Solution

To arrive at the required elements of Eqs. (1.3) and (1.4), some calculations, with reference to Figure 1.6, are being made as follows :

$$JD = 0.4 \text{ m}, \ \frac{PK}{JK} = \frac{1}{s} = \frac{1}{5}$$

$$\therefore \quad PK = \frac{JK}{s} = \frac{6}{5} = 1.2 \text{ m}$$

$$BP = PK - KB = 1.2 - 0.4 = 0.8 \text{ m}$$

Also,
$$\frac{JD}{DC} = \frac{BP}{BC} = \frac{BP}{BD - DC}$$

$$\therefore \quad \frac{0.4}{DC} = \frac{0.8}{6 - DC}$$

which gives,

$$DC = 2 \text{ m}$$

Further,
$$\frac{IE}{EC} = \frac{1}{s} = \frac{1}{5}; \quad \text{or} \quad IE = \frac{EC}{5}$$

But,
$$EC = 6 \text{ m} + CD$$
$$= 6 + 5\,JD = 6 + 5 \times 0.4$$
$$= 8 \text{ m}$$

$$\therefore \quad IE = GH = \frac{8.0}{5} = 1.6 \text{ m}$$

Now, with reference to the overall cross-slope of the fill, we can write :

$$\frac{FH}{CH} = \frac{1}{5}$$

or
$$\frac{FH}{HE + EC} = \frac{1}{5}, \quad \text{or} \quad FH = \frac{HE + EC}{5}$$

Also
$$\frac{FH}{HE} = \frac{1}{1.5}, \quad \text{or} \quad FH = \frac{HE}{1.5}$$

Hence,
$$\frac{HE + EC}{5} = \frac{HE}{1.5}$$

or,
$$\frac{HE + 8.0}{5} = \frac{HE}{1.5}$$

$$\therefore \quad HE = \frac{12}{3.5} = 3.42 \text{ m}$$

$$FH = \frac{3.42}{1.5} = 2.28 \text{ m}$$

$$\frac{AM}{MC} = \frac{1}{1.5}, \quad \text{also} \quad \frac{AM}{MB} = \frac{1}{2.5}$$

$$\therefore \quad AM = \frac{MC}{5} = \frac{MB}{2.5}$$

or,
$$\frac{MB + BC}{5} = \frac{MB}{2.5}$$

where,
$$BC = BD - CD$$
$$= 6.0 - 2.0 = 4.0 \text{ m}$$

$\therefore \qquad x_2 = 25 - 14.13 = 10.87$ m (≈ 10.94 m)

Similarly, with reference to other point, L_2, one can write :

$$\frac{0.47}{x_3} = \frac{0.2}{x_4}, \text{ where } x_3 + x_4 = 25$$

It gives, $\quad x_3 = 17.53$ m (≈ 17.65 m) and $x_4 = 7.47$ m (≈ 7.35 m)

(Moreover, Figure 1.8 shows representative cross-sections – one in cutting and other in filling.)

Armed with the necessary data, one can next proceed to estimate the quantity of earthwork (cutting and embankment, respectively) involved in this road construction as detailed in Table 1.1 – in this Table, it is important to point out, two more chainage points (i.e. RDs), namely, 14.06 m and 167.65 m, that have been added for obvious reasons. [Each h_m is the mean of two values of h, and is entered against the end of the particular stretch.]

Table 1.1 : Calculation of Quantity of Earthwork (Bill of Quantities) – Example 1.3

b = 12.0 m; Side slope in filling, z = 2.5; Side slope in cutting, z = 2.0;

Chainage or Reduced Distance (RD)	Difference of GL and Formation		Mean Value of		Central Area ($b \times h_m$)	Two Side Triangle Areas (zh_m^2)	Total Cross - sectional Area ($b \times h_m + zh^2_m$)	Distance between Adjacent Chainage Points (l)	Quantity of Earthwork between Two Chainage Points, ($b \times h_m + zh_m^2$)	
	Depth, i.e., Cutting (h)	Height i.e., Filling (h)	Cutting (h_m)	Filling (h_m)					In Cutting	In Filling
(m)	(m)	(m)	(m)	(m)	(m^2)	(m^2)	(m^2)	(m)	(m^2)	(m^2)
0	–	0.13	–	–	–	–	–	–	–	–
14.06	0	0	–	0.065	(+) 0.78	(+) 0.010	(+) 0.790	14.06	–	11.10
25	0.10	–	0.05	–	(– 0.60)	(–) 0.005	(–) 0.605	10.94	6.61	–
50	0.09	–	0.095	–	(– 1.14)	(–) 0.018	(–) 1.158	25.00	28.95	–
75	0.17	–	0.13	–	(– 1.56)	(–) 0.033	(–) 1.593	25.00	39.82	–
100	0.30	–	0.235	–	(– 2.82)	(–) 0.110	(–) 2.93	25.00	73.25	–
125	0.84	–	0.57	–	(– 6.84)	(–) 0.649	(–) 7.489	25.00	187.22	–
150	0.47	–	0.655	–	(–7.86)	(–) 0.858	(–) 8.718	25.00	217.95	–
167.65	0	0	0.235	–	(– 2.82)	(–) 0.110	(–) 2.93	17.65	51.71	–
175	–	0.20	–	0.10	(+ 1.2)	(+) 0.025	(+)1.225	7.35	–	9.00
200	–	0.76	–	0.48	(+ 5.76)	(+) 0.576	(+) 6.336	25.00	–	158.40
225	–	0.63	–	0.695	(+ 8.34)	(+) 1.207	(+) 9.547	25.00	–	238.67
250	–	1.11	–	0.87	(+ 10.44)	(+) 1.892	(+)12.332	25.00	–	308.30
275	–	1.28	–	1.195	(+ 14.34)	(+) 3.570	(+)17.91	25.00	–	447.75
300	–	1.16	–	1.22	(+ 14.64)	(+) 3.721	(+)18.361	25.00	–	459.02
325	–	1.43	–	1.295	(+ 15.54)	(+) 4.192	(+)19.732	25.00	–	493.30
350	–	1.01	–	1.22	(+ 14.64)	(+) 3.71	(+)18.35	25.00	–	458.75
								Total	605.51	2584.29

{+indicates quantity in filling, – indicates quantity in cutting}

Assuming suitable rates for earthwork in cutting and filling, say, Rs. A and Rs. B

$= 17.06 + 5.577$

$= 22.637\ m^2$

Area ABEF (AB to 3 m above GL)

$$= 2\left\{\frac{1}{2}[2.25 + (0.795 + 2.25 + 0.795)] \times 0.53\right\}$$

$= [6.09] \times 0.53$

$= 3.227\ m^2$

Full Sectional Area at Chainage '900 m', A_{900} (Figure 1.16)

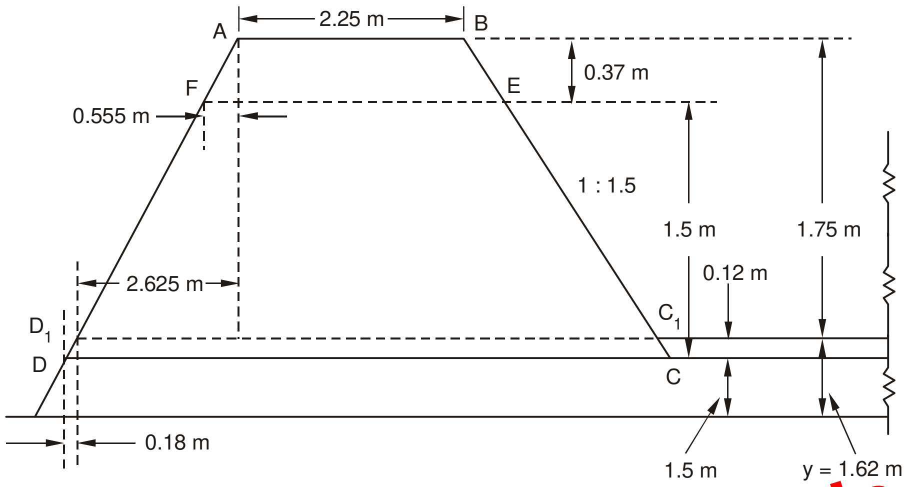


Figure 1.16 : Area Calculations at Chainage '900 m' (Example 1.3)

$= 12.468 + 1.5\ (1.75 + 1.62)^2 + (14.25) \times 1.62$

$= 12.468 + 17.035 + 23.085$

$= 52.588\ m^2$

Area ABCD (from AB upto 1.5 m above GL)

$$= 17.06 + \frac{1}{2}[19.5 + 2\ (9.75 + 0.18)] \times 0.12$$

$= 17.06 + (2.361)$

$= 19.421\ m^2$

Area ABEF (AB to 3 m above GL)

$$= 2 \times \frac{1}{2}[2.25 + (0.555 + 2.25 + 0.555)] \times 0.37$$

$= [5.61] \times 0.37$

$= 2.075\ m^2$

Full Sectional Area at Chainage '1200 m', A_{1200} (Figure 1.17)

$= 12.468 + 14.508 + 19.38$

$= 46.356\ m^2$

Area ABCD (top to 1.5 m above GL) – Figure 1.17,

$$= 2\left[(2.25 \times 1.61) + 2\left(\frac{1}{2} \times 2.415 \times 1.61\right)\right]$$

$= 2\ [3.622 + 3.888]$

Earthwork in filling under the floor is given to be 7.5 cm thick (Figure 1.23(b)). It is observed that this filling has following dimensions in plan :

Length = 5.0 – 2 (one offset between the width of plinth and width of wall)

$$= 5.0 \text{ m} - 2\left[\frac{1}{2}(40 \text{ cm} - 30 \text{ cm})\right]$$

$$= 5.0 - [0.40 - 0.30]$$

$$= 5.0 - 0.1$$

$$= 4.9 \text{ m}$$

and, Breadth = 4.0 – 0.1 = 3.9 m

With these dimensions in hand, one is ready to prepare a bill of quantities as follows :

Bill of Quantities – Earthwork (Example 1.5)

Item No.	Particulars	No.	Dimensions/Measurements			Quantity (m^3)
			L (m)	B (m)	H (or D) (m)	
1	Earthwork in excavation (by centre line method)	1	19.2	0.60	0.2	2.30
	(By Long Wall and Short Wall) Earth work in excavation : (a) Long Wall (b) Short Wall	 2 2	 5.9 3.7	 0.60 0.60	 0.2 0.2	 1.42 0.88
						Total = 2.30 m^3
2	Earthwork in filling (a) Earthwork in filling under the floor	1	4.9	3.9	0.075	1.43
	(b) Earthwork in filling in foundations	Item (1) – [Item (3) + Item (4)] = x (say)				
						Total = 1.43 + x
3	Lime concrete (LC), 1 : 3 : 6, in foundations	Can be calculated as shown in Unit 2				
4	Stone masonry in mud, below ground level (i.e. in foundations)	Can be calculated as shown in Unit 3				

SAQ 1

(a) A road has been aligned along a given direction; the relevant survey data, and also the proposed formation levels are tabulated as under :

Distance (Chainage)	0 m	30 m	60 m	90 m	130 m	150 m	180 m
NSL (Natural Surface Level)	111.87 m	111.87 m	115.62 m	114.50 m	116.31 m	113.90 m	115.20 m
Proposed Formation Level	111.87 m	111.87 m	111.97 m	112.07 m	112.203 m	112.203 m	112.203 m

Take the proposed road cross-section as trapezoidal with side slopes of 1 : 1, and the formation width equal to 7.50 m.

200			5.37		214.8
					Total = 1446.80 m^2

Abstract of Estimated Cost of Turfing

Item No.	Particulars of Item	Quantity	Unit	Rate	Per	Amount
1	Turfing on both the side slopes of embankment	1446.8	m^2	100/–	% m^2	1446.8
						Total = 1446.8
						Add 3% contingency = 43.40
						Add 3% workcharge establishment = 28.94
						Grand Total = 1519/– (say)

Other Items of Road Work

(i) Quantity of brick soling

$$= (1.5 \times 1000) \times 10 \times 0.075 = 1125 \text{ m}^3$$

(ii) Quantity of stone ballast (WB wearing coat)

$$= (1.5 \times 1000) \times 10 \times 0.12 = 1800.00 \text{ m}^3$$

(iii) First coat painting : 12.5 mm nominal size stone grit

$$= 1500 \times 10 \times \frac{1.5}{100} = 225.0 \text{ m}^3$$

(iv) Second coat painting : 10.00 mm nominal size stone grit

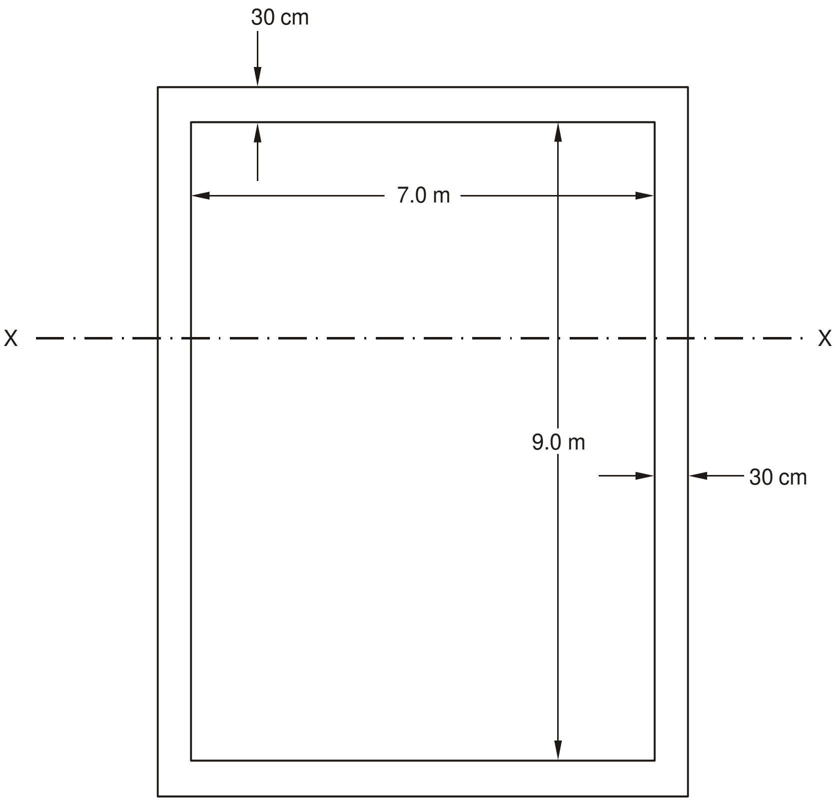
$$= 1500 \times 10 \times \frac{1.1}{100} = 165.0 \text{ m}^3$$

(v) Quantity of Bitumen = 1500 × 10 × (1.8 + 1.1)

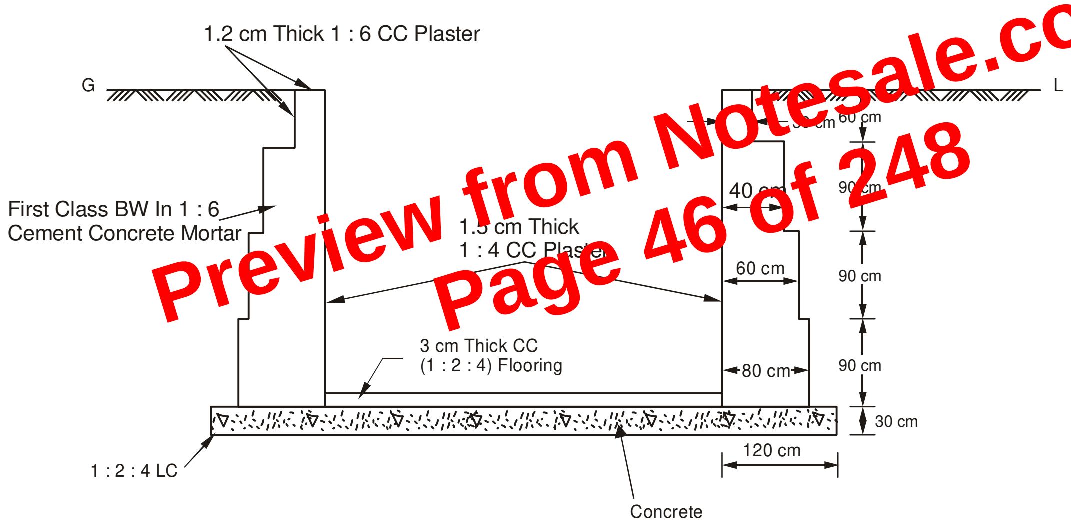
$$= 43500 \text{ kg} = 43.50 \text{ tonne}$$

(c) 3574.5 m^2 of banking and 6489 m^2 of turfing.

(d) 2582.0 m^3



(a) Plan at Ground Level



(b) Section X-X

Figure 2.1 : Underground Masonry Water Tank (Example 2.1)

Solution

It is easy to discern that lime concrete covers the whole length and breath of the full excavation, up to a thickness of 0.30 m. These dimensions – length and breadth – are worked out as follows:

Length = Internal dimension of tank + 2 (0.80) + 2 (1.20 – 0.80)

= 9.00 + 1.60 + 0.80

= 11.40 m

Breadth = 7.0 + 1.6 + 0.8

= 9.4 m

tank, and under the steps that lead from the ground level to the top of the tank that stands 60 cm above the GL. The bill of quantities can be tabulated as shown below :

Details (or Description)	Measurements			Contents or Quantity (m^3)	Total
	L(m)	B(m)	D(m)		
Lime concrete (1 : 2 : 4)					
(a) Under floor	5.0	4.0	0.20	4.0	
(b) Under steps	0.90	1.20*	0.15	0.16	4.16 m^3

* = width of steps + sum of offsets (on both sides)

= 1.0 m + (0.10 m + 0.10 m)

= 1.20 m

(*This offset is the difference of thickness of tank masonry wall between top two courses,as is clear from the Figure*).

2.2.1 General Specifications of Lime Concrete (LC) Work in Buildings

Line concreting in order to be full of desired strength, finish and workmanship has to conform to some standards formulated on the basis of experience and experiments.

If the aggregate, used, is brick ballast, it shall be soaked by profusely sprinkling with water for at least *three* hours before the layer of *surkhi* and lime is added. The materials shall be measured and mixed on a specially put up platform – and this mixture shall be free of earth, dirt, or any other foreign matter. Measuring is done by stacking the ballast etc., in rectangular layer with trapezoidal cross section – to facilitate its stability and thus ease in measuring up the dimensions.

For achieving satisfactory mixing, the materials shall be turned over, at least, three times while in dry condition; and then again thrice when wet (i.e., mixing with water). Wetting should be only enough to render it wet but not sloppy. The mixture shall be laid immediately after it is ready for use – however, it should not be thrown down into the intended position from a height. It should be laid in layers not exceeding 15 cm in thickness; and should be thoroughly consolidated (with no further addition of water) with rammer of specified weight.

Consolidation is not taken as complete until a film of pure mortar covers the surface and completely hides the aggregate, and until a stick dropped endways from a height rebounds with a ringing sound.

For a speedy and good work, mixing and ramming shall go on continuously when once started. No concrete shall be laid later than two hours before the work is stopped for the day.

A lower layer shall in each case be swept (or washed) clean prior to laying the next layer. Whenever, joints in a layer are unavoidable, the end of each layer (in one plane) shall be sloped at an angle of 30^o. Vertical joints (i.e., two joints – one in each layer) must be at least 60 cm apart horizontally.

After completion, lime concrete shall be kept wet for a period of not less than 10 days. No brickwork (or any masonry) shall be laid on this lime concrete for at least 7 days after laying (to the desired height) is complete.

Fine lime concrete shall be exactly like the ordinary lime concrete, except for : size of the aggregate, consolidation, and finish – the aggregate (brick ballast, Foundation in 1 : 2 : 4 LC

1st class brickwork in 1 : 6 cement sand mortar is plinth and foundations

Depth of almirah = 23.0 cm

Bearing of lintels over the gate is 20 cm on either side

Bearing of lintels over windows and almirahs is 10 cm on either side

Slabs in almirah shall have width equal to the thickness of wall, and a bearing of 10 cm on either side.

The rate for the sheet iron gate includes fittings.

Window shutters shall have iron fittings included in the rates.

Soil may be taken as ordinary soil, and the excavation will be paid at the rate that includes lead up to 30 m, and lift up to 1.5 m.

1st class brickwork in L.M. (lime mortar in superstructure).

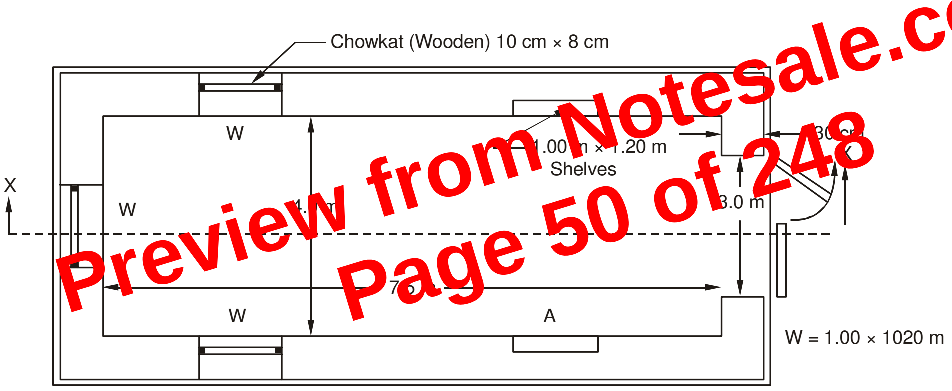
All RCC work is in 1 : 2 : 4 mix – shall be calculated in volumetric measure; its mild steel (in the absence of details) shall be taken as 1% of its cubic content. Its rate will include centering and shuttering.

LC in roof terracing (8 cm thick) shall be paid as per sq. m. measure

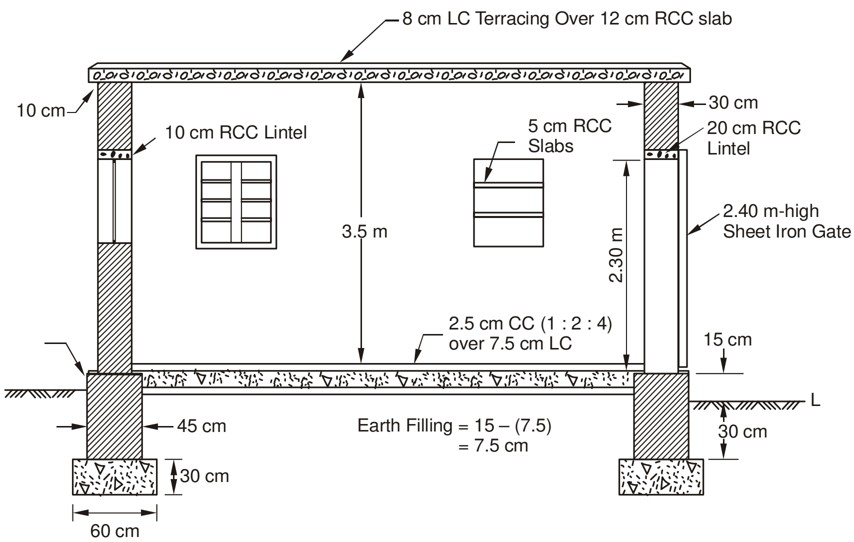
13 mm thick plaster in CM (1 : 6) inside and outside the garage

2.5 mm CC (1 : 2 : 4) floor over 7.5 cm LC together form one item of work, to be paid at the scheduled rate.

DPC shall be paid as per sq. m. measure.



(a) Plan at Window Level



(b) Section at X-X

Figure 2.3 : Motor Garrage (Example 2.3)

This process of arriving at the appropriate rate for the item is known as the *analysis of rate* or simply as *rate analysis*. Usually a profit of 10% (unless otherwise specified under special circumstances) for the contractor is allowed on all the items arranged by him (i.e., if some controlled items like, tar, steel, cement, etc. are supplied by the government, no profit falls due to the contractor).

Rate analysis bases our assessment of the overall cost on the economical use of materials, effort (labour), and processes, vis-a-vis, completing a given item of work. Sometimes, items, in addition to those covered by the contract bond, are needed to be done in the course of a project (small or big); and then rate analysis helps to work out the appropriate cost. And, it is obvious that rate analysis is the tool used to revise the schedule of rates (Departmental list of rates) from time to time due to increase in the cost of materials and labour as well as due to change in the work technology – increasing use of mechanization and automation.

Labour costs are basically (in addition to increase in wages) dependent on the *output of the labour* – progress of work (out turn) per day for various types of labour. Similarly, mechanized work costs are based on the output of various types of tools plants used in a given construction work. Generally, to the sum of material and labour costs is added 1.5% of this sum for those items of work that require addition/use of water in any way. Considering one unit (say, 1.0 m^3) of work :

Let the cost of materials for a given *unit* of work (say 1.0 m^3) = a

Cost of labour = b

Cost of tools and plants = c

∴ Total of material and labour costs = $a + (b + c)$

Add 1.5% towards charges for adding water (if any) = $\frac{1.5}{100}[a+(b+c)]$

Add 10% contractor's profit = $\frac{10}{100}[a+(b+c)]$

Grand Total Cost **= 1.115 [a + (b + c)]**

which is the rate per **unit** of the particular item, namely, 1.115 [a + (b + c)]

Knowing the well established standards regarding the required quantities of various materials, vis-à-vis, a given item of work, and the number of labour of various categories involved, one can directly determine the appropriate rates. A few examples about the materials and labour, etc. are given as under :

(a) **10 m^3 of Kankar Lime Concrete in Roof Terracing** (with 2.5 cm gauge brick ballast including raking a shallow drain on the edge if so desired).

Required Materials

Brick ballast	10 m^3
Kankar lime	4.5 m^3
Bael frint	7.0 kg
Gur	12.0 kg

Labour

ordinary concrete; and the finishing layer shall be either of the two specifications, depending on the wearing qualities that are desired.

As in all cases of concrete (*lime or cement*) *aggregates shall consist of sand and crushed stone, and shall be clean and free from crushes, dust or adherent coatings*. Obviously, aggregates take the wear and abrasion imposed on the floor.

These shall be sufficiently tough and hard. Hard fine grained granite, basalt, limestone, quartzite, etc., are particularly suitable as *coarse aggregate. All aggregates shall be clean, free from dust, and preferably angular in shape – however*, round shaped material too is in use where it is available naturally in sub-Himalayan areas (like in Kashmir, and Himachal, etc.). Deleterious materials like *mica, iron pyrites, coal or laminated flaky or elgonated particles are unacceptable.*

For granolithic finish the usual mix consists of 1 part of cement (by volume) to 2.5 parts of mixed aggregate, or 1 part of cement to 1 part of sand and two parts of coarse aggregate. For ordinary concrete finish, the usual proportion of the mix (by volume) shall be one part of cement to 3.5 parts of mixed aggregate, or 1 part of cement to 1.5 parts of fine aggregate and
3 parts of coarse aggregate. The consistency of the mixed concrete shall give a slump of about 1.50 cm. The moisture content present in the aggregate should be allowed for while determining the quantity of water to be added while mixing the mass.

The most desirable degree of adhesion between the base and the finish in monolithic construction is obtained laying the finish as soon as the base has stiffened up sufficiently to allow walking on it. In non-monolithic finish, if the finish is to laid until the hardening of the base has advanced far, a thorough preparation of the base is necessary. The surface of this sub-floor concrete shall be brushed with a stiff broom just before it hardens, to remove all laitance and loose aggregates and to roughen, the surface to improve the bond. Whenever this is not quite possible, the hardened concrete shall be roughened by chipping or by some other suitable treatment. Suitable, detergents can be used to wash off superficial oil, etc.

Screed battens carefully levelled and placed on mortar pads shall be fixed at a proper height to suit the thickness of the floor, while preparing to lay the floor. Mixed concrete is spread on the base floor or levelled with a screeding board and well compacted by floating and tamping. Flooring shall be laid in panels not exceeding 2.4 × 2.4 m. When laid on a hardened base the joints shall be left to correspond to the joints in the base.

When laying on a hardened base, alternate bays should be laid, and the intermediate bays should be filled in after a few days – allowing the bays laid first to harden up and the screening boards to be removed before the remaining bays are laid, thus preventing the adjacent bays to bond and also permitting some shrinkage to take place before a continuous surface is formed. It shall be aimed to achieve clean vertical butt joints extending through the depth of the finish.

All floated and levelled surface shall then be trowelled. Only just sufficient trowelling is to be done to render a level surface, immediately after laying. However, further trowelling shall be done when the mix has stiffened to the point where a solid well compacted surface could be obtained without bringing up the slurry. Dusting the surface with neat cement to facilitate

It is obvious that with the decrease in the thickness of walls of a room, (i.e. proceeding up from the first footing towards the superstructure) the length of a long wall decreases, whereas the length of a short wall increases in accordance with the breadth (or, thickness as it is generally designated). At the plinth level, the length of long wall = the length of the room (wall to wall, i.e. inner dimension plus twice the wall thickness; and the length of short wall = width of the room (inner dimension). If the thickness of the walls is different, the dimensions are reckoned accordingly.

Example 3.1

A 20 cm brick wall (of a 4.8 × 3.30 m hut, having one door opening 1.5 × 2.5 m) has directly a beam built on a 30 cm thick plinth which goes 20 cm below ground level and remaining 50 cm above ground. Under this plinth there lie two footings – 40 cm, and 60 cm thick (i.e., wide), respectively, while their respective heights are 10 cm and 20 cm. The LC is 100 cm wide and 20 cm deep.

All this brickwork has been erected on LC 1.0 m thick (i.e., wide) and 20 cm deep.

Draw the cross-section of the wall and the foundation (to an enlarged scale) and also the trench plan, superimposed with the plan for footings, plinth and wall.

Calculate the following items of work by Long- and Short-wall method (as well as by centre line method) :

(a) Earthwork in excavation,

(b) LC in foundation,

(c) Brickwork in first two footings,

(d) Masonry in the plinth,

(e) Masonry in superstructure.

Take the height of the hut form the plinth = 3.5 m.

Solution

[**Note :** *The student shall draw the figures: section and plan as asked for and check the dimensions therewith as worked out in this solution.*]

The following Table presents the quantification of the required items by Long- and Short-wall procedure :

Quantification of Items

Sl. No.	Items	No.	Dimensions			Quantity	Remarks
			L (m)	B (m)	H/D (m)	(m^3)	
1.	Earthwork in excavation						
	(i) Long walls	2	6.0	1.0	0.70	8.4	
	(ii) Short walls	2	2.5	1.0	0.70	3.5	
					Total	**11.9 m^3**	

Table 3.1 : General Specifications and Classifications of Single Storey Residential/Office Buildings

Item of Work	1st Class Building	2nd Class Building	3rd Class Building
Concrete in Foundations	LC or CC	LC	LC
Brick masonry in foundations and up to plinth top	1st class BW in lime or cement mortar	1st class BW in lime mortar	2nd class BW in lime mortar
DPC (Over plinth top)	Shall consist of CM (1 : 2) for 2.0 cm thickness; and, for 2.50 cm thickness it shall be 1 : 1.5 : 3 CC with 3.5 to 5.0 % (by weight) of suitable water proofing material.	Shall consist CM (1 : 2) of 2.0 cm thickness with 3.5 to 5.0 % (by weight) of suitable water proofing material.	No DPC may be provided at all, or very ordinary type be made (i.e. just nominal one).
Superstructure	It shall consist of 1st class BW with lime or cement mortar.	1st shall be of 2nd class BW in mud mortar, except for the use of LM (lime mortar) in sills, pillars, etc.	Only 2nd class BW in mud mortar shall be used.
Roofing	Roof shall comprise RCC slab with an insular layer and LC terracing over it. Thickness of RCC beams (if any as per design provisions) shall not be less than 30.0 cm.	Flat terraced roof shall be provided that is supported over wooden battens and beams. Or, a reinforced brick (RB) roof shall be provided; or Jack arch roof (in BW) shall be given with usual terracing. Verandah roof shall consist of tiles or asbestos cement (AC) sheeting.	Tile roofing or galvanized iron (GI) sheeting is provided on ordinary beams. Sometimes mud over planks, or bricks on planks supported by ordinary wooden beams is given.
Flooring	Flooring for drawing and dining room, bath room and WCs shall be of mosaic (chips in appropriate CM). For bed rooms, flooring shall be coloured and polished – 2.5 cm CC over 7.5 cm LC Other floors in the building (say, passages, store rooms, etc.) shall be without colour (2.5 cm CC over 7.5 cm LC).	For all inside floors (i.e., other than verandah) flooring shall consist of 2.5 cm CC over 7.5 c.m LC. Verandah floor shall be of bricks – flat over LC. These shall be finished with cement pointing.	Brick-on-edge floor directly over well-rammed earth.

Sl. No.	Description	No	Measurements L (m)	B (m)	H/D (m)	Quantity (m^3)
(1)	*First class BW in plinth and foundations, in 1 : 6 CM*					
	(a) By centre-line method	1	24.2	0.45	0.45	4.90 m^3
	(b) By L-S wall method					
	LW	2	8.25	0.45	0.45	3.34
	SW	2	3.85	0.45	0.45	1.56
					Total	4.90 m^3
(2)	*First class BW in lime mortar, in superstructure*					
	(a) By centre-line method	1	24.2	0.3	3.53	25.63 m^3
	(b) By L-S wall method					
	LW	2	8.1	0.3	3.53	17.16
	SW	2	4.0	0.3	3.53	8.47
					Total	25.63 m^3
Deductions [Some of the following items have already been done in the solution to Example 2.3] OPENINGS						
	Windows	3	1.2	0.3	1	1.08
	Almirahs	2	1.0	0.23	1.2	0.55
	Gate opening	1	3.0	0.3	2.3	2.07
	(Neglecting Almirah shelves that go into the masonry) LINTELS					
	Over gate opening	1	3.4	0.3	0.2	0.2
	Over Windows } Over Almirahs	5	1.2	0.[illegible]	0.[illegible]	0.18
					Total Deductions =	4.08 m^3
					Net BW in superstructure	= 25.63 (–) 4.08
						= 21.55 m^3

(b) Double-line plan, above the plinth level (say, at window level) is shown in Figure 3.8; calculations, explaining its various dimensions, are given below (for the student, to apply his/her mind to) in order the student correlates the same with the plan layout :

1	7.3 + 0.2 = 7.5
2	8.8 + 0.2 = 9.0
3	8.1 + 0.2 = 8.3
4	0.8 + 0.2 = 1.0
5	3.7 – 0.2 = 3.5
6	3.0 – 0.2 = 2.8
7	2.5 – 0.2 = 2.3
8	1.6 – 0.2 = 1.4
9	1.9 – 0.2 = 1.7
10	1.4 – 0.2 = 1.2
11	1.3 – 0.1 + 0.1 = 1.3

12	1 + 0.2 = 1.2
13	2.1 – 0.2 = 1.9
14	1.4 –0.2 = 1.2
15	3.0 –0.2 = 2.8
16	9.00 – 0.4 –3.5 = 5.1
17	4.3 – 0.2 = 4.1
18	Passage ⇒ 1.7 + 0.2 + 2.3 = 4.2
19	Verandah ⇒ (a) 3 – 0.2 + 0.2 = 3.0 1.2 + 0.2 + 3.5 + 0.2 = 5.1

Collar-beam roof is a variation of the couple close roof where a greater headway is required, the tie beam being raised half way up the rafters. However, it is a bad form of construction as the rafters bend in the middle and the thrust is borne by the walls. The situation can be improved by adding a tie beam or tie rod at the foot of rafters. This roof could be used only for small buildings not exceeding ***5.5 m in span.***

King post roof (truss) has a frame work consisting of rafters, king post, struts and tie beam known as ***King Post Truss***. These are used for spans up to 9.0 m (30 ft). In this truss, rafters are supported at the middle by means of props (termed braces or struts) – thus, their effective spans being reduced to half. Thus, the rafters are able to bear twice the load that these could carry otherwise. The heads of the struts are *tennoned* into the rafters and their feet into the foot of the king post. In order to guard against any cross strain coming under the rafters, the heads of the struts shall be fixed almost immediately near the purlins.

Queen post roof (truss) is best suited upto a span of about 14.0 m (≈ 45 ft). If the span is more than 9.0 m, the tie beam shall require more than one support – this is provided by means of two *Queen* posts. The queen posts, between them, carry about two-thirds of the weight of the tie beam and any addition of load brought upon the tie beam. The heads of the queen posts are kept apart by a straining beam and this feet are tennoned into the tie beam and prevented from moving inwards by a straining sill.

For spans greater than 14.0 m, roof trusses shall be designed by various combinations of posts and struts – however, then steel trusses prove economical.

Once the pitch (inclination of rafters to vertical) is known, the length of principal rafters can be ascertained by drawing the arrangement on a sheet. For too long rafters, it is appropriate to divide them into portions about 2.5 m (8 ft) long, placing a strut under each point of division. In actual practice, trusses shall be set up along the building, about 2.5 m to 3.00 m apart, and across these trusses (principals) are laid purlins, which fix them to their positions.

First a full-size truss diagram (as per drawing) shall be drawn on a levelled platform. From this full-size diagram, templates of all joints (as for tennons, mortices, scarfs etc.) shall be made to be used in guiding the fabrication work. Templates of corresponding truss members shall also be made – plate holes for screws and bolts shall thereafter be marked on these and drilled. These templates shall later be laid on wooden members, and the holes for screwing and bolting marked on them. The ends of the wooden members shall also be marked for the purposes of cutting. The base of RCC columns and the position of anchor bolts shall be carefully set out. Individual truss members must be first (before the final fabrication) assembled together to ensure close abutting or lapping of the surfaces of these various members.

After the trusses are fabricated, these shall be hoisted and placed in position very carefully. Trusses shall be screwed to walls by means of holding down bolts – hoisting having been done by using hoisting equipment. Trusses shall be stayed temporarily till these are finally secured permanently in position, and then purlins shall be laid connecting the trusses with each other.

Metal forms (if used) shall comprise shaped steel sections, like as channels, etc. They should be at least 3.0 m in length for tangents and for curves having radius 45 m and above. Smaller pieces upto 1.5 m can be used for curves having radius less than 45 m. The depth of the forms shall be the same as the thickness of the slab – using adequate number of bracing pins or stakes to prevent any displacement of forms due to pressure of the concrete slab or impact of tamper, etc.

Forms shall be set to the exact alignment (and grade) at least 30 m in advance of the point where concrete is to be deposited. Before the setting of forms, these shall be thoroughly cleaned. After setting is done satisfactorily, forms should be thoroughly oiled prior to placing concrete against them. Forms, when in place, must be subject to checking, and correction of alignment and grade from time to time. It is important that forms shall be rigid: an essential condition for the even running of the intended finished surface.

No forms shall be removed until at least 24 hours have elapsed after the placement of concrete against them; and every care shall be taken while removing them ensuring no damage to concrete. Forms need be cleaned thoroughly before any reuse. [All the considerations discussed in Section 2.5.2 about formwork do apply along with the points discussed ***herein***.]

Where metal forms are used, all bolts and nuts (that go with this arrangement) shall be counter sunk, and well ground to provide a smooth, plain surface.

Chamfers, bevelled edges and mouldings shall be shaped in the form itself. Openings for fan clamps and other such fittings shall be provided in the shuttering as required. As far as possible the clamps shall be used to hold the forms together – wherever the use of nails is unavoidable, minimum number of nails shall be used, and these shall be left projecting so that these can be withdrawn easily. Use of double headed nails should be preferred.

For special type of locations – for tall structures, etc. – the use of moving/climbing forms shall be resorted to.

In long spans, suitable camber shall be given to the horizontal members – to counteract the effects of deflection under dead load, etc. Assembly of the formwork shall be so done as to allow the desired camber to the provided – say, bottom boards of beams require a camber of about 6.0 to 7.5 mm for a span of 1.5 m, i.e. $1/24^{th}$ of the spans, i.e., about 4 to 5 mm per meter (1 in 250). For cantilevers, camber at free end shall be $1/50^{th}$ of the projected length or so.

Temperature and humidity of air, and the nature of stress to which a member is subjected to (direct compression as in columns; flexure as in beams and slabs), and the relative proportions of dead and live load – all do influence the time required to keep the formwork in position. In cold (wet) whether, hardening of concrete is retarded and the forms must be kept in position a little longer. Also, wherever bending stresses (flexure) do occur, (as in slabs and beams) forms are kept longer than where direct compression acts (generally columns). Moreover, if the ratio of dead load to live load is quite high, the member has to bear a greater proportion of load

	(i) Planks (2.5 cm thick)	1	5.75	5.25	0.025	0.755 m^3	
	(ii) Beams (10 × 4 cm) – each is 5.5 m long, and their total number is 4 (one on each centre line in the plan)	4	5.50	0.10	0.04	0.022m^3	
	(iii) Ballies (10 cm ϕ)	16	4.1	0.008 m^2	–	0.525 m^3	
	(iv) Lateral supports (10 × 5 cm @ 1.2 m c/c)	36	1.2	0.1	0.05	0.006 m^3	
	(v) Base plates (30 × 30 × 5 cm)	16	0.30	0.30	0.05	0.072 m^3	
							1.38 m^3
	(vi) Pairs of wedges (This minor item can be expressed in numbers)	16				16 Nos.	16 Nos.
2.	*Woodwork for one RCC beam formwork*						
	(i) Planks						
	(a) Side plank	2	5.5	0.025	0.355	0.0986 m^3	
	(b) Bottom planks	1	5.5	0.30	0.025	0.04 m^3	
	(ii) Laterals (5 × 4 cm) @ 0.9 m c/c	14	0.38	0.05	0.04	0.011 m^3	
	(iii) Tapering blocks on base beams – 23 × 5 × 7.5 cm. (the last dimension is perpendicular to paper)	10	0.23	0.075	0.05	0.0086 m^3	
	(iv) Base beams (10 × 7.5 cm) @ 1.2 m c/c	5	0.48	0.10	0.075	0.018 m^3	
	(v) Struts (below base beams) – 5 × 5 cm, 0.30 m long	10	0.3	0.05	0.05	0.0075 m^3	
	(vi) Ballies (10 cm ϕ)	5	3.67	0.008 m^2	-	0.15 m^3	
	(vii) Base plate (30 × 30 × 5 cm)	5	0.3	0.3	0.05	0.023 m^3	
	(viii) Blocks (a minor item – allowing, say, 0.03 m^3)	-	-	-	-	0.03 m^3	
							0.39 m^3
	(ix) Pair of wedges	5				5 pairs	5 pairs
3	*Column (one) woodwork for its formwork*						
	(i) Planks (2.5 cm thick)						
	(a) In *x*-direction	2	4.25	0.3	0.025	0.064 m^3	
	(b) In *y*-direction	2	4.25	0.35	0.025	0.074 m^3	

(c) Woodwork in eaves boards, and barge boards,

(d) Area of tiled roof,

(e) GI sheet eaves gutter, and

(f) Concrete bed blocks.

6	*1 : 2 : 4 mix concrete bed* – providing and laying as per specifications *(there being 5 trusses)*	2 × 5	0.60	0.50	0.19	0.57 m^3
					Total	= 0.57 m^3

[**Note :** After working out the cost (for any given set of rates for various items), one can express the cost of this roofing per 10 m^2 of the area covered.]

Example 4.4

A galvanized corrugated iron roof is to be installed over eight trusses, from end-to-end of the godown shed (Figure 4.4). The roof covering will be 22 BWG galvanized iron with 20.5 cm gutters at the eaves.

(a) ⇒ $6 \times 35 = 210$ Nos. of 2.1 m × 0.81 m

(b) ⇒ $2 \times 34 = 68$ Nos. of 3.0 m × 0.81 m

[**Note :** 34.5 has been rounded off to 35 – so 35 and 34 numbers are a little arbitrary; and one can always calculate exactly as per given drawings.]

The bill of quantities of various items of the truss is prepared as given below :

Bill of Quantities of Steel Truss – Example 4.4

Sl. No.	Description of Item	No.	Measurements			Quantity
			L (m)	B (m)	H/D (m)	
1.	***Steel in one truss***					
	(i) T. S. Rafters (100 × 65 × 10 mm) @ 12.2 kg / m	2	90	–	–	219.60 kg
	(ii) Brackets for gutters (L. S. 50 × 50 × 6 mm) @ 4.5 kg/m [Straight portion = 30 cm; curved portion = $\pi \times \left(\frac{20.5}{2}\right) = 32.2$ cm. Total Length = 62.2 cm.]	2	0.622		–	5.60 kg
	(iii) Knees (LS – 60 × 60 × 10 mm) for purlins, @ 8.6 kg/m [length = 100 mm = 0.1 m, to fit on TS rafter.]	2 × 6	0.1			10.32 kg
	(iv) Tie rod (F.B – 60 mm ×10 mm), @ 78.5 kg/m^2	1	15.2	0.06		71.60 kg
	(v) Sloping FB – (4) in the *legend* – 60 mm × 10 mm), @ 78.5 kg/ m^2	2	2.29	0.06		21.57 kg
	(vi) FB (60 mm × 10 mm) – (5) in the *legend* – @ 78.50 kg/ m^2	2	2.44	0.06		22.98 kg
	(vii) FB (60 mm ×10 mm) – (6) in the *legend* – @ 78.50kg/ m^2	2	3.35	0.06		31.56 kg
	(viii) FB (60 mm × 10 mm) – (7) in the *legend* – @ 78.50 kg/ m^2	1	2.67	0.06		12.58 kg
	(ix) TS vertical struts (80 × 80 × 8 mm) – (8) in the *legend* – @ 9.6 kg/m	6	1.30	–		74.88 kg
	(x) Foot plates (10 mm thick) @ 78.50 m^2	2 × 2	0.45	0.50		70.65 kg
	(xi) Gusset plates, 10 mm thick, @ 78.50 kg/ m^2					
	Item 9 in the *legend*	1	0.38	0.23		6.86 kg
	Item 10 in the *legend*	1	0.30	0.20		4.71 kg

(a) Explain how trusses are more economical and efficient than load bearing beams?

(b) Under what conditions are pitched roofs recommended for buildings? Which regions in our country go in for trussed roofs?

4.6 SUMMARY

Trusses (timber and steel) have their own general specifications for their appropriate construction and erection, as have various formworks required for RCC items to be constructed. These specifications also guide the designer and an estimator to classify various items of these works to be paid appropriately as per the rates of payment arrived at prior to any exercise in estimation. Specifications clearly lay down the methods of measurement and the relevant units to be adopted.

It is always advantageous to work out the required dimensions (if not directly available from drawings or written data) of an item to make the procedure of preparing a bill of quantities a pleasant exercise, and avoid any ambiguities, doubts or confusions.

4.7 ANSWERS TO SAQs

Refer to relevant preceding text in the Unit or other useful books listed in section 'Further Reading' to get the answers of SAQs.

samples) – its all sides and edges shall be finished in a thoroughly workman-like manner. Also, wherever, the work is to fit into each other, or to move on a hinge, a fine workmanship shall be applied to impart a good fit. The rate should be for the finished work fixed in position, including material, and two coats of paint.

Second Class Ironwork (also known as second class forged work) shall consist of all ordinary forged work weighing more than about a kilogram. This class of work comprises all works, such as, grills, gratings, railings, etc. It also includes parts of trusses (like tie bars) in which labour has been expended on forging. Further, steel or iron record racks can be included in this class of work although no forging is called for here, because of the light sections involved and the complexity of the work. Workmanship shall be such as to give the exact dimensions of the item – and all bars must be a full fit in the hole through which these pass or in which these are fixed. In making grated doors or window-gratings for, say, jail, other buildings, the ends of square bars shall not be reduced to a section less than that which will just allow their insertion into a circular hole of diameter equal to the side of the bar. When placed in position in its frame, before rivetting, the end of each bar must project to a length equal to the diameter of this hole, to admit of a proper rivet head being formed. The rate of payment is for finished work fixed in position that includes material and one coat of paint.

Cold ironwork (also known as unforged ironwork, or third class ironwork) shall consist of all work on which no labour has been expended on forging, but only on cutting to length, filing the ends, drilling and fitting. It includes all portions of trusses and railings which are not forged and *includes the preparation of reinforcing for cement concrete or reinforced brickwork*. The only exception is steel or iron record racks, which will be paid for as second class ironwork (as said earlier) on account of their light section.

Reinforcing bars (falling under cold ironwork class) shall be bent exactly to size as shown in the drawings (and in bar bending schedule) – with correct curvature and without damaging the bar in any way. Laps shall not be inserted (unless expressly allowed) in bars less than 4.25 m in length – and where allowed shall be paid for as a single length of bar.

The rate for cold ironwork is for work fixed in position including material, and includes two coats of paint, *except in the case of ironwork required for reinforcing* (which is included in the rate for RCC work, per m^3 of RCC work. In fact, either, to reiterate, an RCC work is taken as one item which includes concreting, centering and shuttering, and mild steel reinforcement; or all the three components are measured and paid for separately). The rate for reinforcing (if, sometimes, paid for separately) shall provide for the bars, their bending and placing in positions, and includes wire and tying with wire. It also allows for removing of loose scale and rust but the bars *shall not be oiled or polished in anyway*.

However, the construction agency (say, a contractor/firm) has to know about the actual, and exact dimensions (diameter, and length) of bars, their shape, and number of each description so as to provide the required reinforcement at site. After designing on RCC work, its bar bending schedule is prepared for reference – calculations are based on actual (as per design) requirements including permissible overlaps, hooks, cranks, etc. *No deductions are to be made in the volume of the concrete that may occur due to the presence of reinforcement. Bending wire is included* in the steelwork, and separate measurements are made for the same.

connecting bolts shall be paid for separately as cold ironwork, on the basis of the actual weight of material used in them.

In structural steel work (say, on bridge construction, etc.) all plates, bars and sections must be carefully levelled and straightened by pressure and not by hammering, before and after these are worked upon. All drilling, punching and rivetting shall be done in accordance with the general specifications for iron and steel work.

All steel work intended to be rivetted or bolted together, shall be in contact over the whole of the surface. In revitted work, all parts in contact shall, before assembling, be painted on each surface with one heavy coat of pure *red oxide* freshly ground in pure double boiled linseed oil, and the surfaces brought in contact while still wet. All members, when built, shall be true and free from twists, kinks, buckles or open joints between component pieces.

Trusses shall be drawn out to full size on a level platform, a steel tape and an accurate square being used for laying out. The members shall be drawn in, and the joints arranged as shown in the drawings. Wooden templates shall be made to correspond to each member and plate in the truss, and rivet holes drilled accurately into them.

The rate in truss work (or any structural work) is with reference to the item fixed in position, cleaned, finished and painted with one coat of paint – and includes material, etc.

Rainwater Pipes

Down pipes (for rain water) shall be provided to all the buildings taller than one storey, and in case of all walls that are unprotected by a varandah. Rain water pipes shall be of cast iron in 6 feet lengths (say, 1.8 to 2.0 m), with socket joints and shall have lugs cast on for fixing. Rates shall cover proper cast shoes and heads as well as cast branches, bends and iron nails (supply and fitting). *A general thumb rule apportions each size to a pipe as to provide one square cm of bore per 6.65 m² of roof area drained* (*i.e. one square inch per 60 square feet*), *but no pipe shall be less than 7.5 cm in diameter*. The spacing shall be so arranged (depending on the position of openings in the wall) as to be about 7.5 m.

The pipes shall be fixed by bolting the lugs to proper iron stirrups or hold fasts of a flattened U-shape. The head shall be flat and of the same size as the lug and shall have holes to correspond with those in the lug. The legs of the stirrups shall have splayed ends and at least 15 cm must be embedded in the wall. *The stirrup must be fixed so as to hold the pipe about 2.5 cm from the wall in order to facilitate painting*.

The rate of payment includes the outside and inside pipes as well as fitting and fixtures with two coats of paint. The paint shall be such as will resist the bitumastic coating with which these come from the manufacturers.

Unless otherwise specified, for pent roofs, gutters shall be provided, semi-circular in shape, and of twice the diameter of the down pipes. Gutters shall be made of 18 gauge galvanished iron sheet, properly fashioned and laid at a slope of 1 in 120 (10 cm in 12 m). Where gutters do not run straight, the slope shall be doubled. The rate for gutters shall include all supports (or WI brackets, and nozzles, stop ends, angles or returns).

Roof Ventilators

Roof ventilators shall be made of 22 gauge iron sheet. If made from ungalvanised sheet these shall, on completion, be painted with two coats of bitumastic solution, after removing all scale and dirt. The cylinder shall be about 23 cm in diameter and project 15 cm above the surface of the roof when fixed. The canopy shall be a cone – it shall be fixed to the cylinder by flat iron bars so that the base of the cone is level with the top of the cylinder. This block shall be given two coats of hot creosote or solignum – and shall preferably be fixed in place in the centre of the roof. The opening between the cylinder and the cone shall be closed with galvanised iron webbing to prevent the ingress of birds and wasps. The wire-gauge shall be in continuation of the cylinder and fixed to the flat iron bars holding the canopy.

The rate shall cover providing the ventilator complete with cylinder, canopy, supports, wire-gauge, and base block (wood or CC), and fixing all (complete in all respects), on the roof. *The unit of measure shall be by number*.

"Click" Hooks

It is appropriate to build in iron "*click*" *hooks* into the inner face of all the exterior varandah walls, at a level 5 cm above the top of lintels or arch openings – *this shall be done whilst the work is in progress and shall not be driven after the completion of the wall*.

The hooks shall be made from 10 mm diameter rods. The end to be inserted into the wall shall be ragged or splayed, and shall be of such a length as to allow of at least 15 cm being inserted into the wall. The projecting lug shall stand out 2.5 cm from the finished face of the wall or plaster and shall be about 4.00 cm deep. *All hooks must be placed in a straight line, and the projections and depths must be uniform throughout*.

5.2.8 Measurement of Steel and Ironworks

The procedure for the measurement of steel and ironworks is laid down in IS 1200 : Part VIII.

The dimensions (excepting cross-section and thickness of a plate) shall be measured to the nearest 0.001 m except for reinforcement which shall be measured to the nearest 0.005 m. Areas, excluding cross-sectional measurements, shall be worked out to the nearest 0.001 m^2. Weights shall be worked out to the nearest *one kg*. Mill tolerance shall be ignored when weight is determined by calculation. Priming coat shall be described and included in the item of fabrication.

Steel work shall be measured by weight in the absence of any other instructions. Various items of steel work shall be classified and measured separately under various categories – each classification being fully described. Bolted, rivetted, and welded structures shall be described separately.

If not specified otherwise, weight of cleats, brackets, packing pieces, bolts, nuts, washers, distance pieces, separators, diaphragms, gusset plates (*for which overall square dimensions shall be considered*, and not the actual polygonal shapes), fish plates, etc. shall be added (as a percentage of total weight of the work or on the basis of actual numbers) to the weight of the respective items. In rivetted work, allowance shall be made for the weight of rivet heads. *No deductions shall be made for bolt holes* (excluding holes for anchor or holding down bolts).

measured in the clear. *What is of essence, herein, is that the grading between these limits shall be such, as to produce a dense concrete of the specified proportions and consistency.* **In the preparation of a special grade concrete, the "Fineness Modulus" method shall be used for determining the limits for fine and coarse aggregates, to produce the densest concrete with the materials available.**

5.3.1 Proportioning and Mixing of Cement Concrete

Cement concrete shall be prepared by mixing the appropriately graded aggregates with cement in specified *proportions* with the *necessary* quantity of water. The grading and quantity shall be such as to give maximum compressive strength of 140 kg/cm^2, and 210 kg/cm^2 at 7 days and 28 days, respectively, for 1 : 2 : 4 mix. Sample testings shall be carried out as per laid down norms.

Proportioning shall be done by weight. However for minor works proportioning by volume may be allowed. Boxes of 35 × 25 × 40 cm usual size shall be used as measuring devices for sand and coarse aggregate (usually called only *aggregate*) in day-to-day construction work. The unit of measurement for cement shall be a bag of 50 kg (= 0.0347 m^3); and while measuring the aggregate, shaking, ramming or heaping shall not be done. Proportioning of sand shall be on the basis of its dry volume – for damp sand, allowance for bulking has to be made.

For hand mixing of the material – a smooth, water tight, clean platform of suitable size shall be chosen. Measured quantity of sand shall be spread evenly, and cement shall be poured on the sand and then distributed evenly over this sand – mixing shall be done intimately with spade, turning the mixture over and over again till one gets an even, uniform colour throughout the mass, free of all streaks. Over this (spread out) mass of sand and cement, a measured quantity of coarse aggregate shall be spread evenly – or, one can first spread the coarse aggregate, and then spread sand-cement even mix over it. This shall now be mixed (with spade/shovel) at least three times – turning over from centre to side, then back to the centre, and again to the sides. About three quarters of the total quantity of water (as per mix design) shall be added while the material is turned in towards the centre. Rest of the water quota shall be added slowly while the whole mixture is turned over and over again – achieving a uniform mix, uniform colour, and the desired consistency throughout the mass. *When an increase or decrease in strength is desired, the quantity of cement be varied as per requirement* – the proportion of aggregates remaining unchanged. For quicker pace of work and to prepare quality concrete machine batching and mixing is being done almost everywhere these days.

The amount of water to be used in the mix depends on the desired consistency – however, it shall not be more than 34 litre (for 1 : 3 : 6 mix) per 50 kg of cement; for 1 : 2 : 4 mix, it shall not be more than 30 litre; not more than 27 litres (for 1 : 1.5 : 3 mix); and not more than 25 litre for 1 : 1 : 2 mix. For vibrated concrete the limit for water quantity is decided with reference to avoiding segregation. However, regular slump tests (as per IS Codes) shall be carried to monitor the requirement of water for each specific item of work. As a rough guide following slump values meet the requirements.

Sl. No.	Description of RCC Work	Acceptable Slump
1.	Mass concrete, rammed	1.27 mm to 2.54 cm
2.	RCC slabs	5.00 cm to 10.00 cm
3.	RCC beams and columns	5.00 cm to 10.00 cm (according to the difficulty involved in placing)

workmanship in the construction of a given piece of masonry; and, also it conceals cheap/unsound quality of material used in building up the masonry. It is only after plastering that an appropriate base is ready to further decorate the surface by white-washing, colour-washing, distempering, or painting. Plastering is done to both the surfaces of a wall one, on the external face, and, secondly, on the internal face. External plastering is also referred to as "*rendering*". Its other (rather main) purpose is to improve the resistance of the surface to the penetration of rainwater, and to other environmental influences like temperature, and humidity changes.

Plaster is a sort of mortar obtained by mixing and working together materials like cement, lime, clay, or any special substance, with fine aggregate (sand), and water.

6.2.1 General Specifications of Plastering

Lime Plastering

The mortar shall be of the specified mix say, 1 : 7 : 12 (by volume) mix of cement, lime and sand, for inside plaster; 1:1:6 (by volume) mix of cement, lime and sand for outside plaster; and, for arrises of all corners and door and window jambs the mix may consist of 1 : 3 (by volume) cement and sand.

In the work of *surface preparation*, all the joints shall be raked out thoroughly; and all loose material – dust and masonry mortar or mud of kaccha brickwork – shall be brushed off. All efflorescence shall also be removed. Raking shall be done with a hook (not hammer, etc.) to a depth of 1.25 cm (say, ½ inch). It is easier to rake out the joints before the masonry mortar has set. After raking is done, and loose material washed off by water, the surface to be plastered shall be watered for 24 hours before the plaster is applied. If any chemical retarder has already been applied to the formwork, the surface should be roughened by wire brush – leaving no retarders behind on the surface. All putlog holes shall be filled up in advance of the plastering work as the scaffolding is being taken down.

Ceiling plasters shall be done before the wall plastering is begun. Plastering on the walls shall be started from the top and worked down towards the floor.

All lime used shall be well slaked stone lime. Slaking shall be done by sprinkling water slowly on the burnt lime, which must be spread out on a dry brick platform in a 15 cm layer (all these procedures apply also to LC in foundations, etc.). *No more water shall be used than is sufficient to convert it to a fine powder*. After slaking, lime shall be left in a covered shed for a day or two before screening.

Lime that is to be used in conjunction with cement for the purpose of making mortar, shall be ground dry. Stone lime shall be measured by weight. Unslaked lime shall only be measured when freshly burnt. Sand used in the mix shall be clean, *gritty to the touch* and free from any admixture of clay, loam, salts, organic matter etc. The sand shall be of such a degree of cleanness that when a handful of it is shaken in a glass with clean water and allowed to stand for one hour, the precipitation of mud, etc. on the sand shall not exceed 10 percent.

Measurements shall be done as described for plastering. Various types of pointing shall be measured separately, stating the proportions of materials. Pointing on different types of surfaces shall be measured separately. All payments shall be as per m^2 of the area covered.

In case of repairs, pointing in single detached joints, or for flashings shall be measured in running metres.

If necessary, raking out of joints shall also be measured in m^2, or otherwise included in the overall rate of payment.

Deductions shall be done as for plastering.

6.4 WHITE WASHING, COLOUR WASHING AND DISTEMPERING

White-wash is prepared from white stone lime (i.e., pure fat lime) or shell lime. This unslaked lime is immersed in sufficient quantity of water, and stirred very thoroughly with a wooden pole or so – till the substance attains the consistency of a thin cream. Generally, water in the proportion of 5 litres to one kg of lime, is added for getting the desired consistency. This mix is left to stand in a receptacle (say, a tub) for about 24 hours – later being strained through a clean coarse cloth. Later gum (etc.) – dissolved in hot water – is added (5 kg of gum to a m^3 of thin cream) to impart a good sticking power to it.

It is to take off glare, and impart a pleasing effect, Indigo (*Neel*) – 3 kg per m^3 of thin cream – is added at the end. Sometimes alum or common salt is also added to increase the sticking power.

Colour wash is prepared, adding mineral colours (i.e., those not affected by lime) of the required shade to the prepared white wash. The mixture shall be stirred continuously (with a bamboo stick) while it is being applied to the walls, or ceiling.

A distemper is a water paint comprising *whiting* (powdered chalk), a colouring pigment (if so desired) and glue – all mixed in water. Distemper can give either a washable or non-washable surface – mediums used being different. Distempers are cheaper than paints or varnishes, and are easier to work. Distempers act as sealers over porous surfaces, and are generally applied over plastered surfaces on which a priming coat of whiting has been applied. Distempers for exterior work (on cement concrete, brick surface, stucco) have a weather resistant ingredient. These give more durable, smoother, and better surface than simple colour or white wash. Distempers are best used in dry climates: wet conditions yield poor results.

6.4.1 General Specifications

White Washing

Towards the surface preparation for white washing of a new surface, it shall be perfectly brushed free from mortar droppings (while under plastering work) and any other extraneous matter. Similarly, for an old surface all loose material has to be taken off (scrapped) – and, all gaps (holes) in the plaster as also all patches (less than 50 m^2 in area) shall be done completely with mortar of the original mix. The whole surface of the old white wash (if any) has to be completely removed.

New plaster to be white washed shall not be trowelled to a glazed surface for the white wash to adhere to it properly. The surface to be white washed

Table 6.1 : Basic Data Input for Rate Analysis of Some Items of Work

Sl. No.	Description of Item	Quantity of Item	Requirements of Men and Material: Labour Component	Requirements of Men and Material: Material Component
1.	**Pointing and Plastering** 12 mm thick, cement and sand mortar (1:6) plastering on brickwork – including base preparation, etc.	100 m^2 surface area	Mistri – 0.33 Nos. Mason – 10 Nos. Beldar – 11 Nos. Bhisti – 3.8 Nos. (for watering) [**Note :** Add suitably (on LS basis or on actual field-value basis) for scaffolding and tools, etc.]	Cement 7.5 bags (= 0.25 m^3) Sand 1.5 m^3
2.	12 mm thick, cement and sand mortar (1:2) plastering on brickwork – including base preparation, etc.	100 m^2 surface area	Same as for Item (1) above. [**Note :** Same as for Item (1) above.]	Cement 20.25 bags (= 0.675 m^3) Sand 1.35 m^3
3.	Flush pointing with 1 : 2 cement and sand mortar on brickwork – including base preparation, etc.	100 m^2	Mistri – 0.25 Nos. Mason – 15 Nos. Beldar – 5 Nos. Mazdoor – 10 Nos. Bhisti – 3 Nos. (for watering) [**Note :** Same as for Item (1)	Cement 6 bags (= 0.2 m^3) Sand 0.4 m^3
4.	12 mm thick, cement-sand mortar (1:4) plaster on brick wall – including base preparation, etc.	100 m^2	Mistri – 0.33 Nos. Mason – 10 Nos. Beldar – 11 Nos. Bhisti – 3.8 Nos. (for watering) [**Note :** Same as for Item (1)	Cement 11.25 bags (= 0.375 m^3) Sand 1.5 m^3
1.	**White Washing and Colour Washing** White Washing three coats.	100 m^2	Labour – 1.73 Nos. (for white washing) Mazdoor – 1.73 Nos. (helper) [**Note :** Same as for Item (1) of pointing and	White lime 33 kg Add glue/gum and a blue pigment on LS basis
2.	White washing one coat	100 m^2	White washer – 0.73 Nos. Helper – 0.73 Nos. [**Note :** As usual]	White lime 11 kg Add as per Item (1) above.
3.	Colour washing one coat	100 m^2	White washer – 0.75 Nos. Helper – 0.75 Nos. [**Note :** As usual]	White lime 11 kg Colouring material 2.5 kg Gum or glue powder as per requirement.
1.	**Cement Washing** Cement Washing (one coat)	100 m^2	Labour – 1 No. (say, white washer) Helper – 1 No. [**Note :** As usual]	Cement 0.8 bag Add glue/gum on LS basis

1.	**Distempering** One coat of dry distemper, over one priming coat (on a fresh, new work)	100 m^2	Labour – 0.73 No. Distemperor – 3.5 Nos. (i.e. painter) Helper – 4.23 Nos. [**Note :** As usual]	Dry distemper 8.1 kg White lime 11 kg Gum, etc. on LS basis
2.	Second coat of dry distemper over first coat	100 m^2	Distemperor – 1.8 Nos. Helper – 1.8 Nos. [**Note :** As usual]	Dry distemper 6.5 kg

Example 6.1

Use the following data, and arrive at the rate for struck pointing with 1 : 2 cement-sand mortar on brickwork, including raking, watering, supply of materials, labour, tools and plants (T and P), for *100 m^2* of work:

Cost of cement = Rs. 150 per bag

Cost of local sand = Rs. 50 per m^3

Rate for Labour

Mistri	–	Rs. 120 per day
Mason	–	Rs. 100 per day
Beldar	–	Rs. 60 per day
Coolie	–	Rs. 50 per day
Bhisti	–	Rs. 50 per day

Assume suitable rates for scaffolding; and T&P, and sundries, etc.

Solution

With reference to the standard and schedules for material and labour requirements, following tabulation is done :

Rate Analysis

Sl. No.	Particulars	Quantity/No.	Rate	Amount
1.	*Materials*			
	Cement (0.2 m^3)	6 bags	Rs. 150 per bag	Rs. 900
	Local sand	0.4 m^3	Rs. 50 per m^3	Rs. 20
			Total of (1)	Rs. 920
2.	*Labour*			
	Mistri	0.25 Nos.	Rs. 120 per day	Rs. 30
	Mason	18 Nos.	Rs. 100 per day	Rs. 1800
	Beldar	8 Nos.	Rs. 60 per day	Rs. 480
	Coolie	10 Nos.	Rs. 50 per day	Rs. 500
	Bhisti	3.8 Nos.	Rs. 50 per day	Rs. 190
	Scaffolding (LS)			Rs. 150
	T&P, etc. (LS)			Rs. 90
			Total of (2)	Rs. 3240

Total of (1) and (2) = Rs. 4160

Add 1.5% for work-charged establishment = Rs. 62.40

Add 10% for contractor's profit = Rs. 416

GRAND TOTAL = Rs. 4638.40

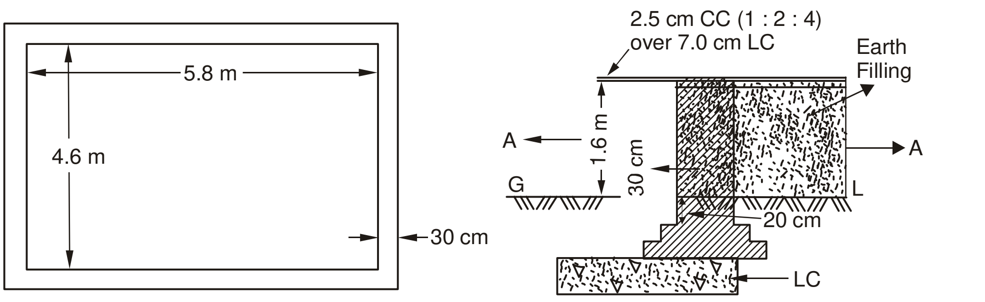
$\therefore$ **Rate per m^2 = 46.384 ≈ Rs. 46.40 (say)**

6.6 CASE STUDIES

Following solved examples, starting with the simplest case, are given to initiate the reader to one of the simplest procedures (yet calling for keen knowledge/conception of the layout and elevation of a structure) of estimation of quantities in a civil engineering work.

Example 6.2

A simple brick masonry platform (Figure 6.7) has to be plastered as per following specifications :



(a) Sectional Plan A-A **(b) Section through a Wall of the Platform**

Figure 6.7 : Brick-Masonry Platform – [Not to Scale]

13 mm thick plastering in CM (1 : 6) over outside face of walls, up to 10 cm below GL.

Compute the required quantity of this plastering.

Solution

Particulars of the Item	No.	Measurements			Quantity	Remarks
		L (m)	B (m)	H/D (m)		
13 mm thick plastering as specified						5.8 + (2 × 0.30) = 6.4
						(1.6 + 0.025) + 0.10 = 1.725
						4.6 + (2 × 0.30) = 5.2
LW	2	6.4	–	1.725	22.08 m^2	
SW	2	5.2	–	1.725	17.94 m^2	

	$\left[3.5 + (2 \times 0.343) + 2\left(\dfrac{0.457 - 0.343}{2}\right) = 4.3\right]$					
	Plinth projections					
	LW	2	7.8	0.057	–	0.89 m^2
	SW	2	4.19	0.057	–	0.48 m^2
	[4.3 – (2 × 0.057) = 4.186 ≈ 4.19]					
	Total of (1)					169.60 m^2
	Deductions					
	W	3	1	–	1.2	3.60 m^2 (deducted once only – plastering being on both sides of the wall)
	Gate (G)	2	2.5	–	2.3	11.50 m^2
	[Gate opening is deducted twice because its jambs have been already added above.]					
	Projection of plinth under the gate floor	1	2.5	0.057	–	0.14 m^2 (This quantity is small, it could have been neglected) –
	Total deduction					15.24 m^2
	Net of item (1)					169.60 m^2 (–) 15.24 m^2 = **154.36 m^2**
2.	*13 mm thick, 1 : 6 CM plastering on ceiling*	1	7.0	3.5	–	24.5 m^2
	Add soffit above the opening "G"	1	2.5	0.343	–	0.86 m^2
	Total of Item (2)					**= 25.36 m^2**
3.	*3 coats of white washing on walls- inside and outside*					
	Same as for Item (1)					154.36 m^2
	and Item (2)					+ 25.36 m^2
	Sub-Total					= 179.72 m^2
	Add projection of roof slab – soffits, and vertical face					
	LW	2	7.89	0.22 (i.e. 0.12+ 0.1)	–	3.47 m^2
	[7.686 + (2 × 0.1) ≈ 7.89]					
	SW	2	4.19	0.10	–	0.84 m^2

	Dining space (3)	2	4.6	–	3.2	29.44 m^2	Appropriate deductions for open space on right shall be made later on.
		2	1.8	–	3.2	11.52 m^2	
		Deductions for open space to right (stair-side) = (1.8 + 2.5 – 1.0) × 2 = 3.3 × 2 = 6.6 m^2					
	Bed rooms						
	LW	2 × 2	4.5	–	3.2	57.60 m^2	
	SW	2 × 2	3.5	–	3.2	44.80 m^2	
	Open varandah						
	LW	1	10.4	–	3.2	33.28 m^2	
	SW	1	1.5	–	3.2	7.04 m^2	
	Bath	3	1.8	–	3.2	17.28 m^2	
		(2 + 1)					
		2	3.35	–	3.2	21.44 m^2	
	Pillars						
	3 faces (P_1)	2	1.5	–	3.2	9.6 m^2	P_1 (and P_2) ⇒ 0.6+0.6+0.3 = 1.5
	2 faces (P_3)	1	0.9	–	3.2	2.88 m^2	P_3 ⇒ 0.6+0.3 = 0.9
	Sides of verandah beams (over P_1, P_2 and P_3)	1	9.5	–	0.3	2.85 m^2	8.4 + 2 – 3 × 0.30 = 10.4 – 0.9 = 9.5
	(over P_3 and wall of (6))	1	1.2	–	0.3	0.36 m^2	1.5 – 0.3 = 1.2 (already counted in pillars)
	Stair case						
	SW a)	1	2	–	1.47	2.94 m^2	
	above landing⇒ b)	1	2	–	0.3	0.06 m^2	(upto below Jali)
	LW a)	1	3.2	–	3.2	10.24 m^2	(neglecting deductions done to staircase contact)
			[4.5 – 1.3 = 3.2]				
	b)	1	2.8	–	3.2	8.96 m^2	
			[2.5 + 0.3 = 2.8]				
	Passage before staircase	2	1.8	–	3.2	11.52 m^2	(i.e., two faces of one wall, in which a large deduction shall be done)
	Sides of beam over (a) – (a)	2	5.30	–	0.3	3.18 m^2	No deductions for beams over walls is being made-being negligible
		[3.0 + 0.3 + 2 = 5.3 m]					
					Total of (1) =	379.95 m^2	
	Deductions :						
	[**Note:** Doors shall be deducted once for all internal plaster to take care of jambs, etc. Similarly						

of the *chowkhat*, the projection being 1 cm for each 12 cm width of leaf. The top of the *chowkhat* (and sill when this has been provided) shall be enlarged to a corresponding wedge shape, the cost of this arrangement being included in the rate. Generally, the width and position of lock and bottom rails on wire gauze doors shall be the same as those of the other leaves hung on the same *chowkhat*.

Where moveable wire gauze flaps (or leaves) are provided to windows, all specifications for wire gauze doors shall be followed with the following departures :

(a) wire gauze windows shall not be provided with springs or spring hinges,

(b) double hung wire gauze windows shall close flush with the *chowkhat* without the meeting styles projecting in any way, and

(c) wire gauzed windows shall open outwards and be provided with hinged chocks, to keep them in the open position; and with stops, to prevent damage to plaster.

In fixed wire gauze construction, all panels shall be in one piece, no joints being allowed in the gauze. Wire gauze shall be fixed to the outside of the *chowkhat* – this shall be drawn taut to the full width of the *chowkhat* and nailed down, and a cover strip (of the same width as the *chowkhat*), so as to seem part of the *chowkhat*, fixed all round with screws. Or, the wire gauze shall be fixed to the *chowkhat* by a fillet screwed into a rebate of the same size.

7.6 RATE ANALYSIS (BASICS) : DOORS, WINDOWS AND CEILINGS

Materials, and labour constitute the main components that make up the cost of a civil engineering item (as also of any other work). The composition of these components differ as per the specifications, and design of an item – like in wooden doors, windows, and wooden ceilings. Some of the works under these groupings are discussed in outline as under :

(a) **Wood work in CP teak wood one-door chowkhat, wrought, framed and fixed, including simple mouldings – door opening ⇒ 1.0 × 2.0 m; section of 3-piece chowkhat (i.e. chowkhat without sill) ⇒ 10 × 7 cm.**

Materials	**No.**	**L (m)**	**B (m)**	**Thickness (m)**	**Quantity/No.**
Timber for posts	2	2.0	0.1	0.07	0.028 m^3
Timber for head	1	1.0	0.1	0.07	0.007 m^3
				Total	0.035 m^3
				Add 5% wastage (= 0.00175 m^3)	0.002 m^3 (say)
				Grand Total	**0.037 m^3**

Labour	**No.**
Mistri	0.06
Carpenter	0.05

Helper (i.e. beldar) 0.25

Add T and P Sundries, etc. on LS basis

(b) **Wood work in a shutter ($b \times l$ m) of ledged and braced door (Figure 7.1) without a chowkhat, using country wood, including fixing on the chowkhat all fittings.**

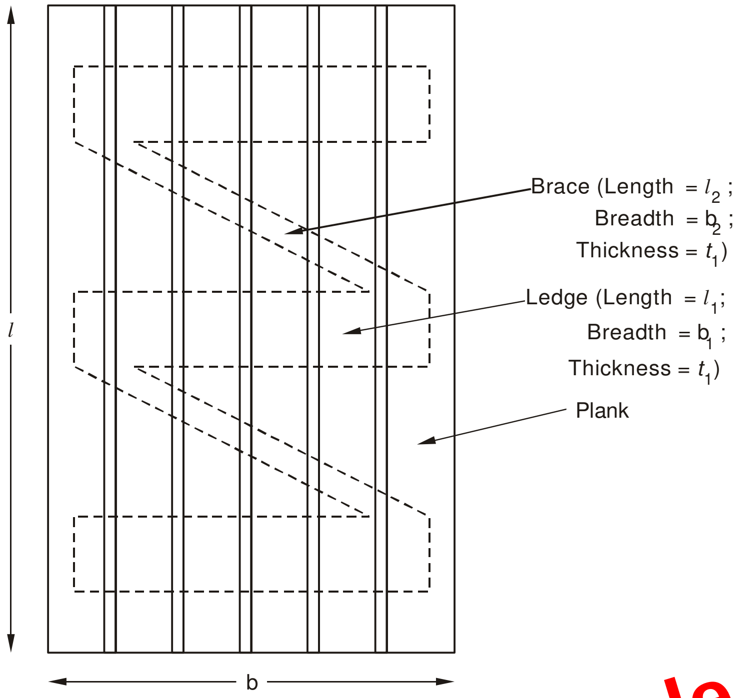


Figure 7.1 : Ledged and Braced Door

Materials

(i) ***Timber***	**No.**	**L (m)**	**B (m)**	**H/D (m)**	**Quantity/No.**
Timber for planks	1	ℓ	b	t (say)	$(1 \times \ell \times b \times t)$ m^3
Timber for ledges	3	ℓ_1	b_1	t_1	$(3 \times \ell_1 \times b_1 \times t_1)$ m^3
Timber for braces	2	ℓ_2	b_2	t_2	$(2 \times \ell_2 \times b_2 \times t_1)$ m^3
				Total	$= T$ m^3 (say)
Add 5% wastage, and 5% more for overlapping at joints $\left(= \frac{10}{100} \times T\right)$					$= \frac{1}{10}(T)$ m^3
				Grand Total =	**$(1.1T)$ m^3**

(ii) ***Fittings***

Tower bolts (20 cm)	2 Nos.
Strap hinges	3 Nos.
Steel handles	2 Nos.
Wooden cleats	2 Nos.
Hinges 2.5 cm for cleats	2 Nos.
Screws 40 mm	30 Nos.
Screws 20 mm	50 Nos.

Nails, putty, etc. Add on LS basis

Labour

Mistri 0.1 No.
Carpenter 1.5 No.
Helper 1.5 No.
Glue, *T* and *P*, Sundries, etc. Add on LS basis

Note: Similar analysis can be applied to other types of doors based on the detailed drawings of the item.

(c) **Fixing 10.0 m^2 of 2.5 cm deodar-wood plank ceiling including 2.5 cm × 4.0 cm beading over plank joints – without ceiling frame work.**

Materials

Planks (including rebate overlap and wastage	0.34 m^3
Beading	0.06 m^3
Total timber	= 0.4 m^3
Nails 3 kg Screws 35 mm 300 Nos.	
Labour Mistri 2 Nos. Carpenter 2 Nos. Beldar (helper) 4 Nos. Add for scaffolding; and *T* and *P* and Sundries, etc. on LS basis	

7.7 CASE STUDIES : DOORS AND WINDOWS – ESTIMATION OF QUANTITIES

Analysis of data, as given in the relevant drawings is the best way to master the art/skill of estimating quantities in any item of work. Practice develops imagination, perfects concepts, and helps develop expertise and speeds up the task of estimation. A few solved examples as presented below should inculcate the ability to analyse doors/windows with a view to estimating the material quantities that go into the make-up of the particular item.

Example 7.1

A building has following doors, windows, and a ventilator fixed in the superstructure :

(a) Windows (W) – 10 Nos.; size : 2.0 (horizontal) × 1.3 m

(b) Four sizes of door :

(i) D_1 – 3 Nos.; size : 1.5 × 2.0 m
(ii) D_2 – 1 No.; size : 1.3 × 2.0 m
(iii) D_3 – 4 Nos.; size : 1.0 × 2.0 m
(iv) D_4 – 2 Nos.; size : 0.75 × 2.0 m

All are having 3-piece chowkhats (frames), except the ventilator and windows which have a 4-piece frame.

(c) Ventilator – 1 No.; size : 0.5 × 0.5 m

(d) Chowkhat-piece sizes :

6.	(*a*) *Painting (woodwork) doors, windows, ventilator – two coats over one coat of priming*						(i) 1.3 is a factor for each side – i.e., 2.6 for both sides – that takes care of chowkhat area, etc. (ii) For V (*glazed*) the factor is 1.0 for one side – i.e., 2 for two sides
	D_1	3×2.6	1.5	–	2	23.4 m²	
	D_2	1×2.6	1.3	–	2	6.76 m²	
	D_3	4×2.6	1	–	2	20.8 m²	
	D_4	2×2.6	0.75	–	2	7.80 m²	
	W	10×2.6	2	–	1.3	67.60 m²	
	V	1×2	0.5	–	0.5	0.50 m²	
	Sub-Total of (a)					126.86 m²	
	(*b*) *Painting of mild steel bars*						We pay for one flat area, excluding chowkhats
	W	10	1.86	–	1.22	22.692 m²	
	V	1	0.36	–	0.42	0.151 m²	
	Sub-Total of (b)					22.84 m²	
	Grand Total =					149.70 m²	

Example 7.2

(a) A given structure has following doors, windows and ventilators :

Doors	*Size*	*No.*	*Remarks*
D_1	1.5 × 2.1 (vertical) m	2	with 3-piece frame
D_2	1.2 × 2.1 m	4	
D_3	0.9 × 2.1 m	5	
D_4	0.75 × 2.0 m	5	

(b)

Windows	*Size*	*No.*	*Remarks*
W	1.0 × 1.3 m	17	with 4-piece frame

(c)

Ventilators	*Size*	*No.*	*Remarks*
V	0.5 × 0.5 m	4	with 4-piece frame

					Total =	163.96 m²	
6.	*Iron and steel items – hold fasts, and grating of windows and ventilators*						
	Hold fasts :						
	D_1	2 × 6				12	(i) Providing 6 Nos. in each door
	D_2	4 × 6				24	
	D_3	5 × 6				30	(ii) Providing 4 Nos. in each window
	D_4	5 × 6				30	
	W	17 × 4				68	(iii) Providing 2 Nos. in each ventilator
	V	4 × 2				8	
					Total which, @ 1 kg each =	172 Nos. 172 kg	
	16 mm round bars:						
	W	17 × 9	–	–	1.3	198.9 m	Providing (at 10 cm distances) 9 bars in each window and 4 bars in each ventilator
	V	4 × 4	–	–	0.5	8.0 m	
					Total	206.9 m @1.58 kg/m = 326.90 kg	
					Grand Total	= 498.90 kg	

[**Note :** As has been stressed earlier, exercising one's mind solving problems, as many as possible, is the most effective way to master any procedure, and more so in the case of estimating quantities in civil engineering work. Some SAQs are given below for students to try their hands on – and it is advised that the solutions worked out individually must be compared with the solutions given in Section 7.9.]

SAQ 1

(a) The ground floor of a building has following openings in its superstructure :

	Item	*Size*	*No.*	*Remarks*	
Doors					
	D_1	1.3 × 2 m	5	Ht. of door = 2 m	All doors have 3-piece frames
	D_2	1 × 2 m	2	Ht. of door = 2 m	
	D_3	0.8 × 2 m	1	Ht. of door = 2 m	
Windows					
	W	2 × 1.3 m	6	Ht. of window = 1.3 m	
Glazed Ventilator					
	V	0.5 × 0.5 m	1		

Windows, each have two bays with two vertical posts in the middle (one bay has two shutters; and the other has only one shutter) – each piece of the frame (vertical or horizontal) of *D*s, *W*s, or *V* has a 12 × 7 cm sectional area.

Rebate in chowkhats for shutters to be received in appropriately is detailed below :

D_1; D_2; D_3 ⇒ 1 cm in horizontal direction; and 3.5 cm in vertical direction.

W ⇒ 1 cm in horizontal direction; and 1 cm in vertical direction.

V ⇒ 1 cm all around.

Compute the following quantities, presenting the results as a *bill of quantities :*

(i) Salwood work in chowkhats.

(ii) 30 mm thick deodar panelled shutters (with ordinary steel fittings) in doors and windows (including hold fasts, etc.)

(iii) 30 mm thick deodar wood glazed shutter in the ventilator.

(iv) Painting two coats over one coat of priming coat on doors, windows, and ventilator.

(v) Solignum painting, two coats in the back of chowkhats.

(vi) Grating (grill) – 16 mm mild steel round bars in windows and ventilator.

(b) A structure has doors windows, and ventilators in its superstructure as detailed below :

Sl. No.	Item	No.	Size (Horz. × vertical)	Chowkhat Size	Rebate	
					Vertical	Horizontal
1.	D_1	5	1.2 × 2 m	10 × 8 cm	5 cm	2 cm
2.	D_2	1	1 × 2 m	10 × 8 cm	5 cm	2 cm
3.	D_3	2	0.8 × 2 m	10 × 8 cm	5 cm	2 cm
4.	W	4	1.5 × 1.2 m	10 × 8 cm	5 cm	2 cm
5.	V	2	0.6 × 0.6 m	10 × 8 cm	2 cm	2 cm

All doors have 3-piece frames, while windows and ventilators have 4-piece frames.

Take out the following quantities in the form of a *bill of quantities :*

(i) Kail woodwork in chowkhats.

(ii) Deodar woodwork in 3 cm-thick panelled shutters for all *D*s, *W*s and *V*s.

(iii) Two coats painting over one coat of priming on *D*s, *W*s, and *V*s.

(iv) Solignum painting (2 coats) in the back of chowkhats.

(v) Mild steel in hold fasts for windows and ventilators; and 16 mm round bars in *W* and *V* grills – 13 bars in *W*s; and 4 bars in *V*s.

[**Note :** Taking twice the vertical rebate into account for 3-piece doors allows the due clearance of the shutter with respect to the flooring.]

(iii) *30 mm-thick glazed shutter*

V	1	0.38	–	0.38

(iv) *Painting, two coats, of D_s, W_s and V over one coat of priming*

D_1	5×2.6	1.3	–	2
D_2	2×2.6	1.0	–	2
D_3	1×2.6	0.8	–	2
W	6×2.6	2.0	–	1.3
V	1×2	0.5	–	0.5

Mild steel bars (grating)

W	6×2	0.44	–	1.18
	6×1	0.88	–	1.18

16 mm-round bars in grating

W	6×9	2	–	– Taking spacing of bars as 20 cm

(Assume wt. of bars @1.58 kg/m)

V	1×2	0.5	–	–

(v) *Solignum painting, two coats, in the back of chowkhats*

D_1	5	5.3	0.12	–
D_2	2	5.0	0.12	–
D_3	1	4.8	0.12	–
W	6	6.6	0.12	–

(**Note :** Central two posts are not to be painted, as these are not in contact with the masonry.)

V	1	2.0	0.12	–

SAQ 2

(i) *Chowkhat lengths*

$D_1 \Rightarrow 1.2 + 2\ (2) = 5.2$ m

$D_2 \Rightarrow 1 + 2\ (2) = 5.0$ m

$D_3 \Rightarrow 0.8 + 2\ (2) = 4.8$ m

$W \Rightarrow 2 \times 1.5 + 2\ (1.2) = 5.4$ m

$V \Rightarrow 2 \times 0.6 + 2\ (0.6) = 2.4$ m

(ii) *Shutter dimensions (length $\times$ breadth)*

$D_1 \Rightarrow 1.8 \times 1.94$ m

$D_2 \Rightarrow 0.88 \times 1.94$ m

$D_3 \Rightarrow 0.68 \times 1.94$ m

$W \Rightarrow 1.38 \times 1.14$ m

$V \Rightarrow 0.48 \times 0.48$ m

} Work out these quantities yourself

It is obvious that the technical sanction follows the administrative approval. Without technical sanction, in fact, no work can be taken in hand. The detailed estimate shall, as usual, consists of bill of quantities, and an abstract of cost, and complete, detailed specifications. However, when there is any ambiguity about the rate of payment of an item, lump sum earmarking has to be made : subject to the final revision on the basis of actual analysis of rates; and, large lump sum provisions in the detailed estimate are not admissible.

Contingencies of 5% shall be added to the net total cost to address any minor error or omission.

Factors Affecting Costs

As is evident, the factors that influence the cost are mainly : material, labour, transport (cartage), overhead charges, including work charged establishment, and incidentals.

Rates should be based on actual conditions at the site of work : location, soil characteristics, best location for any plant that is an essential part of the effort, location of the yard to store materials, availability of power and water, locally applicable rules and regulations, availability of banking facilities, distances to railway yards and dealers in materials, prevailing conditions regarding wages of labour, supply and efficiency of local workmen, and facilities that can be mustered for positioning labour at site.

Material Estimates

Preparation of a list of required materials (known as the "*take-off*") is a helpful exercise. An estimator takes off the necessary materials with the help of drawings and specifications. The results are tabulated on "*quantity sheets*" giving number, size, weight, volume, etc. For a large job, many quantity sheets are needed – and, then "*summary*" sheets are prepared. This information helps in appropriate planning and accurate estimation.

For obtaining material costs, the cost of all the materials at the site are to be considered. This cost has, in general, the following components :

(a) First cost

(b) Freight

(c) Unloading

(d) Cartage

(e) Storage

(f) Inspection

(g) Testing

(h) Insurance

Estimates of Labour and Wages

While working out labour estimates, appropriate space shall be given to the inevitable variations in wages, variations in the time span (hours) to complete one and various items of work, variations in working conditions, and above all variations in the availability of skilled and unskilled men power – and, the influence of interplay between supply and demand of labour. Also, a prudent manager of works (as every civil engineer should be) should, as far as possible, foresees the affect of union politics on the daily output of a worker.

In the event of the contractor not completing the work in the scheduled time (or also within the extended time, if allowed by the authorities on valid grounds) due charge is levied on him. Such sum is usually a specified sum per day for each day of delay – this sum is termed *ascertained or liquidated damages*, and not as a penalty. This charge can also be deducted from the amount falling due to the contractor.

All engineering contracts carry an important clause that deals with the *bankruptcy* of the contractor or *liquidation* of a Company. In case the party, while the work is under progress, commits any act as if it is bankrupt (or has entered into a liquidation) – whether voluntarily or otherwise – or do some similar acts, the department (Employer herein) is empowered (without affecting the contractor's liabilities) to employ any other contractor/contractors with a view to completing the incompletely – left work. In such a case, the department has full liberty to use the tools and plants and materials of the contractor. Any expenses/costs that may be incurred by the department shall be recovered from the contractor.

A common method of settling disputes between the contractor and the department (or a private owner) is *arbitration*. It is a process which is preferred in settling disputes that involve technical points/questions. An arbitrator can be a person having an expert knowledge of the matters, vis-à-vis, the dispute. He may inspect the work in order to save time and effort spent over hearings, etc. Arbitration involves less legal expenses compared to the action of law-, and, is binding on the parties. An arbitrator shall have the power to reopen the earlier decisions of the department, review and revise any earlier actions done by the parties.

As mentioned earlier, the contractor shall be paid by the Employer from time to time (i.e., by instalments) under *on-account* (or *running-account*) mode of payment, for the works executed till date. Whenever such a type of payment is proposed to be made, it is imperative to ensure that the value of the work done is not less than the specified amount that is being paid in conformity with the contract agreement, and that the work has been done according to the relevant drawings and specifications.

Contract drawings, as stressed earlier also, have to be accurate and complete – its importance is highlighted every time it is stated that : the work shall be carried out in accordance with the signed drawings, and in accordance with any further drawings, and details as may be issued from time to time (of course, in accordance with the terms of the agreement).

It has to be understood here that a set of specifications coupled with detailed drawings is indeed a complete guide that can lead to a piece of good work. Drawing is the language of engineering, and thus the following rules shall be followed for this language to be comprehensively articulate :

(a) All the drawings should be drawn true to scale, and exhaustively but carefully dimensioned.

(b) Dimensions for openings shall be clear of all finishing.

(c) Room heights (from top of floor to the underside of the next floor/or to its top) should be indicated.

(d) It is useful to distinguish different kinds of floors (timber, RCC, etc.) by different colours.

(e) Rooms/bedrooms/hotel rooms, etc., should be numbered consecutively – avoiding the use of the same sets of numbers in one building.

(f) All the main dimensions must be given on each floor of a building – care being taken that these do agree in all respects.

(g) It is helpful to indicate all the floor levels on the elevation of the building by distinctive colours.

(h) All the sectional elevations should give the required dimensions clearly. Staircases should be detailed out by taking sections through them – and, it is advantageous to show them by bold colour.

(i) Those parts of brickwork which are to be built in different mortars (cement, line, mud) should be given different colours.

(j) It is appropriate to draw all the drawings (as far as feasible) to a uniform scale – say, 0.5 m = 1 cm, or 1.0 m = 1 cm.

Stores

Departmental stores have stocks of the following materials :

(a) Materials charged direct to works like, cement, bitumen, steel, etc.

(b) Tools and plant.

(c) Other necessary items.

Every staff member of the department is obliged to take up the duties of a store keeper – departmental stores may be left at or near the station (with appropriate protection) where the staff member is located; but, in general, proper structures are available to function as stores.

General administration of all the stores of a Division (including those at the level of Sub-Divisions) is the responsibility of the Executive Engineer – being charged with the task of acquisition and custody and distribution (according to needs) of stores.

Stores are procured by floating tenders for the supply of materials – on the same pattern as for the execution of all the construction works. Detailed specifications and descriptions, quantities, location to be supplied at, time period given for the supply to be made (and the rate of supply with respect to time), etc., are to be included in the tender notice/agreement, as the case may be.

The staff concerned to look after the store is responsible for maintaining correct and up-to-date records and returns of the materials.

The head "*Stock*" is opened in every Division – under this head all the stocks are maintained; there always being a limit on the amount of money for which *stock reserves* can be kept. The account head " Stock" is charged with all the expenditure, vis-à-vis, the acquisitions of stocks, and with all *manufacturing operations*. The sub-heads of the stock account can be :

(a) small stores,