LECTURE NOTE

On

ESTIMATION & COST EVALUATION-II

(5th SEM. Civil Engineering)

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CHAPTER 7

ROAD ESTIMATING

EARTHWORK

Cross-section of earthwork of road in banking or in cutting is usually in the form of trapezium, and the quantity of earthwork may be calculated by the following methods :—

Quantity or volume = Sectional area × Length.

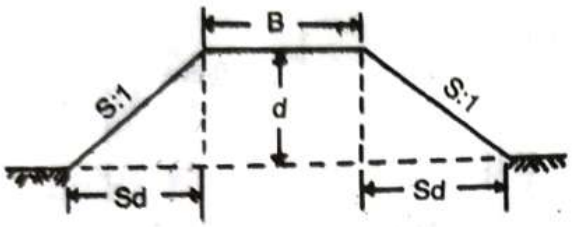

Fig. 7-1
Banking

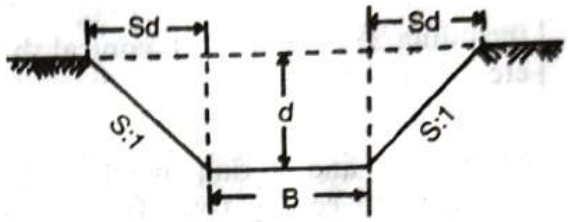

Fig. 7-2
Cutting

Sectional area = Area of central rectangular portion + Area of two-side triangular portions.

$$= Bd+2(\tfrac{1}{2}\, sd\times d) = Bd+sd^2$$

S : 1 is the ratio of side slopes as horizontal : vertical. For 1 vertical, horizontal is s, for d vertical, horizontal is sd.

Quantity= $(Bd+sd^2)\times L$.

When the ground is in a longitudinal slope, the height of bank or the depth of cutting will be different at the two ends of the section, and mean height or depth may be taken for "d" and sectional area at mid-section is taken out for mean height. Alternatively, sectional area at the two ends may be calculated and the mean of two sectional area is taken out. Sectional area at the mid-section or the mean sectional area, multiplied by the length gives the quantity.

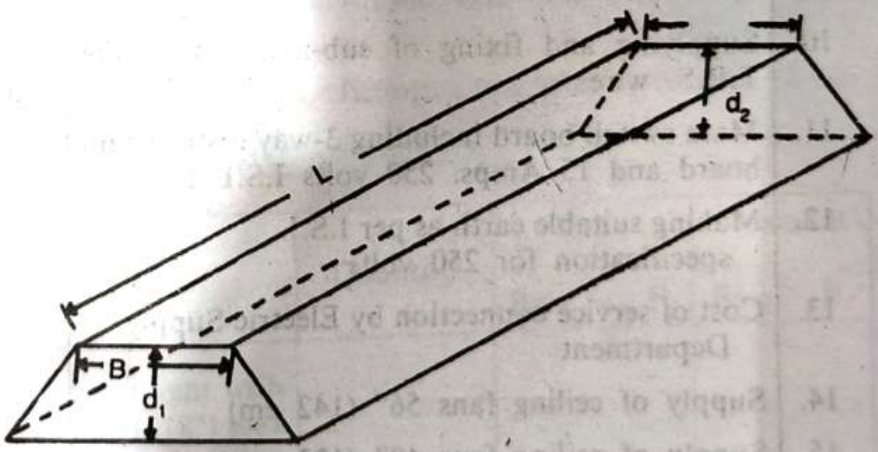

Fig. 7-3

Mean height = $\dfrac{d_1+d_2}{2}$

Different kinds of soil as sandy, clayey, rocky, etc., estimated separately as the rates vary.

Lead and Lift—Normally earthwork is estimated for 30 m lead for distance and 1.5 m lift for height or depth, and this distance of 30 m and the height of 1.5 m are known as *normal lead and lift.* Normal rate for earthwork is for 30 m lead and 1.5 m lift. For greater lead or lift the rates will be different (higher) for every unit of 30 m lead and for every unit of 1.5 m lift. The earthwork is, therefore, estimated separately for every 30 m lead and for every 1.5 m lift.

For the calculation of earthwork in a road longitudinal section and cross-section of the ground are taken and the formation line is fixed. The formation line is fixed in consideration of flood level, gradient, height of bank, depth of cutting, etc. In plain countries road is usually in banking, but if the road is in cutting for some length and in banking for some other length, the excavated earth from the cutting portion should be utilised for the banking portion within economical limits, during the execution of the work. But for estimating of earthwork this point of utilising excavated earth from cutting in certain length in banking of the adjacent length may not be taken into account to avoid complicacy. In hilly countries road is usually both in banking and in cutting and the excavated earth from cutting is utilised for banking within economical limits.

From the L-section and formation line, the height of bank and depth of cutting are calculated the difference of R.L. of ground and R.L. of formation gives the height of bank or depth of cutting. For plain country the ground is considered as level accross, that is there is no cross-slope. The earthwork is calculated by parts of the length in between two consecutive stations of L-section and continued until the whole length is covered.

For longitudinal section R.L. of ground is usually taken by levelling instrument at every 30 metre apart along the centre line of the road. When the ground is fairly even the levels may be taken at 40 or 50 metre apart or even up to 100 metre apart. In uneven ground or hilly areas the R.L. of ground may be taken at 20 metre or more or less depending on the nature of the ground. Estimate of road is prepared kilometre wise. It is better if the distance apart of L-section is such that it is multiple to make the kilometre.

Longitudinal section is usually plotted with a horizontal scale of 1 cm = 10 m to 1 cm = 30 m and a vertical scale of 1 cm (=) 1 m to 1 cm = 5 m.

The quantity of earthwork may be calculated by the various methods of mensuration out of which three methods are given below :—

Method I. Mid-Sectional Area Method.—Quantity=Area of mid-section×length. Let d_1 and d_2 be the height of bank at two ends portion of embankment, L the length of the section, B the formation width and S : 1 (horizontal : vertical) the side slope then,

Area of mid section = Area of rectangular portion + area of two triangular portion

$= Bd_m + \frac{1}{2}sd_m^2 + \frac{1}{2}sd_m^2 = Bd_m + sd_m^2$

$\therefore$ Quantity of earthwork $= (Bd_m + sd_m^2) \times L$

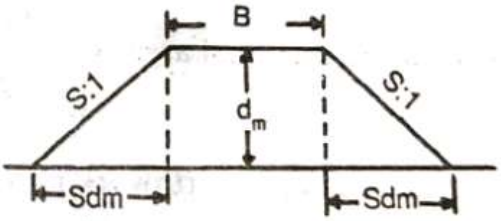

Fig. 7-4

General, $Q = (Bd + sd^2) \times L$, where d stands for mean height or depth.

The quantities of earthwork may be calculated in a tabular form as below :—

Stations or Chain-age	Depth or Height	Mean Depth or Height "d"	Area of central portion Bd	Area of sides Sd^2	Total Sectional Area $Bd+sd^2$	Length between stations L	Quantity $(Bd + sd^2) \times L$	
							Embank-ment	Cutting

Area of side sloping surface —

The area of sides which may require turfing or pitching, may be found by multiplying the mean sloping breadth by the length.

The mean sloping breadth = $\sqrt{(sd^2+d^2)} = \sqrt{5^2+1}$, where d stands for mean d.

Area of both side slopes = 2 L, × d $\sqrt{s^2+1}$.

This also may be calculated in a tabular form —

Station or Chain-age	Depth or Height	Mean depth or Height	Breadth of side slopes $d\sqrt{s^2+1}$ *Sloping breadth*	Length between stations L	Total Area of both side slopes $2 L d\sqrt{s^2+1}$

This table may be added to the previous table or may be worked out separately, d being mean depth or height.

Method II. Mean Sectional Area Method — Quantity = Mean Sectional area × length, Sectional area at one end $A_1 = Bd_1+sd_1^2$, sectional area at the other end $A_2=Bd_2+sd^2_2$, d_1 and d_2 are the heights or depth at the two ends.

The mean sectional area $A = \frac{A_1+A_2}{2}$, Quantity $Q = \frac{A_1+A_2}{2} \times$ Length.

The quantities of earthwork may be calculated in a tabular form as given below :—

Stations or Chainage	Height or Depth "d"	Area of central portion Bd	Area of sides Sd^2	Total Sectional Area $Bd+Sd^2$	Mean Sectional Area	Length between station L	Quantity $(Bd+sd^2) \times L$	
							Emba-nkment	Cutting

Note : *See Example 6 for Method II.*

Method III. Prismoidal Formula Method. — Quantity or volume $= \frac{L}{6}(A_1+A_2+4A_m)$

Where A_1 and A_2 are the cross-sectional areas at the two ends of a portion of embankment of a road of length L, and A_m is the mid-sanctional area.

Let d_1 and d_2 be the heights of banks at the two ends, and d_m be the mean height at the mid-section, B be the formation width and S:1 be the side slope.

Cross-sectional area at one end —

$$A_1 = Bd_1 + Sd_1^2$$

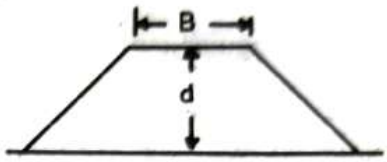

Fig. 7-5

Cross-sectional area at other end —

$$A_2 = Bd_2 + Sd_2^2$$

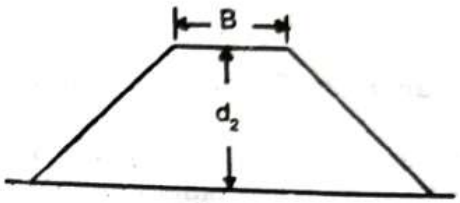

Fig. 7-6

Cross-section at middle —

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

$$A_m = Bd_m + Sd_m^2$$

$$= B\left(\frac{d_1+d_2}{2}\right) + S\left(\frac{d_1+d_2}{2}\right)^2$$

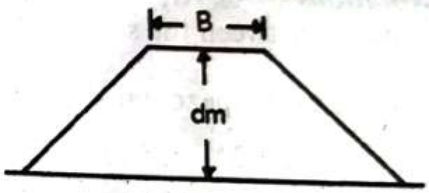

Fig. 7-7

$$\text{Quantity} = \frac{L}{6}(A_1+A_2+4A_m)$$

$$= \frac{L}{6}\left[(Bd_1+sd_1^2) + (Bd_2+sd_2^2) + 4\left\{B\left(\frac{d_1+d_2}{2}\right) + s\left(\frac{d_1+d_2}{2}\right)^2\right\}\right]$$

$$= \frac{L}{6}\left[(Bd_1+Bd_2+4\frac{Bd_1}{2} + 4\frac{Bd_2}{2}) + sd_1^2+sd_2^2+4s\frac{d_1^2+d_2^2+2d_1d_2}{4}\right]$$

$$= \frac{L}{6}\left[(3\,Bd_1+3\,Bd_2) + 2sd_1^2 + 2sd_2^2 + 2sd_1d_2\right]$$

$$= \frac{3BL}{6}(d_1+d_2) + \frac{2Ls}{6}(d_1^2 + d_2^2 + d_1d_2)$$

$$= \frac{BL}{2}(d_1+d_2) + \frac{Ls}{3}(d_1^2+d_2^2+d_1d_2)$$

$$= \left\{B\left(\frac{d_1+d_2}{2}\right) + s\left(\frac{d_1^2+d_2^2+2d_1d_2}{3}\right)\right\} \times L$$

= [Sec. Area of central portion + Sec. Area of side slope portions] × Length.

The same is also applicable for cutting.

Tabular Form for Prismoidal Formula — The above may be set in a tabular form for calculating the quantity of earthwork for a road. See Example 8, page 345 for tabular form.

(*i*) Find also the area of the side slopes and the cost of turfing the side slopes at the rate of Rs. 60.00% sq. m.

Chainage	10	11	12	13	14	15	16	17	18	19	20
R.L. of ground	105.00	105.60	105.44	105.90	105.42	104.30	105.00	104.10	104.62	104.00	103.3

R.L. of Formation 107.00.

Gradient Down gradient 1 in 150 ⟶ ⟵ Down gradient 1 in 100

L=Section and Typical cross-section of the road are as given in Fig. 7-8.

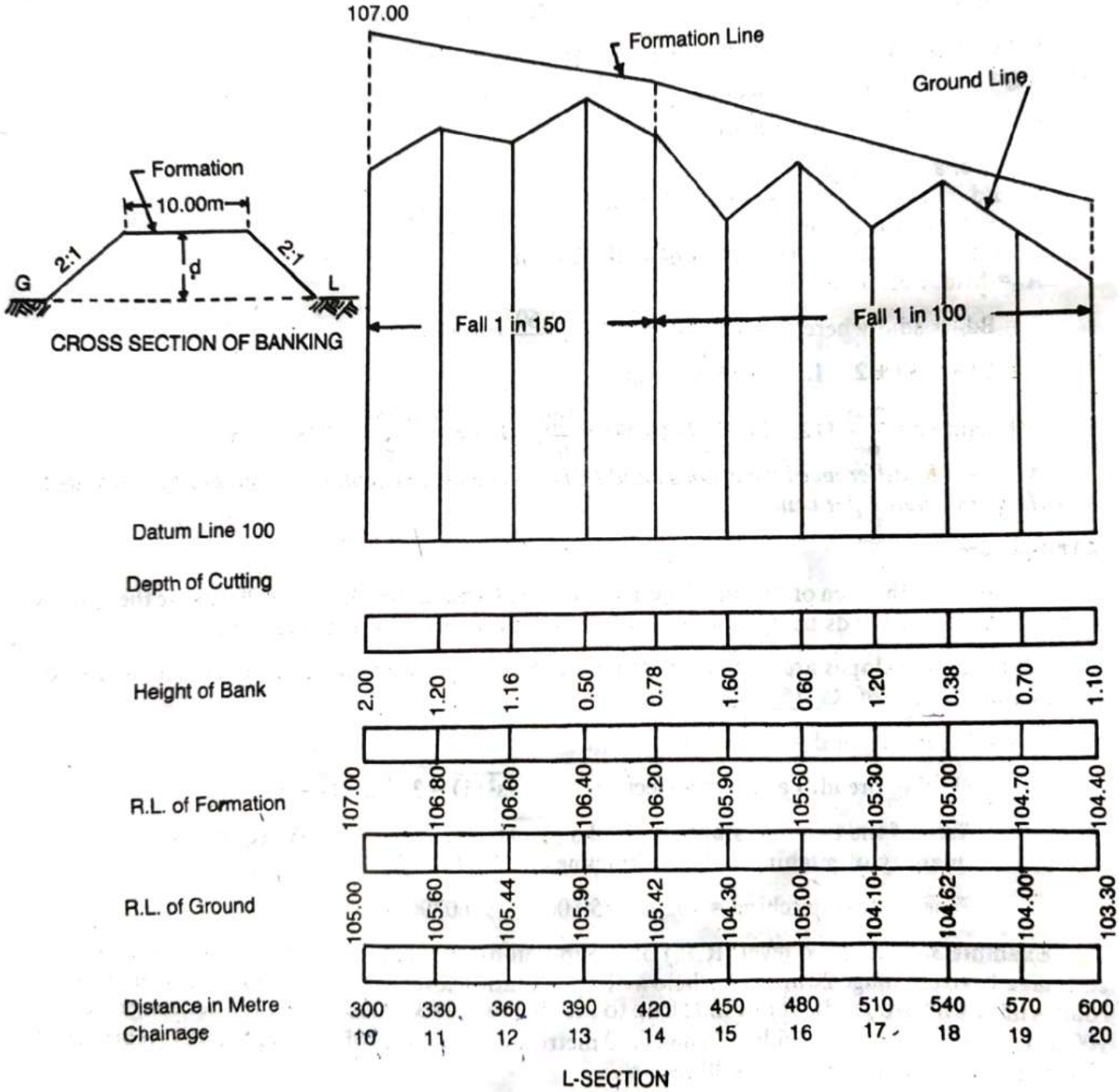

Fig. 7-8

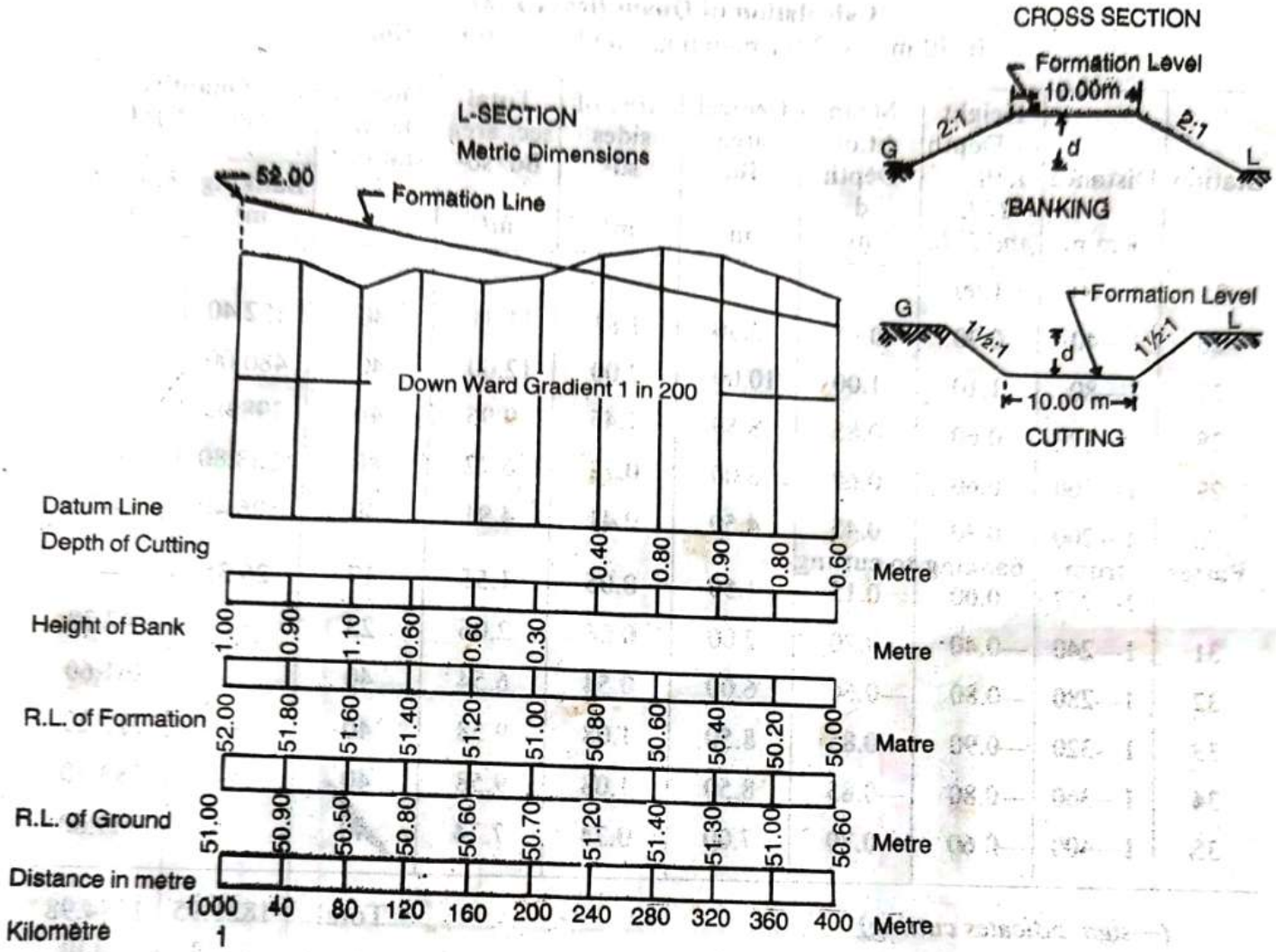

Fig. 7-9

The road passes from banking to cutting in between the stations 30 (1200 m) and 31 (1240 m). The distance where it passes through zero, *i.e.*, ground level, may be determined as follows :—

The two traiangles on either side of zero point are symmetrical. (Fig. 7-10).

$$\frac{x}{.3} = \frac{40 - x}{.4} \text{ ; or . } 4x = .3\,(40 - x)$$

or $.4x = 12 - .3x$. or $.7x = 12$

$$\therefore\ x = \frac{12}{.7} = 17.14 \text{ m} = 17 \text{ m say}$$

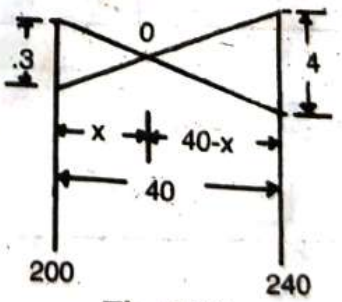

Fig. 7-10

Therefore length of banking portion is 17 m, and the length of cutting portion is 40—17=23 m.

ESTIMATE OF EARTHWORK

Calculation of Quantities (Ex. 4)

B=10 m, s=2 for banking, and s=1½ for cutting

Station	Distance Km m	Height or Depth Diff. of G.L. and F.L.	Mean ht.or Depth d m	Central area Bd m	Area of sides sd^2 m^2	Total sec. area $Bd+sd^2$ m^2	Dist. in betw. stations L m	Quantity $(Bd+sd^2)\times L$ Banking m^3	Quantity $(Bd+sd^2)\times L$ Cutting m^3
25	1—00	1.00	—	—	—	—	—	—	—
26	1—40	0.90	0.95	9.50	1.81	11.31	40	452.40	—
27	1—80	1.10	1.00	10.00	2.00	12.00	40	480.00	—
28	1—120	0.60	0.85	8.50	1.45	9.95	40	398.00	—
29	1—160	0.60	0.60	6.00	0.72	6.72	40	268.80	—
30	1—200	0.30	0.45	4.50	0.41	4.91	40	196.40	—
Passes	from	banking	to cutting						
—	1—217	0.00	0.15	1.50	0.05	1.55	17	26.35	—
31	1—240	—0.40	—0.20	2.00	0.06	2.06	23	—	47.38
32	1—280	—0.80	—0.60	6.00	0.54	6.54	40	—	261.60
33	1—320	—0.90	—0.85	8.50	1.08	9.58	40	—	383.20
34	1—360	—0.80	—0.85	8.50	1.08	9.58	40	—	383.20
35	1—400	—0.60	—0.70	7.00	0.74	7.74	40	—	309.60
							Total	1821.95 cu m	1384.98 cu m

(—sign indicates cutting)

ABSTRACT OF COST (Ex. 4)

Item No.	Particulars of items	Quantity	Unit	Rate Rs. P.	Per	Cost Rs.	Cost P.
1	Earthwork in banking ...	1821.95	cu m	275.00	% cu m		5010.36
2	Earthwork in cutting ...	1384.98	cu m	350.00	% cu m		4847.43
					Total ...		9857.79
					Add 3% for Contingencies ...		295.73
					Add 2% for Workcharged Establishment ...		197.16
					Grand Total ...		10350.68

Example 5.—Prepare a detailed estimate for earthwork for a portion of a road from the following data :—

Dist. in m	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
R.L. of ground	114.50	114.75	115.25	115.20	116.10	116.85	118.00	118.25	118.10	117.80	117.75	117.90	119.50
R.L. of Formation	115	Upward gradient 1 in 200 up to 600 m →					←Downward gradient 1 in 400						

Formation width of road is 10 metre side slope 2 : 1 in banking and 1½ : 1 in cutting. Adopt suitable rates.

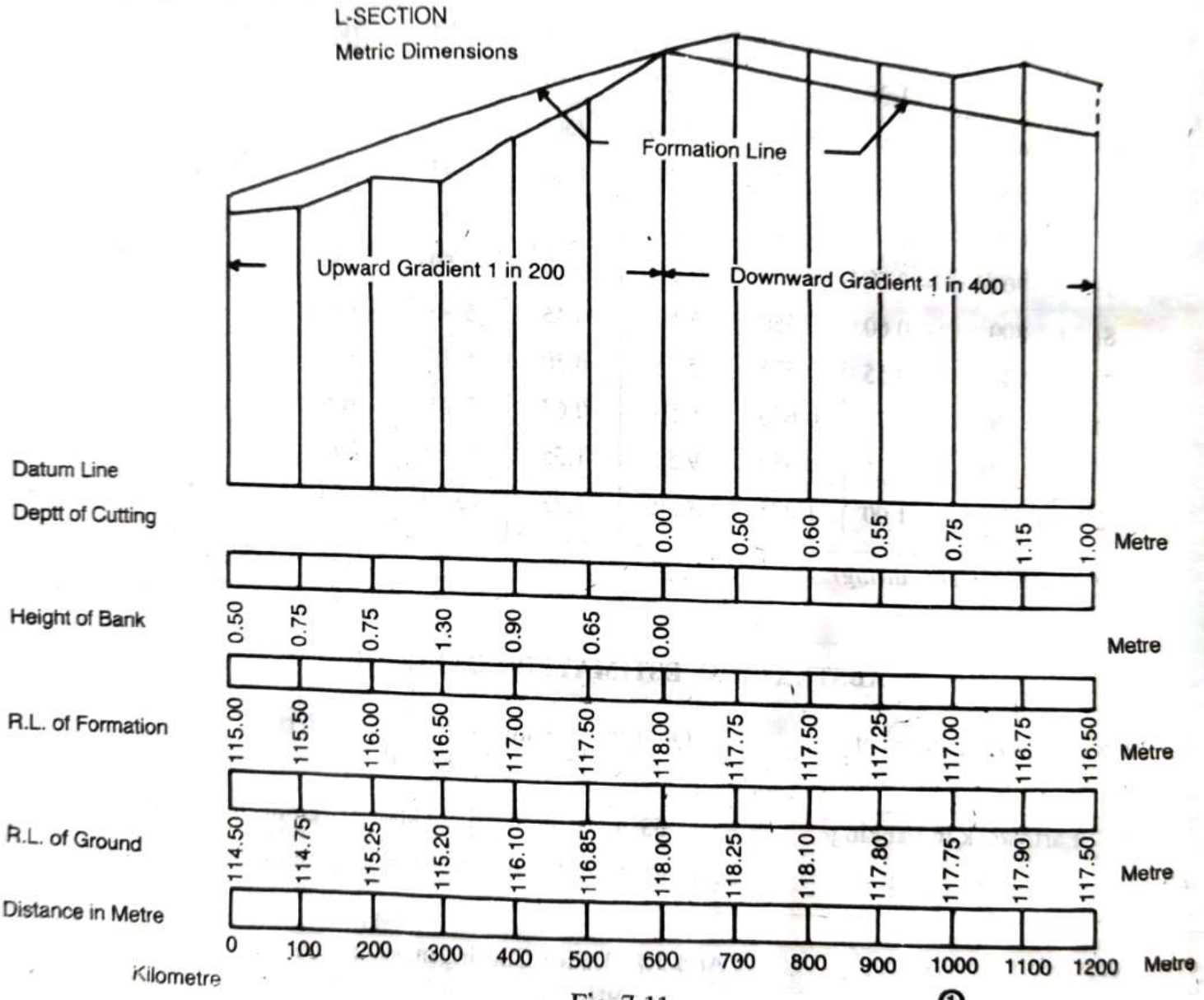

Fig. 7-11

From the data given. L-section can be plotted and heights of bank and depths of cutting of different stations can be calculated. The heights of bank, and depths of cutting are the difference of R.L. of ground, R.L. of formation, and even without plotting L-section the height and depth can be calculated.

Example 1. — Prepare a detailed estimate of a slab culvert of 1.50 metre span and 4.00 metre roadway from the given drawing (Fig. 8.5). The general specifications are as follows :—

Foundation concrete shall be of cement concrete 1 : 3 : 6 with stone ballast and coarse sand. Masonry shall be of first class brickwork in 1 : 4 cement coarse sand mortar. Slab shall be of R.C.C. 1 : 2 : 4 with reinforcement as per drawing. Exposed surface of brick masonry shall be cement pointed 1 : 2. Road shall be provided with 10 cm thick wearing coat of 1 : 2 : 4 cement concrete. Assume suitable rates.

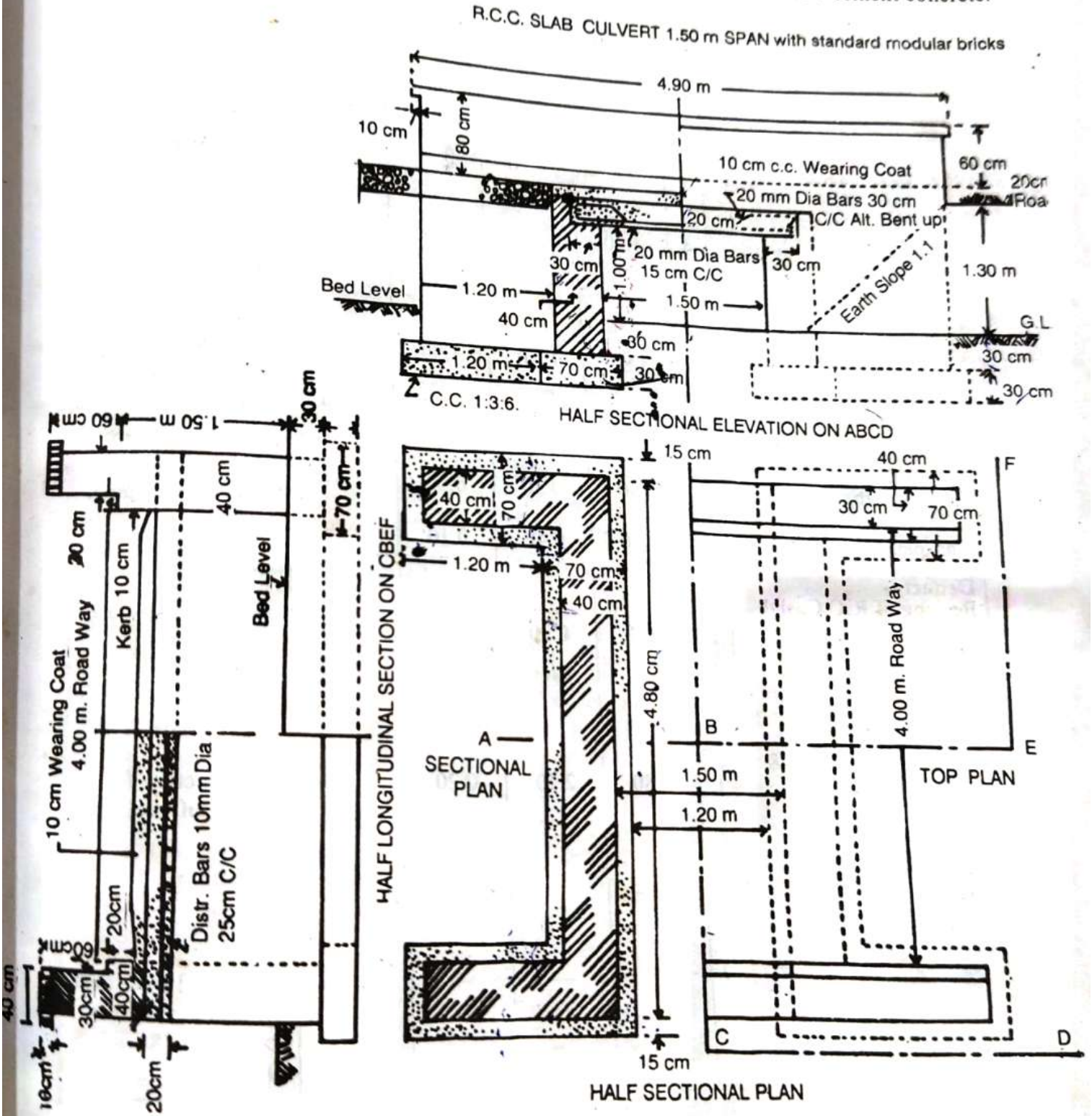

Fig. 8-5

Details of Measurement and Calculation of Quantities (Ex. 1)

Item No.	Particulars of items of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
1.	**Earthwork in excavation** in foundation —						
	Abutments ...	2	5.10	0.70	0.60	4.28	
	Wings walls ...	4	1.20	0.70	0.60	2.02	
					Total	6.30	cu m
2.	**Cement concrete** 1:3:6 in foundation with stone ballast— Abutments ...	2	5.10	0.70	0.30	2.14	½ of earthwork in excavation in item 1.
	Wings walls ...	4	1.20	0.70	0.30	1.01	
					Total	3.15	cu m
3.	**I-class brickwork in** 1 : 4 cement mortar—						
	Abutments ...	2	4.80	0.40	1.50	5.76	Up to top of R.C.C. slab.
	Wing walls ...	4	1.20	0.40	1.50	2.88	
	Parapets up to kerb ...	2	4.70	0.40	0.30	1.13	Above R.C.C. slab up to kerb.
	Parapets above kerb ...	2	4.70	0.30	0.50	1.41	Above kerb excluding coping.
	Parapet coping ...	2	4.90	0.40	0.10	0.39	
					Total	11.57	
	Deduct— Bearing of R.C.C. slab in abutment	2	4.80	0.30	0.20	0.57	
4.	**R.C.C. work 1 : 2 : 4 in** slab excluding steel and its bending but including centering shuttering and binding steel			Net	Total	11.00	cu m
		1	4.80	2.10	0.20	2.016 cu m	No deduction for volume of steel.
5.	**Steel bars including bending in R.C.C. work—** 20 mm dia. bars— Main straight bars 30 cm c/c ...	17	2.38	—	—	40.46 cu m	L=2.10—2 side covers + 2 hooks = 2.10—(2×4 cm)+(18×20 mm) = 2.38 m
	(No.= $\frac{4.80}{.30}$ + 1 = 17)						

	Particulars of items of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
	Main bent up bars 30 cm c/c ... (No. = $\frac{4.80}{.30}$ = 16)	16	2.54	—	—	40.64 m	Adding one depth. 16 cm for two bent ups
			Total	81.10 m	@ 2.47	kg m= 200.32kg	L=2.38+.16 = 2.54 m
	10 mm Dia. bars— Distributing bottom bars 25 cm c/c ...	9	4.90	—	—	44.10 m	L=4.80—2 end covers +3 hooks =4.80— (2×4 cm) + (18× 10mm)= 4.90 m
	Distributing top bars	4	4.90	—	—	19.60 m	
	To	tal	63.70 m	@ .62 kg	=	39.49 kg	
			Total	of	steel	239.81 kg	2.398 quintal
6.	**Cement concrete 1:2:4 wearing coat** ...	1	4.00	2.30	0.10	0.92 cu m	In between parapets
7.	**Cement pointing 1:2 in walls—**						
	Face wall from 10 cm below G.L. up to bottom of coping	2	4.70	—	2.10	19.74	
	Inner side of parapet excluding coping	2	4.70	—	0.80	7.52	Ht.=(20+10+50) =0.80 mm
	Coping (inner edge, top, outer edge and outer and side) ...	2	4.90	0.70	—	6.86	B=(10+40+10+10) cm = 0.70 m
	Ends of parapet ...	4	—	0.40	0.20	0.32	Up to kerb.
	Ends of parapet ...	4	—	0.30	0.50	0.60	Above kerb.
	Ends of coping ...	4	—	0.40.	0.20	0.32	Edge and under side.
					Total	35.36	
	Deduct— Rectangular opening	2	1.50		1.30	3.90	Including 10 cm below G.L. and edge of R.C.C. slab.
	Triangular portion below earth slope	2	(½×1.30	× 1.30)		1.69	
				Total of	deductio	n 5.59	
				Net	Total	29.77	sq m

Example 7.—Prepare a detailed estimate of Hume pipe Culvert of three pipes each of 60 cm diameter from the given plan and elevations Fig. 8-14. Foundation concrete shall be of 1 : 4 : 8 cement concrete and brickwork shall be of first class in 1 : 6 cement sand mortar. Exposed surfaces shall be pointed with 1 : 2 cement sand mortar.

Assume suitable rates.

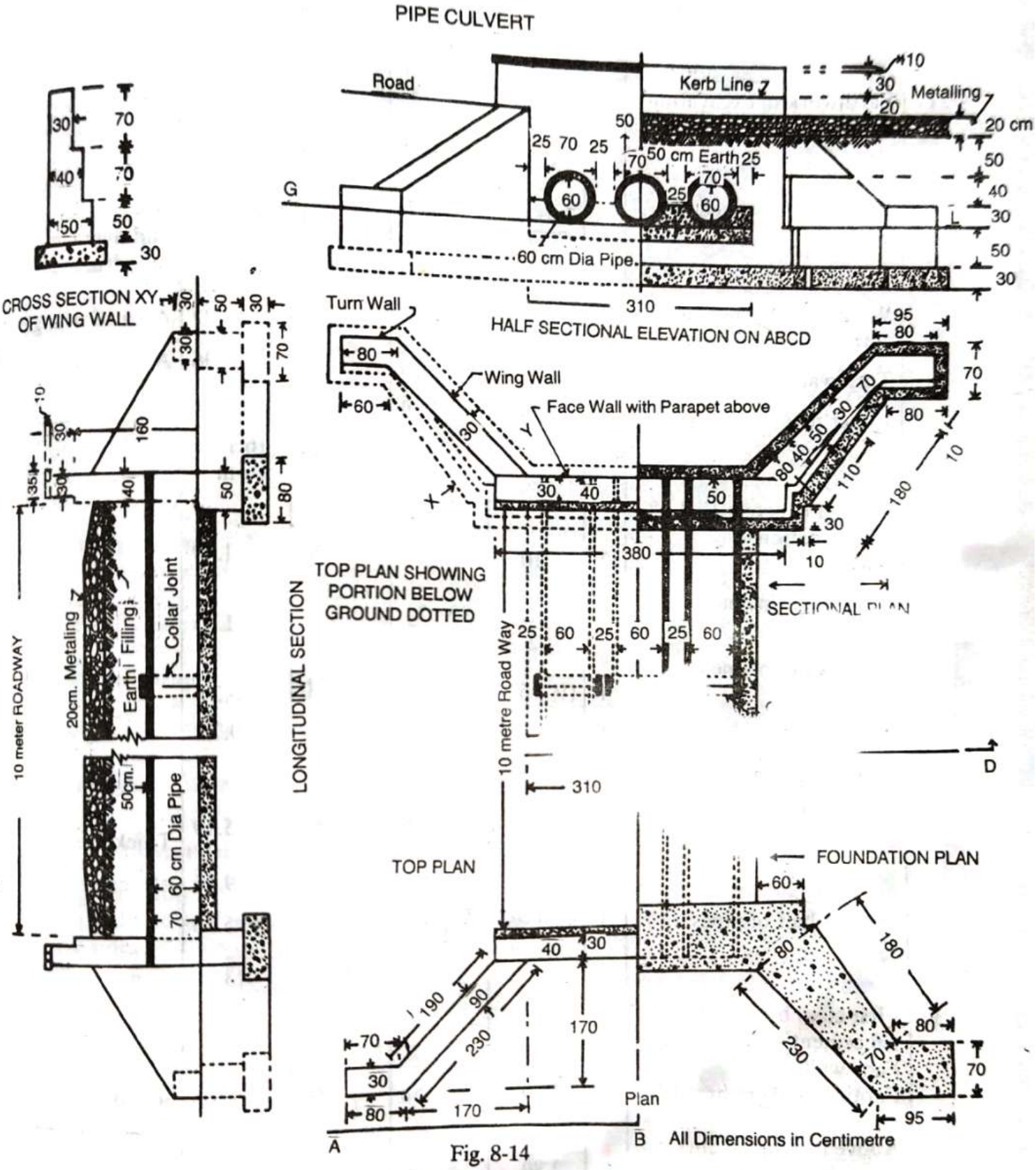

Fig. 8-14

Details of Measurement and Calculation of Quantities (Ex. 7)

Item No.	Particulars of items	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
1	Earthwork in excavation in foundation						
	Face walls ...	2	3.10	.80	.80	3.97	
	Wing walls inclined portion ...	4	$\frac{2.3+1.8}{2}$	$\frac{.8+.7}{2}$	.80	4.92	Average length and average breadth.
	Wing walls triangular corner ...	4	(½×.6×	.8)	.80	0.77	Area of triangle.
	Turn walls ...	4	$\frac{.95+.80}{2}$	.70	.80	1.96	Average length.
	Under pipe ...	1	9.80	3.10	.15	4.56	
					Total	16.18 cu m	
2	Cement concrete 1 : 4 : 8 in foundation—						
	Face walls ...	2	3.10	.80	.30	1.49	
	Wing walls inclined portion ...	4	$\frac{2.3+1.8}{2}$	$\frac{.80+.70}{2}$	.30	1.85	
	Wing walls inclined portion ...	4	(½×.6×	.8)	.30	0.29	
	Turn walls ...	4	$\frac{.95+.80}{2}$	.70	.30	0.74	
	Upper pipe and in between pipe up to half height ...	1	9.80	3.10	.50	15.19	Thickness=$15+\frac{70}{2}$
					Total	19.56	=50 cm = .50 m
	Deduct half of pipes ...	3	9.80×½	$\frac{\pi\times.7^2}{4}$		5.66	
					Total	13.90	cu m
3	First class brickwork in 1:6 cement sand mortar—						
	Face walls—						
	Footing—50 cm breadth	2	4.00	.50	.50	2.00	Breadth means thickness of wall.
	Above footing 40 cm breadth ...	2	3.80	.40	1.60	4.86	
					C.O.	6.86	

Item No.	Particulars of items	No.	Length m	Breadth m	Ht. or Depth m	Quantity	Explanatory notes
	Parapet 30 cm breadth	2	3.80	.30	B.F. 30	6.86	
	Coping 35 cm breadth	2	4.00	.35	10	0.68 0.28	
	Wing walls—						
	1st step—40 cm breadth	4	1.10	$\frac{.5+0}{2}$	.50	0.55	
	2nd step—40 cm breadth—						
	(*i*) Straight portion ...	4	1.80	.40	.30	0.86	
	(*ii*) Sloping portion ...	4	1.80	.40	$\frac{.40+.0}{2}$	0.58	Average height.
	3rd step—30 cm breadth	4	1.90	.30	$\frac{.70+0}{2}$	0.80	Average height.
	Turn wall—40 cm breadth	4	$\frac{.8+.7}{2}$	.40	.50	0.60	
	Turn wall—30 cm breadth ...	4	$\frac{.80+.75}{2}$	.30	.30	0.28	
					Total	11.49	cu m
4	Cement pointing 1 : 2 in exposed surfaces above G.L.—						
	Face walls outer sides ...	2	3.10	—	1.40	8.68	Up to road level
	Face wall parapet outer side	2	3.80	—	.65	4.94	Above road level including coping. Ht.=20+30+10 +5=65 cm =.65 m
	Parapet inner faces ...	2	3.80	—	.70	5.32	Including kerb offset of 10 cm
	Wing walls vertical face	4	2.30	—	$\frac{1.40+.50}{2}$	8.74	Average height.
	Wing walls top ...	4	2.30	.30	—	2.76	
	Turn walls vertical face three sides ...	4	1.80	—	.30	2.16	L = Perimeter = 80 + 30 + 70 = 180 cu m = 1.80 m
	Turn walls top ...	4	$\frac{.8+.7}{2}$	.30	—	0.90	
					Total	33.50	sq m
5	Hume pipe heavy type 60 cm dia. including collar joint ...	3	10.80	—	—	32.40	L = 10 + .4 + .4 = 10.8 m

Due to relative levels sometime it is required to lower the bed of the irrigation channel or the drainage channel at their crossing. When the bed of the irrigation channel is depressed and taken under nala or stream it is known as Irrigation Syphon. When the bed of the nala or stream is depressed and taken under the irrigation channel it is known as Drinage Syphon. The Syphon crossing may be of rectangular closed masonry channel or of circular brickwork of of R.C.C. or Hume pipe of the required diameter and number. Approach and exit may be through masonry drop pit or of masonry sloped channel. The down stream end is kept lower than the up stream end by at least 15 cm for better flow. An estimate of a small Drainage Syphon has been given in Example 7.

DRAINAGE SYPHON ACROSS A MINOR

Example 7. —Prepare a detailed estimate of a Drainage Syphon across a minor from the given drawing, Figs. 9-8 and 9-9.

Foundation concrete shall be of 1 : 4 : 8 cement concrete with brick ballast. All brickwork shall be of 1 : 4 cement mortar. Exposed surfaces of brickwork shall be struck pointed with 1 : 2 cement mortar. Brick pitching shall be of dry brick with straight over burnt bricks.

Assume suitable rates for the different items of work.

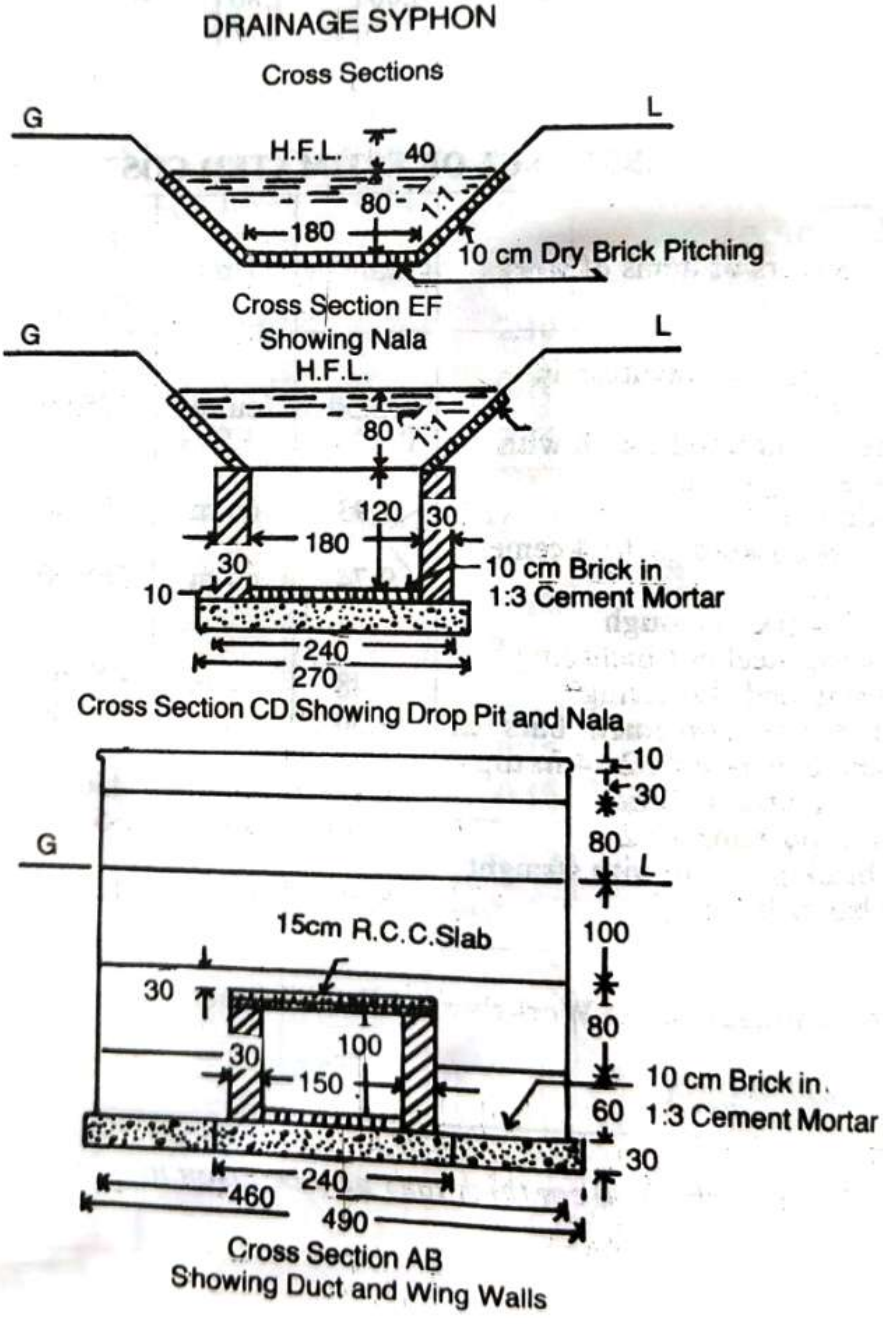

Fig. 9-8

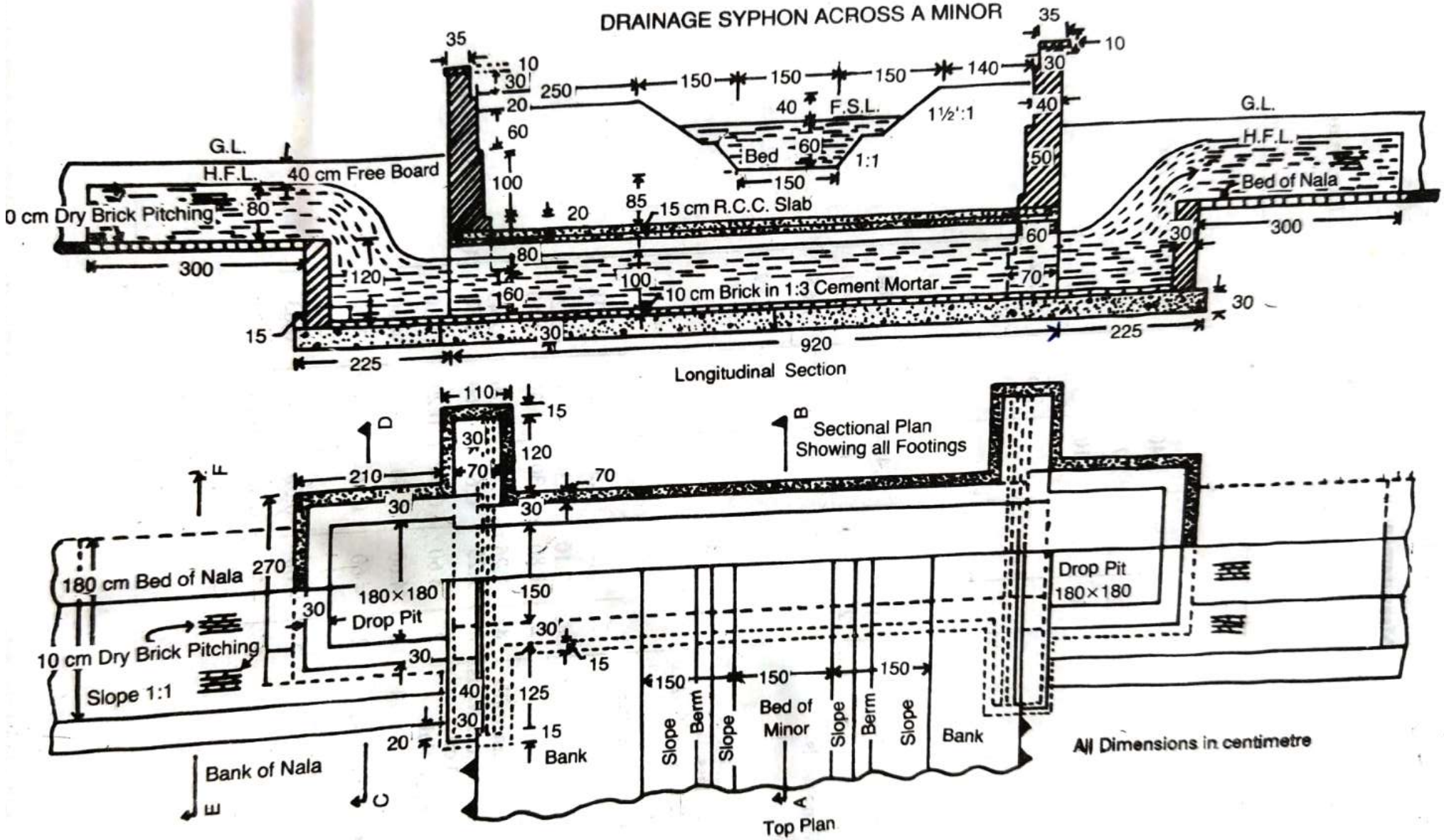
DRAINAGE SYPHON ACROSS A MINOR
G.L.
H.F.L.
40 cm Free Board
0 cm Dry Brick Pitching
F.S.L.
Bed
1½':1
1:1
15 cm R.C.C. Slab
10 cm Brick in 1:3 Cement Mortar
Bed of Nala
Longitudinal Section
Sectional Plan
Showing all Footings
180 cm Bed of Nala
10 cm Dry Brick Pitching
Slope 1:1
Drop Pit
180×180
Bank of Nala
Slope
Berm
Bed of
Minor
Bank
All Dimensions in centimetre
Top Plan

Fig. 9.9

Details of Measurement and Calculation of Quantities (Ex. 7)

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
1	Earthwork in excavation in foundation—						
	Syphon duct ...	1	9.50	2.40	1.60	36.48	*For bed level of nala.*
	Drop pit ...	2	2.10	2.70	1.60	18.14	
	Wing walls ...	4	1.25	1.10	1.60	8.80	
					Total	63.42 cu m	
2	Cement concrete 1 : 4 : 8 with brick ballast—						
	Syphon duct ...	1	9.50	2.40	0.30	6.84	
	Drop pit ...	2	2.10	2.70	0.30	3.40	
	Wing walls ...	4	1.25	1.10	0.30	1.65	
					Total	11.89 cu m	
3	First class brickwork in 1 : 4 cement mortar—						
	Syphon duct side walls	2	9.20	0.30	1.30	7.18	
	Drop pit walls ...	2×2	2.10	0.30	1.30	3.28	
	Wing walls—	2	1.80	.30	1.30	1.40	
	1st step 70 cm walls	4	1.25	0.70	0.70	2.45	
	2nd step 60 cm walls	4	1.25	0.60	0.60	1.80	Upto top of slab.
	2nd step 60 cm walls above slab	2	4.60	0.60	0.20	1.10	
	3rd step 50 cm wall	2	4.60	0.50	1.00	4.60	
	4th step 40 cm wall	2	4.60	0.40	0.80	2.94	
	5th step 30 cm wall (parapet)	2	4.60	0.30	0.30	0.83	
	Coping	2	4.70	0.35	0.10	0.33	
					Total	25.91 cu m	

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
4	R.C.C. slab of syphon duct including steel reinforcement complete work	1	9.20	2.10	0.15	2.90 cu m	
5	10 cm thick brick floor in 1 : 3 cement mortar including 1 : 2 cement pointing —						
	Floor of syphon duct	1	9.20	1.50	—	13.80	
	Floor of drop pit ...	2	1.80	1.80	—	6.48	
					Total	20.28 sq m	
6	Cement struck pointing 1 : 2—						
	Syphon duct inner faces	2	9.20	—	1.00	18.40	
	Drop pit 3 vertical faces	2×3	1.80	—	1.20	12.96	
	Drop pit 3 top faces	2	5.70	—	0.30	3.42	L=2×180+210 =570 cm
	Parapet wall inner face top and outer face up to G.L.	2	4.60	—	2.30	21.16	Ht.=20+10+30+10 +35+10+5+110 =230 cm
	Outer face of wing wall above slab ...	2	1.80	—	1.20	4.32	
	Triangular portion of outer face of wing wall	2×2	(½×.8	×.8)	=	1.28	
					Total	61.54 sq m	
7	10 cm dry brick pitching with straight over burnt bricks—						*Thin piching, unit in area basis.*
	Bed of nala	2	3.00	1.80	—	10.80	*Up and down streams.*
	Side slopes of nala	2×2	3.00	1.13	—	13.56	*Sloping breadth=* $\sqrt{.8^2+.8^2}$=1.13 m
					Total	24.36 sq m	

ESTIMATE OF A 60 cm FALL

Example 8 — Prepare a detailed estimate of a 60 cm fall for a distributory of 360 cm bed width and 90 cm depth of water, from the drawing given (Fig. 9-10 page 441). Side slope of bank and channel are 1½ : 1. The general specifications are as follows :—

Foundation and apron concrete—Cement concrete 1 : 3 : 6 with stone ballast.
Masonry—All brickwork shall be of I-class in 1 : 4 cement mortar.
Pointing—All exposed surfaces shall be pointed with 1 : 4 cement and sand mortar.
Pitching—Pitching shall be of dry brick with straight over burnt bricks.
Rates—Assume suitable rates.

Details of Measurement and Calculation of Quantities (Ex. 8)

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
1	**Earthwork in excavation** Crest wall, side walls and floor (taken together)—						
	(i) ...	1	2.65	6.00	1.15	18.29	B=4.5+2×.6+2×.15 =6.00 m
	(ii) ...	1	2.10	5.80	1.05	12.79	B=4.5+2×.5+2×.15 =5.80 m
	(iii) ...	1	1.50	5.60	0.95	7.98	B=4.5+2×.4+2×.15 =5.60 m
	Wing walls beyond side walls ...	2	1.80	0.70	1.00	2.52	
	Curtain walls ...	1	4.50	0.60	1.20	3.24	
	Up stream pitching 20 cm depth—						
	Bed	1	1.80	3.60	0.20	1.30	
	Side slopes (up to F.S.L.)	2	1.80	1.62	0.20	1.17	Sloping breadth $=h\sqrt{s^2+1}$ $=.9\sqrt{(1\frac{1}{2}^2+1)}$ =1.62 m
	Down stream channel beyond curtain wall. trapezium section $(Bd+sd^2)\times L$ ...	(4.0	5×.8+1½	×.8²)	×3.90	=16.38	Average breadth $=\frac{4.5+3.6}{2}=4.05$ m Average depth $=\frac{.60+1.00}{2}=.80$ m
	(L=4.20-.30=3.90 m)						
	Down stream pitching 20 cm depth, excluding toe wall—						
	Bed	1	3.90×	$\frac{4.1+3.2}{2}$	×0.20=	2.85	Sloping breadth at middle
	Side slopes up to F.S.L. (Upper length =2.0 m) ...	2	$\frac{4.2+2.0}{2}$	×1.44	×0.20=	1.79	$=d\sqrt{s^2+1}$ $=8\sqrt{1\frac{1}{2}^2+1}=1.44$ m
					C.O.	68.31	

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
					B.F.	68.31	
	Curved portion ...	2	$\pi \times .6^2$	(area)	×0.20	0.45	Taken as quadrant of sphere.
	Top wall ...	2	3.90	0.20	0.30	0.47	
					Total	69.23	
	Deduct for set back of wing wall ...	2	0.60	0.10	1.15	0.14	
				Net	Total	69.09 cu m	
2	**Cement concrete 1 : 3 : 6** in foundation and floor—Crest wall side walls and floor—						
	(i) ...	1	2.65	6.00	0.45	7.16	
	(ii) ...	1	2.10	5.80	0.35	4.26	
	(iii) ...	1	1.50	5.60	0.25	2.10	
	Wing wall beyond side wall	2	1.80	0.70	0.30	0.76	
	Curtain wall ...	1	4.50	0.60	0.20	0.54	
					Total	14.82	
	Deduct for set back of wing wall ...	2	0.60	0.10	1.15	0.14	
				Net	Total	14.68 cu m	
	I-class brickwork in 1 : 4 cement mortar—						
	Crest wall—						
	1st step ...	1	4.50	0.70	0.40	1.26	
	2nd step ...	1	4.50	0.60	1.00	2.70	
	Side wall—						
	(i) 1st step ...	2	2.35	0.60	0.40	1.13	As per cross sec. BC
	2nd step ...	2	2.35	0.50	0.50	1.18	
	3rd step ...	2	2.35	0.40	0.50	0.94	
	4th step ...	2	2.35	0.30	0.70	0.99	
	(ii) 1st step ...	2	2.10	0.50	0.40	0.84	As per cross sec. EF
	2nd step ...	2	2.10	0.40	0.50	0.84	
	3rd step ...	2	2.10	0.30	0.90	1.13	
	(iii) 1st step ...	2	1.50	0.40	0.90	1.08	As per cross sec. GH
	2nd step ...	2	1.50	0.30	0.60	0.54	
	3rd step ...						
					C.O.	12.63	

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
					B.F.	12.63	
	Wing wall beyond side wall	2	1.80	0.40	0.40	0.58	As per cross sec. XY
		2	1.90	0.40	0.50	0.76	
		2	2.00	0.40	0.50	0.80	
		2	2.10	0.30	0.70	0.88	
	Curtain wall	1	4.50	0.30	0.40	0.54	
	Toe wall	2	3.90	0.20	0.30	0.47	
					Total	16.66	cu m
4	**Brick-on-edge floor in 1:8** cement mortar including pointing ...	1	5.40	4.50	—	24.30 sq m	Down stream in between walls
5	**Cement pointing in 1 :3** cement mortar— Crest wall (up stream face top and down stream (face)	1	4.50	—	2.40	10.80	Ht.=.6+.6+1.2 =2.40 m
	Side wall inner face (i)...	2	1.80	—	2.00	7.20	
	(ii)...	2	2.10	—	1.70	7.14	
	(iii)...	2	1.50	—	1.40	4.20	
	Side wall portion above crest wall ...	2	0.60	—	0.80	0.96	
	Vertical faces of steppings	2×2	—	0.30	0.30	0.36	
	Vertical face of end	2	—	0.40	0.90	0.72	
		2	—	0.30	0.60	0.36	
	Top of side walls ...	2	6.00	0.30	—	3.60	Full length of 30 cm wall
	Top of curtain wall-	1	4.50	0.30	—	1.35	
	Top of toe walls ...	2	3.90	0.20	—	1.56	
	Wing wall top face	2	2.10	0.30	—	1.26	
	Wing wall up-stream side triangular portion above slope ...	2	½(2.10×1.40)		—	2.94	Triangular portions of slope
					Total	42.45 sq m	

Item No.	Particulars of items and details of works	No.	Length m	Breadth m	Height or Depth m	Quantity	Explanatory notes
6	**Brick-pitching—**						
	Up-stream bed ...	1	1.80	3.60	0.20	1.30	
	Up-stream side slopes	2	1.80	1.62	0.20	1.17	
	Down-stream bed ...	1	3.90×	$\frac{4.1+3.2}{2}$	×0.20=	2.85	Dimensions same as in item 1)
	Down-stream side slopes	2	$\frac{4.2+2.0}{2}$	×1.44	×0.20=	1.79	
	Side curved portions	2	$\pi x.6^2$	(area)	×0.20=	0.45	
					Total	7.56 cu m	

ABSTRACT OF ESTIMATED COST (Ex. 8)

Item No.	Particulars	Quantity	Unit	Rate Rs. P.	Per	Amount Rs. P.
1	Earthwork in excavation ...	69.09	cu m	350.00	% cu m	241.81
2	Cement concrete 1 : 3 : 6 in foundation and floor with stone ballast ...	14.68	cu m	400.00	/ cu m	5872.00
3	I-class brick work in 1 : 4 cement mortar	16.66	cu m	365.00	/ cu m	6080.90
4	Brick-on-edge floor in 1 : 3 cement mortar including pointing ...	24.30	sq m	40.00	/ sq m	972.00
5	Cement pointing 1 : 2 cement mortar ...	42.45	sq m	5.60	/ sq m	237.72
6	Brick pitching (dry) ...	7.56	cu m	120.00	/ cu m	907.20
					Total ...	14311.63
	Add 3% for Contingencies ...				...	429.35
	Add 2% for Workcharged Establishment				...	286.23
					Grand Total Say Rs....	15027.00

Note :— *In calculating the earthwork in excavation, up-stream bed-level has been considered at G.L. for whole length of the fall. Instead of calculating, earthwork so accurately, it may be calculated approximately.*

Execution of work

A work can be executed by departmentally or through the contractors by inviting tenders.

Contract → An agreement enforceable by law is known as contract. The contract invariably follows a proposal from one party and its acceptance by the other. As fast as PWD is concerned, the term 'contract' means a written undertaking for execution of works or supply of materials or for the performance of any service connected there with duly accepted and registered by the competent authority on behalf of the Union or State govt.

Contractor → The term contractor means Private individuals, partnership firms, Public or Private limited concerns who have made such an undertaking for the execution of works, supply of materials or for service concerned therewith the respective Govt. In PWD the contractor is categorised as

a) for Roads & Buildings (R & B)
b) for sanitary installation & water supply
c) for electrical & Air conditioning
d) for furniture.

Competent Authorities → The tenders can be accepted by different authorities according to their power prescribed in financial rule. The following are the powers of different authorities for sanctioned work

Chief Engineer	- Full Power
Superintending Engineer	- Full Power
Executive Engineer	- upto 5,00000
S.D.O	- upto 50,000
Assistant Engineer	- upto 20,000

Administrative Approval :-

It is a formal acceptance from the administrator of a department to bear the expenditure of a work to be carried out by PWD for the mentioned department. This approval is given on rough cost estimate. The engineering department prepares approximate estimate and preliminary plans and submit it to the concerned department for administrative approval.

Technical sanction :-

Technical sanction means the sanction of the detailed estimate, design calculations, quantities of work, rates and cost of the work by the competent authority of the Engineering department. TS is taken after the administrative approval and the work is only taken up for construction of the the Technical sanction.

Contingency Budget →

It is defined as incidental charges of miscellaneous characters, which cannot be classified under any distinct subhead, but cost is added. It is generally 3% to 5% of total estimated cost and added in the estimate.

Tender :- Tender is an offer in writing to execute some specified work or to supply some specified material at certain rates, within a fixed time under certain conditions of contract and agreement, between the contractor and the department. Sealed tenders are invited and the work is usually entrusted to the lowest tender.

Earnest money :- It is a guarantee in the shape of money, given by the contractor along with their tenders confirming their willingness to work for the department. It is generally 2% of the total estimate and is submitted in form of Demand draft in favour of the department.

Tender Notice → Tender for work or supply are invited by issuing tender notice in prescribed forms. The tender notice contains following particulars

i) Name of the authorities inviting tender
ii) Name of work and its location
iii) Estimated cost
iv) Time of completion
v) Cost of complete set of tender forms & conditions
vi) Date, time & place of tender
vii) Amount of earnest money & security money
viii) Validity of tenders

Security money →

This is the money which the contractor has to deposit with the department when the contract is alloted to him. This amount is 10% of total estimate. This amount is kept as a check so that the contractor fulfils all the terms & conditions of the contract and maintains the progress of work as per the specifications. This money can be forfeited by the department of the progress & quality of work is not satisfactory.

Quotations →

The rates quoted by a contractor in response to tender call to carry out the work or supply of materials are called "Quotations". It is in response to notice inviting tenders by the department.

Advance payment →

This means payment made on a running account to a contractor for work done by him but not measured. Advance payment is not generally made to the contractor, but may be made under special cases when the work is sufficiently progressed but measurement cannot be taken for some valid reasons.

On Account or Running or Interim payment :-

This means payment made on a running account to a contractor for works done or supplies made by him duly measured and entered in M.B, when only a part of the whole work or supply was been done and the work or supply is in progress.

final payment →

This means the payment made on running account made to a contractor on the completion of his contract and in full settlement of the account. The bill on which final payment is made is known as final Bill.

permanent Establishment :-

An establishment which can neither be increased or decreased with the increase & decrease of the workload, in the department is called permanent establishment.

The chargeable head of salary of such employees is 'Establishment'. They are governed by rules and regulations mentioned in CSR regarding their pay, TA, Leave, PF, Pension, gratuity etc.

Temporary Establishment :-

The establishment which is employed on monthly basis, to help the regular establishment, when there is increase in workload, is known as Temporary establishment. The sanction to employ them is given by the competent authority.

Cash → The term 'cash' includes legal tender coins or notes, cheques payable on demand, remittance transfer receipts and demand drafts. A small supply of revenue stamps may be kept as part of the cash balance.

Debit & credit → Debit means expenditure and Credit means receipts. When an amount is to be debited to a work means the amount is to be shown as expenditure on the work. Similarly when an amount is to be credited to a work it means the amount is to be shown as receipt under the work.

Major Head of Account →

All the public works including original works, Repairs, establishment or Tools & plants etc comes under the major head of account. The major head is classified as major Revenue heads & major expenditure heads.

→ The major revenue & expenditure heads includes Multipurpose River schemes, irrigation & electricity schemes and public works including roads and schemes of miscellaneous public improvements.

Subheads of Account →

The subheads of account includes buildings, communication and miscellaneous items.

→ police, education, Jails & medical etc comes under subheads of Account.

Temporary Advance :-

Temporary advance also known as temporary imprest is the amount which is advanced by a disbursing officer to a sub-ordinate officer to ~~can~~ enable him to make a number of specific payment out of muster-roll or any other vouchers which has already been passed for payment.

Issue rate →

It is defined as a rate per unit of an Article borne on stock of department. The rate is fixed on the principle that the cost to be charged to work on which the materials are to be used, should be approximately equal to the actual cost of stores and there may not be ultimate loss or profit on stock account. The issue rate includes actual cost, transportation charges plus the storage charges.

Storage charges → This means expenditure incurred on store materials after the acquisition of stores, on work charged establishment employed on handling and keeping initial accounts, the custody of stock and the maintenance of store godown or yards etc.

→ This is added on a percentage basis of cost, so as to form a part of the issue rate.

Supervision charges →

The charges which are levied at the time of transfer or issue of stock in addition to the book value and storage charges are termed as supervision charges.

→ These charges cover the expenditure incurred on stores which do not enter the book value and are not included in storage charges.

Voucher → Voucher is a written document with details which is kept in record as a proof of payment. for any payment first a bill is prepared and payment is made on the bill duly checked and acknowledged by the payee, by signature on revenue stamp as required and after the payment is made bill becomes voucher document which is kept in record.

Suspense head of Account :-

Suspense heads are such heads which are reserved for the temporary booking of the transactions of the following nature

i) when the final head of account, to which the cost is ultimately debitable can not be determined at once.

ii) when the materials have been received from a supplier or some other division and bills of the same have not been received.

iii) To watch recovery of cost of materials on their sale and other shortages, pending adjustment by recovery or otherwise.

→ The suspense sub heads include, purchase, stock, miscellaneous, London stores & workshop suspense.

Measurement Book :-

The measurement of all works & supplies are recorded in a book made from form No-23 and payment of of all works & supplies are made on the basis of measurement recorded in that book which is known as measurement book.

Measurement Book

Particulars	No	Details of measurement L	B	D	Contents of area

→ All measurement book are numbered serially and a register is maintained in the divisional office showing the serial number of each book, the names of the sub-division or officer to whom issued, the date of issue, the date of receipt and remark.

→ A similar register is maintained in sub-divisional office showing the name of officer to whom it is issued, date of issue & date of return etc.

Making entries to the M B

The following instructions should be followed while writing the M.B.

1) Each set of measurement should be recorded with the following entries

a) In case of bills for works done
   i) Full name of work ii) Location of work
   iii) Name of contractor iv) No. & date of agreement
   v) Date of written order to commence work
   vi) Date of actual completion of works or running
   vii) Date of recording measurement
   viii) Reference to previous measurements (e.g. RA-1, RA-2)

b) In case of bills for supply of materials
   i) Name of supplier ii) No. & date of supply order
   iii) Purpose of supply iv) Date of written order to commence the supply v) Date of actual supply
   vi) Date of recording measurement
   vii) Reference to previous measurement in case of running account bill.

2) made in ink. No eraser is allowed. If a mistake is made, it should be corrected by striking out incorrect one and inserting the correct one in between the lines and the correcting made should be initialled & dated.

3) measurement should be recorded neatly & directly, in the measurement book at the site of the work and the signature of the contractor or his authorised representative should be obtained at the time of measurement.

4) when any measurement is cancelled or disallowed, this must be supported by the dated initial of the officer ordering cancellation or by a reference of his orders, initialled by the officer who made the measurement

5) Entries must be recorded continuously and no blank page left or torn out.

6) The person recording the measurement shall put his signature with date at the end of measurements book certifying "measured by me".

7) After completing the cash abstract, the measurement book shall be submitted to the Assistant Engineer for his final checking.

8) Each measurement book should be provided with an index and be kept up to date.

common irregularities →

i) Over writing or use of whiteners in the M.B which should be avoided by striking out the incorrect one

ii) Striking any incorrect measurement without the initial of the officer.

iii) Leaving the blank page without cancelling it or missing of page from the M.B.

iv) measurement without the signature of officer or signature of contractor.

v) measurement book with unupdated index page.

Standard Measurement Book :-

A measurement book where the detailed measurements of certain items of works of a building is recorded correctly on the completion of the construction and the accuracy of which is certified by an Assistant Engineer, is known as the standard measurement book.

→ The book is maintained as record, to facilitate the preparation of estimate for periodical repairs & their execution.

→ S.M.B is checked in every five years and alteration if any are entered in the S.M.B which is known as Quinquennial checking.

→ The S.M.B is mainly used for annual repair & maintenance works.

Muster Roll →

When work is executed departmentally by employing daily labour, the attendance of labourers is kept in a format made from form no-21 is known as muster Roll.

→ It is maintained by the Junior engineer or by his authorised agent like supervisor or mate etc. and is used for the payment of the labourers.

→ It is periodically checked & initialed by Assistant engineer or sub-divisional officer.

→ The muster Roll consist of two parts

Part I → Nominal Roll where attendance are recorded.

Part II → Details of quantity of work done by the labourer and the progress of work are recorded in this part.

Rules for preparation of muster Roll

→ One or more muster rolls may be kept for each work, but M.R should not be prepared in duplicate.

→ Labourers may be paid more than once in a month, but separate M.R must be prepared for each period of payment.

→ The daily attendance and absence of labourers ~~& fines if~~ should be recorded in ink daily in the M.R, so that the calculations may be done correctly for payment.

→ After a M.R has been passed, payment should be made as quickly as possible and each payment is initialled and dated by the paying officer.

→ The amount of unpaid wages is deposited in the cash and amount is kept as deposit. The amount may be paid later on hand Receipt.

Labour Report →

for large work or a group of works which is done through daily labour, a consolidated report is prepared by the JE showing the labourers employed day-to-day from the muster Roll is known as Labour Report and it is submitted daily to the S.D.O or EE for control & check.

→ The Labour Report is submitted in following format

Labour Report

Daily Report of the day ... of 20—

Work on which employed	Class of Labour	No. of each	Rate	Approx. Quantity of work done	Remarks