing brass ferrule including connection with G. I. pipes of I. T. C. make upto 45 cm long with screw, jamnut, socket etc. complete in all respects.		
	(a) 25 mm dia. ...	102·00	Each
	(b) 20 mm dia. ...	80·00	,,
	(c) 15 mm dia. ...	56·00	,,
4.	Supplying, fitting and fixing wheel valve gunmetal tested to 21 kg/sq cm		
	(a) 32 mm dia ...	125·00	,,
	(b) 25 mm dia. ...	80·00	,,
	(c) 20 mm dia. ...	55·00	,,
5.	Supplying, fitting and fixing check valve (vertical) G. M. tested to 21·00 kg/sq cm		
	(a) 32 mm dia. ...	110·00	,,
	(b) 25 mm dia. ...	70·00	,,
	(c) 20 mm dia. ...	48·00	,,
6.	Supplying fitting and fixing Stop cock Bib cock tested to 21 kg per sq cm		
	(a) Gun metal— (i) 15 mm ...	30·00	,,
	(ii) 20 mm ...	45·00	,,
	(iii) 25 mm ...	66·00	,,
	(b) Chromium plated (c p.)—(i) 15 mm ...	60·00	,,
	(ii) 20 mm ...	90·00	,,
	(iii) 25 mm ...	105·00	,,
	(c) Alloy iron with brass spindle (i) 15 mm ...	18·00	,,
	(ii) 20 mm ...	28·00	,,
7.	Supplying, fitting and fixing shower rose		
	(a) Chromium plated (i) 15 mm × 125mm ...	18·00	,,
	(ii) 20 mm × 150mm ...	21·00	,,

Sl. No.	Description of Item	Rate Rs. P.	
	(b) Porcelain Octagonal shower rose 15mm × 125mm	... 26·00	each

(K) Sanitary Works

Sl. No.	Description of Item	Rate Rs. P.	
1.	Supplying, fitting and fixing Indian type white glazed Earthen ware water closet with P. trap (excluding concrete for fixing)		
	(a) 450 mm long	... 180·00	
	(b) 500 mm long	... 200·00	,,
	(c) 580 mm long	... 220·00	,,
2.	Supplying, fitting and fixing Orissa pattern water closet in white glazed the cost of P or S trap (excluding the concrete for fixing)		
	(a) 580 mm × 440mm	... 420·00	,,
	(b) 630 mm × 450mm	... 442·00	,,
3.	Supplying, fitting and fixing European pattern water Closet of white glazed vitreous china ware of approved make (a) With P- trap	... 265·00	,,
	(b) With S- trap	... 285·00	,,
4.	Supplying, fitting and fixing Flat back urinal (half stall urinal) in white vitreous china ware of approved make		
	(a) 470mm × 300mm × 265mm	...170·00	
	(b) Corner urinal 430mm × 340mm × 260mm	...180·00	,,
5.	Supplying, fitting and fixing 12·5 litres porcelain low down cistern with brackets complete with all internal fittings (white)	...640·00	,,
6.	Supplying, fitting and fixing 12·5 litres C. I. plain low down flushing cistern complete with polythene syphon, C. P. cap, handle, ring washer, I. R. adapus joint M.S. Bend, Brass ball cock, polythene ball, polythene over flow, C. I. brackets complete	...250·00	,,
7.	Supplying, fitting and fixing 32mm dia. polythene flush pipe with necessary fixing materials and clamps complete	...16·50	,,
8.	Supplying, fitting and fixing white vitreous china wash Basin of best quality with C.I. brackets, C. P. waste fittings of 32mm dia, C.P. piller cock of 15mm dia, P.V.C. waste pipe with C.P. nut 32mm dia, 900mm long P.V.C. connection pipe with heavy brass C.P. nut including mending good all damages and painting the bracket with two Coats of approved paint		
	(a) 450mm × 300mm size	...240·00	
	(b) 550mm × 400mm ,,	...300·00	,,
9.	Supplying, fitting and fixing pedestal for wash Basin	...250·00	,,

Sl. No.		Rate Rs. P
10.	Supplying, fitting and fixing sink in mosaic in silver grey colour with C.P. Waste and other fittings, rubber plug and chain, C. I. heavy brackets	
	(a) 600mm × 450mm × 200mm	...80·00 Each
	(b) 600mm × 450mm × 250mm	...95·00 ,,
11.	White vitreous china sink supplied, fitted and fixed in position on C.I. brackets including two coats of painting	
	(a) Plain edge sink with overflow	
	(i) 600mm × 450mm × 200mm	...830·00 ,,
	(ii) 600mm × 450mm × 250mm	...1000·00 ,,
12.	Supplying, fitting and fixing cast Iron soil pipe conforming to I.S. 3989/1970 and I.S. 1729/1964 with bobbins, nails etc. including making holes in the wall, floor etc. and cutting trenches etc. in any soil or through masonry concrete if necessary and mending good the damages and painting two coats to the exposed surface with approved paint complete (a) With valamoid joints including sealing with cement mortar (1:4) upto top quarter depth	
	(i) 150mm dia.	90·00 metre
	(ii) 100mm dia.	50·00 ,,
13.	Supplying, fitting and fixing Cast Iron equal with door, conforming to I.S. 1729/1970 including jointing and painting two coats to the exposed surface	
	(a) Single branch with valamoid joints including sealing the top with cement mortar (1:4) (i) 150mm dia.	95·00 Each
	(ii) 100mm dia.	55·00 ,,
	(b) Double branch with valamoid joints including sealing the top with cement mortar (1:4)	
	(i) 150mm dia.	110·00 ,,
	(ii) 100mm dia.	65·00 ,,
14.	H.C.I. heel rest bend conforming to I.S.I. including valamoid joints with cement mortar (1:4) (i) 150mm dia.	62·00 ,,
	(ii) 100mm dia.	35·00 ,,
15.	H.C.I. offset conforming to I.S.I. including jointing with valamoid joints with cement mortar (1:4) with or without ear (75mm projection)	
	(i) 150mm dia.	56·00 ,,
	(ii) 100mm dia.	33·00 ,,

Sl. No.	Description of Item	Rate Rs. P.	
16.	H.C.I. bell mouth plain trap supplied, fitted and fixed with lead jointing complete 100mm dia.	...55·00	Each
17.	C.I vent Cowl conforming to I.S.I.		
	(i) 100mm dia.	...22·00	„
	(ii) 75mm dia.	...14·00	„
	(iii) 50mm dia.	...12·00	„
18.	C.I. inverted or antisy phase all degrees conforming to I S. including valamoid joints with cement mortar (1:4)	66·00	„
	(i) double junction 100mm × 50mm × 50mm	57·00	„
	(ii) single junction 100mm × 50mm	...33·00	„
19.	Fresh air inlet valve 100mm	...16·00	Each
20.	Supplying, fitting and fixing with cement jointing (1:3) salt glazed stone ware pipe including excavation of earth upto 1·50m depth in all sorts of soil (excluding concreting at bottom and sides)		
	(i) 300mm	...65 00	metre
	(ii) 225mm	...59·00	„
	(iii) 150mm	...28·00	„
	(iv) 100mm	...20·00	„
21.	Supplying fitting and fixing yard gully with H.C.I. grating complete with it chamber		
	(a) 225mm × 150mm with (230mm grating)	...56·00	Each
	(b) 150mm × 100mm with (150mm grating)	...30·00	„
22.	Supplying, fitting and fixing S.W. Master trap with chamber		
	(a) 300mm × 300mm	...500·00	„
	(b) 225mm × 225mm	...225·00	„
23.	Supplying, fitting and fixing glass shelf with Aluminium guard rails		
	(a) Heavy special type with 5·5m sheet glass		
	(i) 450mm × 125mm	...60 00	„
	(ii) 600mm × 200mm	...95·00	„
	(b) Ordinary style with 4mm sheet glass		
	(i) 450mm × 125mm	...20·00	„
24.	Supplying, fitting and fixing best quality mirror 5·5mm thick with silvering as per I.S.I. specifications supported on fibre glass frame 550mm × 400mm	...165·00	„
25.	Supplying, fitting and fixing towel rail with two brakets C. P. Over brass—		
	(i) 25mm dia. and 450mm long	...40·00	„
	(ii) 25mm dia and 600mm long	...50 00	„
26.	Construction of septic tank For (i) 10 users	...1350·00	„
	(ii) 20—do—	...2025·00	„
	(iii) 30—do—	...2625·00	„

(L) Road works

Sl. No.	Description of Item	Rate Rs. P.	
1.	Earth work in excavation from borrow pits and depositing the soil in layer not exceeding 250mm to form the road embankment to correct profile in all sorts of soil including mixed soil		
	(i) Within a lead of 50m and lift 1·5m	...290·00%	cum
	(ii) For each additional lead of 50m beyond the initial 50m lead upto total lead of 200m	...40·00	„
2.	Earthwork in road embankment with carried earth supplied by the contractor including the cost of carried earth	...1440·00	„
3.	Consolidating sub-grade with power roller of road	...16 00%	sqm

Sl. No.	Description of Item	Rate Rs. P.
4.	Box cutting in road embankment including consolidating and dressing sub-grade	...300·00% cum
5.	Brick soling with picked jhama bricks including preparation of bed and brick joints properly filled in and packed with powdered earth and with necessary cushion	
	(i) Single brick flat soling (thickness 75mm)	...15·00 sqm
	(ii) Double brick flat soling	..29·50
6.	Labour for laying soling with departmental bricks including carriage upto 150m	...170·00% sqm
7.	Brick edging 75mm wide with picked overburnt bricks laid true to line	
	(i) Brick-on-end edging 150mm depth	...390·00% metre
8.	Supplying overburnt brick metal 50 to 65mm size at road side and stocking	...122·00 cum
9.	Supplying trap stone 100mm size (partially quoted) for edging at road side	...110·00 cum
10.	Labour for laying stone edging with departmental stone materials 100mm wide 250mm deep	...65·00% metre
11.	Labour for laying brick edging wide with departmental brick 75mm wide and 250mm depth	...50·00 ,,
12.	Supplying 1st class brick bats at road side and stacked at intervals	...95·00 cum
13.	Labour for spreading and consolidation in layers for	
	(i) Bat consolidation	...12·00 cum
	(ii) Overburnt metal consolidation thickness (loose) upto 110 mm	...15·00 ,,
	(iii) —do— —do— —do— above 110mm	...14·00 ,,
	(iv) Stone metal consolidation thickness (loose) upto 100mm	...18·00 ,,
	(v) —do— —do— —do— 100mm or above	19·00 ,,

(b) **Labour rates for different items of building works**

Item No.	Description of item	F. P. System Rs. P.		Metric System Rs. P.	
1.	Earthwork in excavation in foundation trenches	125·00%	cft	4·41	cum
2.	Earthwork in filling	100·00	,, cft	3·53	,,
3.	Brickflat soling in foundation or floor ...	8·50	,, sft	0·91	sq m
4.	Lime concrete in foundation or floor ...	55·00	,, sft	5·92	,,
5.	Cement concrete— do—do—upto 15cm ...	44·00	,, sft	4·74	,,
6.	R. C. —do do— do— ...	7·50	cft	264·85	cum,
7.	Brickwork in cement morter in foundation and plinth ...	50·00%	cft	17·65	,,
8.	Brickwork in cement mortar in superstructure (solid measurement) ...	55·00	,, cft	19·42	,,
9.	10cm or 5″ or 3″ brickwork (solid measurement) ...	45·00	,, sft	4·84	sqm
10.	Extra charge for each upper floor for Item No. 8 or 9 ...	10·00	,, per unit	1·08	perunit
11.	2·5cm Thick damp proof course	0·28	sft	3·00	sqm
12.	Fixing door or window frames with brickwork ...	6·50	,, Each	6·50	Each

Labour rate for casting R. C. members includes supplying timber planks only for shuttering and labour for binding and placing the reinforcement in position and casting the concrete excluding hire of mixture machine and vibrator.

13.	Casting R. C. Lintel	3·00 rft	9·65 rm
14.	—do— Beam	4·50 rft	14·48 rm
15.	—do— Slab	100·00% sft	10·76 rm
16.	—do— column	5·00 rft	16·09 rm
17.	—do— slab cantilevered	125·00% sft	13·45sq m
18.	—do— jaffri	4 00 sft	43·05 ,,
19.	Sand cement plaster to ceiling ...	24·00% sft	2·58 ,,
20.	—do— —do— to outside walls (solid measurement) ...	22·00 ,, sft	2·37 ,,
21.	—do— —do— to inside walls	20·00 ,, sft	2·15 ,,
22.	—do— —do— to beam, column ...	0·60 per sft	6·45 ,,
23.	—do— —do— to chajjas (with bothside complete) ...	1·50 per sft	16·15 ,,
24.	Making water drip course	0·30 sft	0·97 rm
25.	Lime punning to ceiling	22·00% sft	2·37 sqm
26.	—do— to wall (solid measurement ...	20·00 ,, sft	2·15 ,,
27.	Extra for item no 19, 20, 21, 25, and 26 for each upper floor ...	1·25 ,, sft	0·13 ,,
28.	Patent stone floor	40·00% sft	4·30 sqm
29.	For each upper floor extra over rate of Item no 28. ...	3·00% sft	0·32 ,,
30.	Step neat cement complete...	1·70 rft	5·58 ,,
31.	Dedo neat cement finish	0·70 sft	2·15 ,,
32.	Tiles fixing in floor	1·80 sft	19·37 ,,
33.	Situ Terrazzo i.e. Mossaic floor	1·80 sft	19·37 ,,
34.	Situ Terrazzo i.e. Mossaic dado floor... ...	2·70 sft	29·06 ,,
35.	Situ —do— —do step etc.	3·50 sft	37·67 ,,
36.	Step brickwork and plaster	3·00 rft	9·84 rm
37.	Plinth step brickwork and plaster	2 60 rft	8·20 ,,
38.	10cm thick roof teracing	100·00% sft	10·76 sqm
39.	Extraover for item no. 38 for each additional story ...	8·00 ,, sft	0·86 ,,
40.	Cleaning the surfaces and white wash per coat ...	2·50 ,, sft	0·27 ,,
41.	Colour washing per coat including cleaning wall surfaces ...	3·00 ,, sft	0·32 ,,
42.	Snowcem per coat including cleaning ...	9·00 ,, sft	0·97 ,,
43.	Distempering per coat	12·00 ,, sft	1·29 ,,
44.	Cement priming per coat	12·00 ,, sft	1·72 ,,
45.	Plastic paint per coat	16·00% sft	0·91 ,,
46.	Enamel painting per coat	8·50% sft	1·72 ,,
47.	Oil painting per coat	16·00 ,, sft	

Labour charge for plumbing works

48.	Handling and fixing 100 mm dia C.I. Rainwater pipe ...	1·50 ,, rft	4·92 rm
49.	—do— —do— —do— 'Junction' ...	3·00 ,, Each	3·00 Each
50.	—do— —do— 100mm dia. H. C. I. pipe ...	2·00 ,, rft	6·56 rm
51.	—do— —do— 100mm dia H. C. I. Junction	4·00 ,, Each	4·00 Each
52.	—do— —do— 100mm dia H. C. I. trap	4·50 ,, Each	4·50 ,,

CONVERSION OF RATES

F.P.S. System Unit of rate	Metric System Unit of rate	Conversion Factors F.P.S. to Metric	Metric to F.P.S.
Rs. per cft.	Rs. per cu m	35·315	0·0283
Rs. per % cft.	Rs. per cu m	0·35315	2·8317
Rs. per ‰ cft.	Rs. per. cu m	0·035315	28·32
Rs. per sft.	Rs. per sq m	10·764	0·0929
Rs. per % sft.	Rs. per sq m	0·10764	9·29
Rs. per ‰ sft.	Rs. per sq m	0·010764	92·9
Rs. per rft.	Rs. per r m	3·281	0·3048
Rs. per 100 rft.	Rs. Per r m	0·03281	30·48
Rs. per mile	Rs. per km	0·6214	1·6093
Rs. per gallon	Rs. per litre	0·220	4·546
Rs. per lb.	Rs. per kg	2·2046	0·4536
Rs. per cwt.	Rs. per kg	0·01968	50·802
Rs. per cwt.	Rs. per quintal	1·968	0·508
Rs. per seer.	Rs. per kg.	1·0717	0·933
Rs. per md.	Rs. quintal	2·6792	0·3732
Rs. per ton	Rs. metric tonne	0·9842	1·016
Rs. per md. per mile	Rs.per kg per km	0·01665	60·067
Rs. per % cu ft per mile	Rs.per cum per km	0·22034	4·54
Rs. per acre	Rs. per hectare	2·471	0·4047

N. B. From the above table it may be seen that only knowing the conversion factor as given in the prepage conversion of rates from one system to the other may be done without knowing the conversion factor of rates.

CONVERSION TABLES

FORM F.P.S. TO METRIC UNIT			FORM METRIC TO F.P.S. UNIT		
Foot pound Unit	Metric Unit	Conversion factor	Metric Unit	Foot pound Unit	Conversion factor
LENGTHS					
In.	cm	2·54	Cm.	In	3·3937
Ft.	m.	0·3048	Metre	Ft.	3·2808
Yd.	m.	0·9144	Metre	yd.	1·0936
Fg.	km.	0·2017	Km.	yd.	1093·51
Mile	km.	1·6093	Km.	Mile	0·6214
AREA					
sq. in	sq. cm	6·4516	sq. cm	sq. in	0·1550
sq. ft.	sq. m	0·0929	sq. m	sq. ft.	10· 639
sq. yd.	sq. m	0·8361	sq. m	sq. yd.	1·196
Acre	sq. m	4046·869	sq. m	Acre	0·00025
Acre	Hectare (he)	0·4047	Hectare (he)	sq. yd.	11960
sq. mile	sq. km.	2·59	sq. km.	sq. mile	0·39
sq. mile	Hectare	259·0	Hectare	Acre	2·4711
VOLUME					
cu. in.	cu cm	16·3862	cu.cm	cu. in.	0·061
cu ft.	cu m	0·0283	cu. m	cu. ft.	35·3147
cu. yd.	cu m	0·7646	cu. m	cu. yd.	1·3080
CAPACITY					
cu. ft.	Litre	28·316	Litre	cu. in	0·0353
Gallon (U.K.)	Litre	4·546	Litre	Gallon (U.K.)	0·2198
WEIGHT					
Seer (Ind.)	kg.	0·9331	Kg.	Seer (Ind.)	1·0717
Maund (Ind.)	Quintal	0·3732	Quintal	Maund (Ind.)	2·6792
Pound	kg.	0·4536	Kg.	Pound	2·2046
Cwt.	kg.	50·802	Kg.	Cwt.	0·0197
Cwt.	Quintal	0·50802	Quintal	Cwt.	1·97
Ton	Metric Tonne	1·016	Metric tonne	Ton	0·9842

MISCELLANEOUS CONVERSION FACTOR

Quantity	F. P. S. Units	Metric Units	Conversion Factor From F. P. S. to Metric	Conversion Factor From Metric to F.P.S
1. Weight per unit length	...lb/ft ton/ft	kg/m tonne/m	1·488 3·333	0·672 0·3
2. Bearing pressure ...	...lb/sq ft ton/sq ft	kg/sq m tonne/sq m	4·482 10·937	·205 0·0914
3. Stress (tensile, compressive, bearing or shear)	lb/sq. in ...ton/sq in	kg/sq cm kg/sq m	0·070 1·575	14·286 0·636
4. Bending moment and moments	in-lb ft-lb ft-lb in-ton ft-ton	kg-cm kg-cm kg-m kg-m kg-m	1·152 13·825 0·1383 25·803 309·69	0·868 0·0723 7·233 0·0387 0·0032
5. Moment of Inertia ...	...in^4	cm^4	41·623	0·024
6. Section Modulus ...	...in^3	cm^3	16·387	0·061
7. Work and Energy ...	...foot pound	kilo (force) m	0·138	7·246
8. Power ...	...h·p ...h·p	kilo watt Metric hp	0·746 1.014	1.341 0.9862
9. Speed and Velocity ...	...mile/h ...ft/sec	km/h m/sec	1·609 0·305	0·6215 3·279
10. Acceleration ...	...ft/sec/sec	m/sec/sec	0·305	3·279
11. Density ...	...lb/cu in lb/cu ft	grams/cu cm kg/cu m	27·680 16·019	0·0361 0·0624
12. Discharge in rivers, channels	...cu sec	cu m/sec	0·0283	35·336
13. Flow	...gal/sec	litres/sec	4·546	0·22
14. Storage in reservoir ...	...million gallons acre ft	meg litres hectare m	4·53 0·1234	0·221 8·104
15. Reduced Levels ...	...ft above mean sea level	metres above mean sea level	0·305	3·276
16. Catchment area ...	...sq mile	m/kg	2·59	0·386
17. Gradient ...	...ft/mile	m/km	0·1894	5·28
18. Duties ...	...acre/cu ft/day	hectare/cu m/day	14·464	0·0691
19. Temperature ...	...°F	°C	$\frac{5}{9}$(F-32)	$c \times \frac{9}{5}$
20. Land areas ...	...acre	hectare	0·405	2·469

WEIGHTS OF SOME ENGINEERING MATERIALS FOLLOWING INDIAN STANDARD

Materials	Kg/cu m	lb/cft	Materials	Kg/cu m	lbs cft
Cement (ordinary)	1440	90	Reinforced concrete	2400	
White lime fresh	960	60	Cement mortar	2080	130
White lime slaked	640	40	Lime morter	1760	110
Kankar lime fresh	1100	74	Dry loose earth	1280	80
Kankar lime slaked	1030	64	Dry compact earth	1550	97
Dry clean sand	1600	100	Pig iron	7200	450
River sand	1840	115	Wrought iron	7700	480
Wet sand	1760 to 2000	110 to 125	Steel	7850	406
Stone ballast	1600 to 1920	100 to 120	Marble dressed	2700	169
Brick ballast	1200	75	Tar	1010	63
Brick dust (surki)	1010	63	Sand stone	2240 to 2400	140 to 150
Brick masonry	1920	120	Lime stone	2400 to 2640	150 to 165
Dry rubble stone masonry	2080	130	Asbestos cement sheets	16 kg.sm	
Ashlar granite masonry	2640	165	Granite stone	2640 to 2800	165 to 175
Lime concrete	1950		Hard wood	640 to 930	40 to 58
Cement conc. (brick aggre.)	1840	115	Light wood	400 to 420	25 to 26
Cement conc. (stone ballast)	2300	140			

MENSURATION

1. **Area of a square**$=\text{side}^2$

2. **Area of a circle**$=\frac{\pi}{4}\times\text{dia}^2=\pi\times\text{radius}^2$.

3. **Area of a Triangle**$=\frac{1}{2}$ base $\times$ perpendicular height $=\sqrt{s(s-a)(s-b)(s-c)}$

   Where a, b, c, are sides and $s=\frac{1}{2}(a+b+c)$

4. **Area of a Trapezium**$=\frac{1}{2}$(sum of parallel sides) $\times$ height.

5. **Area of a regular polygon**$=$radius of inscribed circle $\times\frac{1}{2}$ sum of all sides.

6. **Area of a Hexagon**$=0{\cdot}866d^2=0{\cdot}649D^2$

   Where, $d=$ dia. of inscribed circle and $D=$ dia. of circumscribed circle.

7. **Area of a Octagon**$=0{\cdot}82d^2=0{\cdot}707D^2$

   Where, $d=$ dia. of inscribed circle and $D=$ dia. of circumscribed circle.

8. **Convex surface area of a circular conc**$=\frac{1}{2}\times$ peremeter of base $\times$ slant height.

9. **Surface area of a sphere** $=\pi\times\text{dia}^2$ and **volume** $=\frac{4}{3}\pi r^3$

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    Where, c = chord of the sphere, h = height of segment from the chord.

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Where, θ = Central angle of the arc in degrees, r = radius of the circle.

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$$d = \frac{W}{A \times w}\left(\frac{1-\sin\theta}{1+\sin\theta}\right)^2$$

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Where, W = wt. of the wall rft. A = area of the base, e = excentricity, B = Base width

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Where, θ = deflection angle or central angle which subtends by the length of curve.

19. **Apex. distance** i.e., the distance from the point of intersection of the tangents to the apex of the curve $= R\left(\dfrac{1}{\cos \frac{\theta}{2}} - 1\right)$

20. **Length of Long chord,** $L = 2R \sin \dfrac{\theta}{2}$

21. **Versed sign of the curve,** i.e., the dist. from apex of the curve to the centre point on long chord $= R\left(1 - \cos \dfrac{\theta}{2}\right)$

22. **Deflection angle (Theodlight method)** $\delta = 1718{\cdot}9 \dfrac{C}{R}$

Where, C = Length of a chord (may be full or sub-chord).

23. **Length of first offset** (by chords and offsets method, offset from chords produced)
$$=\frac{\text{1st. chord}^2}{2R}$$

24. **Length of Intermidated offset** $=\frac{\text{present chord}^2}{R}$

25. **Length of 2nd and last offset** $=\frac{\text{present chord (previous chord}+\text{present chord)}}{2R}$

26. **Length of vertical curve** $=\frac{g_1-g_2}{r}$ in 100 ft. stations

Where, $g_1-g_2=$ the algebric difference of the two grades
$r=$ the rate of change of grade.

27. **Error due to Curvature only** $=\frac{2}{3}D^2$ in feet.

28. **Error due to refraction only** $=\frac{1}{7}\left(\frac{2}{3}D^2\right)=\frac{2}{21}D^2$ in feet.

∴ Combined error $=0{\cdot}57D^2$. Where, $D=$ dist. in miles.

29. **Superelevation for highways** in ft. per ft. width of road surface, $E=\frac{V^2}{64R}$

Where, $V=$ speed designed in mph. $R=$ radius of curve in ft.

30. **To find position of Netural Axis** (*This is critical netural axis or oxis for balanced design*)

(i) $\frac{c}{t}=\frac{n}{m(d-n)}$ (ii) $K=\frac{mfc}{fs+mfc}$

Symbols (i) are generally followed in U.K. and symbols (ii) in U.S.A.
c or fc = Maximum compressive stress of concrete.
t or fs = Maximum tensile stress in steel.
m = Modular ratio, n = depth of Netural Axis.
K = Netural Axis constant ($n=kd$).

31. **To find actual position of Netural Axis** (*This is for unbalanced design and applicable when all dimensions of a section, including those of the steel, are known*).

(i) $\frac{bn^2}{2}=m\,As(d-n)$ (ii) $K=\sqrt{m^2p^2+2mp}-mp$

Where, b = breadth of the section, As = Area of Steel

p = ratio of reinforcement $=\frac{As}{bd}$

32. **Lever arm** $jd=d-\frac{kd}{3}$ i.e., $a=d-\frac{n}{3}$ where, j = lever arm constant.

33. **M. R. of compressive jone** $=\frac{1}{2}\,b.\,n.\,c.\left(d-\frac{n}{2}\right)$ i.e., $\frac{fc}{2}\,k.j.b.d^2$

34. **M. R. of tensile jone** $=As.\,t,\left(d-\frac{n}{3}\right)$ i.e., $As.\,fs.\,jd.$

35. **Spacing of bars in a slab** $=\frac{12\times\text{area of one rod}}{As}$

36. **Safe load carried by a short column, with ordinary lateral ties**
$P=c\{A+m+1)As\}$ i.e., $fc\,\{A+(m-1)As\}$ Where A = area of column.

37. **Spacing of lateral ties** $=\frac{12\times\text{vol. per turn}}{\text{vol. per foot length of column}}$

CONVERSION OF RATES

F.P.S. System Unit of rate	Metric System Unit of rate	Conversion Factors F.P.S. to Metric	Conversion Factors Metric to F.P.S.
Rs. per cft.	Rs. per cu m	35·315	0·0283
Rs. per % cft.	Rs. per cu m	0·35315	2·8317
Rs. per ‰ cft.	Rs. per. cu m	0·035315	28·32
Rs. per sft.	Rs. per sq m	10·764	0·0929
Rs. per % sft.	Rs. per sq m	0·10764	9·29
Rs. per ‰ sft.	Rs. per sq m	0·010764	92·9
Rs. per rft.	Rs. per r m	3·281	0·3048
Rs. per 100 rft.	Rs. Per r m	0·03281	30·48
Rs. per mile	Rs. per km	0·6214	1·6093
Rs. per gallon	Rs. per litre	0·220	4·546
Rs. per lb.	Rs. per kg	2·2046	0·4536
Rs. per cwt.	Rs. per kg	0·01968	50·802
Rs. per cwt.	Rs. per quintal	1·968	0·508
Rs. per seer.	Rs. per kg.	1·0717	0·933
Rs. per md.	Rs. quintal	2·6792	0·3732
Rs. per ton	Rs. metric tonne	0·9842	1·016
Rs. per md. per mile	Rs.per kg per km	0·01665	60·067
Rs. per % cu ft per mile	Rs.per cum per km	0·22034	4·54
Rs. per acre	Rs. per hectare	2·471	0·4047

N. B. From the above table it may be seen that only knowing the conversion factor as given in the prepage conversion of rates from one system to the other may be done without knowing the conversion factor of rates.

CONVERSION TABLES

FORM F.P.S. TO METRIC UNIT			FORM METRIC TO F.P.S. UNIT		
Foot pound Unit	Metric Unit	Conversion factor	Metric Unit	Foot pound Unit	Conversion factor
		LENGTHS			
In.	cm	2·54	Cm.	In	3·3937
Ft.	m.	0·3048	Metre	Ft.	3·2808
Yd.	m.	0·9144	Metre	yd.	1·0936
Fg.	km.	0·2017	Km.	yd.	1093·51
Mile	km.	1·6093	Km.	Mile	0·6214
		AREA			
sq. in	sq. cm	6·4516	sq. cm	sq. in	0·1550
sq. ft.	sq. m	0·0929	sq. m	sq. ft.	10· 639
sq. yd.	sq. m	0·8361	sq. m	sq. yd.	1·196
Acre	sq. m	4046·869	sq. m	Acre	0·00025
Acre	Hectare (he)	0·4047	Hectare (he)	sq. yd.	11960
sq. mile	sq. km.	2·59	sq. km.	sq. mile	0·39
sq. mile	Hectare	259·0	Hectare	Acre	2·4711
		VOLUME			
cu. in.	cu cm	16·3862	cu.cm	cu. in.	0·061
cu ft.	cu m	0·0283	cu. m	cu. ft.	35·3147
cu. yd.	cu m	0·7646	cu. m	cu. yd.	1·3080
		CAPACITY			
cu. ft.	Litre	28·316	Litre	cu. in	0·0353
Gallon (U.K.)	Litre	4·546	Litre	Gallon (U.K.)	0·2198
		WEIGHT			
Seer (Ind.)	kg.	0·9331	Kg.	Seer (Ind.)	1·0717
Maund (Ind.)	Quintal	0·3732	Quintal	Maund (Ind.)	2·6792
Pound	kg.	0·4536	Kg.	Pound	2·2046
Cwt.	kg.	50·802	Kg.	Cwt.	0·0197
Cwt.	Quintal	0·50802	Quintal	Cwt.	1·97
Ton	Metric Tonne	1·016	Metric tonne	Ton	0·9842

MISCELLANEOUS CONVERSION FACTOR

Quantity	F. P. S. Units	Metric Units	Conversion Factor From F. P. S. to Metric	Conversion Factor From Metric to F.P.S
1. Weight per unit length	...lb/ft ton/ft	kg/m tonne/m	1·488 3·333	0·672 0·3
2. Bearing pressure ...	...lb/sq ft ton/sq ft	kg/sq m tonne/sq m	4·482 10·937	0·205 0·0914
3. Stress (tensile, compressive, bearing or shear)	lb/sq. in ...ton/sq in	kg/sq cm kg/sq m	0·070 1·575	14·286 0·636
4. Bending moment and moments	in-lb ft-lb ft-lb in-ton ft-ton	kg-cm kg-cm kg-m kg-m kg-m	1·152 13·825 0·1383 25·803 309·69	0·868 0·0723 7·233 0·0387 0·0032
5. Moment of Inertia ...	...in^4	cm^4	41·623	0·024
6. Section Modulus ...	...in^3	cm^3	16·387	0·061
7. Work and Energy ...	...foot pound	kilo (force) m	0·138	7·246
8. Power ...	...h·p ...h·p	kilo watt Metric hp	0·746 1.014	1.341 0.9862
9. Speed and Velocity ...	...mile/h ...ft/sec	km/h m/sec	1·609 0·305	0·6215 3·279
10. Acceleration ...	...ft/sec/sec	m/sec/see	0·305	3·279
11. Density ...	...lb/cu in lb/cu ft	grams/cu cm kg/cu m	27·680 16·019	0·0361 0·0624
12. Discharge in rivers, channels	...cu sec	cu m/sec	0·0283	35·336
13. Flow	...gal/sec	litres/sec	4·546	0·22
14. Storage in reservoir ...	...million gallons acre ft	meg litres hectare m	4·53 0·1234	0·221 8·104
15. Reduced Levels ...	...ft above mean sea level	metres above mean sea level	0·305	3·276
16. Catchment area ...	...sq mile	m/kg	2·59	0·386
17. Gradient ...	...ft/mile	m/km	0·1894	5·28
18. Duties ...	...acre/cu ft/day	hectare/cu m/day	14·464	0·0691
19. Temperature ...	...°F	°C	$\frac{5}{9}$(F-32)	$c \times \frac{9}{5}$
20. Land areas ...	...acre	hectare	0·405	2·469

WEIGHTS OF SOME ENGINEERING MATERIALS FOLLOWING INDIAN STANDARD

Materials	Kg/cu m	lb/cft	Materials	Kg/cu m	lbs cft
Cement (ordinary)	1440	90	Reinforced concrete	2400	
White lime fresh	960	60	Cement mortar	2080	130
White lime slaked	640	40	Lime morter	1760	110
Kankar lime fresh	1100	74	Dry loose earth	1280	80
Kankar lime slaked	1030	64	Dry compact earth	1550	97
Dry clean sand	1600	100	Pig iron	7200	450
River sand	1840	115	Wrought iron	7700	480
Wet sand	1760 to 2000	110 to 125	Steel	7850	406
Stone ballast	1600 to 1920	100 to 120	Marble dressed	2700	169
Brick ballast	1200	75	Tar	1010	63
Brick dust (surki)	1010	63	Sand stone	2240 to 2400	140 to 150
Brick masonry	1920	120	Lime stone	2400 to 2640	150 to 165
Dry rubble stone masonry	2080	130	Asbestos cement sheets	16 kg.sm	
Ashlar granite masonry	2640	165	Granite stone	2640 to 2800	165 to 175
Lime concrete	1950		Hard wood	640 to 930	40 to 58
Cement conc. (brick aggre.)	1840	115	Light wood.	400 to 420	25 to 26
Cement conc. (stone ballast)	2300	140			

MENSURATION

1. **Area of a square** = side^2.

2. **Area of a circle** $= \frac{\pi}{4} \times$ **dia**$^2 = \pi \times$ **radius**^{2}.

3. **Area of a Triangle** $= \frac{1}{2}$ base $\times$ perpendicular height $= \sqrt{s(s-a)(s-b)(s-c)}$

   Where a, b, c, are sides and $s = \frac{1}{2}(a+b+c)$

4. **Area of a Trapezium** $= \frac{1}{2}$(sum of parallel sides) $\times$ height.

5. **Area of a regular polygon** = radius of inscribed circle $\times \frac{1}{2}$ sum of all sides.

6. **Area of a Hexagon** $= 0{\cdot}866d^2 = 0{\cdot}649D^2$

   Where, d = dia. of inscribed circle and D = dia. of circumscribed circle.

7. **Area of a Octagon** $= 0{\cdot}82d^2 = 0{\cdot}707D^2$

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20. **Length of Long chord,** $L = 2R \sin \dfrac{\theta}{2}$

21. **Versed sign** of the curve, i.e., the dist. from apex of the curve to the centre point on long chord $= R\left(1 - \cos \dfrac{\theta}{2}\right)$

22. **Deflection angle** (Theodlight method) $\delta = 1718{\cdot}9\,\dfrac{C}{R}$

Where, C = Length of a chord (may be full or sub-chord).

23. **Length of first offset** (by chords and offsets method, offset from chords produced)

$$=\frac{\text{1st. chord}^2}{2R}$$

24. **Length of Intermidated offset** $=\frac{\text{present chord}^2}{R}$

25. **Length of 2nd and last offset** $=\frac{\text{present chord (previous chord+present chord)}}{2R}$

26. **Length of vertical curve** $=\frac{g_1-g_2}{r}$ in 100 ft. stations

Where, g_1-g_2 = the algebric difference of the two grades
r = the rate of change of grade.

27. **Error due to Curvature only** $=\frac{2}{3}D^2$ in feet.

28. **Error due to refraction only** $=\frac{1}{7}\left(\frac{2}{3}D^2\right)=\frac{2}{21}D^2$ in feet.

∴ Combined error $=0{\cdot}57D^2$. Where, D = dist. in miles.

29. **Superelevation for highways** in ft. per ft. width of road surface, $E=\frac{V^2}{64R}$

Where, V = speed designed in mph. R = radius of curve in ft.

30. **To find position of Netural Axis** (*This is critical netural axis or oxis for balanced design*)

(i) $\frac{c}{t}=\frac{n}{m(d-n)}$ (ii) $K=\frac{mfc}{fs+mfc}$

Symbols (i) are generally followed in U.K. and symbols (ii) in U.S.A.
c or fc = Maximum compressive stress of concrete.
t or fs = Maximum tensile stress in steel.
m = Modular ratio, n = depth of Netural Axis.
K = Netural Axis constant (n = kd).

31. **To find actual position of Netural Axis** (*This is for unbalanced design and applicable when all dimensions of a section, including those of the steel, are known*).

(i) $\frac{bn^2}{2}$ m As(d−n) (ii) $K=\sqrt{m^2p^2+2mp}-mp$

Where, b = breadth of the section, As = Area of Steel

p = ratio of reinforcement $=\frac{As}{bd}$

32. **Lever arm** $jd=d-\frac{kd}{3}$ i.e., $a=d-\frac{n}{3}$ where, j = lever arm constant.

33. **M. R. of compressive jone** $=\frac{1}{2}$ b. n. c. $\left(d-\frac{n}{2}\right)$ i.e., $\frac{fc}{2}$ k.j.b.d^2

34. **M. R. of tensile jone** = As. t. $\left(d-\frac{n}{3}\right)$ i.e., As. fs. jd.

35. **Spacing of bars in a slab** $=\frac{12\times\text{area of one rod}}{As}$

36. **Safe load carried by a short column, with ordinary lateral ties**

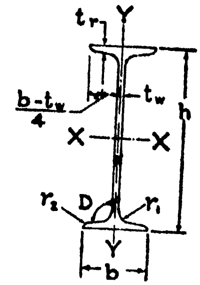
P = c{A+m+1)As} i.e., fc {A+(m−1)As} Where A = area of column.

37. **Spacing of lateral ties** $=\frac{12\times\text{vol. per turn}}{\text{vol. per foot length of column}}$

METRIC STANDARD TABLES

ROLLED STEEL I BEAMS

DIMENSIONS AND PROPERTIES



Size Depth × width n×b	Wt. per Metre	Section Area	Thickness Flange	Thickness Web	Moment of Inertia Ixx	Moment of Inertia Iyy	Radii of Gyration Rxx	Radii of Gyration Ryy	Moduli of section Zxx	Moduli of section Zyy	Maximum size of flange Rivet
mm	kg.	cm	mm	mm	cm⁴	cm⁴	cm	cm	cm³	cm³	mm
150×50	7 1	9.01	4.6	3 0	322.1	9.2	5 98	1.01	42.9	3.7	6
17 ×50	8.1	10.28	4.8	3.2	479.3	9 7	6.83	0.97	54.8	3.9	6
200×60	9.9	12.64	5 0	3.4	780.7	17.3	7.86	1.17	78.1	5.8	6
225×80	12.8	16.28	5.0	3.7	1308.5	40.5	8.97	1.58	116.3	10.1	12
75×50	6.1	7.71	5.0	3.7	72.7	10 0	3.07	1.14	19.4	4.0	6
100×5	8.0	10.21	6.4	4.0	168 0	12.7	4.06	1.12	33.6	.1	6
125×75	11.5	15.12	6.5	4.4	406-9	43.4	5.19	1.69	65.1	11.6	12
150×80	14.2	18.08	.8	4.8	688.2	55.2	6.17	1 75	91.8	13.8	12
175×90	16.7	21.30	6 9	5.1	1096.2	79.6	7.17	1,93	125.3	17.7	12
200×100	19.8	25.27	7.3	5.4	1696 6	115 4	8.19	2.13	169.7	23.1	16
225×100	23.5	29.92	.6	5.8	2501.9	112.7	9.15	1.94	222.4	22.5	16
250×125	27.9	35.53	.2	6.1	3717.8	193.4	10.23	2.33	297.3	30.9	22
275×140	33.0	42.02	8.8	6.4	5375.3	287.0	11.31	2.61	392.4	41.0	22
300×150	37.7	48.08	9 4	6 7	7332.9	376.2	12.35	2.80	488.9	50.2	22
325×165	43.1	54.90	9.8	7.0	9874.6	510.8	13.41	3.05	607.7	61.9	25
350×161	49 5	63.01	11.4	7.4	13158.3	631.9	14.45	3 17	751.9	76.6	25
400×165	56 9	72.43	12.5	8.0	19306.3	716.1	16.33	3.15	965.3	86.8	25
450×170	65.3	83.14	13.4	8.6	27536.1	853.0	18 20	3.20	1223.8	100.4	25
500×180	75.0	95.50	14.1	9.2	38579.0	1063.9	20.10	3.34	1543.2	118.2	28
550×190	86.3	109.97	15.0	9.9	53161.6	1335.1	21.99	3.48	1933.2	140.5	32
600×210	99.5	126.69	15.5	10.5	72867.6	1821.9	23.98	3.79	2428.9	173.5	25,32
100×75	11.5	14.60	7.2	4.0	257.5	40.8	4 20	1.67	51.5	10.9	12
125×75	13.0	16.60	7.6	4.4	449.0	43.7	5.20	1.62	71.8	11.7	12
150×90	14.9	19.00	7.6	4.8	726.4	52.6	6.18	1.66	96.6	13.1	12
175×90	19.3	24 62	8.6	5.5	1272.0	85.0	7.19	1.86	145.4	18.9	12
200×100	25.4	32.33	10.8	5.7	2235.4	150.0	8.32	2.15	223.5	30.0	16
225×110	31.2	39.72	11.8	6.5	3441.1	218.3	9.31	2.34	305.9	39.7	20
250×125	37.3	47.53	12.5	6.9	5131.6	334.5	10.39	2.65	410.5	53.5	22
300×140	44.2	56.26	12.4	7.5	8603.6	453.9	12.37	2.84	573.6	64.8	22
350X140	52.4	66.71	14.2	8.1	13630.3	537.7	14.29	2.84	778.9	76.8	22

METRIC STANDARD TABLES

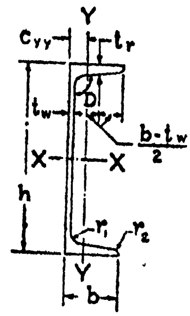
I-BEAMS (*Continued*)

Size Depth × width. h×b	Wt. per metre	Section Area	Thickness		Moment of Inertia		Radii of Gyration		Moduli of Section		Maximum size of Flange Rivet
			Flange	Web	Ixx	Iyy	Rxx	Ryy	Zxx	Zyy	
mm	kg	cm	mm	mm	cm4		cm	cm	cm4	cm4	mm
400×140	61·6	78·46	16·0	8 9	20458·4	622·1	16·15	2 82	1022·9	88·9	22
450×150	72·4	92·27	17·4	9·4	30390·8	834·0	18·15	3·01	1350 7	111·2	22
500×180	86·9	110·74	17·2	10·2	45218·3	1369·8	20·21	3·52	1808·7	152 2	28
550×190	103·7	132·11	19·3	11·2	64893·6	1833·8	22:16	3·78	2359 8	193·0	28
600×210	122·6	156·21	20·8	12·0	91813·0	2651·0	24·24	4·12	3060·4	252·5	25,32
150×100	17·0	21·67	7·0	5·4	839·1	94·8	6·22	2·09	111·9	19 0	16
175×125	22·1	28·11	7·4	5·8	1509·4	188·6	7·33	2·59	172·5	30 2	22
200×140	28·8	36·71	9·0	6·1	2624·5	328·8	8·46	2·99	262·5	47·0	22
225×150	33·9	43·24	9·9	6·4	3920·5	448·6	9·52	3·22	348·5	59·8	·22
250×200	40·9	52·05	9·0	6·7	5943 1	857·5	10·69	4·06	475 4	85·7	22·32
300×200	48·1	61·33	10·0	7·4	9821·6	990-1	12·66	4·02	654·8	99·0	22 2
350×200	56·9	72·50	11·4	8·0	15512·7	1175·9	14·63	4·03	837 0	117·6	22·32
400×200	66·7	85·01	13·0	8·6	23426·7	1388·0	16·60	4·04	1171·3	138 8	22·32
450×200	79·4	101·15	15·4	9·2	35057·6	1706·7	18·63	4·11	155[illegible]·1	170·7	22·32
500×250	95·2	121·22	14·7	9·9	52290·9	2987·8	20·77	4·96	2091-6	239·0	32
550×250	112·5	143·34	17·6	10·5	74906·1	3740·6	22·86	5·11	2723·9	299·2	32
600×250	133·7	170·38	21·3	11·2	106198·5	4702·5	24·97	5·25	3540·0	376·2	32
600×250	145·1	184·86	23·6	11·8	115626·6	5298·3	25·01	5·35	3854·2	423·9	32
150×150	27·1	34·48	9·0	5·4	1455·6	431·7	6·50	3·54	194·1	57·6	22
150×150	30·6	38·98	9·0	8·4	1540·0	460·3	6·29	3 44	205 3	60·2	22
150×150	34·6	44·08	9·0	11·8	1635·6	494.9	6·09	3·35	218·1	63·2	22
200×200	37·3	47·54	9·0	6·1	3608·4	967·1	8·71	4·51	360·8	96·7	22·32
200×200	40·0	50·94	9·0	7·8	3721·8	994·6	8·55	4·42	372·2	98·6	22·32
225×225	43·1	54·94	9·1	6·5	5279·5	1353·8	9·80	4·96	469·3	120·5	28
225×225	46·8	59·66	9·1	8 6	5478·8	1396·6	9·58	4·84	487 0	123·0	28
250×250	51·0	64·96	9·7	6 9	7736·5	1961·3	10·91	5·49	618·9	156·9	32
250×250	54·7	69·71	9·7	8·8	7988·9	2011·7	10·70	5·37	638·7	159·7	32
300×250	58·8	74·85	10·6	7·6	12545·2	2193·6	12·95	5·41	836·3	175·5	32
300×250	63·0	80·25	10·6	9·4	12950·2	2246·7	12·70	5·29	863·3	178 4	32
350×250	67·4	85·91	11·6	8·3	19159·7	2451·4	14·93	5·34	1094·8	196·1	32
350×250	72·4	92·21	11 6	10·1	19802·8	2510·5	14·65	5·22	1131·6	199·4	32
400×250	77·4	98·66	12·7	9·1	28083·5	2728·3	16·87	5 26	1404·2	218·3	32
400×250	82·2	104·66	12·7	10·6	28823 5	2783·0	16·61	5·16	1444·2	221·3	32
450×250	87·2	111·14	13·7	9·8	39210·8	2955·2	18·78	5·18	1742·7	238·8	32
450×250	92·5	117·89	13·7	11·3	40349·9	3045·0	18·50	5 09	1793·3	242·1	32

METRIC STANDARD TABLE

ROLLED STEEL CHANNELS

DIMENSIONS AND PROPERTIES

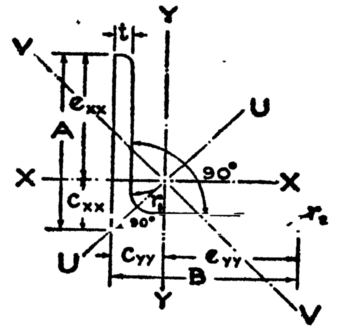


Size Depth width h×b (mm)	Wt per Metre (kg)	Sectional Area (cm²)	Thickness Flange (mm)	Thickness Web (mm)	Moment of Inertia Ixx (cm⁴)	Moment of Inertia Iyy (cm⁴)	Radii of gyration Rxx (cm)	Radii of gyration Ryy (cm)	Moduli of section Zxx (cm³)	Moduli of section Zyy (cm³)	C. G From back Y (mm)
100×45	5·8	7·41	5·1	3 0	123·8	14·9	4·09	1·42	24·8	4·8	1·40
125×50	7·9	10·07	6·6	3·0	270·0	25·7	5·18	1·[illegible]0	43·2	7·6	1·64
150×55	9 9	12·65	6·9	3·6	471·1	37·9	6·10	1·73	62·8	9 9	1·66
175×60	11 2	14·24	6·9	3·6	719·9	50·5	7·11	1·88	82·3	11·9	1·76
200×70	13·9	17·77	7·1	4·1	1161·2	84·2	8·08	2·18	116·1	16·7	1·97
75×40	5·7	7·26	6·0	3·7	66·1	11·5	3·02	1·26	17·6	4·3	1·35
100×50	7·9	10·02	6·4	4·0	164·7	24·8	4·06	1·57	32·9	7·3	1·62
125×65	10·7	13·67	6·6	4·4	356·8	57·2	5·11	2·05	57·1	12·8	2·04
150×75	14·4	18 36	7·8	4·8	697·2	103·2	6·16	2·37	[illegible]3·0	20 2	2·38
175×75	17·6	22·40	9·5	5 1	1148·4	12[illegible]·5	7·16	2·38	131·3	24·8	2·40
200×75	20.6	26·2 2	10·8	5·5	1725·5	146·9	8·11	2·37	172·6	28·8	2·35
225×90	24·0	30·53	10·2	5·8	2547·9	209·5	9·14	2·62	22[illegible]·5	32·0	2·46
250×100	28·0	35 65	10.7	6·1	3687 9	298·4	10·17	2·89	295·0	40·9	2·70
300×100	33·1	42·11	11·6	6·7	6047·9	346·0	11·98	2·87	403·2	46·4	2·55
350×100	38·8	49·47	12·5	7 4	9312·6	394·6	13·72	2·82	532·1	52·0	2·41
400×100	45·7	58·25	14·0	8 0	13989·5	460·4	15·50	2·81	699·5	60·2	2·36
75×40	6·8	8·67	7·3	4·4	76·0	12·6	2·96	1·21	20·3	4·7	1·13
100×50	9·2	11 70	7·5	4·7	186·7	25·9	4·00	1·49	37·3	7·5	1·53
125×65	12·7	16·19	8·1	5·0	416·4	59·9	5·07	1·[illegible]2	66·6	1[illegible]·1	1·94
150×75	16·4	20·88	9·0	5·4	774·[illegible]	102·3	6·11	2·21	103·9	19·4	2·22
175×75	19·1	24·38	10·2	5·7	1223·3	121 0	7·08	2·23	139·8	22·8	[illegible]·20
200×75	22·1	28·21	11·4	6·1	1819·3	140·4	8·03	2·23	181·9	26·3	2·17
225×80	25·9	33·01	12·4	6.4	2694·6	187·2	9·03	2·38	239·5	32·8	2·30
250×[illegible]0	30·4	38·67	14·1	7·1	3816·8	219·1	9·94	2·38	305·3	38·4	2·30
300×90	35·8	45·64	13·6	7·6	6362·6	310 8	11·81	2·61	42[illegible]·2	46·8	2·36
350×100	42·1	53·66	13·5	8·1	10008·0	430·6	13·66	2·83	571·9	57·0	2·44
400×100	49·4	62·93	15·3	8·6	15082 8	504·0	15·48	2·83	754·1	66·6	2·42

METRIC STANDARD TABLES

ROLLED STEEL EQUAL ANGLES

DIMENSIONS AND PROPERTIES



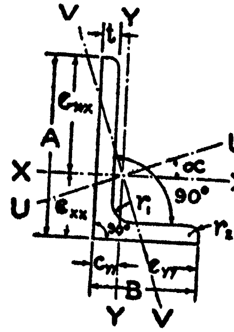
Size A×B×t mm	Wt per metre kg.	Section Area cm²	Centre of Gravity $C_{xx} = C_{yy}$ cm	Moment of Inertia $I_{xx} = I_{yy}$ cm⁴	Radii of Gyration $r_{xx} = r_{yy}$ cm	Section Moduli $Z_{xx} = Z_{yy}$ cm³
20×20×2	0·9	1·12	0·59	0·4	0·58	0.3
,, ,, ×4	1.1	1·45	0·63	0·5	0·58	0·4
25×25×3	1·1	1·41	0·71	0·8	0·73	0·4
,, ,, ×4	1·4	1·84	0·75	1·0	0·73	0·6
,, ,, ×5	1·8	2·25	0·79	1·2	0·72	0·7
30×30×3	1·4	1·73	0·83	1·4	0·89	0·6
,, ,, ×4	1·8	2·[illegible]6	0·87	1·8	0·89	0·8
,, ,, ×5	2·2	2·77	0·92	2·1	0·88	1·0
35×35×3	1·6	2·03	0·95	2·3	1·05	0·9
,, ,, ×4	2·1	2·65	1·00	2·9	1·05	1·2
,, ,, ×5	2·6	3·27	1·04	3·5	1·04	1·4
,, ,, ×6	3·0	3·86	1·08	4·1	1·0[illegible]	1·7
40×40×3	1·8	2·34	1·08	3·4	1·21	1·2
,, ,, ×4	2·4	3·07	1·12	4·5	1·21	1·6
,, ,, ×5	3·0	3·78	1·16	5·4	1·20	1·9
,, ,, ×6	3·5	4·47	1·20	6·3	1·19	2·3
45×45×3	2·1	2·64	1·20	5·0	1·38	1·5
,, ,, ×4	2·7	3·47	1·25	6·5	1·37	2·0
,, ,, ×5	3·4	4·[illegible]8	1·29	7·9	1·36	2·5
,, ,, ×6	4·0	5·07	1·33	9·2	1·35	2·9
50×50×3	2·3	2·95	1·32	6·9	1·53	1·9
,, ,, ×4	3·0	3·88	1·37	9·1	1·53	2·5
,, ,, ×5	3·8	4·79	1·41	11·0	1·52	3·1
,, ,, ×6	4·5	5·68	1·45	12·9	1·31	3·6
55×55×5	4·1	5·27	1·53	14·7	1·67	3·7
,, ,, ×6	4·9	6·26	1·57	17·3	1·66	[illegible]·4
,, ,, ×8	6·4	8·18	1·65	22·0	1·64	5·7
,, ,, ×10	7·9	10·02	1·72	26·3	1·62	7·0
60X60×5	4·5	5·75	1·65	19·2	1·82	4·4
,, ,, X6	5·4	6·84	1·69	22·6	1·82	5·2
,, ,, X8	7·0	8·96	1·77	29·0	1·80	6·8
,, ,, X10	8·6	11·00	1·85	34·8	1·78	8·4
65X65X5	4·9	6·25	1·77	24·7	1·99	5·2
,, ,, X6	5·8	7·44	1·81	29·1	1·98	6·2
,, ,, X8	7·7	9·76	1·89	37·4	1·96	8·1
,, ,, X10	9·4	12·00	1·97	45·[illegible]	1·94	9·9

Size A×B mm	Wt per metre kg	Section Area cm²	Centre of Gravity $C_{xx} = C_{yy}$ cm	Moment of Intertia $I_{xx} = I_{yy}$ cm⁴	Raddi of Gyration $r_{xx} = r_{yy}$ cm	Section Moduli $Z_{xx} = Z_{yy}$ cm
70×70×5	5·3	6·77	1·89	31·1	2·15	6·1
,, ,, ×6	6·4	8·06	1·94	36·8	2·14	7·3
,, ,, X8	8·3	10·58	2·02	47·4	2·12	9·5
,, ,, X10	10·2	13·02	2·10	57·2	2·10	11·7
75X75X5	5·7	7·27	2·02	38·7	2·31	7·1
,, ,, X6	6·8	8·66	2·06	44·7	2·30	8·4
,, ,, X8	8·9	11·38	2·14	59·0	2·28	11·0
,, ,, X10	10·3	14·02	2·22	71·4	2·26	13·5
80X80X6	7·3	9·29	2·18	56·0	2·46	[illegible]·6
,, ,, X8	9·6	12·21	2·27	72·5	2·44	1[illegible]·0
,, ,, X10	11·8	15·05	2·34	87·7	2·41	15·5
,, ,, X12	14·0	17·81	2·4[illegible]	101·9	2·39	18·3
90X90X6	8·2	10·47	2·42	80·1	2·77	12·2
,, ,, X8	10·8	13·79	2·51	104·2	2·75	16·0
,, ,, X10	13·4	17·03	2·59	126·7	2·74	19.8
,, ,, X12	15·8	20·19	2·66	147·9	2·71	23·3
100X100X6	9·2	11·67	2·67	111·3	3·09	15·2
,, ,, X8	12·1	15·39	2·76	145·1	3·07	20·0
,, ,, X10	1[illegible]·9	19·03	2·04	177·0	3·05	25·7
,, ,, X12	17·7	22·59	2·92	207·0	3·03	29·2
110X110X8	13·4	17·02	3·00	195·0	3·38	24·4
,, ,, X10	16·5	21·06	3·08	2[illegible]8·4	3·36	38·1
,, ,, X12	19·6	25·02	3·16	27[illegible]·6	3·34	34.7
,, ,, X15	24·2	30·81	3·27	337·4	3·31	43·7
130X130X8	15·0	20·22	3·50	328·3	4·03	34·5
,, ,, X10	19·7	25·06	3.58	402·7	4·01	42·7
,, ,, X12	23·4	29·82	3·66	473·8	3·99	50·7
,, ,, X15	28·9	36·81	3·78	574·6	3·95	62·2
150X150X 10	22·8	2[illegible]·03	4·06	622·4	4·63	56·9
,, ,, 12	27·2	34·59	4·14	735·8	4·61	67·7
,, ,, 15	33·6	42·78	4·26	896·4	4·58	80·5
,, ,, X18	39·9	50·79	4·38	1048·9	4·54	98·3
200X200X12	36·6	46·61	5·36	1788·9	6·20	122·2
,, ,, X15	45·4	57·80	5·49	2197·7	6·13	151·4
,, ,, X18	54·0	6[illegible]·81	5·61	2588·7	6·13	179·9
,, ,, X25	73·6	93·80	5·88	3436·3	6·05	244·3

METRIC STANDARD TABLES

ROLLED STEEL UNEQUAL ANGLES

DIMENSIONS & PROPERTIES



Size A×B×t	Wt. per metre	Section Area	Centre of Gravity		Moments of Inertia		Radii of Gyration		Moduli of Section	
			C_{xx}	C_{yy}	I_{xx}	I_{yy}	r_{xx}	r_{yy}	Z_{xx}	Z_{yy}
mm	kg	cm²	cm	cm	cm⁴	cm⁴	cm	cm	cm³	cm³
×20×3	1·1	1·41	0·98	0·49	1·2	0·4	0·92	0·54	0·6	0·3
" ×4	1·4	1·84	1·02	0·53	1·5	0·5	0·92	0·54	0·8	0·4
" ×5	1·8	2·25	1·06	0·57	1·9	0·6	0·91	0·53	1·0	0·4
×25×3	1·5	1·88	1·30	0·57	3·0	0·9	1·25	0·68	1·1	0·5
" ×4	1·9	2·46	1·35	0·62	3·8	1·1	1·25	0·68	1·4	0·6
" ×5	2·4	3·02	1·39	0·66	4·6	1·4	1·24	0·67	1·8	0·7
" ×6	2·8	3·56	1·43	0·69	5·4	1·6	1·23	0·66	2·1	0·9
×30×3	1·7	2·18	1·42	0·69	4·4	1·5	1·42	0·84	1·4	0·7
" ×4	2·2	2·86	1·47	0·73	5·7	2·0	1·41	0·84	1·9	0·9
" ×5	2·8	3·52	1·51	0·77	6·9	2·4	1·40	0·83	2·3	1·1
" ×6	3·3	4·16	1·55	0·81	8·0	2·8	1·39	0·82	2·7	1·3
×30×3	1·8	2·34	1·63	0·65	5·9	1·6	1·59	0·82	1·7	0·7
" ×4	2·4	3·07	1·68	0·70	7·7	2·1	1·58	0·82	2·3	0·9
" ×5	3·0	3·78	1·72	0·74	9·3	2·5	1·57	0·81	2·8	1·1
" ×6	3·5	4·47	1·76	0·78	10·9	2·9	1·56	0·80	3·4	1·3
×40×5	3·7	4·76	1·95	0·96	16·9	6·0	1·89	1·12	4·2	2·0
" ×6	4·4	5·65	1·99	1·00	19·9	7·0	1·88	1·11	5·0	2·3
" ×8	5·8	7·37	2·07	1·08	25·4	8·0	1·86	1·10	6·5	3·0
×45×3	4·1	5·26	2·07	1·08	22·1	8·6	2·05	1·28	5·0	2·5
" ×6	4·9	6·25	2·11	1·12	26·0	10·1	2·04	1·27	5·9	3·0
" ×8	6·4	8·17	2·19	1·20	33·2	12·8	2·02	1·25	7·7	3·9
45×5	4·3	5·52	2·27	1·04	27·2	8·8	2·22	1·26	5·7	2·5
×6	5·2	6·56	2·32	1·09	32·0	10·3	2·21	1·25	6·8	3·0
×8	6·7	8·58	2·40	1·16	41·0	13·1	2·19	1·24	8·9	3·9
×10	8·3	10·52	2·48	1·24	49·3	15·6	2·16	1·22	10·9	4·8
50×5	4·7	6·12	2·39	1·16	34·1	12·2	2·38	1·42	6·7	3·2
×6	5·6	7·16	2·44	1·20	40·3	14·3	2·37	1·41	8·0	3·8
×8	7·4	9·38	2·52	1·28	51·8	18·3	2·35	1·40	10·4	4·9
×10	9·0	11·58	2·60	1·36	62·3	21·8	2·33	1·38	12·7	6·0
50×5	4·9	6·27	2·60	1·12	40·6	12·3	2·55	1·40	7·5	3·2
×6	5·9	7·46	2·64	1·16	48·0	14·4	2·54	1·39	9·0	3·8
×8	7·7	9·78	2·73	1·24	61·9	18·5	2·52	1·37	11·7	4·9
×10	9·4	12·02	2·81	1·32	74·7	22·1	2·49	1·36	14·4	6·0

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METRIC STANDARD TABLES

NOMINAL WEIGHT OF GALVANIZD CORRUGATED IRON SHEETS

Depth of Corrugation—18 mm nominal
Pitch 75mm nominal

Class IV 375 g of Zinc (spelter) Coating per sq m. Both sides Inclusive

Thickness of Sheet			1·00 mm (20 B. G.)			0·80 mm (22 B. G.)			0·63 mm (24 B. G.)		
Weight per unit area			8·22 kg/sq m			6·66 kg/sq m			5·32 kg/sq m		
Size m×m	Area in sq m	No of corru-gations	kg per Sheet	Sheet per Bundle	kg per Bundle	kg per Sheet	Sheet per Bundle	kg per Bundle	kg per Sheet	Sheet per Bundle	kg per Bund
1·8×0·9	1·62	10	13·32	8	106·6	10·79	10	107·9	8·62	12	103
2·2×0·9	1·98	10	16·28	7	114·0	13·19	8	105·5	10·53	10	105
2·5×0·9	2·25	10	18·50	6	111·0	14·98	7	104·9	11·97	9	107
2·8×0·9	2·52	10	20·71	5	104·0	16·78	6	100·7	13·41	8	107
3·0×0·9	2·70	10	22·19	5	111·0	17·98	6	107·9	14·36	7	100
3·6×0·9	3·24	10	26·63	—	—	21·58	—	—	17·24	—	—
1·8×0·75	1·35	8	11·10	9	99·9	8·98	12	107·9	7·18	14	100
2·2×0·75	1·65	8	13·56	8	108·5	10·99	10	109·9	8·78	12	10
2·5×0·75	1·75	8	15·41	7	107·9	12·48	9	112·4	9·98	10	99
2·8×0·75	2·10	8	17·26	6	103·6	13·99	8	111·9	11·17	9	10
3·0×0·75	2·28	8	18·50	5	92·5	14·98	7	104·9	11·97	8	9
3·6×0·75	2·70	8	22·19	—	—	17·97	—	—	14·36	—	—

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