Estimation & Costing

Annual instalment for Sinking fund

$$I = \frac{Si}{(1+i)^n - 1}$$

- Total amount of Sinking fund to be accumulated at the end of its life,
  - S = Initial cost - Scrap/salvage value → (It may be zero)
  - i = Rate of interest (eg. 4% = 0.04)
  - n = Life of item/building.

Gross rent = Net return + outgoings

$$\text{Year's purchase} = \frac{100}{\text{Rate of interest}}$$

Capitalized value of the property
= Net income × Year's purchase.

Total plinth area = No. of persons × plinth area per person

Cubic contents = No. of storys × plinth area × Height of each storey
$\rightarrow (G+n)$

Cost of building = No. of units × Cost per unit
= plinth area × plinth area rate
= Cubic content × Cubic content rate.

Like
- Contractors profit
- Contingency
- Petty Supervision (PS)

} Are added to Cumulative cost/total cost
eg
added to building cost if mension.

Assume Suitable provisions

1. Add for water supply & sanitary charges at 12½% of building cost.
2. Add for electrical installations charges at 12½% of building cost
3. Add 3% for petty supervision & contingencies on over all cost.

2013 - 20M - 3a

① The annual Sinking fund of a machine costing ₹ 50,000 is ₹ 150 and its Salvage value is estimated to be ₹ 5,000. Assume interest rate @ 4%, determine the life of the machine

Sol) Total amount of Sinking fund to be accumulated at the end of its life

S = Initial Cost - Salvage Value

= 50,000 − 5000 = ₹ 45,000

Rate of interest (i) = 4% = 0.04

Annual instalment for Sinking fund

$$I = \frac{Si}{(1+i)^n - 1}$$

$$150 = \frac{45,000 \times 0.04}{(1+0.04)^n - 1}$$

$$(1+0.04)^n = 13$$

$$n = \frac{\log 13}{\log 1.04}$$

∴ Life of machine (n) = 65.4 years

② A pumping set with a motor has been installed in a building at a cost of Rs. 2,500. Assuming the life of the pump @ 15 years, work out the amount of annual instalment of Sinking fund required to be deposited to accumulate the whole amount of 4% compound interest.

Sol) Total amount of Sinking fund to be accumulated at the end of its life

S = ₹ 2,500

life of Pump (n) = 15 years

Compound interest (i) = 4% = 0.04.

∴ Annual instalment for Sinking fund

$$I = \frac{Si}{(1+i)^n - 1} = \frac{2500 \times 0.04}{(1+0.04)^{15} - 1} = \text{Rs } 125.$$

i.e The owner is to deposit Rs 125/- annually in 4% compound interest carrying investment for 15 years to accumulate Rs. 2,500/-

(3) An old building has been purchased by a person at a cost of Rs ₹60,000/- excluding the cost of the land. Calculate the amount of annual sinking fund at 5% interest. Assuming the future life of building as 25 years and the scrap value of the building as 10% of the cost of purchase.

Sol) Total amount of Sinking fund to be accumulated at the end of 20 years

S = initial cost − scrap value

= 60,000 − 0.1 × 60,000

= ₹ 54,000

Annual interest (i) = 5% = 0.05

life of building (n) = 25 yrs

∴ Annual instalment of sinking fund

$$I = \frac{Si}{(1+i)^n - 1}$$

$$= \frac{54,000 \times 0.05}{(1+0.05)^{25} - 1}$$

$$\boxed{I = ₹ 1,132}$$

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(4) A building costing Rs. 7,00,000.00 has been constructed on a free hold Land measuring 100 sq.m recently in a big city. prevailing rate of land in the neighbourhood is Rs. 1500.00 per Sq.m. Determine the net rent of the property. If the expenditure on an outgoing including Sinking fund is Rs. 9,000 per annum workout also the gross rent of the property per month. The owner expecting 8 percent return on the Cost of Construction and 5 percent return on the Cost of Land.

Sol) Cost of Construction : Rs 7,00,000

Cost of land @ 1500 per Sq.m = 100 × 1500 = 1,50,000

Net return

on building @ 8% on the Cost of Construction

= 7,00,000 × $\frac{8}{100}$ = Rs. 56,000

on land @ 5% on the cost of land

= 1,50,000 × $\frac{5}{100}$ = Rs 7,500

Total net rent per year = Rs. 63,500.

Gross rent = Net rent + outgoings

= 63,500 + 34000

= Rs. 97,500 per annum.

∴ Gross Rent per month

$= \frac{97,500}{12}$ = Rs. 8,125.

(5) A property fetches a net annual income of Rs. 900.00 deducting all outgoings. workout the capitalized value of the property if the rate of interest is 6% per annum.

Sol) Year's purchase $= \frac{100}{\text{Rate of interest}}$

$= \frac{100}{6} = 16.67$

∴ Capitalised value of the property

= Net income × Y.P

= 900 × 16.67

= Rs. 15,003

(6) Prepare an approximate estimate of a hospital building in a primary health Centre for 20 beds. The cost of construction for each bed is arrived at Rs 70,000/- by considering the hospital building constructed recently in near by locality. Determine the cost of hospital building.

Sol) No. of beds = 20

Cost of construction per bed = Rs. 70,000

Total cost of hospital building = 20 × 70,000 = Rs. 14,00,000/-

(7) Prepare an approximate estimate of a polytechnic hostel for 180 students capacity. The cost of construction of a hostel in adjacent campus recently including all provisions arrived at 50,000/- per student. Determine the total cost of hostel building.

Sol) No. of Students = 180

Cost of building per student = Rs. 50,000/-

Total cost of hostel building = 180 × 50,000

= Rs. 90,00,000/-

(8) Prepare an approximate estimate of the hostel for 200 students if area allowed per student is 10m². The plinth area rate is Rs. 4000/ per m².

Sol) Total plinth area of hostel = No. of students × plinth area per student
= 200 × 10
= 2000 m²

Approximate estimate cost = plinth area × plinth area rate
= 2000 × 4000
= Rs. 80,00,000/-

(9) Prepare the total cost of the building by plinth area method with the following data:
1. plinth area of the building = 200 m²
2. plinth area rate = Rs. 10000 per m²
3. 25% of building cost is allowed for different provisions of water supply, Sanitary, Electrical installations, architectural features, P.S & Contingencies etc. put together.

Sol) plinth area of the building = 200 m²
plinth area rate = Rs. 10,000/- per m²
Cost of building = plinth area × plinth area rate
= 10,000 × 200
= 20,00,000.

provisions allowed = $20,00,000 \times \frac{25}{100}$ = 5,00,000/-

Total cost of building = 20,00,000 + 5,00,000 = 25,00,000/-

(10) prepare an approximate estimate for a residential building with the following data by using plinth area method.
1. plinth area = 100 m²
2. plinth area rate of structural cost = Rs 3200/- per m²
3. provide the following as a percentage on the structure cost.
   a) water supply & Sanitation - 12½ %
   b) Electrification - 7½
   c) Architectural purpose - 1%
   d) work charged establishment - 3%

Cost of building = plinth area x plinth area rate.
= 100 x 3200 = Rs. 3,20,000/-

Provisions

a) Water Supply and Sanitation = $3,20,000 \times \frac{12.5}{100}$ = 40,000
b) Electrification = $3,20,000 \times \frac{7.5}{100}$ = 24,000
c) Architectural Purpose = $3,20,000 \times \frac{1}{100}$ = 3200
d) Work charged establishment = $3,20,000 \times \frac{3}{100}$ = 9,600
76,800.

∴ Total cost of building = 3,20,000 + 76,800
= Rs. 3,96,800/-

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(11) Prepare the approximate estimate of a proposed construction of a building with the following data:
a) plinth area = 116 m²
b) Cost per unit area = Rs. 1800/- per m²
c) Electrification @ = 7% building cost.
d) Formation of roads & lawns @ 5% building cost
e) P.S. charges at 3% building cost.

Sol) Cost of building = plinth area x plinth area rate
= 116 x 1800 = 2,08,800/-

Provisions

a) Electrification = $2,08,800 \times \frac{7}{100}$ = 14616
b) Formation of roads & lawns = $2,08,800 \times \frac{5}{100}$ = 10440
c) P.S Charges = $2,08,800 \times \frac{3}{100}$ = 6264
31,320

∴ Total Cost of building = 2,08,800 + 31,320
= Rs. 2,40,120

(12) Prepare an approximate of building project with total plinth area of building is 600 m² from the following data Calculate the total cost of the project.

a) Plinth area rate Rs. 12,000/- per Sq.m.
b) Cost of water supply @ 7½ of Cost of building
c) Cost of Sanitary and electrical installations each 7½ of Cost of building.
d) Cost of architectural featury 1% of building Cost.
e) Cost of roads & lawns @ 5% of building costs.
f) Cost of P.S & Contingency @ 4% of building Cost.

Sol) Cost of building = plinth area × plinth area rate
= 600 × 12,000 = Rs. 72,00,000.

Provisions

a) water supply = 72,00,000 × 7.5/100 = 5,40,000
b) Sanitary & electrical = " × 7.5/100 × 2 = 10,80,000
c) Architectural featus = " × 1/100 = 72,000
d) PS & Contingency = " × 4/100 = 2,88,000
e) roads & lawns = " × 5/100 = 3,60,000

23,40,000

∴ Total Cost of building = 72,00,000 + 23,40,000
= Rs. 95,40,000.

(13) Prepare a preliminary estimate of a proposed building having plinth area 350 m².

a) Plinth area rate Rs 1500/- per m²
b) Add for water supply and Sanitary fittigs @ 12½ %.
c) Add for Electrification @ 7½ %.
d) Add for Architectural treatment @ 2%
e) Add for unforeseen items @ 3%.
f) Add for fluctuation of rate @ 5%.
g) Add for petty Supervision charge @ 3%.

Sol: Cost of building = plinth area × plinth area rate
= 350 × 1500 = ₹ 5,25,000/-

Provisions

a) Water and Sanitary fittings = $5,25,000 \times \frac{12.5}{100}$ = 65,625
b) Electrification = " × $\frac{7.5}{100}$ = 39,375
c) Architechural treatment = " × $\frac{2}{100}$ = 10,500
d) Unforeseen items = " × $\frac{3}{100}$ = 15,750
e) fluctuation rates = " × $\frac{5}{100}$ = 26,250
f) Petty Supervision = " × $\frac{3}{100}$ = 15,750
1,73,250

∴ Total cost of building = ₹ 5,25,000 + 1,73,250
= Rs. 6,98,250/-

(14) prepare a preliminary estimate of a Cinema theatre whose Cubic Contents are 10,000m³. Cost of theatre building is Rs. 500/- per m³. Assume Suitable provisions.

Sol: Cost of Cinema theatre = Cubical Content × Cubical Content rate
= 10,000 × 500 = 50,00,000/-

a) Add for water Supply @ Sanitary Charges at
12½% of building cost = $50,00,000 \times \frac{12.5}{100}$ = 6,25,000

b) Add for Electrical Charges at
12½% of building cost = $50,00,000 \times \frac{12.5}{100}$ = 6,25,000
Rs. 62,50,000.

Add 3% for petty Supervising & Contingencies on own all cost
= $62,50,000 \times \frac{3}{100}$ = 1,87,500

∴ Total Cost = Rs. 64,37,500/-

(15) Prepare a rough estimate of a proposed Commercial Complex in the Corporation limits for the following:

Plinth Area = Rs 400 m²/floor

Height of each Storey = 3m

No. of Storey = G+2

Cubic content rate = Rs 3000/- per m³.

Provide the following provisions as percentage of building cost

1. W.S and Sanitary arrangements - 8%.
2. Electric fiction - 6%
3. Fluctuation of rate - 5%.

Provide the following provisions as percentage of total cost

4. Contractors profit - 10%.
5. PS. and Contigency - 3%.

Sol) Cubic Content = No. of Storey x plinth area x Height of each storey

= (1+2) x (400 x 3) = 3600 m³

Cost of building = Cubic Content x Cubic Content rate

= 3600 x 3000 = 108,00,000/-

Provisions

1. W.S and Sanitary arrangements = $108,00,000 \times \frac{8}{100}$ = 8,64,000
2. Electric fiction = " $\times \frac{6}{100}$ = 6,48,000
3. Fluctuation of rate = " $\times \frac{5}{100}$ = 5,40,000

Rs. 128,52,000

4. Contractors profit = $128,52,000 \times \frac{10}{100}$ = 12,85,200.
5. PS and Contigency = $128,52,000 \times \frac{3}{100}$ = 3,85,560

Total cost of Commerical Complex = Rs. 145,22,760

(16) Prepare a plinth area estimate of a building with a total plinth area of 240 m². Given that

1. plinth area rate Rs. 9000/- per m².
2. Extra for architectural appearance = 1½% of building cost
3. Extra for Electrical installations = 1½% of building cost
4. Extra for water supply & Sanitary installation = 5% of building cost.
5. Contingency - 3%
6. Supervision Charge. - 8%

Sol) Building Cost = plinth area × plinth area rate
= 240 × 9000 = = 21,60,000

a) Architectural appearance = $21,60,000 \times \frac{1.5}{100}$ = 32,400

b) Electrical installance = $21,60,000 \times \frac{14}{100}$ = 3,02,400

c) WS & Sanitary installation = $21,60,000 \times \frac{5}{100}$ = 1,08,000

Added Cost. Rs. 26,02,800/-

d) Contingency = $26,02,800 \times \frac{3}{100}$ = 78,084

e) Supervision charge = " × $\frac{8}{100}$ = 2,08,224

Total cost of building = 28,89,108

① Determine the number of bags of Cement required for a Standard brick masonry for a wall of thickness 20cm for a height of 10m and length 200m. in 1:4 mortor.

Sol) Volume of bricle masonry = $200 \times 10 \times 0.3 = 600\ m^3$

Volume of each brick with mortor = $20 \times 10 \times 10\ cm^2 = 0.002\ m^3$

∴ No. of bricks req = $\frac{600}{0.02} = 3,00,000$ no's

Mortor for each bricle = $(20 \times 10 \times 10) - (19 \times 9 \times 9)$

$= 461\ cm^3 = 461 \times 10^{-6}\ m^3$

∴ Total quantity of mortor req for maronry

$= 300.000 \times 461 \times 10^{-6}$

$= 138.3\ m^3$

Quantity of Cement required = $\frac{1}{(1+4)} \times 138.3 = 27.66\ m^3$

Let 1 bag of Cement = 35 lit = $0.035\ m^3$

∴ No. of bag of Cement req (n) = $\frac{27.66}{0.035} = 790.3$.

$n \approx 800$ bags

② Calculate the quantity of Cement Concrete (1 : 1½ : 3) required for RCC lintels over doors and windows of a residential building. There are 6 doors of size 1.1 x 2.10m and 8 windows of size 1.10 x 1.80m. Thickness of wall is 230mm and thickness of Lintel is 100 mm and a bearing on either side of doors and windows is 150mm.

Sol)

a) No. of doors = 6

Size of lintel over doors = $(0.15 + 1.10 + 0.15) \times 0.23 \times 0.10$

∴ Quantity of CC (1 : 1½ : 3) = $6 \times [1.4 \times 0.23 \times 0.10] = 0.1932\ m^3$

b) No. of windows = 8

Size of linter over window = $(0.15 + 1.10 + 0.15) \times 0.23 \times 0.10$

∴ Quantity of Cc (1 : 1½ : 3) = $8 \times [1.4 \times 0.23 \times 0.1] = 0.2576\ m^3$

∴ Total quantity of CC over doors & windows = $0.1932 + 0.2576$

$= 0.4508\ m^3$

(3) A Single room building is having 3.60m x 6.00m internal dimensions with 300mm thick wall and height of room is 2.30m. Calculate.

a) plinth area

b) Brick work for Single room without Consideration of deductions for Super Structure.

Sol) a) plinth area = Inner dimensions of room and walls area

$= (0.3 + 3.6 + 0.3) \times (0.3 + 6 + 0.3)$

$= 27.72\ m^2$

b) Centre line length $= 2(3.9 + 6.6) = 20.4\ m$

Brick work $= 1 \times 20.4 \times 0.3 \times 2.3 = 14.076\ m^3$

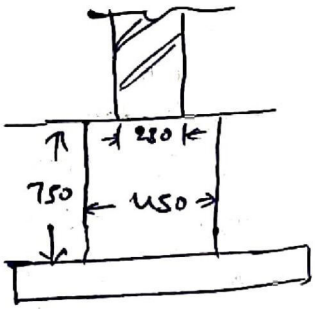
(or) $= \left[(4.2 \times 6.6) - (3.6 \times 6)\right] \times 2.3 = 14.076\ m^3$

(4) The internal dimensions of a room are 6.25 x 4.25m find the quantity of Sand filling in basement. The height and thickness of basement are 750mm and 450mm respectively. The wall thickness of room is 230mm.

Sol) Centre line dimensions

$= (6.25 + 0.23) \times (4.25 + 0.23)$

$= 6.48 \times 4.48\ m^2$



∴ Area of Sand filling

$= (6.48 - 0.45) \times (4.48 - 0.45)$

$= 6.03 \times 4.03\ m^2$

Height of Sand filling $= 0.75\ m.$

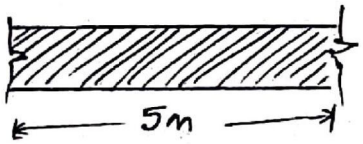
∴ Quantity of Sand filling $= 6.03 \times 4.03 \times 0.75$

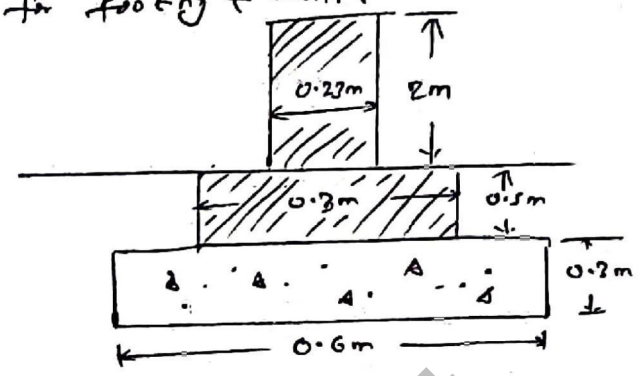
$= 18.226\ m^3$

(5) Fig shows the plan and Section of a part of a Compound wall Calculate the quantity of

a) Cement Concrete required for foundations

b) Brick masonry required for footing & wall.





Sol) Centre line Length = 5m.

a) Cement Concrete required for foundation

$= 5 \times 0.6 \times 0.3 = 0.90\ m^3$

b) Brick masonry required for footing

$= 5 \times 0.3 \times 0.5 = 0.75\ m^3$

c) Brick masonry required for wall

$= 5 \times 0.23 \times 2 = 2.3\ m^3$

Additional Sand filling $= 5 \times (0.6 - 0.3) \times 0.5 = 0.75\ m^3$

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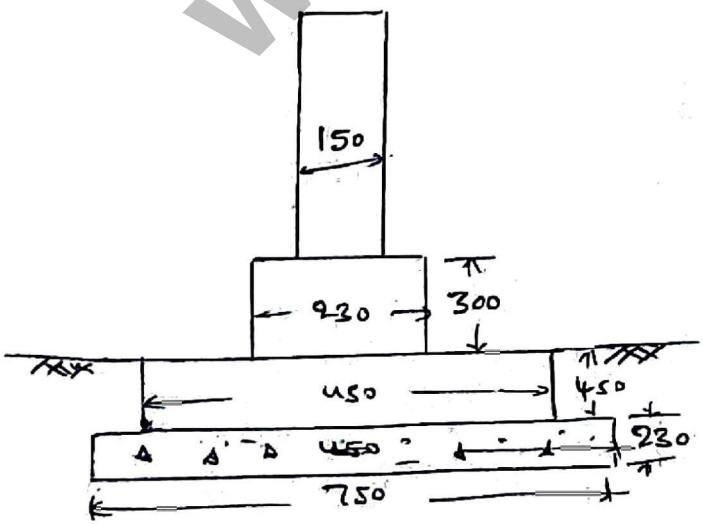
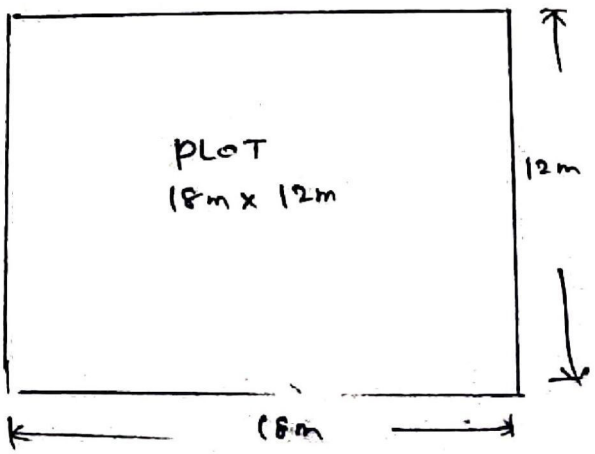
(6) Estimate the quantity of material req for the compound wall shown in fig for the following items.

a) Earth work excavation for foundation

b) Brick masonry in foundation and basements in Cm (1:8)

c) plastering the wall above the ground level with Cm (1:5)





5.) Centre line length $= 2[(18-0.75)+(12-0.75)]$

$= 2[17.25 + 11.25]$

$= 57\ m$

a) Earth work excavation for foundation

$= 57 \times (0.45+0.23) \times 0.75$

$= 29.07\ m^3$

b) Brick masonry in

foundation $= 57 \times 0.45 \times 0.45 = 11.54\ m^3$

basement $= 57 \times 0.23 \times 0.30 = 3.93\ m^3$

$15.47\ m^3$

c) plastering the wall above GL

1) Base met

→ Inside $= (57-4\times0.23)\times0.3 = 16.824$

→ outside $= (57+4\times0.23)\times0.3 = 17.376$

$34.2\ m^2$

2) wall

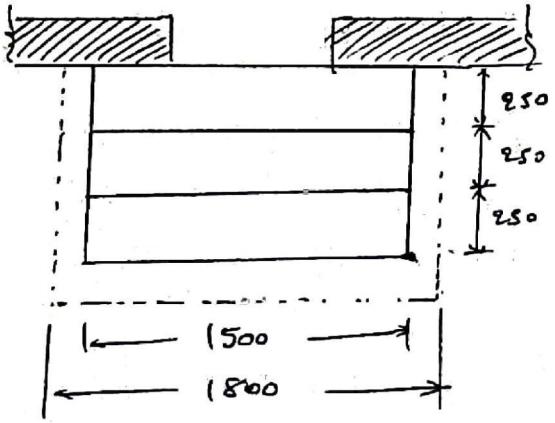
→ Inside $= (57-4\times0.15)\times1.8 = 101.52$

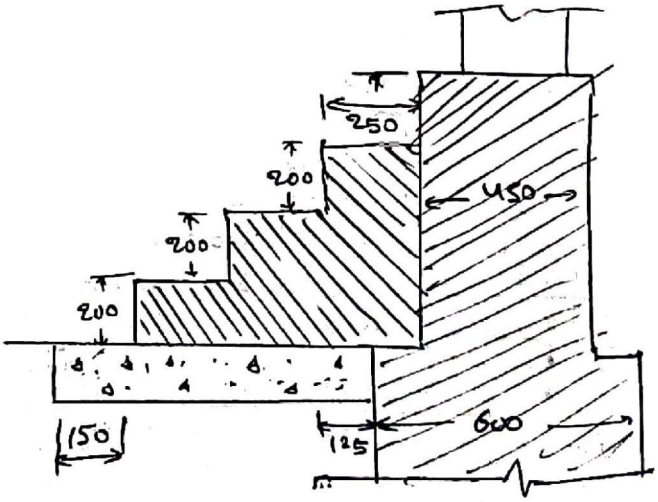
→ outside $= (57+4\times0.15)\times1.8 = 103.68$

$205.2\ m^2$

Total $= 239.40 m^2$

⑦ The fig shows a plan and section of steps at the front of a residential building. find the quantity of Cement Concrete (1:4:8) for foundation and brickwork for steps.





Sol) Width of CC $= (3 \times 0.25 + 0.15) + \frac{0.45}{2} - \frac{0.6}{2}$

$= 0.825\ m$

a) Quantity of Cement Concrete for steps (1:4:8)

$= 1.8 \times (0.825) \times 0.15 = 0.223 m^3$

b) Brick work for

1st step $= 1.5 \times (0.75) \times 0.2 = 0.225\ m^3$

2nd step $= 1.5 \times (0.50) \times 0.2 = 0.150\ m^3$

3rd step $= 1.5 \times (0.25) \times 0.2 = 0.075\ m^3$

$0.45\ m^3$

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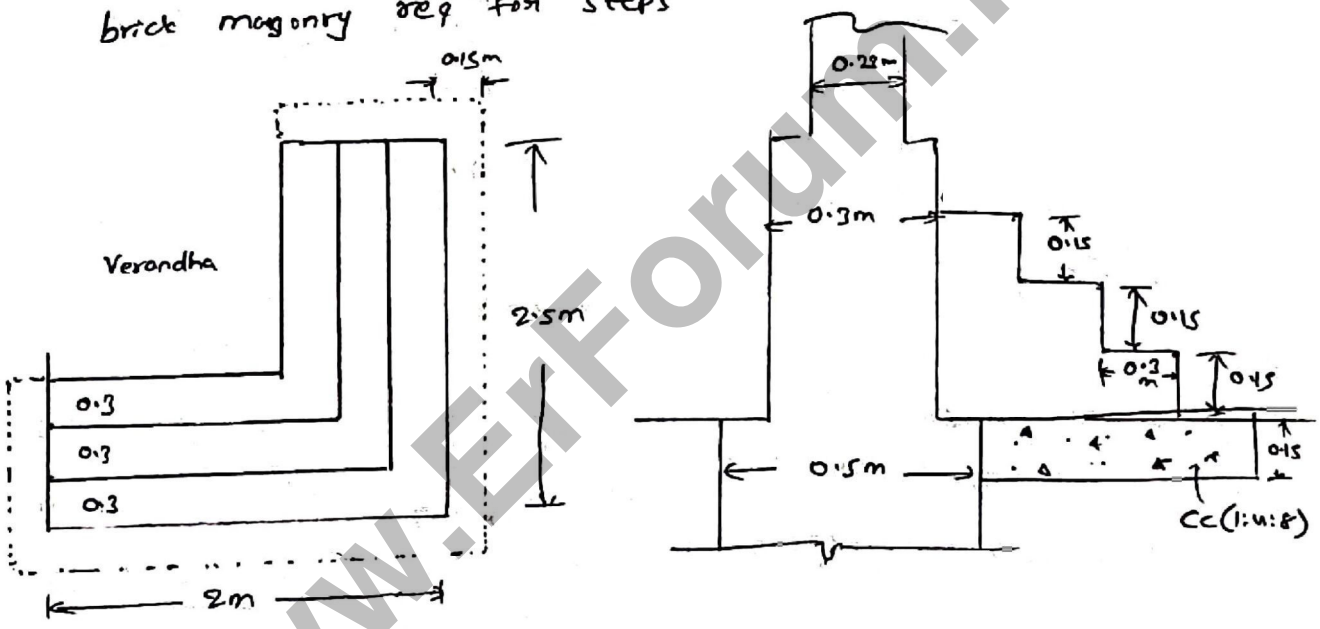
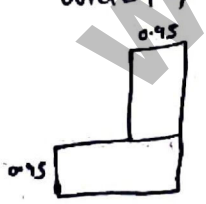
⑧ The plan & section of steps are given in Fig, calculate the quantity of CC (1:4:8) for steps calculate the quantity of brick masonry req for steps



a) CC (1:4:8) req for steps

width of CC $= (0.9 + 0.15) + \frac{0.3}{2} - \frac{0.5}{2} = 0.95m.$

Quantity $= [2.3 + 2.5 - 0.9 + 0.15] \times 0.95 \times 0.15 = 0.577 m^3$



Area $= 3.8475$

Quantity $= 3.8475 \times 0.15 = \boxed{0.577\ m^3}$

b) Brick masonry for steps

1st step $= [2 + (2.5 - 0.9) \times 0.9] \times 0.15^* = 0.486$

2nd step $= [1.7 + 2.2 - 0.6) \times 0.6 \times 0.15 = 0.297$

3rd step $= [1.4 + 1.9 - 0.3) \times 0.3 \times 0.15 = 0.135$

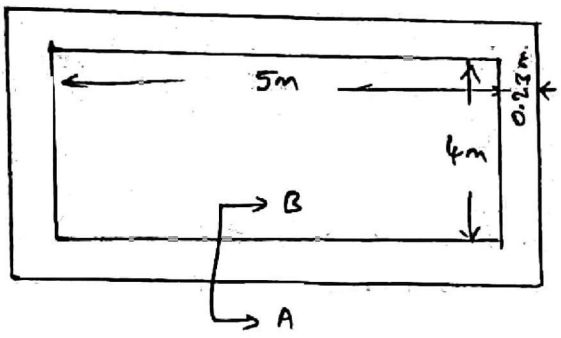
$0.918\ m^3$

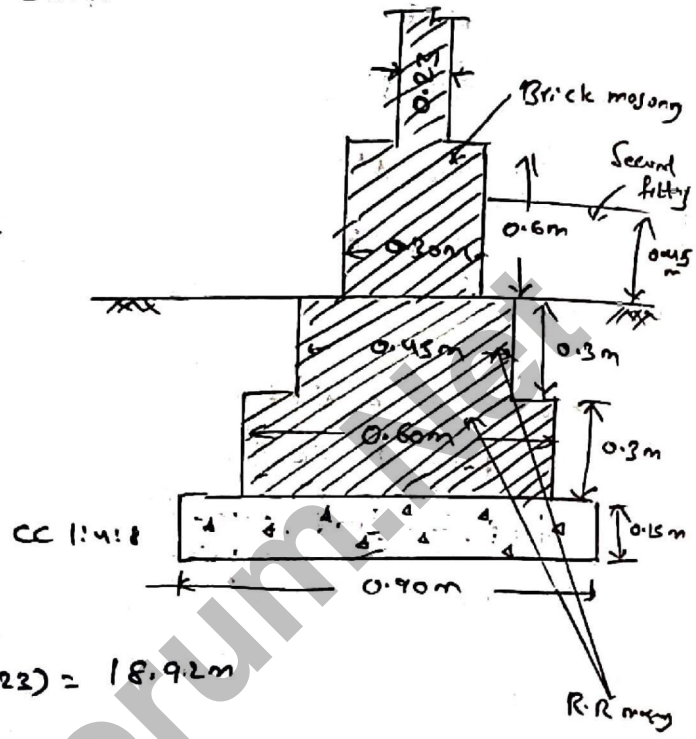
(9) The plan and section of a room is given below Fig. & Calculate the following quantities by Centre line method:

a) Earth work excavation b) Cement Concrete (1:4:8)

c) RR masonry for 1st & 2nd footing

d) Filling of basement with Sand.





Sol) Centre line length of room

$= 2(5.23 + 4.23) = 18.92\text{m}$

a) Earth wor Excavation

$= 18.92 \times 0.90 \times 0.75 = 12.771\ m^3$

b) RR masonry

- 1st footing $= 18.92 \times 0.60 \times 0.3 = 3.406\ m^3$
- 2nd footing $= 18.92 \times 0.45 \times 0.3 = 2.554\ m^3$

$5.96\ m^3$

c) Brick Masonry for basement

$= 18.92 \times 0.30 \times 0.60 = 3.406\ m^3$

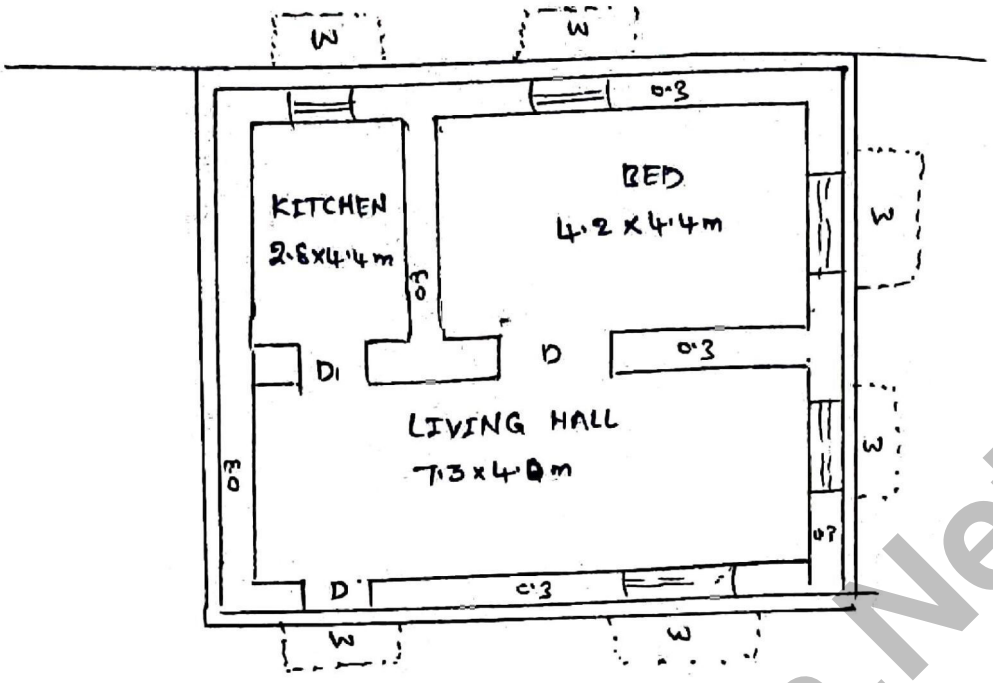
d) Filling of Foundation with Sand

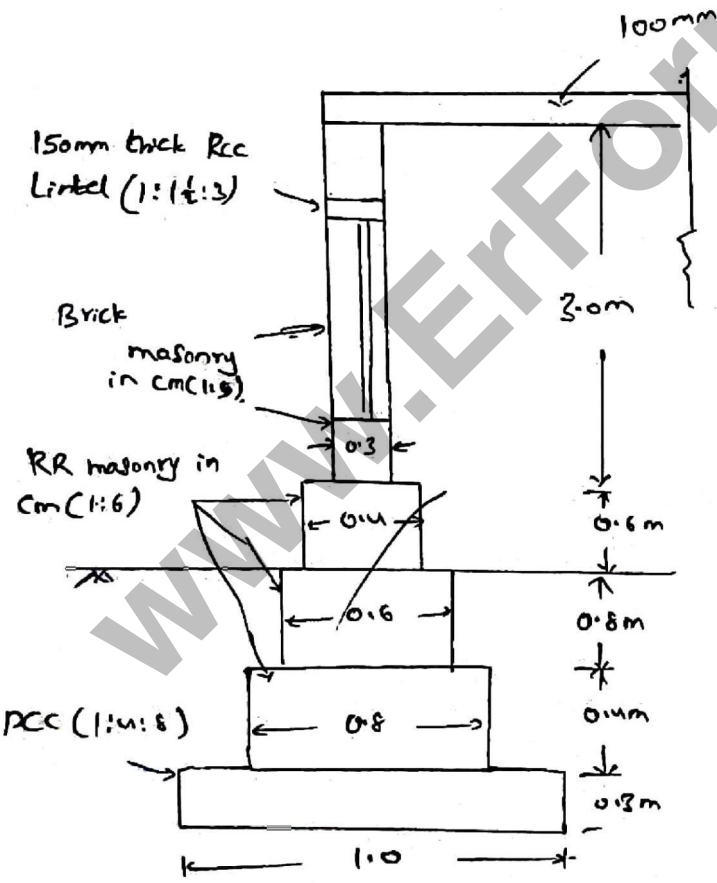
$= \left(18.92 \times 0.90 \times (0.3+0.3)\right) - 5.96 = 4.257\ m^3$

$18.92 \times [0.3 \times 0.3 + 0.45 \times 0.3]$

d) Filling of basement with Sand.

$= (5.23 - 0.3) \times (4.23 - 0.3) \times 0.45 = 8.72\ m^3$.





Reference:

D = 1×2m

D_1 = 0·8×2·0m

W = 1·20×1·25m.

Centre line length (without deductions)

$= 2\left[(7.6) + (4.4 + 4.0 + 0.3 + 0.3)\right]^{23.2} + 7.3 + 4.4$

$= 44.9\text{m}$

a) PCC (1:4:8)

$= 44.9 \times 1 \times 0.3$ $= 13.47\ m^3$

b) RR masonry in Cm (1:6) for foundation

- 1st footing $= 44.9 \times 0.8 \times 0.4$ $= 14.368$
- 2nd footing $= 44.9 \times 0.6 \times 0.8$ $= 21.552$

$35.92\ m^3$

c) Sand filling for foundation $(0.2 \times 0.4 + 0.4 \times 0.6)$

$= 44.9$ $= 19.76$

d) RR masonry (1:6) above G.L

$= 44.9 \times 0.4 \times 0.6$ $= 10.776\ m^3$

e) Lintel RC (1:1½:3)

Assume bearing of lintel on either side = 150mm

- Doors D $= 2 \times 1.3 \times 0.3 \times 0.15$
- Doors D_1 $= 1 \times 1.1 \times 0.3 \times 0.15$
- windows $= 5 \times 1.5 \times 0.3 \times 0.15$

$= 0.504\ m^3$

f) Brick masonry in Cm (1:5)

Gross quantity $= 44.4 \times 0.3 \times 3$ $= 40.41\ m^3$

$= -0.504\ m^3$

Deductions

Lintels

- Doors D $= 2 \times 1 \times 2 \times 0.3$
- Door D_1 $= 1 \times 0.8 \times 2 \times 0.3$
- windows $= 5 \times 1.20 \times 1.25 \times 0.3$

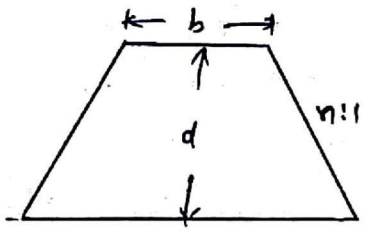
$= -3.93\ m^3$

$35.976\ m^3$

g) RCC (1:½:3) for RCC Slab

$= (7.3 + 0.3 + 0.3) \times (4.4 + 4 + 3 \times 0.3) \times 0.1 = 7.347\ m^3$

Earth Work Calculations



$n:1 = \frac{nH}{TV}$

bottom width $= (b + \frac{2}{n}nd)$

Area $= (b+nd)d$

Order of table

a) Road/Railway embankment

Chainage, Formation level, Reduced/Ground Level, Height

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

b) Canal Cutting

Chainage, R.L of G.L, R.L of Canal bed, Depth of cutting.

Area of c/s $A = (b+nd)d$

Volume Calculation formula

When more than 2 cross section (L = one chainage, Dist b/n successive c/s's

a) Trapezoidal rule

$$V = \frac{L}{2}\left[A_1 + A_n + 2(A_2 + A_3 + A_4 + \cdots)\right]$$

b) prismoidal or Simpson's rule

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

(L = Distance b/n the two c/s's.

2 c/s at the ends

a) Mid section or Mid ordinate method

$V = L A_m$ ($d_m = \frac{d_1 + d_2}{2}$, $A_m = (b + n d_m) d_m$

b) Mean Sectional or Trapezoid rule

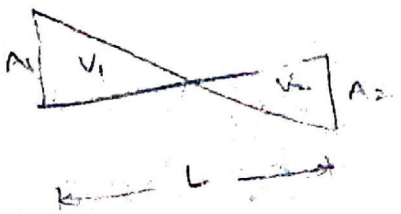
$$V = \frac{L}{2}(A_1 + A_2)$$

c) prismoidal or Simpsons rule

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

$$V_1 = \frac{L}{2} \times \frac{h_1}{h_1 + h_2} \times A_1$$

$$V_2 = \frac{L}{2} \times \frac{h_2}{h_1 + h_2} \times A_2$$



2006 - 20M - 1a

(i) An embankment is 16m wide with side slopes 2:1. Assume the ground to be level in the direction transverse to the centre line. Calculate the volume contained in a length of 100m. The centre heights at 20m intervals being in m 2.0, 4.5, 4.0, 3.5, 2.5, 1.5 Use trapezoidal rule.

Sol Width of formation (b) = 16m.

Side slope (n) = 2.

Chainage	0	20	40	60	80	100
Height (H)	2.0	4.5	4.0	3.5	2.5	1.5
Area = (b+nh)h	40	112.5	96	80.5	52.5	28.5

Volume by trapezoidal rule

$$V = 20\left[\frac{40+28.5}{2} + 112.5 + 96 + 80.5 + 52.5\right]$$

$$\boxed{V = 7515\ m^2}$$

(ii) The ground levels along the centre line of a road are given below

Chainage in (m)	0	50	100	150	200
RL of ground (m)	97.0	96.5	96	97.5	98

The road is to be formed in embankment with the formation level at 100.0 m throughout the 200m length. If the width of road is 10m and side slopes 2:1, calculate the quantity of earthwork by (a) prismoidal rule. Assume the transverse slope of ground is level.

Sol Width of formation (b) = 10m, Side slope (n) = 2

Chainage (m)	0	50	100	150	200
Formation level	100	100	100	100	100
R.L of ground	97	96.5	96	97.5	98
Height (h)	3	3.5	4	2.5	2
Area = (b+nh)h	48	59.5	72	37.5	28

∴ Quantity of earthwork

$$V = \frac{50}{3}\left[(48+28) + 4(59.5+37.5) + 2(72)\right]$$

$$= 10133.33\ m^3.$$

2005 - 20M - 5a

Estimate the quantity and cost of earthwork for a road between two stations A to B with the following data.

Width of road is 10m at formation surface and side slope 2:1

Rate for earthwork in banking and cutting may be taken as ₹ 10.00 per cum including a lead upto 150m with a condition that portion of earthwork available from cutting is to be utilised for banking within the same lead of 150m. The data of field book for the portion of road are as below.

Chainage	0	1	2	3	4	5	6
Reduced level	123.9	125	124.60	122.90	121.60	121.00	120.40
Formation level	122.20	123.60	124.6	123.60	123.20	122.80	122.40

(Note one chain = 30m)

Sol) Width of formation (b) = 10m

Side slope (n) = 2

One chain (L) = 30m

Cost of earthwork = ₹ 10.00/m³

Chainage	Formation Level	Reduced Level	Height (h) (m)	Area A = (b+nh)h
0	123.20	123.9	0.7 (-)	-7.98
1	123.60	125	1.4 (-)	-17.92
2	124	124.60	0.60 (-)	- 6.92
3	123.60	122.90	0.7 (+)	+ 7.98
4	123.20	121.60	1.6 (+)	+ 21.12
5	122.80	121.00	1.8 (+)	+ 24.48
6	122.40	120.40	2.0 (+)	+ 28

-ve indicates cutting & +ve indicates filling

By Trapezoidal formula

$$V = \frac{30}{} \left[\frac{-7.98+28}{2} - 17.92 - 6.92 + 7.98 + 21.12 + 24.48 \right]$$

$$= 1162.5 \text{ m}^3 \quad (\because \text{cutting is used for filling})$$

∴ Cost of earthwork = 1162.5 × 10 = ₹ 11,625/-.

Additional Volume of filling $= 30\left[\frac{7.98+28}{2} + 21.12 + 24.14\right] + \frac{30}{2}\times\left(\frac{0.7}{1.3}\times 7.98\right)$

$= 1972.15\ m^3.$

Volum of Cutting $= 1972.15 - 1162.5 = 810\ m^3.$

(OR) $= 30\left[\frac{7.98+6.92}{2} + 17.72\right] + \frac{30}{2}\times\frac{0.6}{1.3}\times 6.92 = 810\ m^2.$

---

(5) A railway Embankment, 500m long has a width of formation level of 9m with side slopes of 2 in 1. The ground levels at every 100m along the centre line are.

Distance (m)	0	100	200	300	400	500
Ground level (m)	107.8	106.3	110.5	111.20	110.7	112.2

The embankment has a rising gradient of 1:2m per 100m and the formation level is 110.5 at Zero Chainage. Assuming the ground to be level across the centre line, compute the volume of earth works.

Sol) Width of formation (b) = 9m

Side Slope (n) = 2

Distance (m)	Formation Level	Ground level	Height (h)	Area $A=(b+nh)h$
0	110.5	107.8	2.7	38.88
100	111.7	106.3	5.4	106.92
200	112.9	110.5	2.4	33.12
300	114.1	110	4.1	70.52
400	115.3	110.7	4.6	83.72
500	116.5	112.2	4.3	75.68

By Trapezoidal formula

$V = 100\left[\frac{38.88+75.68}{2} + 106.92 + 33.12 + 70.52 + 83.72\right]$

Volume of earth work $= 35156\ m^3.$

④ The road hg the following data

Chainage (m)	0	30	60	90	120	150	180	210	240
G.L in (m)	30.80	31.25	31.85	32.25	32.00	33.65	34.50	34.85	35.5

The formation level at Chainage zero is 32.00m and having a rising gradient of 1 in 120. The top width is 10m and the side slope 2:1 Assuming the transverse slope of the ground level. Calculate the volume of earth work.

Sol) Width of formation (b) = 10m

Side slope (n) = 2

Rising for 30m = $30 \times \frac{1}{120} = 0.25$ m.

Chainage (m)	Formation level	Ground Level	Height (h)	Area A = (b+nh)h
0	32	30.80	1.20	14.88
30	32.25	31.25	1.0	12
60	32.50	31.85	0.65	7.345
90	32.75	32.25	0.50	5.5
120	33	33	0	0
150	33.25	33.65	0.20 (+) -0.40 (-)	2.08 (+) 4.32 (-)
180	33.50	34.50	-1.0	-12
210	33.75	34.85	-1.10	-13.42
240	34	35.50	-1.50	-19.50

-ve indicates cutting.

By using Trapezoidal formula

a) Volume of filling

$$= 30\left[\frac{14.88+2.08}{2} + 12 + 7.345 + 5.5\right] + \frac{30}{2} \times \frac{0.2}{1.2} \times 2.08$$

$$= 1005 \text{ m}^3$$

b) Volume of Cutting

$$= 30\left[\frac{12+19.50}{2} + 13.42\right] + \frac{30}{2} \times \frac{1}{1.2} \times 12$$

$$= 1025.1 \text{ m}^3$$

i.e Volume of cutting > Volume of filling.

By using prismoidal formula

a) Volume of filling (i.e volume of embankment)

$$= \frac{30}{3}\left[\frac{14.88+0}{2} + 4(12+5.5) + 2(7.345)\right]$$

$$= 995.7\ m^2$$

b) Volume of cutting

$$= \frac{30}{3}\left[\frac{(0+19.50)}{2} + 4(4.32+13.42) + 2(12)\right]$$

$$= 1144.6\ m^3$$

---

(5) A reservoir has the following water spread areas at the respective contour levels. The FTL of the reservoir is +160m Compute the capacity of the reservoir.

Contour level (m)	+120	+130	+140	+150	+160
Contour Area (m^2)	0	1250	2700	5400	9500

Sol) Contour interval (d) = 10m

$A_1 = 0\ m^2$, $A_2 = 1250\ m^2$, $A_3 = 2700\ m^2$, $A_4 = 5400\ m^2$, $A_5 = 9500\ m^2$

Capacity of reservoir by prismoidal rule

$$V = \frac{d}{3}\left[(A_1 + A_5) + 4(A_2 + A_4) + 2(A_3)\right]$$

$$= \frac{10}{3}\left[0 + 9500 + 4(1250 + 5400) + 2(2700)\right]$$

$$= 138333.33\ m^3$$

Capacity of reservoir by Trapezoidal rule

$$V = d\left[\frac{A_1+A_5}{2} + A_2+A_3+A_4\right]$$

$$= 10\left[\frac{0+9500}{2} + 1250 + 2700 + 5400\right]$$

$$= 141000\ m^3$$

⑥ From the particulars of a reservoir given below, Calculate the Capacity of a reservoir between the Sill level and MWL of the reservoir by 1. Trapezoidal rule 2. Prismoidal rule.

S.NO	Level in (m)	Area in m²	Particulars
1	40.00	1,500	Bed of reservoir
2	42.00	2,500	
3	44.00	4,200	Sill Level of Sluice
4	46.00	6,500	
5	48.00	9,500	
6	50.00	12,000	FTL
7	52.00	15,000	MWL

Sol) Contour interval (h) = 2 m

$A_1 = 4200\ m^2$, $A_2 = 6500\ m^2$, $A_3 = 9500\ m^2$

$A_4 = 12,000$, $A_5 = 15,000\ m^2$

Capacity of reservoir

a) Trapezoidal rule

$$V = \frac{h}{2}\left[(A_1 + A_5) + 2(A_2 + A_3 + A_4)\right]$$

$$= \frac{2}{2}\left[4200 + 15000 + 2(6500 + 9500 + 12000)\right]$$

$$= 75,200\ m^3$$

b) prismoidal rule

$$V = \frac{h}{3}\left[(A_1 + A_5) + 4(A_2 + A_4) + 2(A_3)\right]$$

$$= \frac{2}{3}\left[(4200 + 15000) + 4(6500 + 12000) + 2(9500)\right]$$

$$= 74,800\ m^3$$

⑦ Calculate the -live and dead storage of a reservoir with the following data

SNO	Level in (m)	Area in (m2)	Particulars
1	100	2100	Bed level
2	105	2850	–
3	110	3600	Sill Level
4	115	5700	–
5	120	8900	–
6	125	12400	FTL
7	130	25600	MWL

Sol) a) Live Storage / Effective Storage = Water between Sill – FTL

$A_1 = 3600$, $A_2 = 5700$, $A_3 = 8900$, $A_4 = 12400$

$$V = \frac{h}{2}\left[(A_1 + A_4) + 2(A_2 + A_3)\right]$$

$$= \frac{5}{2}\left[3600 + 12400 + 2(5700 + 8900)\right]$$

$$= 113{,}000\ m^3$$

b) Dead Storage = Water between Bed level to Sill level.

$A_1 = 2100$, $A_2 = 2850$, $A_3 = 3600$.

$$V = h\left[\frac{A_1 + A_3}{2} + A_2\right]$$

$$= 5\left[\frac{2100 + 3600}{2} + 2850\right]$$

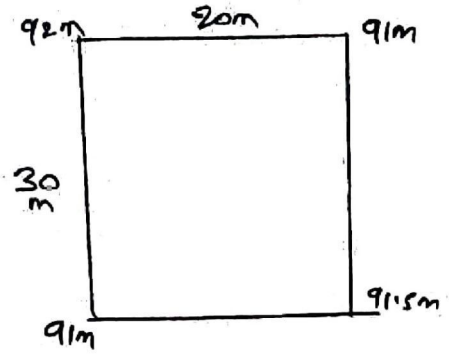
$$= 28{,}500\ m^3$$

Gross Storage = Live Storage + Dead Storage

$= 113000 + 28{,}500$

$= 1{,}41{,}500\ m^3$.

(1) A plot of 20m x 30m, Calculate the quantity of earth work by using spot levels as shown in Fig for general levelling of 90m RL



Sol)

Area of plot = 20 x 30 = 600 m²

Earth work Quantity = $600\left[\frac{2+1+1+1.5}{4}\right]$ = 825 m³

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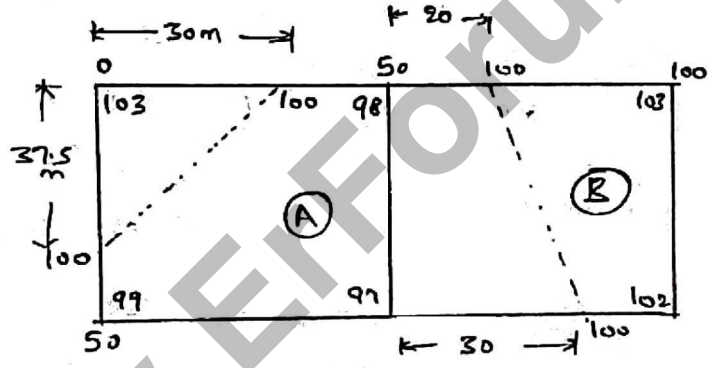
(2) Calculate the quantity of earthwork for general levelling, 100m RL dressing of two plots as shown in fig and spot levels are given at corners.



Sol)

PLOT A

Area of cutting = $\frac{1}{2}$ x 30 x 37.5 = 562.5

Volume of earth work = $562.5\left[\frac{3+0+0}{3}\right]$

= 562.5 m³

Area of filling = (50x50) - 562.5 = 1937.5 m²

Volume of earth work = $1937.5\left(\frac{0+2+3+1+0}{5}\right)$

= 2325 m³

PLOT B

Area of cutting = $\frac{50 \times 50}{2}$ or $\frac{1}{2} \times 50(20+30)$ = 1250 m²

volume of cutting = $1250\left(\frac{0+3+2+0}{4}\right)$ = 1562.5 m³

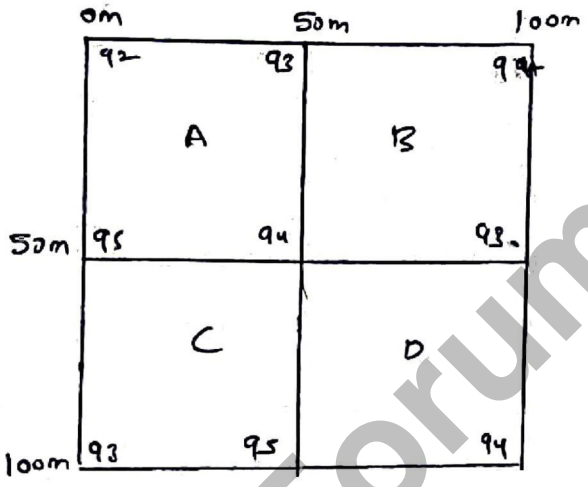
Area of filling $= \frac{50 \times 50}{2} = 1250\ m^2$

Volume of filling $= 1250 \left(\frac{0+2+3+0}{4} \right) = 1562.5\ m^3$

∴ Total volume of earth work in cutting $= 562.5 + 1562.5$
$= 2125\ m^3$

∴ Total volum of earth work in filling $= 2325 + 1562.5$
$= 3887.5\ m^3$

③ Calculate the quantity of earthwork in area where general levelling is required upto 92m RL as shown in fig.



Sol)

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

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

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

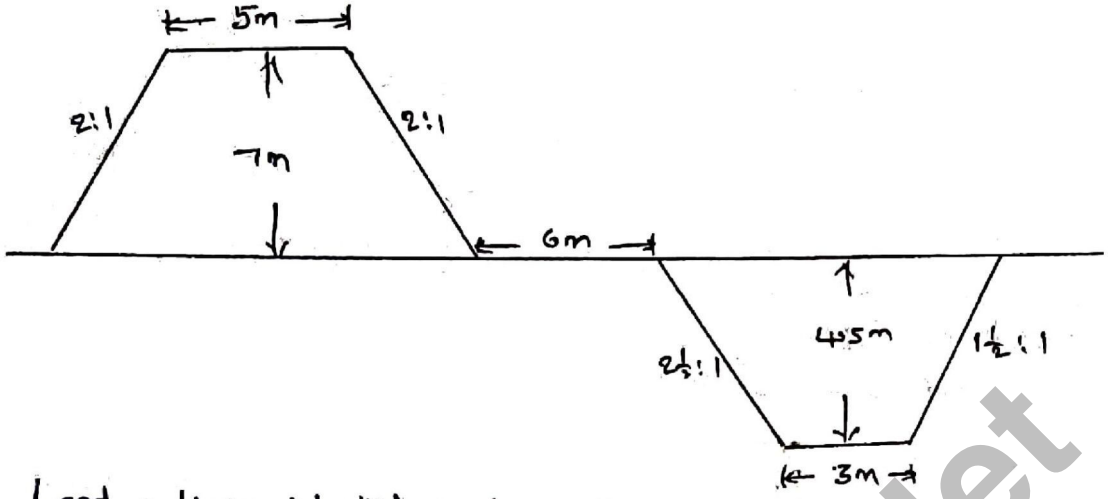
$V_D = 50 \times 50 \left(\frac{2+1+2+3}{4} \right) = 5000\ m^3$

Total volume of earth work $= V_A + V_B + V_C + V_D$

$V = 18125\ m^3$

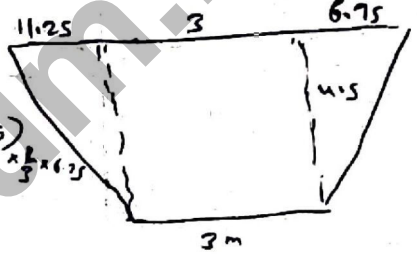
Misselaneous

Find the lead and lift of the following



Sol) Lead = Horizontal distance between the C.G of two banks.

$$C.G_x = \frac{\left(\frac{1}{2}\times 11.25\times 4.5\right)\times\frac{2}{3}\times 11.25 + (3\times 4.5)\times 12.75 + \left(\frac{1}{2}\times 4.5\times 6.75\right)\times\frac{2}{3}\times 6.75}{54}$$



$$= 7.336$$

$$\therefore \text{Lead} = \left(\frac{5+2\times 2\times 7}{2}\right) + 6 + 7.336$$

$$\boxed{\text{Lead} = 29.836\ m}$$

$$C.G_y = \frac{\left(\frac{1}{2}\times 11.25\times 4.5\right)\times\frac{4.5}{3} + (3\times 4.5)\times\frac{4.5}{2} + \left(\frac{1}{2}\times 4.5\times 6.75\right)\times\frac{4.5}{3}}{54}$$

$$= 1.688\ m.$$

$\therefore$ Lift = Vertical distance between the C.G of two banks

$$= \frac{7}{2} + 1.688$$

$$\boxed{\text{Lift} = 5.188\ m}$$

② The particulars of a 50m reach AB of a Canal are given below

Bed width = 10m, the depth of cutting at end A = 2.5m,

Side slope = $1\frac{1}{2}$:1, the depth of cutting at end B = 5.0m,

Calculate the volume of earthwork by

a) Mid Sectional Area method

b) Mean Sectional Area method

c) prismoidal rule

Sol) Given

$b = 10m$, $n = 1.5$, $d_1 = 2.5m$, $d_2 = 5m$, $dm = 3.75m$, $L = 50m$

$A_1 = (b + nd_1)d_1 = (10 + 1.5 \times 2.5) \times 2.5 = 34.375\ m^2$

$A_2 = (b + nd_2)d_2 = (10 + 1.5 \times 5) \times 5 = 87.5\ m^2$

$Am = (b + nd_m)d_m = (10 + 1.5 \times 3.75) \times 3.75 = 58.6\ m^2$

a) Mid Sectional Area method

$V = L \times Am = 50 \times 58.6 = 2930\ m^3$

b) Mean Sectional Area method

$V = L\left(\frac{A_1 + A_2}{2}\right) = 50 \times \left(\frac{34.375 + 87.5}{2}\right) = 3047\ m^3$

c) prismoidal rule

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

$= \frac{50}{6}[34.375 + 4 \times 58.6 + 87.5] = 2969\ m^3$

---

prismoidal excess

$C_{P1} = \frac{L}{12}[w_B - w_A](h_B - h_A)$

$C_{P2} = \frac{L}{12}[h_B - h_A]\left(\frac{b_B - b_A}{2}\right) = 0$

$w_B = 10 + 2 \times 1.5 \times 5 = 25$

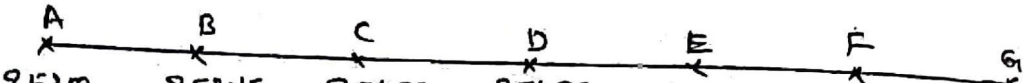
$w_A = 10 + 2 \times 1.5 \times 2.5 = 17.5$

$C_{P1} = \frac{50}{6}[25 - 17.5] \times (5 - 2.5) = 156.25\ m^3$

$V = 3047 - 156.25 = 2890.75\ m^3$

$\therefore$

③ The ground levels along the edge of proposed canal area g shown Fig. The bed of the canal is 4m wide and sloped at 1 in 100 downward in longitudinal direction. The side slopes are $1\frac{1}{2}:1$ R.L of formation level at 0m chainage is 250.00m.



	252m	252.15	251.70	251.75	251.95	251.85	252
Chainage	0m	30m	60m	90m	120m	150m	180m

Determine the Volume of earth work in cutting.

Sol) Bed width (b) = 4m, Side slope (n) = 1:5

Decrese in level for 30m = $30 \times \frac{1}{100} = 0.3$m.

Chainage	R.L of the G.L	R.L of the Canal Bed	Depth of Cutting	Area of C/S A = (b+nd)d
0	252	250	2	14
30	252.15	249.70	2.45	18.8
60	251.70	249.40	2.3	17.14
90	251.75	249.10	2.65	21.13
120	251.95	248.80	3.15	27.48
150	251.85	248.50	3.35	30.23
180	252	248.20	3.8	36.86

a) Trapezoidal formula

$$V = 30\left[\frac{14+36.86}{2} + 18.8 + 17.14 + 21.13 + 27.48 + 30.23\right]$$

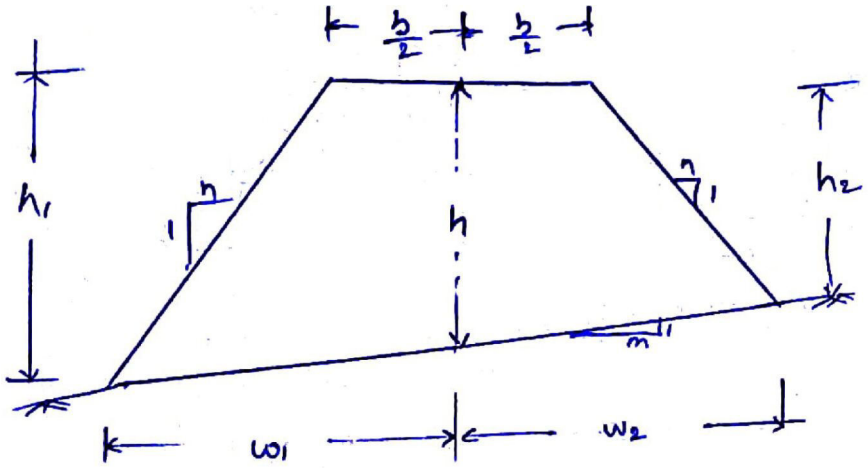
$$= 4206.3\ m^3$$

b) prismoidal Formula

$$V = \frac{30}{3}\left[(14+36.86) + 4(18.8 + 21.13 + 30.23) + 2(17.14 + 27.48\right.$$

$$= 4207.4\ m^3$$

Two Level Section



Where

h = Centre line height or average height

b = Formation width

m = Longitudinal / Ground slope (eg: 15 in 1 meay m=15)

n = Side slope (eg: 2 in 1 meay n=2)

w_1, w_2 = Side widths. h_1, h_2 = Side heights.

Section = $\frac{h_1}{w_1}$ $\frac{h}{0}$ $\frac{h_2}{w_2}$

$$A = \frac{m^2}{n(m^2-n^2)}\left(\frac{b}{2}+nh\right)^2 - \frac{b^2}{4n}$$ (n & n given)

$$A = \frac{1}{2n}(w_1+w_2)\left(\frac{b}{2}+nh\right) - \frac{b^2}{4n}$$ (m not given)

$$A = \frac{h}{2}(w_1+w_2) + \frac{b}{4}(h_1+h_2)$$ (m & n not given)

Where

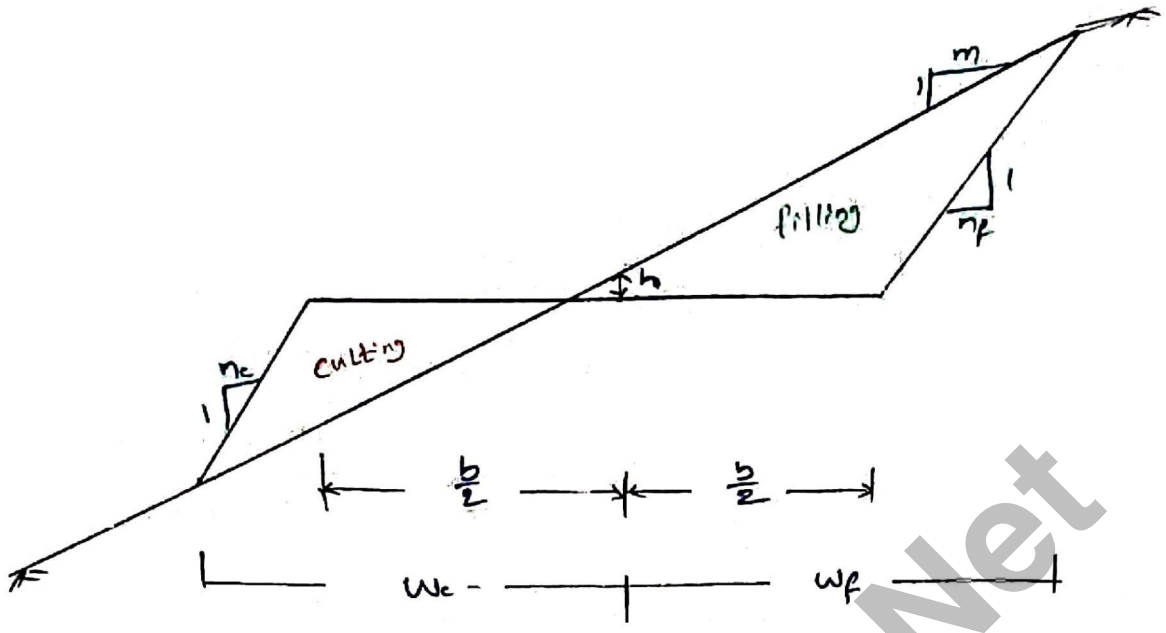
$$w_1 = \frac{m_1}{m-n}\left(\frac{b}{2}+nh\right)$$

$$w_2 = \frac{m_2}{m+n}\left(\frac{b}{2}+nh\right)$$

$$h_1 = h + \frac{w_1}{m}$$

$$h_2 = h - \frac{w_2}{m}$$

Side hill Two-level Section



Where

b = formation width

h = Centre line height

nc = side slope in cutting

nf = side slope in filling

Wc, Wf = side widths

$$W_c = \frac{m}{m-n_c}\left(\frac{b}{2} - n_c h\right), \qquad W_f = \frac{m}{m-n_f}\left(\frac{b}{2} + n_f h\right)$$

$$A_c = \frac{1}{2}\frac{\left(\frac{b}{2} - mh\right)^2}{m-n_c} \qquad A_f = \frac{1}{2}\frac{\left(\frac{b}{2} + mh\right)^2}{m-n_f}$$

Volume of earth work in cutting (V_c) = Length of road × A_c

" " " filling (V_f) = Length of road × A_f

Note

Given that ' The areas of cut & fill are equal'

$A_c = A_f$ ($h = ?$)

① A road embankment 40m wide at the formation level with side slopes 1 to 1 and with an average height of 15m is constructed with an average gradient of 1 in 40 from the contour of 150m to 590 m. The ground has an average slope of 10 to 1 in the direction transverse to the centre line. Find

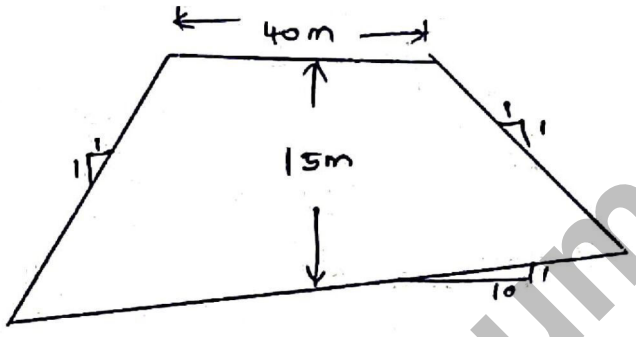
(i) The length of the road

(ii) The volume of embankment in cubic metres, and

(iii) Cost of earthwork @ Rs. 100/- per 1000 m^3

Sol) Length of road = Change of R.L $\times \sqrt{1+n^2}$ $= (590-150) \times \sqrt{1+40^2}$

$= 17605.5$ m.



$b = 40$m, $h = 15$m, $m = 10$, $n = 1$

Area of Cross Section (A) $= \frac{m^2 n}{m^2 - n^2}\left(h + \frac{b}{2n}\right)^2 - \frac{b^2}{4n}$

$= \frac{10^2 \times 1}{10^2 - 1}\left(15 + \frac{40}{2 \times 1}\right)^2 - \frac{40^2}{4 \times 1}$

$= 837.37\ m^2$

Volume of earth work $= 17605.5 \times 837.37$

$= 147,42,383\ m^3$

∴ Cost of earth work @ Rs 100 per 1000 m^3 $= \frac{147,42,383 \times 100}{1000}$

$=$ Rs. 14, 74, 240/-

(2) The dimensions of the two sections of a road embankment are as under

Section A:	-6.50	-7.30	+10.0
	22.50	0.0	30.00
Section B	-7.00	-11.00	-12.50
	28.00	0.0	39.50

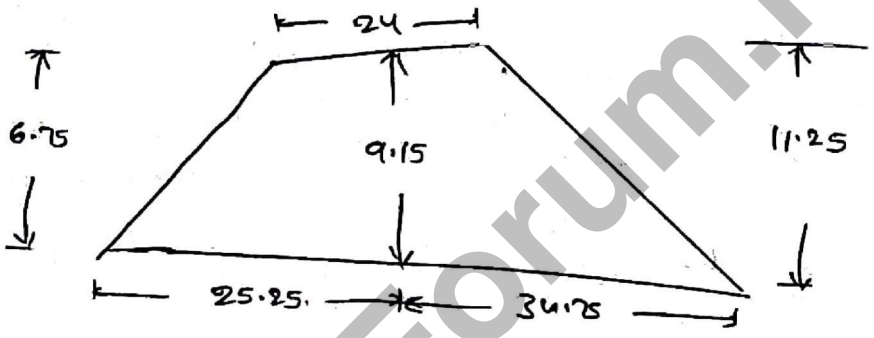
The distance b/n section A and B is 100m. The formation width increases uniformly from 8m at section A to 28m at section B. Calculate the volume of earthwork by

(i) prismoidal formula

(ii) Trapezoidal formula and prismoidal excess

Sol) (i) Prismoidal formula

The dimensions of mid-section is obtained by interpolating the sections A & B.



Section	$\frac{h_1}{w_1}$	$\frac{h}{0}$	$\frac{h_2}{w_2}$

$$\text{Area } (A) = \frac{1}{2}\left[h(w_1+w_2) + \frac{h}{2}(h_1+h_2)\right]$$

1) Section A $(A_1) = \frac{1}{2}\left[7.30(22.5+30) + \frac{20}{2}(6.5+10)\right]$

$= 274.13 m^2$

2) Section B $A_2 = \frac{1}{2}\left[11(28+39.50) + \frac{28}{2}(7+12.5)\right]$

$= 507.75 m^2$

3) Mid section $A_m = \frac{1}{2}\left[9.15(25.25+34.75) + \frac{24}{2}(6.75+11.25)\right]$

$= 382.5.$

$\therefore$ Volume $(V) = \frac{100}{6}\left[274.13 + 4\times382.5 + 507.75\right]$

$= 38531.33 m^3$

(i) Trapezoidal formula

Volume $(V) = \frac{100}{2}(274.13 + 507.75) = 39094\ m^3$

Prismoidal Excess

$$C_{P1} = \frac{L}{12}\left[(w_1+w_2)_B \sim (w_1+w_2)_A\right] \times (h_B \sim h_A)$$

$$= \frac{100}{12}\left[(28+39.5) \sim (22.5+30)\right] \times (11-7.5)$$

$$= 462.50\ m^2$$

$$C_{P2} = \frac{L}{12}\left[(h_1+h_2)_B \sim (h_1+h_2)_A\right] \times \left(\frac{b_B - b_A}{2}\right)$$

$$= \frac{100}{12}\left[(12.5+7) - (10+6.5)\right] \times \left(\frac{28-20}{2}\right)$$

$$= 100\ m^3$$

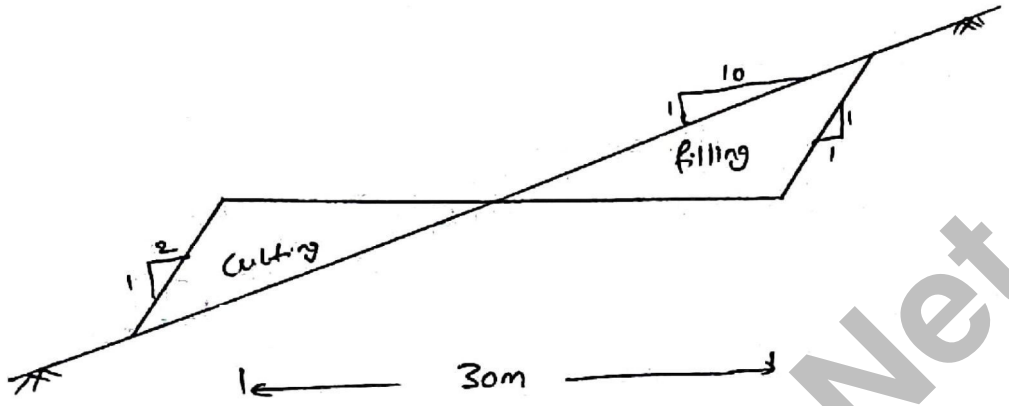
$\therefore$ Total Correction $= 462.50 + 100 = 562.50\ m^2$

$\therefore$ Correct volume $= 39094 - 562.50$

$= 38531.5\ m^3$

③ A straight road is to be formed along hill side having a uniform lateral slope of 10 horizontal to 1 vertical. The formation width is 30m with side slopes 1:2 in cutting and 1:1 in filling. Calculate the total volume of earthwork in a length of 450m if the areas of cut and fill in each cross-section are equal

Side-hill two level section



$b = 30m$, $m = 10$, $n_c = 2$, $n_f = 1$ & $A_c = A_f$

Area of cutting $(A_c) = \frac{1}{2} \frac{(\frac{b}{2} - mh)^2}{m - n_c} = \frac{1}{2} \frac{(15 - 10h)^2}{10 - 2}$

$= \frac{(15-10h)^2}{16}$

Area of filling $(A_f) = \frac{1}{2} \frac{(\frac{b}{2} + mh)^2}{m - n_f} = \frac{1}{2} \frac{(15+10h)^2}{10-1}$

$= \frac{(15+10h)^2}{18}$

Given that $A_c = A_f$

$\frac{(15+10h)^2}{18} = \frac{(15-10h)^2}{16}$

$15 + 10h = \sqrt{\frac{18}{16}} (15 - 10h)$

$h = 0.0442m.$

$\therefore A_c = A_f = 13.22 m^2$

$\therefore$ Volume of earth work $= 13.22 \times 450$

$= \boxed{5950 m^3}$