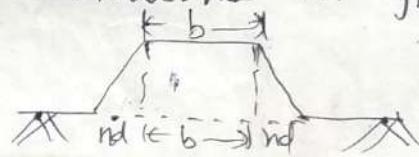


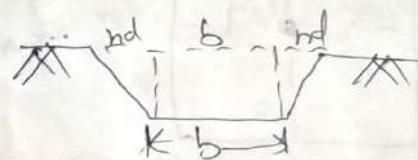
EARTH WORKIntroduction

All most all the civil engg. projects involves the earth work mostly in construction of roads, railways, tracks, earthen dams, canal banks and will be done by the earth work excavation either in cutting (a) in filling (b) sometimes in both as per existing level of ground to get the desired shape and level.

Embankment :- The quantity of earthwork in filling is known as embankment.



Cutting :- The quantity of earthwork in excavation is known as cutting.



Volume of earthwork :- The volume of earthwork is calculated by multiplying the cross-sectional area and depth is called volume of earthwork. It is denoted by the letter 'V' and its units are in  $m^3$ .

Definition the term of 'Lead' :-

Lead is the horizontal distance over which the earth is conveyed. It is measured from the centre of the area of excavation / borrow pit to the centre of the spoil bank / baulk / heap.

Definition of 'Lift' :-

Lift is the vertical distance over which the earth is conveyed. It is measured from centre of excavation to the centre of spoil bank (or) heap.

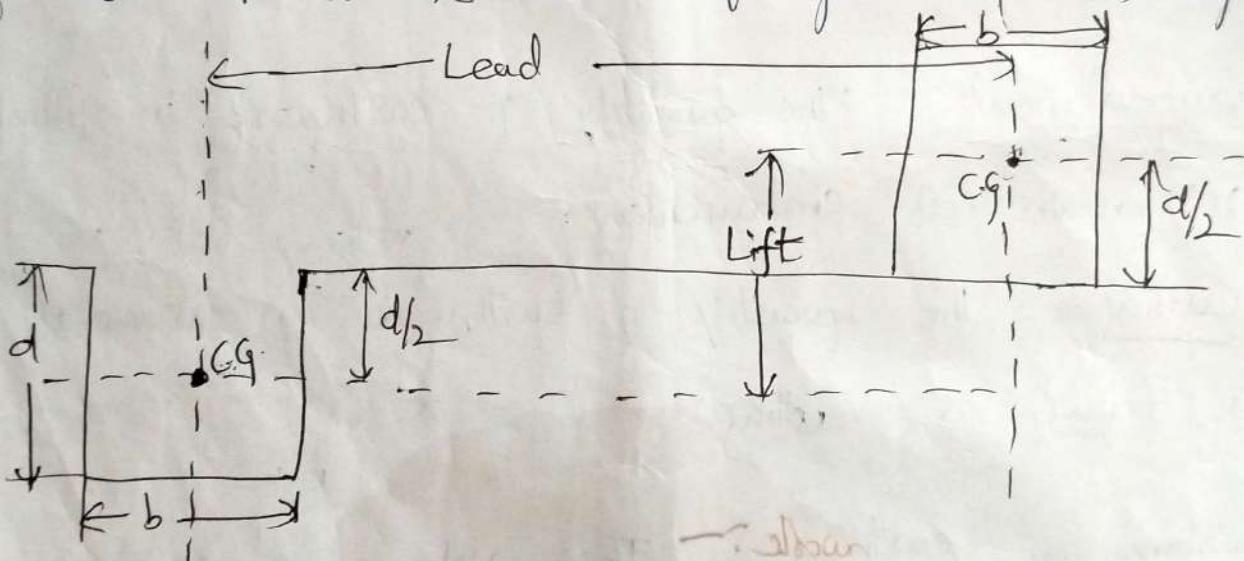


Figure of Lead and Lift.

Standard values of Lead :-

Initial lead is 10m and for every additional 10m (or) part there of one extra lead is to be paid.

Schedule of rates provides rates for different leads.

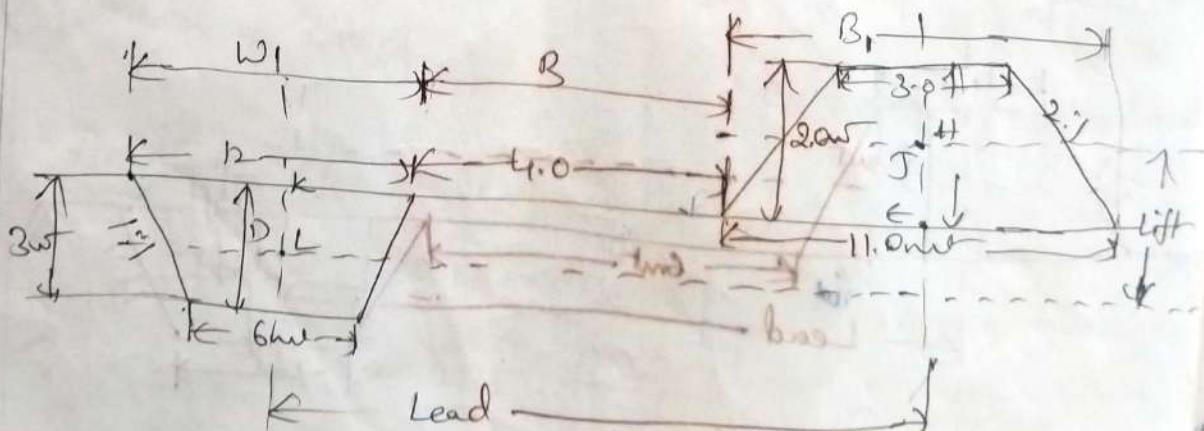
Ex:- If the earthwork carried over a distance of 25m three leads are to be given (one initial lead and two additional leads). (2)

Standard values of Lift:-

Initial lift is 2m and for additional lift (or) part there of one extra lift is to be paid. Schedule of rates provides rates for different lifts.  
 Ex:- If the earthwork carried to a height of 3.8 m three lifts are to be given (one initial lift of 2m and  $\frac{one}{3.8 \rightarrow 2+1.8}$  additional lifts).

Problems on Lead & lift:-

- 1) A canal is excavated as shown in fig. Calculate the leads and lifts to be allowed for earthwork excavation.



Sol:- Let 'L' be the centre of the left half of the canal.

Lead = centre excavation to centre deposition  
=  $LJ$ .

$$= kF + fG + gE$$

$$= \frac{W}{2} + B + \frac{B_1}{2}$$

$$= \frac{12}{2} + 4 + \frac{11}{2}$$

$$= 6 + 4 + 5.5$$

$$\text{Lead} = 15.5 \text{ m}^3$$

$$\text{Extra lead} = 15.5 - 10 = 5.5 \text{ m}^3 \text{ (1 extra lead)}$$

$$\text{Lift} = \frac{D}{2} + \frac{H}{2}$$

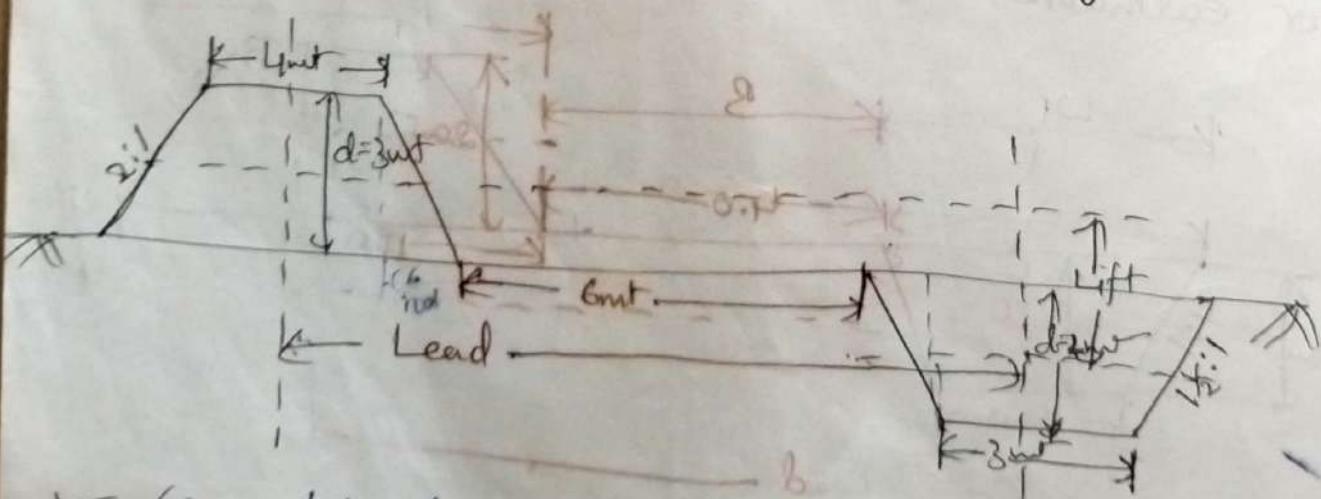
$$= \frac{3}{2} + \frac{2}{2}$$

$$= 1.5 + 1$$

$$= 2.5 \text{ m}$$

$$\text{Extra lift} = 2.5 - 2 = 0.5 \text{ m}^3 \text{ (1 extra lift)}$$

2) Find the lead and lift of the following.



Sol: Given left side of filling  
side slope  $nd = 2:1$   
 $v = \text{depth} = 3 \text{ m}$

Right side  
side slopes  
 $nd = 1:1$

$$H:V = 2:1 \quad \text{Depth} = 3w$$

$$H:V = 6:3$$

$$N = \text{Depth} = 2w$$

$$H:V = 1.5:1$$

$$H:V = 3:2$$

③

$$\text{Lead} = \frac{4}{2} + 6 + 6 + 3 + \frac{3}{2} \quad \text{Ans} \quad \frac{16}{2} + 6 + \frac{9}{2}$$

$$= 2 + 6 + 6 + 3 + 1.5$$

$$= 18.5 \text{ m}$$

$$8 + 6 + 4.5$$

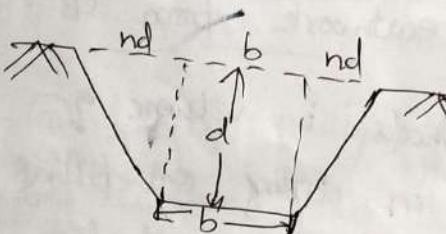
$$18.5 \text{ m}$$

$$\text{Lift} = \frac{3}{2} + \frac{2}{2}$$

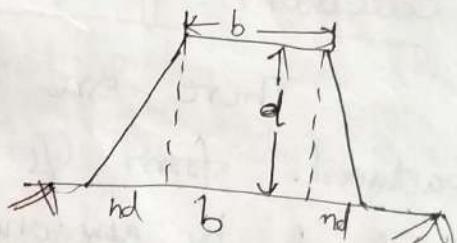
$$= 1.5 + 1$$

$$= 2.5 \text{ m}$$

Calculation of areas of earthwork



Area of cutting



Area of embankment (filling)

Area of cutting = Avg width x depth.

$$A = \frac{b+b+nd+nd}{4} \times d$$

$$= \frac{2b+2nd}{4} \times d$$

$$= \frac{2(b+nd)}{4} \times d$$

$$[A = (b+nd)d]$$

Area of trapezium

$$= \frac{1}{2} h(a+b)$$

Normally trapezoidal shape is used for calculating earthwork.

Calculation of Volumes:- The volume can be calculated by any one of the methods given below:

- ① From cross-sections
- ② From spot levels.
- ③ From contours.

Out of three methods, the first two methods are used for calculating the volume of earthwork and third method is used for calculating the capacity of reservoirs.

Calculation of volume of earthwork from c/s:-

There are four methods in volume of earthwork found from c/s required in cutting or filling by any one of the following methods.

- ① Mean sectional area method
- ② Mid sectional area method
- ③ Trapezoidal rule
- ④ Prismoidal rule

① Mean sectional area method:-

In this method average area of the two end sections is considered. This method is most commonly used by the departments.

additional 10m is to be added of rates

the volume can be  
method given

calculating the volume of the earthwork. (4)

Volume of earthwork.

$V = \text{Mean sectional area} \times \text{distance b/w sections.}$

$$A_1 = (b + nd_1)d_1$$

$$A_2 = (b + nd_2)d_2$$

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

Distance b/w two sections =  $l$ .

Volume of earthwork  $V = \text{Mean sectional area} \times L$

$$V = A \times L$$

② Mid sectional Area method :-

In this method volume of the earthwork is found by multiplying the mid section area with the distance b/w two sections. This method is used when the ground is fairly level and the sections are taken at closed intervals.

Volume of earthwork = Area of mid section  $\times$  distance b/w sections.

$$\text{Area of mid section} = (b + n d_m) d_m$$

where depth at mid section  $d_m = \frac{d_1 + d_2}{2}$

Distance b/w sections =  $L$

Volume = Area of mid section  $\times L$

$$= 4847.43 \text{ m}^3$$

### ③ Trapezoidal Rule :-

This method is the extension of measured sectional area method and is applicable to a series of sections taken at equal intervals.

If  $A_1, A_2, A_3, \dots, A_n$  are the c/s areas along the L.S and L is the equal interval b/w the sections.

Total volume  $V = \frac{L}{2} \left[ (A_1 + A_n) + 2(A_2 + A_3 + \dots + A_{n-1}) \right]$

$$V = L \left[ \left( \frac{A_1 + A_n}{2} \right) + A_2 + A_3 + \dots + A_{n-1} \right]$$

### 4) Prismoidal rule :-

It is also known as Simpson's rule. This method is used when the shape of the solid b/w two parallel c/s is in the shape of a prismoidal. Volume enclosed b/w the two sections by prismoidal rule is given by

$$V = \frac{L}{6} (A_1 + 4A_m + A_n)$$

where  $A_1$  = Area of c/s at one end

when we are avg depths not avg areas

$A_n$  = Area of c/s at other end

$A_m$  = Area of c/s at middle

$L$  = Length of c/s b/w the sections.

additional load is to be included of walls

free surface pressure

is the extension of mean to areas in the intervals and is applicable to equal intervals.

$A_m$  is the area ofcls at the middle and not the average area.

In case series of section are given. This formula can be extended only when there are odd no. of cls and the intervals of b/w them are equal.

$$V = \frac{L}{3} \left[ (\text{First Area} + \text{Last Area}) + 4(\text{sum of even areas}) + 2(\text{sum of odd areas}) \right].$$

$$V = \frac{L}{3} \left[ (A_1 + A_n) + 4(A_2 + A_4 + \dots + A_{n-1}) + 2(A_3 + A_5 + \dots + A_{n-2}) \right]$$

### Problems on Areas

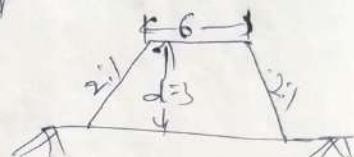
- ① Find the area of embankment, if the top width of the road is 6wt and the depth is 3wt. The side slopes are 2:1

Given top width of the road

$$b = 6wt$$

$$\text{Depth } d = 3wt$$

$$n:1 = 2:1$$



Area of embankment =  $(b+nd)d$ , Bottom width of road

$$A = (6+2 \times 3)3$$

$$= (6+6)3$$

$$= 12 \times 3$$

$$A = 36 \text{ m}^2$$

$$= (b+nd)$$

$$= (6+2 \times 2)3$$

$$= 18 \text{ wt}$$

$$= 4847.43 \text{ m}^2$$

check - Area of embankment  $= \frac{1}{2}(a+b)h$

$$= \frac{1}{2}(6+18)3$$

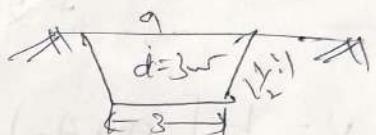
$$= \frac{1}{2} \times 24 \times 3$$

$$A = 36 \text{ m}^2$$

$d = 3w$   
with  $h = 2w$   
 $h : 1 = 2 : 1$   
Area of  
 $A = 1$

2) Find the area of cutting if the bottom width of canal is  $3w$  and depth is  $3w$ , side slopes are  $1\frac{1}{2} : 1$ .

Sol: Given  $b = 3w$   
depth  $d = 3w$   
 $h : 1 = 1\frac{1}{2} : 1$



Area of cutting  $= (b+nd)h$   
 $= (3+1.5 \times 3)3$   
 $= 7 \times 3$   
 $= 21 \text{ m}^2$

Top width of cutting  $= b+2nd$   
 $= 3+2 \times 1.5 \times 3$   
 $= 12 \text{ m}$

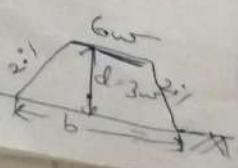
check

Area of cutting  $= \frac{1}{2}(a+b)h$   
 $= \frac{1}{2}(3+12)3$   
 $= \frac{1}{2} \times 15 \times 3$   
 $A = 22.5 \text{ m}^2$

Problems on volume calculations :-

4) find the volume of earthwork in an embankment of length 1 km; top width of a road is 6m and depth is  $3w$ . The side slopes are  $2 : 1$

Sol: Given Length of embankment = 1 km



additional load is to be scheduled of roads

$$d = 3w$$

Top width of road  $b = 6w$

$$n:1 = 2:1$$

$$\text{volume } V = A \times L$$

$$= 36 \times 1000$$

$$V = 36000 \text{ m}^3$$

Area of embankment

$$A = (b + nd)d$$

$$= (6 + 2 \times 3)3$$

$$= 12 \times 3$$

$$A = 36 \text{ m}^2$$

- \* A canal is proposed to be excavated b/w two points A & B which are 500m apart. If the bed width is 8m, side slopes are 2:1 and the depth of cutting is 1.2m at A and 2m at B. Calculate the quantity of earthwork by mid sectional area method.

Given Length b/w A & B = 500m

Bed width = 8m

Side slopes n:1 = 2:1

Depth at A = 1.2m, B = 2m

Mid-sectional Area :-

$V = \text{Mid sectional area} \times \text{Length}$

$$d_m = \frac{d_1 + d_2}{2} = \frac{1.2 + 2}{2} = \frac{3.2}{2} = 1.6 \text{ m}$$

Mid sectional area  $A = (b + 2d_m)d_m$

$$= (8 + 2 \times 1.6)1.6$$

$$= 1.2 \times 1.6$$

$$A = 17.92 \text{ m}^2$$

$$V = A \times L = 17.92 \times 500 = 8960 \text{ m}^3$$

$$= 4847.43 \text{ m}^3$$



Q) Calculate the quantity of earthwork for 1 km for a portion of a road in an uniform ground, heights of banks at the two ends being 1 m, 1.5 m. The formation width is 10 m and side slope 2H:1V. Assume there is no transverse slope:-

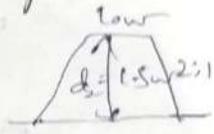
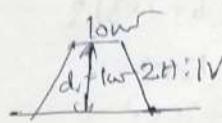
Given length of earthwork

$$L = 1 \text{ km} =$$

$$d_1 = 1 \text{ m}, d_2 = 1.5 \text{ m}$$

$$\text{width of road } b = 10 \text{ m}$$

$$n:1 = 2:1$$



① Mid-sectional Area method:-

$$b = 10 \text{ m}$$

$$\text{Avg. depth } d_m = \frac{1+1.5}{2} = \frac{2.5}{2} = 1.25 \text{ m}$$

$$\text{Mid-sectional Area } A = (b + n d_m) d_m$$

$$= (10 + 2 \times 1.25) 1.25 \\ = 12.5 \times 1.25$$

$$A = 15.625 \text{ m}^2$$

$$V = A \times L = 15.625 \times 1000 = 15625 \text{ m}^3$$

② Mean-sectional Area method:-

$A_1$  = Area of U's at one end

$$= (b + n d_1) d_1$$

$$= (10 + 2 \times 1) 1$$

$$A_1 = 12 \text{ m}^2$$

additional is to be

9 mad in an uniform ground at the two ends being 1m each with is low and side slope no transverse slope. 1m 2H:1V

$A_2$  = Area of another end

$$= (b + nd_2) d_2$$

$$= (10 + 2 \times 1.5) 1.5$$

$$A_2 = 19.5 \text{ m}^2$$

Mean Sectional Area

$$A = \frac{A_1 + A_2}{2} = \frac{12 + 19.5}{2} = \frac{31.5}{2} = 15.75 \text{ m}^2$$

$$\text{Quantity of earthwork } V = A \times L \\ = 15.75 \times 1000 \\ V = 15750 \text{ m}^3$$

③ Prismoidal Rule:-

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

$$A_1 = 12 \text{ m}^2, A_2 = 19.5 \text{ m}^2, A_m = 15.625 \text{ m}^2$$

$$V = \frac{1000}{6} (12 + 19.5 + 4 \times 15.625)$$

$$= \frac{1000}{6} \times 94$$

$$V = 15666.67 \text{ m}^3$$

\* Calculate the quantity of earthwork required according to standard prismoidal formula in a road embankment having 10.5m formation width, 2:1 side slopes in a length of 8 chains (30m) - The level difference b/w formation and ground is 0.9m, 0.7m, 1.2m, 3.4m, 2.9m, 3.0, 3.4m, 2.6 & 2.4 respectively.

$$| 09.78 | 30.00y | \text{cum} | \frac{350}{100} \times 1384.98 | \text{ft} A | \\ = 4847.43 |$$

Assume ground is level in transverse direction  
the centre line.

Sol:- Given  $b = 10.5w$

$$n:1 = 2:1$$

$$L = 30w, d_1 = 0.9w, d_2 = 0.7w, d_3 = 1.2, d_4 = 3.4, d_5 = 2.9, d_6 = 3.1, d_7 = 3.4, d_8 = 2.6, d_9 = 2.4w$$

$$A_1 = (b + nd_1)d_1 = (10.5 + 2 \times 0.9)0.9 = 11.07 \text{ m}^2$$

$$A_2 = (b + nd_2)d_2 = (10.5 + 2 \times 0.7)0.7 = 8.33 \text{ m}^2$$

$$A_3 = (b + nd_3)d_3 = (10.5 + 2 \times 1.2)1.2 = 15.48 \text{ m}^2$$

$$A_4 = (b + nd_4)d_4 = (10.5 + 2 \times 3.4)3.4 = 58.82 \text{ m}^2$$

$$A_5 = (b + nd_5)d_5 = (10.5 + 2 \times 2.9)2.9 = 42.27 \text{ m}^2$$

$$A_6 = (b + nd_6)d_6 = (10.5 + 2 \times 3.1)3.1 = 51.77 \text{ m}^2$$

$$A_7 = (b + nd_7)d_7 = (10.5 + 2 \times 3.4)3.4 = 58.82 \text{ m}^2$$

$$A_8 = (b + nd_8)d_8 = (10.5 + 2 \times 2.6)2.6 = 40.82 \text{ m}^2$$

$$A_9 = (b + nd_9)d_9 = (10.5 + 2 \times 2.4)2.4 = 36.72 \text{ m}^2$$

Volume of earthwork by prismoidal rule

$$V = \frac{1}{3} (A_1 + A_9) + 4(A_2 + A_4 + A_6 + A_8) + 2(A_3 + A_5 + A_7)$$

$$= \frac{30}{3} \left( (11.07 + 36.72) + 4(8.33 + 58.82 + 51.77 + 40.82) + 2(15.48 + 42.27 + 58.82) \right)$$

$$= 10 \left( (42.27) + 4(159.34) + 2(121.57) \right)$$

$$V = 9298.9 \text{ m}^3$$

additional  
load is to be  
Schedule of



ground levels along the ridge of proposed canal area as shown in fig. The bed of the canal is 4m wide and sloped at 1 in 100 downwards in longitudinal direction. The side slopes are 1½:1. R.L of formation level at our chainage is 250m.

A	B	C	D	E	F	G
252	252.15	252.3	252.35	252.35	252.35	252
our	30m	60m	90m	120m	150m	180m

Determine Volume of earthwork in cutting by  
 ① Trapezoidal rule ② Parabolic rule.

Given  $b=4m$ ,  $n:1 = 1\frac{1}{2}:1$

Formation levels

At our chainage = 250.0m

$$30m \quad " \quad = 250 - \frac{30}{100} \times 2 = 249.20$$

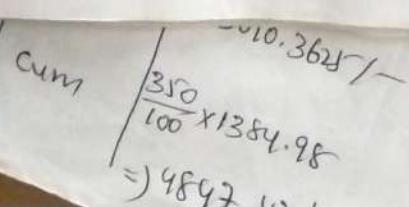
$$60m \quad " \quad = 250 - \frac{30}{100} \times 2 \times 2 = 249.40$$

$$90m \quad " \quad = 250 - \frac{30}{100} \times 3 \times 2 = 249.10$$

$$120m \quad " \quad = 250 - \frac{30}{100} \times 4 \times 2 = 248.80$$

$$150m \quad " \quad = 250 - \frac{30}{100} \times 5 \times 2 = 248.50$$

$$180m \quad " \quad = 250 - \frac{30}{100} \times 6 \times 2 = 248.20$$



Chainage in m	0	30m	60m	90m	120m	150m	180m
RL of GL	252	252.15	251.7	251.75	251.95	251.85	252
RL of canal bed level	250	249.7	249.4	249.10	249.8	248.5	248.2
Depth of cutting	2.0	2.45	2.3	2.65	3.15	3.35	3.8

Definition

which

the

to

8

$$A_1 = (b + nd_0) d_0 = (4 + 1.5 \times 2) 2 = 14 \text{ m}^2$$

$$A_2 = (4 + 1.5 \times 2.45) 2.45 = 18.80 \text{ m}^2$$

$$A_3 = (4 + 1.5 \times 2.3) 2.3 = 17.135 \text{ m}^2$$

$$A_4 = (4 + 1.5 \times 2.65) 2.65 = 21.13 \text{ m}^2$$

$$A_5 = (4 + 1.5 \times 3.15) 3.15 = 27.48 \text{ m}^2$$

$$A_6 = (4 + 1.5 \times 3.35) 3.35 = 30.23 \text{ m}^2$$

$$A_7 = (4 + 1.5 \times 3.8) 3.8 = 36.86 \text{ m}^2$$

Trapezoidal Rule :-

$$V = \frac{L}{2} [ (A_1 + A_7) + 2(A_2 + A_3 + A_4 + A_5 + A_6) ]$$

$$V = \frac{30}{2} [ (14 + 36.86) + 2(18.80 + 17.135 + 21.13 + 27.48 + 30.23) ]$$

$$V = 4206.15 \text{ m}^3$$

Prismoidal rule :-

$$V = \frac{L}{3} [ (A_1 + A_7) + 4(A_2 + A_4 + A_6) + 2(A_3 + A_5) ]$$

$$= \frac{30}{3} [ (14 + 36.86) + 4(18.80 + 21.13 + 30.23) + 2(17.135 + 27.48) ]$$

$$V = 4207.3 \text{ m}^3$$

Lead Schedule  
leads

### problems on spot levels

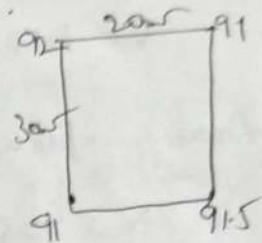
A plot of 20m x 30m, calculate the quantity of earthwork by using spot levels of as shown in fig. for general levelling of 90m RL.

Q1:

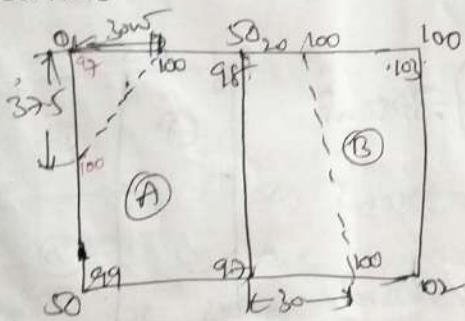
$$\text{Area of plot} = 20 \times 30 = 600 \text{ m}^2$$

$$\text{Volume } V = 600 \left( \frac{2+1+1.5+1}{4} \right)$$

$$V = 825 \text{ m}^3$$



Q2: Calculate quantity of earthwork for general levelling 100m RL dressing of two plots as shown in fig and spot levels are given at the corners.



Plot A

$$\text{Area of cutting} = \frac{1}{2} \times 30 \times 37.5 = 562.5 \text{ m}^2$$

$$V = 562.5 \left[ \frac{3+0+0}{3} \right] = 562.5 \text{ m}^3$$

$$\text{Area of filling} = (50 \times 50) - 562.5 = 1937.5 \text{ m}^2$$

$$V = 1937.5 \left( \frac{0+2+3+1+0}{5} \right) = 2325 \text{ m}^3$$

### Plot B

$$\text{Area of cutting} = \frac{1}{2} (20+30) 50 = 1250 \text{ m}^2$$

$$V = 1250 \left( \frac{0+2+3+0}{4} \right) = 1562.5 \text{ m}^3$$

$$\text{Area of filling} = \frac{1}{2} (20+30) 50 = 1250 \text{ m}^2$$

$$V = 1250 \left( \frac{0+3+2+0}{4} \right) = 1562.5 \text{ m}^3$$

$$\text{Total volume of earthwork in cutting} = 2325 + 1562.5$$

$$\text{Total volume of earthwork in filling} = 1250 \text{ m}^3$$

\* Calculate the quantity where general levelling is required upto 92 m - RL  
as shown in fig.

$$V_A = 50 \times 50 \left( \frac{0+3+2+1}{4} \right) = 3750 \text{ m}^3$$

$$V_B = 50 \times 50 \left( \frac{1+2+2+1}{4} \right) = 3750 \text{ m}^3$$

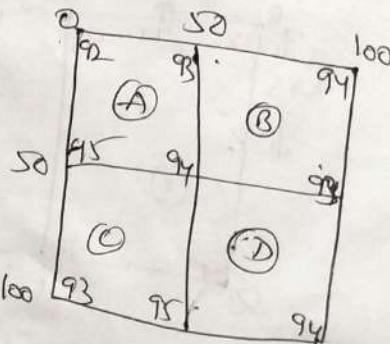
$$V_C = 50 \times 50 \left( \frac{3+2+1+3}{4} \right) = 5625 \text{ m}^3$$

$$V_D = 50 \times 50 \left( \frac{2+1+3+2}{4} \right) = 5000 \text{ m}^3$$

$$\text{Total Volume } V = V_A + V_B + V_C + V_D$$

$$V = 3750 + 3750 + 5625 + 5000$$

$$V = 18125 \text{ m}^3$$



add... lead is " Schedule " V  
leads

water the quantity of earthwork for 200m length for portion of a road in an uniform width ground the heights of banks at the two ends being 1.00m & 1.6m. The formation width is 10m & side slopes 2:1 (H:V) (10)

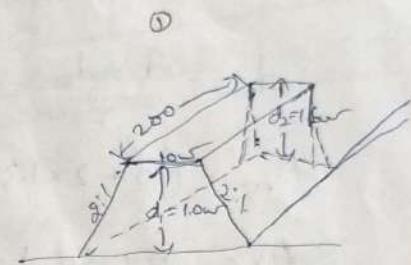
Given  $L = 200\text{m}$

$$d_1 = 1.00\text{m}$$

$$d_2 = 1.6\text{m}$$

$$b = 10\text{m}$$

$$S:1 = 2:1 \text{ (H:V)}$$



### ① Mid sectional area method

$$V = A \times L$$

mean depth

$$d_m = \frac{d_1 + d_2}{2} = \frac{1+1.6}{2} = \frac{2.6}{2} = 1.3\text{m}$$

$$A = (b + Sd_m)d_m = (10 + 2 \times 1.3)1.3 = 16.38\text{m}^2$$

$$V = 16.38 \times 200$$

$$\boxed{V = 3276\text{m}^3}$$

### ② Mean Sectional area method

$$V = A_m \times L$$

Mean Area

$$A_m = \frac{A_1 + A_2}{2}$$

where

$$A_1 = (b + Sd_1)d_1 = (10 + 2 \times 1)1 = 12\text{m}^2$$

$$A_2 = (b + Sd_2)d_2 = (10 + 2 \times 1.6)1.6 = \frac{21.12}{2} = 10.56\text{m}^2$$

$$A_m = \frac{12 + 10.56}{2} = 16.56\text{m}^2$$

$$\begin{aligned} V &= 16.56 \times 200 \\ \boxed{V} &= 3312\text{m}^3 \end{aligned}$$

$$\begin{aligned} &16.56 \times 200 \\ &= 3312\text{m}^3 \end{aligned}$$

S.No	Description of item
1	Earthwork in banking
2	Earthwork in cutting

### Prismoidal formula

$$V = \frac{L}{6} [A_1 + 4A_m + A_2]$$

$$A_m = (b + 5d_m)d_m$$

$$d_m = \frac{d_1 + d_2}{2} = \frac{1 + 1.6}{2} = \frac{2.6}{2} = 1.3 \text{ m}$$

$$A_m = (10 + 2 \times 1.3) 1.3 = 16.38 \text{ m}^2$$

$$A_1 = (b + 5d_1)d_1 = (10 + 2 \times 1) 1 = 12 \text{ m}^2$$

$$A_2 = (b + 5d_2)d_2 = (10 + 2 \times 1.6) 1.6 = 21.12 \text{ m}^2$$

$$V = \frac{200}{6} [12 + 4 \times 16.38 + 21.12]$$

$$V = \frac{200}{6} \times 98.64$$

$$V = 3288 \text{ m}^3$$

- 2) Reduced Level (R.L) of ground along the centre line of a proposed road from a chainage 10 to chainage 20 are given below. The formation level at the 10<sup>th</sup> chainage is 107 and the road is in downward gradient of 1 in 150 upto the chainage 14 and then the gradient changes to 1 in 100 downward. Formation width of road is 10m and side slopes of banking are 2:1 (H:V). Length of the chain is 30 m.

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Q

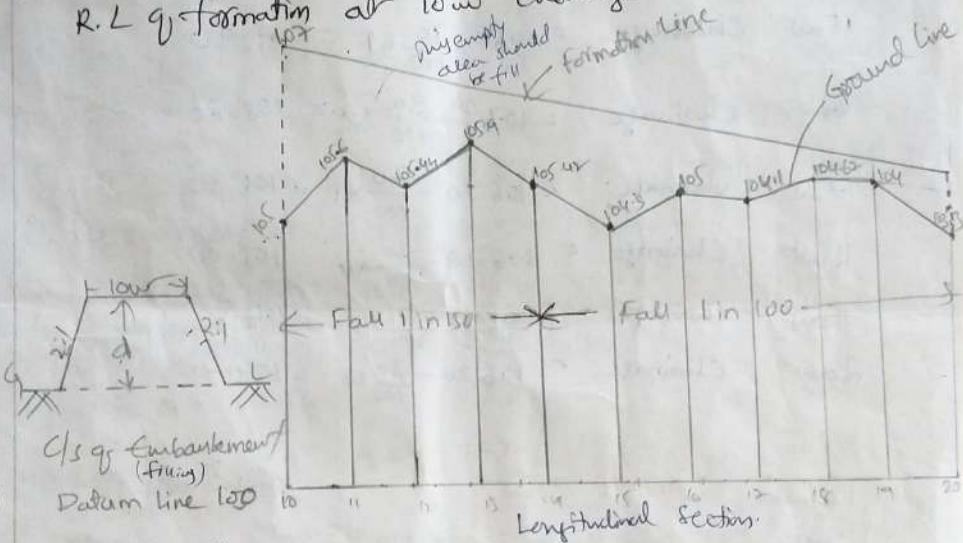
draw longitudinal section of the road and a typical transverse section and prepare an estimate of earthwork at the rate of Rs. 275.00/- /cum.

Q

Chainage	10	11	12	13	14	15	16	17	18	19	20
R.L of ground	105.00	105.60	105.44	105.90	105.64	104.30	105.00	104.10	104.62	104.00	103.3

Gradient 1 in 150  $\rightarrow$  Down gradient 1 in 100  $\rightarrow$  Every 15m = 1m fall

R.L of formation at 10m Chainage is 107.00



Depth of cutting

1.10	0.20	0.38	0.56	0.74	0.92	1.10
104.70	105.00	105.30	105.60	105.90	106.20	106.50
104.62	104.00	103.30	102.60	101.90	101.20	100.50
104.00	103.30	102.60	101.90	101.20	100.50	100.00
103.30	102.60	101.90	101.20	100.50	100.00	100.00

D/H of Bank (filling)

R.L. of Formation

R.L. of Ground

Distance in m  
Chainage

300 330 360 390 420 450 480 510 540 570 600  
10 11 12 13 14 15 16 17 18 19 20  
105.98 104.98 104.98 104.98 104.98 104.98 104.98 104.98 104.98 104.98 104.98

$\Rightarrow 4847.43/-$



## Calculation of Formation Levels

$$10 \text{ m} \text{ chainage} = 107.00 \text{ m}$$

$$11 \text{ m} \text{ chainage} = 107 - \frac{30}{150} \times 1 = 106.80 \text{ m}$$

$$12 \text{ m} \text{ chainage} = 107 - \frac{30}{150} \times 2 = 106.60 \text{ m}$$

$$13 \text{ m} \text{ chainage} = 107 - \frac{30}{150} \times 3 = 106.40 \text{ m}$$

$$14 \text{ m} \text{ chainage} = 107 - \frac{30}{150} \times 4 = 106.20 \text{ m}$$

$$15 \text{ m} \text{ chainage} = 107.20 - \frac{30}{100} \times 5 = 105.90$$

$$16 \text{ m} \text{ chainage} = 107.20 - \frac{30}{100} \times 6 = 105.60$$

$$17 \text{ m} \text{ chainage} = 106.20 - \frac{30}{100} \times 7 = 105.30$$

$$18 \text{ m} \text{ chainage} = 106.20 - \frac{30}{100} \times 8 = 105.00$$

$$19 \text{ m} \text{ chainage} = 106.20 - \frac{30}{100} \times 9 = 104.70$$

$$20 \text{ m} \text{ chainage} = 106.20 - \frac{30}{100} \times 10 = 104.40$$

1 chain length is 30m

Hence 10 chain length =  $30 \times 10 = 300 \text{ m}$ .

Similarly 11 chain length =  $30 \times 11 = 330 \text{ m}$

H	V
150	1
30	X

If you travel a distance of 100m for  
you will go vertically one extra  
So one chainage is 30m

$$= \frac{30}{150} \times 1$$

Lead Schematic  
Lead



Formation level

$$\begin{aligned}
 \text{Chainage} &= 107.00 \text{ m} \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 1 = 106.80 \text{ m} \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 2 = 106.60 \text{ m} \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 3 = 106.40 \text{ m} \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 4 = 106.20 \text{ m} \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 5 = 105.90 \\
 \text{Chainage} &= 107 - \frac{30}{150} \times 6 = 105.60
 \end{aligned}$$

S.No	Description of Item	Quantities of Earthwork								
		Distance (m)	Length (m)	Height Depth (GL-FL)	Mean Height (m)	Central Area (m <sup>2</sup> )	Side area (m <sup>2</sup> )	Total Sectional area (m <sup>2</sup> )	Length in B/w stations (m)	
10		300	2.00	$2 + 1.2 = \frac{3.2}{2}$	1.6	$10 \times 1.6$	$2 \times 1.6^2 = 50.2$	$10 \times 1.6 + 50.2 = 60.2$	-	
11		330	1.20	1.6	1.6	3.12	21.12	30	633.60	
12		360	1.16	1.18	1.18	2.78	14.58	30	437.40	
13		390	0.50	0.83	0.83	8.3	1.38	9.68	30	290.40
14		420	0.78	0.64	0.64	6.4	0.82	7.22	30	216.60
15		450	1.60	1.19	1.19	11.9	2.83	14.73	30	441.9
16		480	0.60	1.1	1.1	11.00	2.42	13.42	30	402.6
17		510	1.20	0.9	0.9	9.00	1.62	10.62	30	318.6
18		540	0.38	0.79	0.79	7.9	1.25	9.15	30	274.5
19		570	0.70	0.54	0.54	8.4	0.58	5.98	30	179.4
20		600	0.10	0.9	0.9	9.0	1.62	10.62	30	318.6

$$\text{Total} = 3573.6 \text{ m}^3$$

$$A = \frac{(b+n)d}{2} = \frac{(bd+nd^2)}{2}$$

### Abstract of Estimate

$$VQ = A \times L$$

Item No	Particulars of Items	Quantity	Unit	Rate	Fee	Amount
1.	Earthwork in banking	3573.6	Cum	22500/- cum	22500/- cum	79662.4

$$\begin{aligned}
 &100 \times 1384.98 \\
 &= 9847.43
 \end{aligned}$$

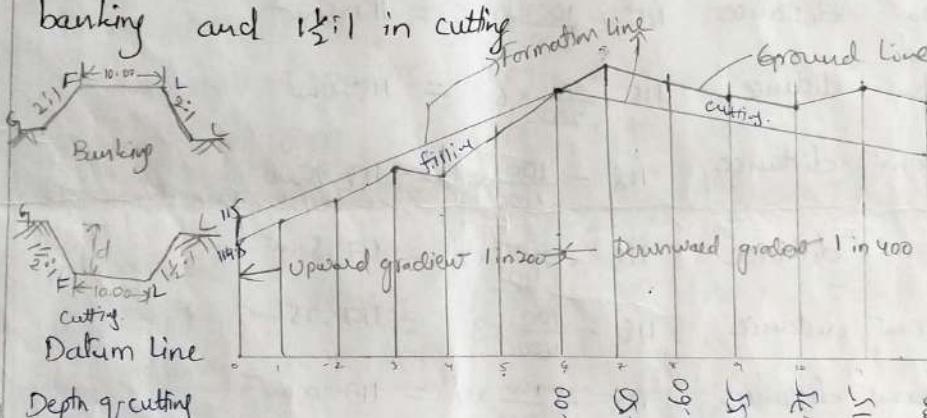


pare a detailed abstract estimate for earthwork for a portion of a road from the following data :-

(b)

Distance in mt	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	118.20	118.25	118.10	117.8	117.2	117.9	117.75
R.L of formation	115												

Formation width of a road is 10mt, side slope 2:1 in banking and 1.5:1 in cutting



Depth of cutting

Height of bank

R.L of formation

R.L of ground

Distance in mt

0	100	200	300	400	500	600	700	800	900	1000	1100	1200
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Distance in mt

Height of bank

R.L of formation

R.L of ground

Distance in mt

$$\begin{aligned}
 & \frac{150}{100} \times 1384.98 \\
 & = 19842.43
 \end{aligned}$$

## Calculation of R.L of formation

0m distance R.L of formation is 115.00m

$$100 \text{ m distance } 115 + \frac{100}{200} \times 1 = 115.5 \text{ m}$$

$$200 \text{ m distance } 115 + \frac{100}{200} \times 2 = 116.0 \text{ m}$$

$$300 \text{ m distance } 115 + \frac{100}{200} \times 3 = 116.5 \text{ m}$$

$$400 \text{ m distance } 115 + \frac{100}{200} \times 4 = 117.0 \text{ m}$$

$$500 \text{ m distance } 115 + \frac{100}{200} \times 5 = 117.5 \text{ m}$$

$$600 \text{ m distance } 115 + \frac{100}{200} \times 6 = 118.0 \text{ m}$$

$$700 \text{ m distance } 118 - \frac{100}{400} \times 1 = 117.75 \text{ m}$$

$$800 \text{ m distance } 118 - \frac{100}{400} \times 2 = 117.5 \text{ m}$$

$$900 \text{ m distance } 118 - \frac{100}{400} \times 3 = 117.25 \text{ m}$$

$$1000 \text{ m distance } 118 - \frac{100}{400} \times 4 = 117.0 \text{ m}$$

$$1100 \text{ m distance } 118 - \frac{100}{400} \times 5 = 116.75 \text{ m}$$

$$1200 \text{ m distance } 118 - \frac{100}{400} \times 6 = 116.5 \text{ m}$$

Therefore cutting length

### Calculation of Quantities

$$B = 10w, S = 2 \text{ for banking, } S = 1\frac{1}{2} \text{ for cutting}$$

Station no	Distance in m	Height of G.F.L	Mean height depth in m	Central area Bd m <sup>2</sup>	Area of Sides Sd m <sup>2</sup>	Total Sect. area Bd + Sd m <sup>2</sup>	Distance in b/w stations L m	Quantity (Bd + Sd <sup>2</sup> ) × L	Banking m <sup>3</sup>	Cutting m <sup>3</sup>
0	0	0.50	—	—	—	—	—	—	—	—
1	100	0.75	0.625	6.25	0.78	7.03	100	703	—	—
2	200	0.75	0.75	7.5	1.13	8.63	100	863	—	—
3.	300	1.30	1.025	10.25	2.10	12.35	100	1235	—	—
4.	400	0.90	1.10	11.0	2.42	13.42	100	1342	—	—
5.	500	0.65	0.775	7.75	1.20	8.95	100	895	—	—
6.	600	0.00	0.325	3.25	0.21	3.46	100	346	—	—
7.	700	0.50	0.250	2.5	0.09	2.59	100	—	259	—
8.	800	0.60	0.55	5.5	0.45	5.95	100	—	595	—
9.	900	0.55	0.575	5.75	0.50	6.25	100	—	625	—
10.	1000	0.75	0.65	6.5	0.63	7.13	100	—	713	—
11.	1100	1.15	0.95	9.5	1.35	10.85	100	—	1085	—
12	1200	1.00	1.075	10.75	1.33	12.48	100	—	1248	—
								Total	5384 m <sup>3</sup>	4525 m <sup>3</sup>

### Abstract Estimate

S.No.	Particulars of item	Quantity	Unit	Rate	Per	Cost
1.	Earthwork in banking	5384	1m <sup>3</sup>	225.00	₹/cum	14806.00
2.	Earthwork in cutting	4525	1m <sup>3</sup>	38.00	₹/cum	15837.5
						<u>30643.5</u>

Therefore  
 estimate the cost of earthwork for a portion of a road for 400 m length from the following data: - (1) (2)  
 Formation width of the road is 10 m, side slopes are 2:1 in banking and 1:1 in cutting.

Station	Distance (m)	R.L. of Ground	R.L. of Formation
25	1000	51.00	52.00
26	1040	50.90	1
27	1080	50.50	1
28	1120	50.80	1
29	1160	50.60	1
30	1200	50.70	1
31	1240	51.20	1
32	1280	51.40	1
33	1320	51.30	1
34	1360	51.00	1
35	1400	50.60	1

Downward gradient

4-1 in 200

1. that means

1 (for every 200 m is downward)

1 m

Longitudinal section of the road and type C/s are given in fig. The rate of banking is Rs. 40/- 250.00% cum and for cutting is Rs. 350.00% cum.

Calculation of formation levels: -

(1)  $\frac{40}{200} = 0.2 \text{ m}$   
 for every RL of formation deduct  
 $0.2 \text{ m}$

$$1000 \text{ m distance} = 52 - \frac{40}{200}$$

$$1040 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 1 = 51.8$$

$$1080 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 2 = 51.6$$

$$1120 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 3 = 51.4$$

$$1160 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 4 = 51.2$$

$$1200 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 5 = 51.0$$

$$1240 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 6 = 50.80$$

$$1280 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 7 = 50.60$$

$$1320 \text{ m distance} = 52 - \frac{40}{200} \times 8$$

$$= 50.40$$

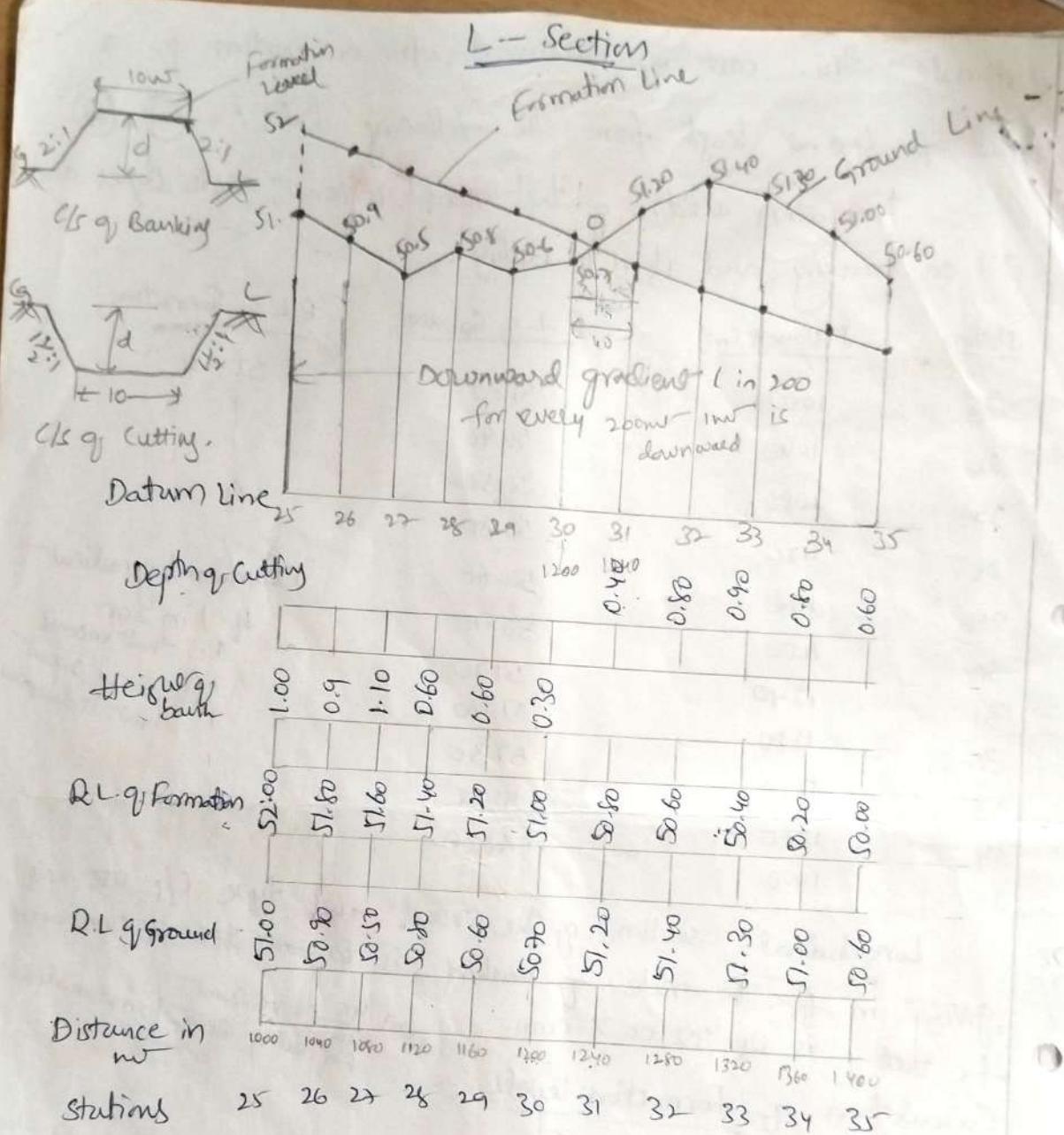
$$1360 \text{ m distance} = 52 - \frac{40}{200} \times 9$$

$$= 50.20$$

$$1400 \text{ m} \quad " \quad = 52 - \frac{40}{200} \times 10$$

$$= 50.00$$

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The road passes from banking to cutting in b/w stations 30 (1200m) and 31 (1240m). The distance where it passes through zero, i.e. E.L., may be determined as follows:-

The two triangles on either side of zero point are symmetrical

$$\frac{x}{0.3} = \frac{40-x}{0.4}$$

$$0.4x + 0.3x = 12$$

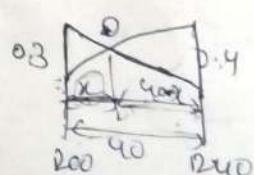
$$0.7x = 12$$

$$x = \frac{12}{0.7}$$

$$x = 17.14 \Rightarrow 17.14 \text{ m (say)}$$

$$0.4x = 0.3(40-x)$$

$$0.4x = 12 - 0.3x$$



0.3 & 0.4 are depth drop

Therefore length of banking portion is 17 m, and length of cutting portion is  $40 - 17 = 23$  m.

Calculation of Quantities

$B = 10\text{m}$ ,  $s = 2$  for Banking,  $s = 1\frac{1}{2}$  for cutting

Station	Distance in m	Height Diff. qf GL & FL	Mean depth 'd'	Central Area Bd	Area of Sides $sd^2$	Total sect. area $Bd + sd^2$	Distance in b/w stations 'L'	Quantity $(Bd + sd^2)L$
25	1000	1.00	—	—	—	—	—	—
26	1040	0.90	0.95	22.5	1.87	24.37	40	452.40
27	1080	1.10	1.00	10.00	2.0	12.00	40	480.00
28	1120	0.60	0.85	8.5	1.45	9.95	40	398.0
29	1160	0.60	0.60	6.0	0.72	6.72	40	268.0
30	1200	0.30	0.45	4.5	0.41	4.91	40	196.40
Passed from Banking to cutting		0.00	0.45	1.5	0.05	1.55	17	26.35
31	1240	0.40	0.20	2.0	0.06	2.06	23	47.38
32	1280	0.80	0.60	6.0	0.54	6.54	40	261.60
33	1320	0.90	0.85	8.5	1.08	9.58	40	383.20
34	1360	0.80	0.85	8.5	1.08	9.58	40	383.20
35	1400	0.60	0.20	7.0	0.74	7.74	40	309.60
Total =					1821.95	1384.98 m <sup>3</sup>		

S.No	Description of item	Quantity	Rate	Per	Amount
1.	Earthwork in banking	1821.95	275.00/-	Cum	$\frac{275}{100} \times 1821.95$ = 5010.3625/-
2.	Earthwork in cutting	1384.98	350.00/-	Cum	$\frac{350}{100} \times 1384.98$ = 4847.43/-

Area of Side sloping Surface:-

17 ~~17~~

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

$$\begin{aligned}
 \text{The mean sloping breadth, } &= \sqrt{(\bar{S}^2 + d^2)} \\
 &= \sqrt{d^2(\bar{S}^2 + 1)} \\
 &= d \sqrt{\bar{S}^2 + 1} \\
 &= d \sqrt{(\bar{S} + 1)^2}
 \end{aligned}$$

where 'd' stands for mean depth.

Area of both side slopes =  $2L \times d \sqrt{5+1}$

This also may be calculated in a tabular form -

Station (s)	Depth (s) the water	Mean depth (s) the water	Breadth of side slopes sloping breadth $d\sqrt{s+1}$	Length b/w stations 'L'	Total Area of both side slopes $2Ld\sqrt{s+1}$	Sur- face

- ① Calculate the area of the side slopes of portion of a bank for a length of 200m the heights of banks at the two ends being 2.5m & 3.5m and the ratio of the slopes 2:1

a) If the side slopes are to be provided with 15mm thick stone pitching, calculate the cost of pitching

at the rate of Rs. 150/- per cum.

Sol: Given  $L = 200\text{m}$

$$d_1 = 2.5\text{m}, d_2 = 3.5\text{m}$$

$$S = 2, t = 15\text{cm} = 0.15\text{m}$$

$$\text{i) Mean height } d = \frac{d_1 + d_2}{2} = \frac{2.5 + 3.5}{2} = 3.0\text{m}$$

$$\text{Sloping breadth at midr section} = d \sqrt{S^2 + 1}$$

$$= 3.0\sqrt{2^2 + 1}$$

$$= 3\sqrt{5}$$

$$= 6.71\text{m}$$

$$\text{Area of the two side slopes} = 2Ld\sqrt{S^2 + 1}$$

$$= 2 \times 200 \times 6.71$$

$$= 2684 \text{ m}^2$$

$$\text{ii) Quantity of pitching} = \text{Area} \times \text{thickness}$$

$$= 2684 \times 0.15$$

$$= 402.6 \text{ m}^3$$

$$\text{Cost of stone pitching} = \text{Quantity} \times \text{Rate}$$

$$= 402.6 \times 150$$

$$= 60,390/-$$

2) Work out the area of the side slopes of a road embankment 12m wide. The side slopes are 2.5:1. The height of embankment at one end is 1.35m and at another end is 2.4m. The length of embankment is 216m.

Sol: Mean depth  $d = \frac{1.35 + 2.4}{2} = 1.875\text{m}$  Area of side slopes =  $2L \times d \times \text{M.S.R}$

$$= 2 \times 216 \times 1.875$$

$$= 2181.668 \text{ m}^2$$

$$\text{Sloping breadth} = d\sqrt{S^2 + 1}$$

$$= 1.875\sqrt{2.5^2 + 1}$$

$$= 5.049\text{m}$$

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## Reinforcement UNIT III UNIT II Bar Bending and Bar Requirement Schedules

Introduction:- In olden days availability and usage of steel as reinforcement is less. After introduction of steel size of the members are reduced, self wt. is reduced tremendously, strength, durability and life of the structure is increased. Almost all engineering structures RCC is used sparingly. Estimation of steel is to be included as a separate item in abstract estimate. Bar bending schedules are very much useful in bending of bars for the required size & shape.

### Methods of Estimation of Steel:-

- 1) Estimation of steel from structural drawings.
- 2) Estimation of steel on the percentage basis of concrete.

#### 1) Estimation of steel from structural drawings:-

The quantity of steel is calculated from the detailed structural drawings by preparing bar bending schedule. The quantity of steel usually measured in ~~wt~~ <sup>in kgs</sup>. No deductions for steel in C.C is being made because of small volume occupied by steel in R.C.C structures.

- 1) Length of the bar includes cranks, bends, hooks etc.
- 2) The wt. of the bar per unit per length multiplied by the length of the bar gives its weight.
- 3) Density of steel is taken as  $7850 \text{ kg/m}^3$  to obtain the weight of the bar.
- 4) Bar bending schedule is prepared showing shapes & keyins the bars.

Units weights of commonly used steel bars

6mm dia — 0.22 kg/m

8mm dia — 0.39 kg/m

10mm dia — 0.62 kg/m

12mm dia — 0.89 kg/m

16mm dia — 1.58 kg/m

20mm dia — 2.49 kg/m

25mm dia — 3.85 kg/m

where  $D$  = Total

Total length of  
(L) = strain

$L = l$   
where

2) Estimation of steel on the percentage basis of concrete

This method is used when the detailed drawings are not available. The percentage of steel depends upon span, type of design, load etc. The approximate percentage of steel used in R.C.C. for different elements are given below.

Beams 1-2%, columns — 1 to 4%, slabs & lintels

— 0.7 to 1%, foundations, raft footings — 0.5 to 0.8%.

1) Main straight bars at bottom: It consists of straight length 'l' and 2 end hooks are provided with a length of  $9d$  on either side.

where 'd' is the dia of bar. Straight length 'l' is calculated by  $4m$ .

$L = \text{Total length of bar} + 2 \times \text{Bending} - 2 \times \text{C bend hook}$

$L = l + 2 \times 9d$

$L = l + 18d$  (9d for each hook)

2) Main Bending bars: Generally alternate bars provided as main R.F. length will be bent up at both ends. Bending bar length is calculated by adding straight length 'l' & additional length due to bend up at both ends plus length of hooks on either side.

$$\text{hypotenuse allowance} = \frac{D}{\sin 45^\circ} = 0.414D \Rightarrow 0.42D$$

where  $D$  is vertical distance b/w the centre of two bars & base of beam.

$$\frac{D}{\sin 45^\circ} - D = D \left[ \frac{1}{\sin 45^\circ} - 1 \right] = D \left[ 1.42 - 1 \right] = 0.414D = 0.42D$$

Sloping breadth

$$= 1.825 \times 2 = 3.65m$$

$$= 5.049m$$

2x0.049

6x5.049

1.568 m<sup>2</sup>

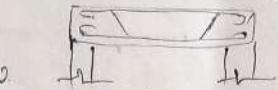


where  $D$  = Total depth of beam - Top clear cover  
 - bottom clear cover - Dia. of bent up bar (2)

Total length of cranked bar at both ends  
 $(L)$  = straight length of bar (1) ~~- 2 x end covers + 2 x~~  
 Hook allowance + 2 x Bent up allowance

$$L = l - 2 \times \text{end covers} + 2 \times qd + 2 \times 0.42D$$

where  $l$  = length clear span + 2 x Bearing - 2 x E.C.



3) Anchor Bars (or) Hanger bars :- Anchor bars are provided at top but similar to that of straight bars are provided at bottom as main RF.

Total length of bar (1) = straight length of bar (1) + 2 x qd.

where  $l$  = clear span of beam + 2 x Bearings - 2 x E.C.

$$\therefore L = l + 2 \times qd$$

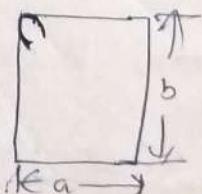
$$\therefore L = l + 18d$$

4) Stirrups :- Generally stirrups are provided two legged at equal intervals

Total length  $L = 2(a+b) + 2 \times 12d$ .

$a$  = Length - 2 x covers

$b$  = Breadth - 2 x covers.



1) Calculate the quantities of steel of R.C.C. Simply supported beam of clear span 3.6m. The walls supporting the beam are 230 mm with full bearing on both sides. Size of the beam is 230 mm x 300 mm. Concrete cover at ends of bars and sides 40 mm and that at top & bottom is 30 mm each. The RF details of the beam are given below. Prepare bar bending schedule.

- 1) Main straight bars at bottom = 12 mm  $\phi$  - 2 nos.
- 2) Main bent up bars = 12 mm  $\phi$  - 2 nos.
- 3) Top anchor bars = 12 mm  $\phi$  - 2 nos.
- 4) Stirrups are 6 mm dia at both ends long and including bearing on either side at 150 mm c/c and middle 1.6m length at 210 mm c/c.

Given wt. of bars = 12 mm  $\phi$  = 0.89 kg/m

6 mm  $\phi$  = 0.22 kg/m

Given Clear span of beam = 3.6m

Wall thick = 230 mm

Size of beam = 230 mm x 300 mm

Side covers = 40 mm

Top & bottom covers = 30 mm

1) Main straight bars at bottom :-

Total length of bar (L) = straight length of bar (l) + 2 x H.A

where straight length (l) = clear span of beam + 2 x bearing

$$l = 3.6 + 2 \times 0.23 - 2 \times 0.04 \text{ m} - 2 \times \text{side cover}$$

$$l = 3.98 \text{ m}$$

or bent up bar

Mean avg

1 in breadth

$$= 1825 \sqrt{25} = 5149 \text{ m}$$

$$\begin{aligned} \text{Slope} &= 2 \times \text{M} \\ &= 2 \times 216 \times 5.0 \\ &= 2181.668 \end{aligned}$$



quantities of steel & R.C.C. Simply clear span 3.6m. The walls are 230mm with full bearing on 1 sides 40mm and that h. The RL details & the bar bending schedule. 12mm $\phi$  - 2 nos. - 2 nos.

and  
and middle

75°  
slopes  
at  
is 2.4m.

= 26x1.65  
6x5.049  
168 m<sup>2</sup>

$$\begin{aligned} \text{Total length (L)} &= l + 2 \times 9d \\ &= 3.98 + 2 \times 9 \times 0.012 \\ L &= 4.196 \text{ m} \end{aligned}$$

2) Main bent up bars = 12mm $\phi$ , 2 nos.

$$\begin{aligned} \text{Total length of bar} &= \text{straight length of bar (l)} + 2 \times H.A + 2 \times B.A \\ l &= l + 2 \times 9d + 2 \times 0.42D. \end{aligned}$$

$$\text{where } l = 3.98 \text{ m}$$

$$12 \times 9 \times 0.012 + 2 \times 0.42D$$

where  $D$  = Total depth of beam - T.C.C - B.C.C - dia. of bars up to

$$D \Rightarrow 300 - 30 - 30 - 12$$

$$D \Rightarrow 228 \text{ mm}$$

$$D = 0.228 \text{ m}$$

$$L = 3.98 + 2 \times 9 \times 0.012 + 2 \times 0.42 \times 0.228$$

$$L \Rightarrow 4.387 \text{ m}$$

3) Anchor bars at top = 12mm $\phi$ , 2 nos.

Total length of bar = Length of straight bar + 2 x H.A

$$L = l + 2 \times 9d.$$

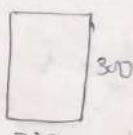
$$L = 3.98 + 2 \times 9 \times 0.012$$

$$L = 4.196 \text{ m}$$

4) Stirrups length

$$\text{Stirrups length} = 2(a+b) + 2 \times 12d.$$

$$\begin{aligned} \text{where } a &= \frac{\text{Width}}{\text{Length} - \text{Cover}} & a &= 230 - 40 \times 2 \\ b &= \frac{\text{Depth}}{\text{Breadth} - \text{T & B covers}} & = 150 \text{ mm} \\ & & b &= 300 - 2 \times 30 = 240 \text{ mm} \end{aligned}$$



$$L = 2[150 + 240] + 2 \times 12 \times 6$$

$$= 780 + 144$$

$$L \Rightarrow 924 \text{ mm}$$

$$L = 0.924 \text{ mtr.}$$

No. of stirrups :-

6 mm  $\phi$  bars for stirrups at 150 mm c/c

Total length on each end = 1 + 0.23  $\Rightarrow$  1.23 mtr.

No. of stirrups at one end =  $\frac{1.23}{0.15} \Rightarrow 9.2 \Rightarrow 10 \text{ nos.}$

For both ends =  $2 \times 10$

= 20 nos.

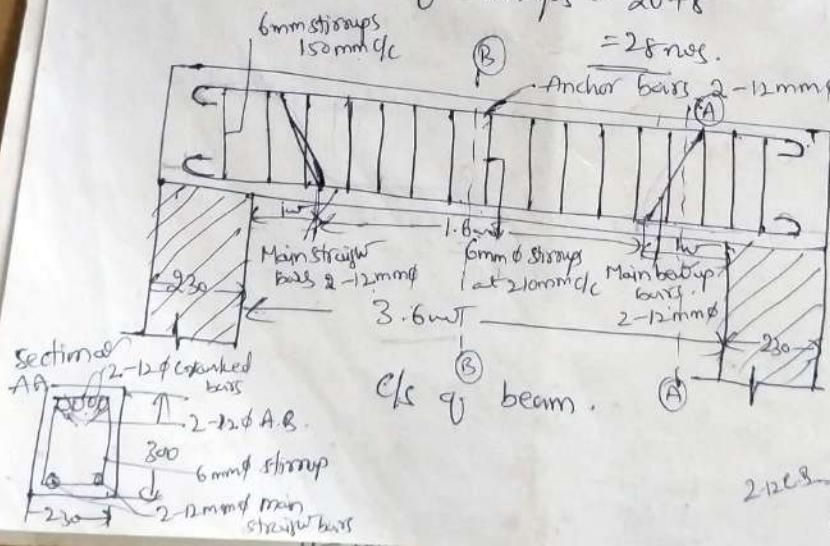
Total length in middle = 1.6 mtr at 210 mm c/c.

No. of stirrups =  $\frac{1.6}{0.21} \Rightarrow$

$\Rightarrow 7.61$

= 8 nos.

Total no. of stirrups = 20 + 8



The mean Sloping breadth =  $1825 \div 5.049 = 363.4 \text{ mtr.}$

Section A-A



Section B-B

$$\text{Slope} = 2L \times M.S.B$$

$$= 2 \times 216 \times 5.049$$

$$= 2181.665 \text{ m}^2$$

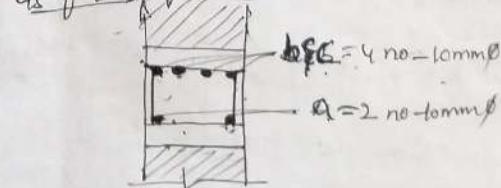
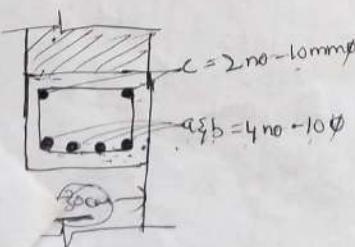
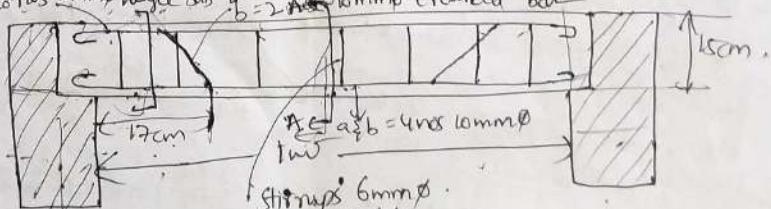
### Bar Bending Schedule -

4)   
 Bar to cover  
 and support  
 non-b - 100  
 Free end

S.No	Description of bars	Shape of bar	Dia	No.	Length	Total Length	Weight per mtr	Total weight in kgs
1.	Main straight bars		12 mm	2	4.196	8.392	0.89 kg/m	7.468 kgs.
2.	Main bent up bars		12 mm	2	4.383	8.774	0.89 kg/m	7.808 kgs
3)	Anchor bars		12 mm	2	4.196	8.392	0.89 kg/m	7.468 kgs
4.	Stirrups		6mm	28	0.924	25.832	0.22 kg/m	5.691 kgs
							Total wt	= 28.435 kgs

### Problem on R.C.C Lintel.

- 2) Prepare a schedule of bars for the R.C.C Lintel shown in figure below, assuming bearing of the lintel to be 15cm on walls at each side. Weight of 10mm Ø bar = 0.62 kg/m & 6mm Ø bar = 0.22 kg/m.



1) Main bars — 4 no - 10 mm  $\phi$ .

a) Total length of bar ( $L$ ) = length of straight bar ( $l$ ) +  $2 \times h_A + 2 \times 0.15$

$$l = 1 + 2 \times 0.15 - 2 \times 0.025 + 2 \times 0.15 \Rightarrow 1.25 \text{ m}$$

$$L = 1.25 + 2 \times 9 \times 0.01 \quad \text{---} \\ L = 1.43 \text{ m}$$

2) Main bent up bars: — (2 no - 10 mm  $\phi$ )

Total length of bar ( $L$ ) = length of straight bar ( $l$ ) +  $2 \times h_A + 2 \times 0.42 \times 0.09$

$$l = 1.15 - 0.025 - 0.25 - 0.01 \Rightarrow 0.9 \text{ m} \quad \text{---}$$

$$L = 1.25 + 2 \times 9 \times 0.01 + 2 \times 0.42 \times 0.09$$

$$L = 1.5056 \text{ m}$$

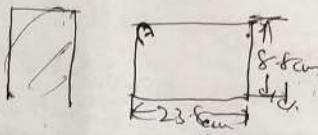
3) Anchor bars: —

Similar to main bars at bottom

$$L = 1.43 \text{ m}$$

4) Stirrups: — 6 mm  $\phi$ .

$$L = 2(a + b) + 2 \times 12 \text{ d}$$



$$= 2(0.288 + 0.088) + 2 \times 12 \times 0.006 \quad \text{Assuming spacing as 15 mm/4c} \\ L = 0.796 \text{ m}$$

$$\text{No. of Stirrups} = \frac{1000 + 2 \times 80 - 2 \times 25}{150} + 1 = \frac{933}{150} = 10 \text{ nos.} \\ \text{Bar Bending Schedule: } 150$$

		10	2	1.43	2.86	1.773
1) Main straight bars					0.62 kg/w	3.564 kg.
2) Main bent up bars		10	2	1.505	3.01	1.866 kg.
3) Anchor bars		10	2	1.43	2.86	3.554 kg
4) Stirrups		6	10	0.796	7.96	4.602 kg.
						1.75 kg.

The Mean age  
Sloping breadth =  $\frac{1.875}{5.049} = 0.373 \text{ m}$

spare bar bending schedule  
from the following specification  
wide and 200 mm depth. Main  
9 Fe 415 grade, 3 bars  
through us at 180 mm  
2 nos. anchor bars  
2) Two leffed stirrups  
3) Clear span of  
200 mm. is given  
Main  
Ma

$$\text{Slope} = 2L \times M.S.B \\ = 2 \times 26 \times 5.049 \\ = 2181.665 \text{ m}^2$$



Prepare bar bending schedule of S.S. R.C.C. lintel from the following specifications: Size of the lintel 230mm wide and 200mm depth. Main bars in the tension zone are of Fe 415 grade, 3 bars of 12mm Ø, of which one is cranked through 45° at 180mm from either end.

- 1) 2 nos. anchor bars of 10mm Ø at top.
- 2) Two legged stirrups of 6mm Ø @ 150mm C/c
- 3) Clear span of the lintel is 1200mm; bearing on either side is 200mm. Assume all round cover as 25mm.

Given size of the lintel = 230mm x 200mm.

Main bars - 2 nos - 12mm Ø.

Main bent up bars - 1 nos - 12mm Ø.

Anchor bars - 2 nos - 10mm Ø.

2 legged stirrups - 6mm Ø @ 150mm C/c.

C.S of lintel = 1200mm.

Wall thickness = 200mm

All round cover is 25mm.

### 1) Main Bars

Total length of bar (L) = straight length (l) +

where  $l = C.S \text{ of lintel} + 2 \times B - 2 \times \text{covers}$

$$\Rightarrow 1200 + 2 \times 200 - 2 \times 25$$

$$l \Rightarrow 1550 \text{ mm}$$

$$l = 1.55 \text{ m}$$

$$\therefore L = 1.55 \text{ m}$$

### 2) Main Bent up bars

Total length of bar (L) = straight length +  $2 \times 0.42 D$

where  $D = \text{Depth of lintel} - \text{F.C.C} - \text{B.C.C} - \text{Bent up dia. A}$

$$D = 200 - 25 - 25 - 12 \text{ mm} \Rightarrow 138 \text{ mm} \Rightarrow 0.138 \text{ m}$$

$$\therefore L = 1.55 + 2 \times 0.42 \times 0.138$$

$$L = 1.665 \text{ m}$$

### 3) Anchor bars

Total length of bar ( $L$ ) = straight length ( $l$ )

$$\text{where } l = 1200 + 2 \times 200 - 2 \times 25 = 1550 \text{ mm} \Rightarrow 1.55 \text{ m}$$

### 4) Stirrups length :-

$$\text{Stirrups length} = 2(a+b) + 2 \times 12.8d$$

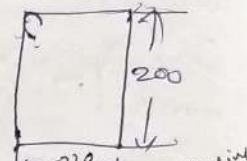
$$\text{where } a = 230 - 25 - 25 = 180 \text{ mm}$$

$$b = 200 - 25 - 25 = 150 \text{ mm}$$

$$L = 2(180 + 150) + 2 \times 12 \times 6 \quad \text{No. of stirrups} = \frac{1200 + 2 \times 200 - 2 \times 25}{150} + 1$$

$$L = 804 \text{ mm}$$

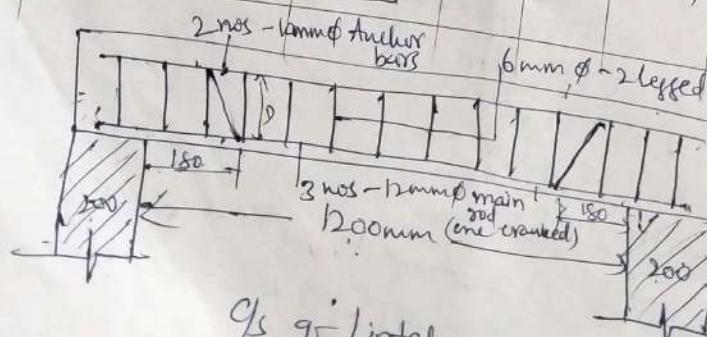
$$L = 0.804 \text{ m}$$



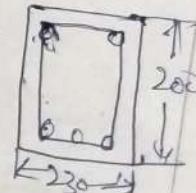
$$\begin{aligned} & \text{Reinforcement: } 1200 + 2 \times 200 - 2 \times 25 \\ & = 1550 \text{ mm} \\ & = 1.55 \text{ m} \end{aligned}$$

$$= 11 \text{ nos.}$$

S.NO	Description of bar	Shape of bar	Dia	No.	Length	Total length	Weight	Total wt. in kgs.
1.	Main Straigw bars	—	12 mm	2	1.55	3.10	0.89	2.759
2.	Main Bent-up bars	—	12 mm	1	1.665	1.665	0.89	1.481
3.	Anchor Bars	—	10 mm	2	1.55	3.10	0.62	1.922
4.	Stirrups	□	6 mm	11	0.804	8.844	0.22 kg	1.945
								8.107 kg



9/8 q. Lintel



$$\begin{aligned} & \text{Mean avg. sloping breadth} = 1.875 \text{ m} \\ & = 5.049 \text{ m} \end{aligned}$$

c.c (1:2:4) rectangular  
overall length  
3 nos. 16 mm  $\phi$  (1.58  
at ends and the  
places with 10  
bars are 20 cm  
bending for  
the r  
and

5 a  
slopes  
at  
d is 2.4 m.

$$\begin{aligned} \text{Slopes} &= 2 \times d \times M.S.B \\ &= 2 \times 216 \times 5.049 \\ &= 2181.668 \text{ m}^2 \end{aligned}$$

2. C. C (1:2:4) rectangular beam 20cm wide  $\times$  30cm deep  $\times$  (6) 3.0m overall length is reinforced with 4 nos. 16mm  $\phi$  (1.58 kg/wt) two outer bars straight & L-hooked at ends and the inner bar bent up at  $45^\circ$  at appropriate places with L-hooked at ends. At top, two outer banger bars are 10mm  $\phi$  (0.62 kg/wt) straight and L-hooked at ends. Stirrups are 6mm  $\phi$  mild steel bars (0.22 kg/wt) and spaced at 20 cm centers. All concrete cover = 2.5cm. Prepare bar bending schedule and draw sketches showing arrangements of RF for the beam, and show appropriate method of entering the measurements in the columns of Measurement Book (MB) and prepare a bill of quantities for four such beams.

Given Rectangular beam 20 cm  $\times$  30 cm.

Overall Length = 3m. including wall thick

Main straight bars = 2 nos - 16mm  $\phi$  with L-hooked at ends.

Main bent up bars = 1 nos - 16mm  $\phi$  with L-hooked at ends.

Anchor bars = 2 nos - 10mm  $\phi$  " " " "

Stirrups = 6mm  $\phi$  @ 200 mm c/c.

All concrete cover = 2.5 cm.

### 1) Main straight bars

Total length of bar (L) = straight length (l) +  $2 \times H.A (2 \times 6d)$

where  $l = 3.0 + 2 \times 0.025 \Rightarrow 2.95 \text{ m}$  for L-hooked

$$L = 2.95 + 2 \times 6 \times 0.016 \Rightarrow 3.142 \text{ m.}$$

### 2) Main bent up bars

Total length of bar (L) =  $l + 2 \times 6d + 2 \times 0.42D$ .

$$D = 300 - 25 - 25 - 16 \Rightarrow 234 \text{ mm} \Rightarrow 0.234 \text{ m}$$

$$L = 2.95 + 2 \times 6 \times 0.016 + 2 \times 0.42 \times 0.234$$

$$L \approx 3.338 \text{ m.}$$

### 3) Anchor Bars:-

1) Anchor Bars :- 2H.A  
Total length of bar (L)  $\Rightarrow$  straight length +  $2 \times 6d$

$$l = 3 - 2 \times 0.025$$

$$l = 2.95 \text{ cm}$$

$$L = 2.95 + 2 \times 6 \times 0.01 \Rightarrow 3.07 \text{ m.s.}$$

4) Stamps :

Stirrups length  $L = 2(a+b) + 2 \times 12 \times d$

$$a = 200 - 2 \times 25 \Rightarrow 150 \text{ mm}$$

$$b = 300 - 2 \times 25 \Rightarrow 250 \text{ mm.}$$

$$L = 2(150 + 280) + 2 \times 12 \times 6$$

L = 944 mm

$$L = 0.944 \text{ m}$$

$$\text{No. of stirrups} = \frac{\text{Overall length} - 2 \times \text{cover}}{\text{spacing}} + 1$$

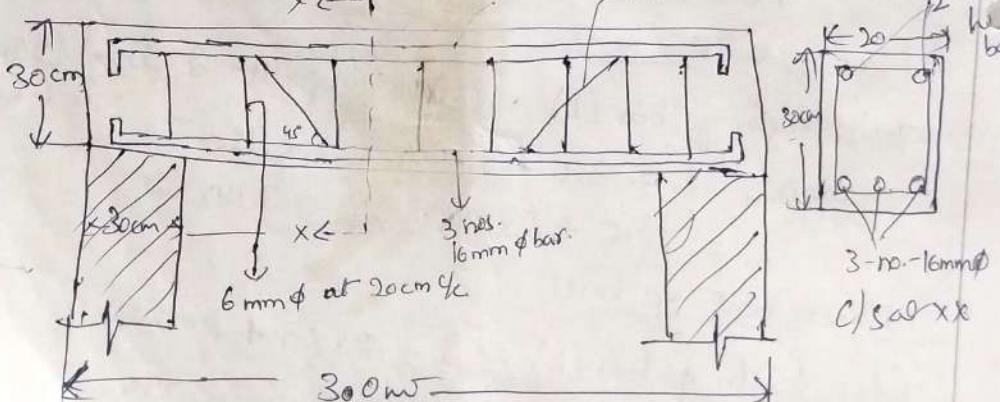
$$= \frac{3 - 2 \times 0.125}{0.2} + 1$$

2) 15.30

$\Rightarrow$  16 nos.

10 mm  $\phi$ , Hayel bar.

led bal



height length +  $2 \times 6d$

No	Description	Shape of bar	No.	Length	Total length	Wt in kg/wt	Total wt. (kg)	Quantity.
1	Main straight bars (16mm $\phi$ (Tors Steel))		2	for 4 beams = 8	3.142	25.136	1.58 kg/wt	39.71 kg. = $1.58 \times 25.136$ (7)
2	Main bent up bar (16mm $\phi$ )		1x4 = 4	3.308	13.352	1.58	21.09 kg.	
3	Hanger bars		2x4 = 8	3.07	24.56	0.62	15.22 kg. 76.02 kg.	
4	Stirrups (mild steel) 6mm $\phi$		16x4 = 64	0.944	60.416	0.22	13.29 kg.	

### Measurement Book :-

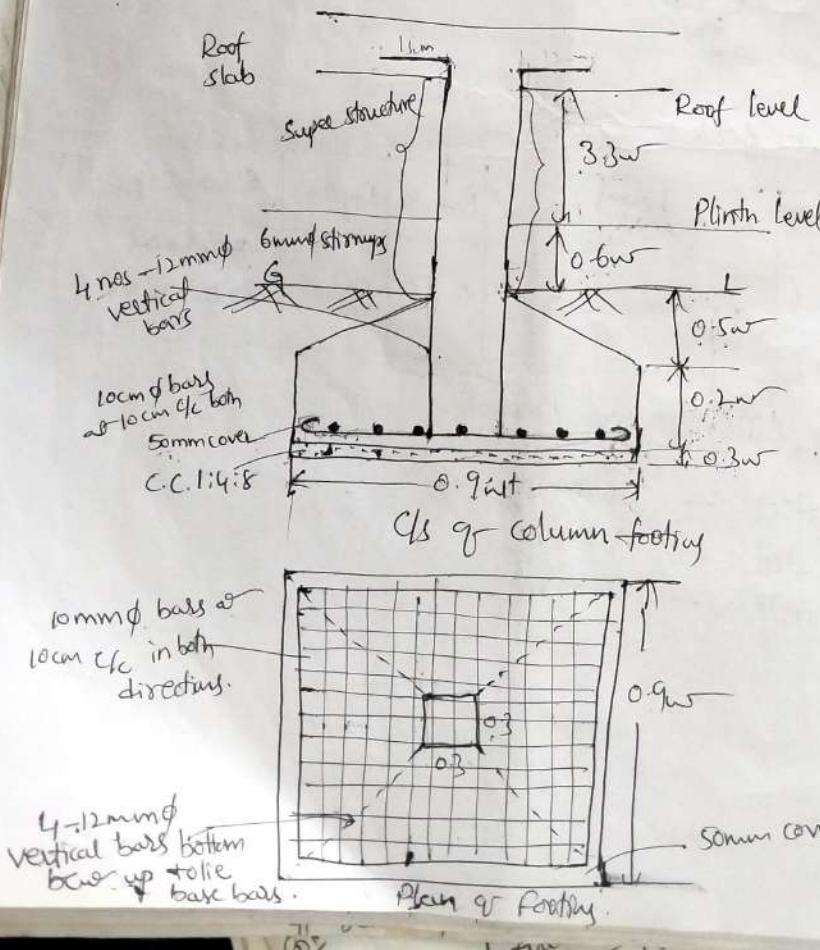
S.No	Description of beam	No. of bars	Length	Breadth	Depth	Quantity.
1.	C.E. R.C.C work (1:2:4)	4	3	0.2	0.3	$3 \times 0.2 \times 0.3$ $\approx 0.72 \text{ m}^3$

### Quantity of Bill for Four Beams

- 1) Tors steel — 76.02 kg.
- 2) Mild steel — 13.29 kg.
- 3) C.Concrete — 0.72 m<sup>3</sup>.

Problem on Column :-

- 5) Determine the quantity of concrete and that of steel in R.C.C. square column. Details in fig. size of base  $0.9 \times 0.9 \times 0.2$ m. Details of RF:- a)  $10\text{mm} \phi$  bars at  $10\text{cm c/c}$  in base portion  
b)  $12\text{mm} \phi$  vertical bars 4 nos. one number at each corner with sufficient holding the base RF  
c)  $6\text{mm} \phi$  stirrups at  $15\text{cm c/c}$ .
- Note:- 1) Height of column from plinth level to bottom of roof slab is  $3.3\text{m}$ . Depth of foundations  $1.0\text{m}$  below GL. Basement height is  $0.6\text{m}$ .
- 2) Extend vertical rod of column  $15\text{cm}$  length above bottom roof level for binding & into roof slab.



Calculation of length of bars  
In base of column  $= 10\text{mm}$   
length of bars  $= 0.9\text{m}$   
length =  $\Rightarrow$   
No. of bars

$$A = 2L \times d \text{ M.S.B}$$

$$2 \times 2.16 \times 5.049$$

$$2181.668 \text{ m}^2$$

Concrete and reinforcement details in R.C.C.  
 Size of base 0.9 x 0.9 x 0.2 m.  
 Bars 10 nos. 16 mm dia. in base portion  
 4 nos. in middle portion  
 The base of  
 to bottom of roof slab  
 N.G.L. Basement  
 above bottom

### Calculation of length of bars

(8)

In base of column :- 10 mm dia. bars at 10 cm c/c in both directions.

$$\text{Length} = \frac{\text{Width of footing} - 2 \times \text{cover}}{(\text{so})} + 2 \times \text{H.A.}$$

$$= 0.90 - 2 \times 0.05 + 2 \times 9 \times 0.01$$

$$L = 0.98 \text{ m}$$



$$\text{No. of bars} = \frac{\text{Width of footing} - 2 \times \text{cover}}{\text{spacing}} + 1$$

$$= \frac{0.9 - 2 \times 0.05}{0.1 \text{ (10 cm)}} + 1$$

$$= 9 \text{ nos.}$$

For both directions, no. of bars required  $\Rightarrow 2 \times 9 = 18$  bars. for mat

2) Vertical main bars :- No. of bars = 4 nos.

Length of each bar = Bent up <sup>AB</sup> to join base + (ht. of base - cover + trapezoidal portion height + Basement height + Superstructure height) + length extend into roof.

$$\therefore \text{Length of bar} = AB + BC + CD + DE$$

AB = Bent up bar to adjoin the base RF

$$AB = 400 \text{ mm} \quad (\text{but not less than } 400 \text{ mm})$$

$$= 40 \times 10$$

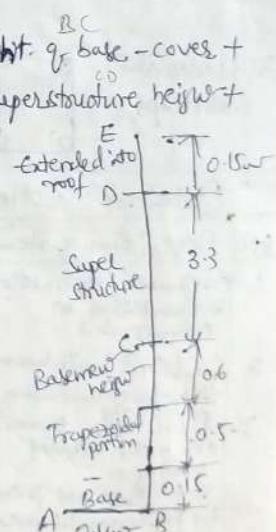
$$= 400 \text{ mm}$$

$$AB = 0.4 \text{ m}$$

$$BC = (200 - 50) + 500 + 600 \Rightarrow 1250 \text{ mm} = 1.25 \text{ m}$$

$$CD = 3.3 \text{ m}, DE = 0.15 \text{ m}$$

$$\text{Length of each bar} = 0.4 + 1.25 + 3.3 + 0.15 = 5.1 \text{ m}$$



3) Horizontal stirrups - 6 mm  $\phi$ .

Column side size

$$\text{Length of stirrups} = 4(0.3 - 2 \times 0.05) + 2 \times 12 \times 0.006 \text{ (cover)} \\ \Rightarrow 0.944 \text{ m.}$$

$$\text{No. of stirrups} = \frac{0.15 + 0.5 + 0.6 + 3.3}{0.15} + 1$$

$$\Rightarrow 31.33.$$

$$\Rightarrow 31 \text{ nos.}$$

#### Bar bending schedule

S.N.	Description of bar	Shape of bar	Dia	No.	Length in	Total length	Weight in kg/m	Total weight in kg.
1.	Main rods base slab metal portion	C	10 mm	18	0.98	17.64	0.62 kg/m	10.936 kg.
2.	Vertical main bars	L	12 mm	4	5.10	20.4	0.89 kg/m	18.156 kg
3)	Horizontal stirrups	□	6 mm	31	0.944	29.264	0.221 kg/m	6.438 kg.

#### Detailed Estimate of Square column.

S.N.	Description of item	Nos	Length	Breadth	Depth	Quantity
1.	Earthwork excavation in foundations in ordinary soils	1	0.9	0.9	1.0	0.81
2.	C.C (1:4:8) with 40mm H.B.G for foundation	1	0.9	0.9	0.3	$0.243 \times \frac{(A^2 + a^2)}{2} \times h$
3.	R.C.C (1:2) with 20mm H.B.G metal including centering etc.	1	$0.9_b$	$0.9$	$0.2$	$0.162 - \frac{4(0.9^2 + 0.3^2)}{2} \text{ nos}$
	a) For Base metal portion	1	$0.5_b$	$0.9$	$0.2$	$0.225 \times 0.9$
	b) For Trapezoidal portion	1	$\frac{3}{3} (0.9_b + 0.5_b + \sqrt{0.9_b \times 0.5_b})$	$0.3$	$3.9 (0.6 + 3.3)$	$0.351 \times 1.79 \text{ m}^3$
4.	for column base & super structure	1	$0.3$	$0.3$	$3.9 (0.6 + 3.3)$	$1.79 \text{ m}^3$
	Quantity as per bending schedule					$35.53 \text{ kg}$

$$\text{Sloping beam} = 5.04$$

6mm  $\phi$   
 side column  
 4 (0.3 - 2 x 0.05) + 2 x 12 x 0.006  
 944 mm  
 + 0.6 + 3.3  
 x 1

Total weight  
 in 1g.  
 36 kg

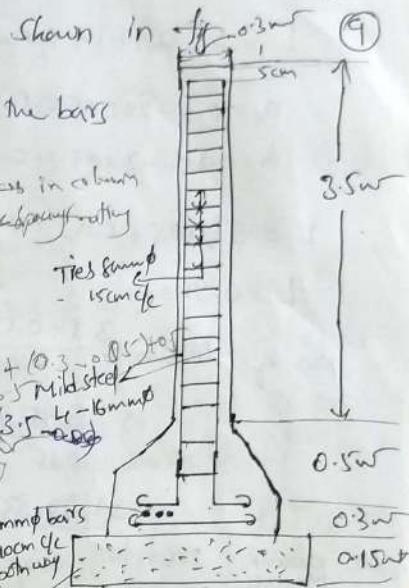
Prepare bar bending schedule with abstract sheet q.  
 R.C.C column with footing as shown in fig.

Assume cover as 5cm all over the bars

Bars in column = 4 - 16mm  $\phi$

Bars in column = 12 mm  $\phi$  @ 100mm c/c

Lateral ties 8mm  $\phi$  @ 15cm c/c



Length of column  $\Rightarrow$  4 - 16mm  $\phi$

Length of column =  $4 \times 0.016 + (0.3 - 0.05) \times 0.01$

13.5m Mild steel

$$\text{Actual length} = 4.0 \text{m} + (0.3 - 0.05) + 0.5 + (3.5 - 0.5) \\ = 4.0 + (0.3 - 0.05) + 0.5 + 3.0 \\ = 4.0 \times 0.016 + 0.085 + 0.5 + 3.0$$

$$L \Rightarrow 4.89 \text{m}$$

$$\text{Base q of column footing} = 1 - 2 \times 0.05 + 2 \times 0.01 \\ = 1 - 2 \times 0.05 + 2 \times 0.01 \times 0.01 \\ = 1.116 \text{m}$$

$$\text{Length} = 1.0 - 2 \times \text{cover} + 2 \times \text{hoes} \\ = 1.0 - 2 \times 0.05 + 2 \times 0.012$$

$$L \Rightarrow 1.116 \text{m}$$

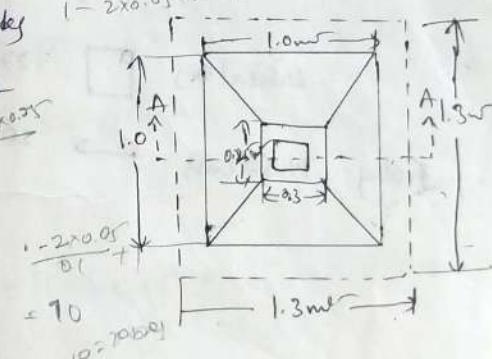
$$\text{No. of bars} = \frac{1.0 - 2 \times 0.05}{\text{Spacing}} + 1$$

$$= \frac{1.0 - 0.1}{0.1} + 1$$

$$= \frac{0.9}{0.1} + 1$$

= 10 nos.

for both directions =  $2 \times 10 \Rightarrow 20 \text{ bars.}$



Lateral ties :- 8 mm  $\phi$  @ 15 cm spacing

$$L = 2(a+b) + 2 \times 12 \times d$$

$$a = 0.3 - 2 \times 0.05 = 0.20$$

$$b = 0.25 - 2 \times 0.05 = 0.15$$

$$L = 2(a+b) + 2 \times 12 \times d$$

$$a = 0.3 - 2 \times 0.05 =$$

$$b = 0.25 - 2 \times 0.05$$

$$L = 2(0.25 + 0.15) + 2 \times 12 \times 0.008$$

$$L = 0.992 \text{ m}$$

$$= \frac{3.5 + 0.5 - 0.05}{0.15} + 1$$

$$\text{No. of ties} = \frac{3.5 + 0.5 - 0.05}{0.15} + 1$$

$$= \frac{3.95}{0.15} + 1$$

$$= 27.33 \text{ no.}$$

S.NO	Column Member	Description	q bar	Shape of bar	NO	Dia	Length	Total length	wt. in length	Total wt
1.	Column V. Main bars		q	q	4	16mm	4.89	19.56	1.58	30.90kg.

Lateral ties  $\square$  27 8mm 0.992 26.784 0.39 10.445kg.

2) Footing 4YSD bars  $\leftrightarrow$  20 12mm 1.116 22.32 0.89 19.86kg.

4. Cost of steel & fabrication (Quantity as per drawing annexure)

## Simply Supported Slab (One-way slab)

(10)

When  $\frac{l}{b}$  ratio i.e. long span : to short span ratio is more than 2 the type of slab is called One-way slab. Otherwise  $\frac{l}{b}$  ratio is less than (or) equal to 2 is called as two-way slab. Generally S.C. slab is supported on all four sides. Main steel is provided in shorter span direction with the designed spacing and alternatively bent up. Distribution steel is provided in the longer direction. All the bars are provided with end hook for M.S. bars and Fe 415 H.S.D. bars - No end hooks are provided.



$\frac{l}{b} > 2$  - one way  
 $\frac{l}{b} \leq 2$  Two way slab

### Types of Bars

1) Usually bottom & top covers provided are 15mm end cover will be 25mm.

$$L = C.S.S + 2 \times \text{Support width} - 2 \times E.C$$



2) Straight Main Bars :-

$$\text{Length of bar} = (\text{Clear span} + 2 \times \text{Support width}) - 2 \times \text{end cover} \\ S.S + 2 \times H.A$$

$$\text{Total no. of bars} = \frac{L - 2 \times \text{end bearing} - 2 \times E.C}{\text{Spacing of bars} \times 2} + 1$$

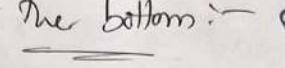
2) Bent up Main Bars

$$\text{Total length} = \text{Length of straight bar} + 2 \times H.A + 2 \times B.A$$

where  $l = \text{Clear short span} + 2 \times \text{end Bearing} - 2 \times \text{end } + 2 \times 9d + 2 \times 0.42 D$ .

where  $D = \text{Depth of slab} - 2 \times \text{C.C} - \frac{\text{Dia. of bar}}{2 \times E.C}$

Total no. of bars =  $\frac{C.L.S + 2 \times E.B - 2 \times E.C}{2 \times \text{Spaing}} + 1$

3) Distribution Bars at the bottom :- 

Total length = Clear L.S + 2 x B - 2 x E.C + 2 x 9d

No. of bars =  $\frac{C.L.S + 2 \times B - 2 \times E.C}{\text{Spaing}} + 1$

4) Distribution bars at top (Anchor Bars) :- These are provided at top bent up part of main steel. Usually 3 nos. in short span over distribution bars are provided.

Length = Length of D.B

No. of bars =  $3 + 3 = 6$ .

Bar Bending Schedule for next page problem

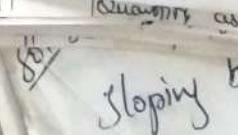
Main steel bottom  12 28 3.13 87.64 0.89/lw 80.00kg

Main bent up bar  12 27 3.18 85.86 0.89/lw 76.42kg

D.S (bottom)  6 20 6.52 130.4 0.22/lw 28.69kg

D.S (at top)  6 6 6.52 39.12 0.22/lw 8.61  
193.72kg

4.1 Cost of steel & fabrication

 Sloping beam = 5.04



Working out the quantities of steel and prepare bar bending schedule of steel for R.C.C one way slab S.S over walls. Shorter span = 2.5m, larger span = 6m, bearing of slab = 230 mm into the walls. Thickness of slab = 100mm. Take end cover = 25mm, bottom & top cover is 15mm. Main steel 12 mm bars alternatively bent up at 120 mm  $\frac{1}{4}$ c. D. steel is 6mm dia and 160mm  $\frac{1}{4}$ c at bottom and 3 nos at top ends of bent up main bars are bent at a distance of  $\frac{1}{7}$  from face of wall.

Sol: Given S.S = 2.5w, L.S = 6w, Bearing of wall = 230mm  
Thickness of slab = 100 mm, end cover = 25mm, T & B cover = 15mm

$$\text{Main steel} = 12 \text{ mm } \phi, \text{ at } 120 \text{ mm C/c} \quad \frac{l}{b} > 2 \text{ (One-way slab)} \\ \text{Dis. steel} = 6 \text{ mm } \phi \text{ at } 160 \text{ mm C/c}$$

i) Length of Main straight bar :-  $\Rightarrow 25 > 2$   
 $24 > 2$  (one-way slab)

$$\text{Total length (L)} = \text{straight length (l)} + 2 \cdot H A$$

$$l = C.S.S + 2 \times B - 2 \times E.C$$

$$= 2500 + 2 \times 230 - 2 \times 25$$

$$l = 2910 \text{ mm}$$

$$L = 2910 + 2 \times 9 \times 12 \Rightarrow 3126 \text{ mm} = 3.126 \text{ m}$$

$$\text{No. of main bars} = \frac{C \cdot L \cdot S + 2 \times B - 2 \times E}{2 \times \text{min.}} + 1$$

$$\Rightarrow \frac{6000 + 2 \times 230 - 2 \times 25}{2 \times 120} + 1$$

2277

$\Rightarrow$  28 nos

## 2) Length of bent up bars

$$L = l + 2 \times 9d + 2 \times 0.42D$$

$$D = \text{Depth of slab} - 2 \times \text{covers} - \text{Dia. of bent up} \\ = 100 - 2 \times 15 - 12 = 58 \text{ mm}$$

$$L = 2910 + 2 \times 9 \times 12 + 2 \times 0.42 \times 58 \\ \Rightarrow 3174.72 \text{ mm}$$

$$L = 3.17 \text{ m}$$

$$\text{No. of bars} = \frac{6000 * 2 \times 230 - 2 \times 25}{2 \times 120} + 1 \\ = 27.7 \\ = 28 \text{ nos.}$$

## 3) Distribution Bars at bottom

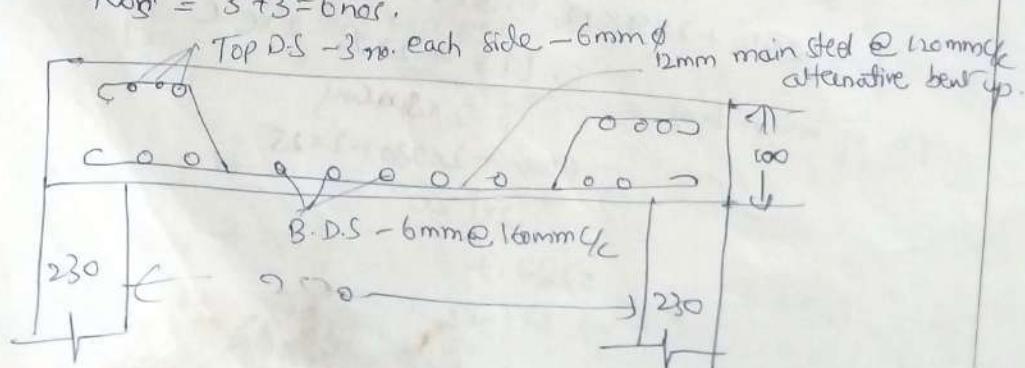
$$\text{Total length (L)} = 6000 + 2 \times 230 - 2 \times 25 + 2 \times 9 \times 6 \\ \Rightarrow 6518 \text{ mm} \\ \Rightarrow 6.52 \text{ m.}$$

$$\text{No. of bars} = \frac{2500 + 2 \times 230 - 2 \times 25}{160} + 1 \\ \Rightarrow 19.16 \\ \Rightarrow 19 \text{ nos.}$$

## 4) Top Distribution Bars

$$L = 6.52 \text{ m}$$

$$\text{Nos.} = 3 + 3 = 6 \text{ nos.}$$



The section along the shorter span of room of size 4x5.5m (internal dimension) is shown in the fig. The thickness of slab is 13 cm. Thickness of wall is 40 cm.

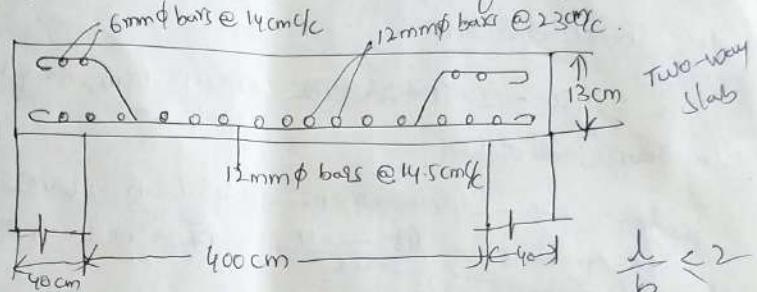


Fig. Showing section of Room slab along shorter span.

Prepare bar bending schedule of the R.C.C. slab. Assume any dimensions not given in the fig.

Sol:

Given. Internal dimension of room = 4x5.5m ( $\because$  In two-

Thickness of slab,  $t_s = 13\text{ cm}$

Thickness of wall,  $t_w = 40\text{ cm}$ .

An end cover of 4cm is adopted, top & bottom of bars is equal to 1.2cm width of slab =  $400 + 2 \times 40 = 480\text{ cm}$ .

Calculation of length of Bars:

- 1) Length of main bar in shorter direction = Width of slab -  $2 \times E.C + 2 \times H.A$ .
- 2) Length of main bars in longer direction = Length of slab -  $2 \times E.C + 2 \times H.A$
- 3) Length of Distribution bar in shorter direction = Width of slab -  $2 \times E.C + 2 \times H.A$
- 4) Length of D.S. in longer direction = Length of slab -  $2 \times E.C + 2 \times H.A$
- 5) Length of cranked bars in S.D. = (Width of slab -  $2 \times E.C + 2 \times H.A$ )  
+  $2 \times 0.42D$ .
- 6) Length of cranked bars in L.D = Length of slab -  $2 \times E.C + 2 \times H.A$   
+  $2 \times 0.42D$

$$\therefore \text{Length of slab} = 550 + 2 \times 40 \Rightarrow 630 \text{ cm}$$

1) Main bars of 12 mm  $\phi$ .

In shorter direction -

$$L = 480 - 2 \times 4 + 2 \times 9 \times 1.2 \Rightarrow 493.6 \text{ cm}, \text{ No. of bars} = \frac{480 - 2 \times 4}{2 \times 14.5} + 1 \Rightarrow 17.27 \Rightarrow 17 \text{ nos.}$$

In longer direction

$$L = 630 - 2 \times 4 + 2 \times 9 \times 1.2 \Rightarrow 643.6 \text{ cm.} \Rightarrow 6.43 \text{ m}$$

$$\text{No. of bars} = \frac{630 - 2 \times 4}{2 \times 14.5} + 1 \Rightarrow 17.27 \text{ nos.} \Rightarrow 18 \text{ nos.}$$

In shorter direction.

$$L = 480 - 2 \times 4 + 2 \times 9 \times 1.2 + 2 \times 0.42 D$$

$$\text{where } D = 13 - 2 \times 4.2 + 1.2 \Rightarrow 9.4 \text{ cm}$$

$$= 480 - 2 \times 4 + 2 \times 9 \times 1.2 + 2 \times 0.42 \times 9.4$$

$$\Rightarrow 501.496 \text{ cm.} \Rightarrow 5.01 \text{ m}$$

$$\text{No. of bars} = \frac{480 - 2 \times 4}{2 \times 14.5} + 1 \Rightarrow 17 \text{ nos.}$$

In longer span

$$L = 630 - 2 \times 4 + 2 \times 9 \times 1.2 + 2 \times 0.42 \times 9.4$$

$$\Rightarrow 651.496 \text{ cm.} \Rightarrow 6.51 \text{ m}$$

$$\text{No. of bars} = 22 \text{ nos. } \left( \frac{630 - 2 \times 4}{2 \times 14.5} + 1 \right)$$

3) Distribution Bars - 6 mm  $\phi$ .

In shorter direction :-  $L = 480 - 2 \times 4 + 2 \times 9 \times 0.6 \Rightarrow 482.8 \text{ cm}$

$$\text{No. of bars} = \frac{480 - 2 \times 4}{2 \times 14} + 1 \Rightarrow \frac{16.85}{28} + 1 \Rightarrow 18 \text{ nos.} \Rightarrow 4.82 \text{ m}$$

In longer direction :-  $L = 630 - 2 \times 4 + 2 \times 9 \times 0.6 \Rightarrow 632.8 \text{ cm}$

$$\text{No. of bars} = \frac{630 - 2 \times 4}{2 \times 14} + 1 \Rightarrow 22 \text{ nos.} \Rightarrow 6.32 \text{ m}$$

80° Sloping beam = 5.04 m



S.No.	Description of bar	Shape of bar	Dia	No	L	Total length	Weight in kg/wt	Total wt in kgs
1)	Shorter span of main bar	U	12mm	17	4.93	83.81	0.89 kg/wt	74.59
2)	Longer span of M. bar	U	12mm	22	6.43	141.46	0.89 kg/wt	125.89
3)	Shorter span of cranked bar	U	12mm	17	5.01	85.13	0.89	75.80
4)	Longer span of cranked bar	U	12mm	22	6.51	143.22	0.89	127.46
5)	Shorter span of D. bars	U	6mm	17	4.82	81.94	0.22	18.02
6.	Longer span of D. bars	U	6mm	22	6.32	139.04	0.22	30.588.
						Total wt. =	<u>452.348 kgs</u>	

at the

Sol:

23/3/21

(2P)

4, 6, 11, 14, 16, 18, 21, 22, 24, 29, 33, 37, 38, 39

15.B

9