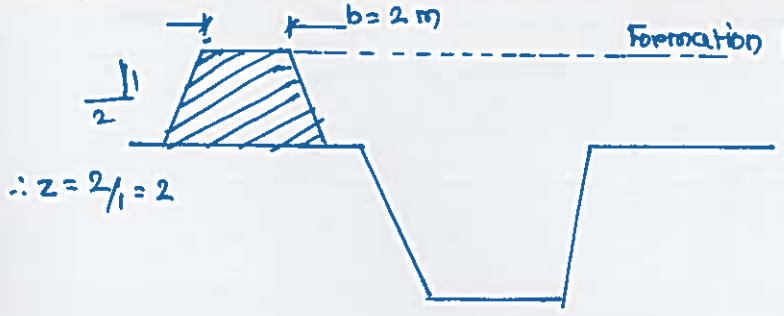
PROBLEMS ON COMPUTATION OF EARTHWORK VOLUME

Problem : The ground level along the center line of the road ig given below :

Chainage (m) -	60	80	100	120	140
G.L. (m) -	101.50	101.00	98.5	98.00	95.00

It is proposed that the formation level of RL 103.00 should be kept constatnt of starting from the chainage 'ZERO'. The formation width of the road is 2 mt. And the side slope is 2 : 1. Find volume of Earthwork.



1] Mid - Sectional Area method :-

Chainage	Depth (d) = F.L. - G.L.	Mean depth (m)	Area = (b+zd)d	L (m)	Quantity (m³) = A×L — Cutting	Quantity (m³) = A×L — Filling
60	103 - 101.5 = +1.5					
		1.5+2/2 = 1.75	(2+2×1.75)×1.75 = 9.625	80-60 = 20		192.50
80	103 - 101 = +2.0					
		3.25	27.646	20		552.50
100	103 - 98.5 = +4.5					
		4.75	54.625	20		1092.520
120	+5.0					
		+6.5	97.50	20		1950
140	+8.0					

V = Σ = 3787.50 m³

2] Mean Sectional Area method :-

Chainage	ht./depth (F.L. - G.L.) = d	Area (m²) = (b+zd)d	Mean Area	L (m)	Quantity = A×L in m² — Cutting	Quantity = A×L in m² — Filling
60	1.5	7.5				
			9.75	20	-	195
80	2.0	12				
			30.75	20	-	615
100	4.5	49.5				
			54.75	20	-	1095
120	5.0	60				
			102	20	-	2040
140	+8.0	144				

V = Σ = 3945 cum

3] Trapezoidal Method ; $V = D\left[\frac{A_0+A_n}{2} + A_1 \cdots A_{n-1}\right]$

Chain.	ht (d)	A. = (b+zd)d	
60	1.5	7.5	A_0
80	2.0	12	A_1
100	4.5	49.5	A_2
120	5.0	60	A_3
140	8.0	144	A_n

$= 20\left[\frac{7.5+144}{2} + (12+49.5+60)\right]$

$= 3945 \text{ m}^3$

4] Prismoidal Method :-

$V = D/3\left[A_0 + A_n + 4(\text{odd}) + 2(\text{even})\right]$

$= \frac{20}{3}\left[7.5+144+4(12+60)+2(49.5)\right]$

$= 3590$ cu. mt.

Problem :- The ground level along the center line of the road is given below :

Chainage (m) -	0	50	100	150	200	250	300
G.L. (m) -	117.50	116.25	115.95	116.65	117.20	117.85	115.75

It is proposed that the formation level of RL 115.00 should be kept constatnt of starting from the chainage 'ZERO'. The formation width of the road is 8 mt. And the side slope is 1 : 1. Find Volume of Earthwork ?

Answer :- **Method]** **By Mid - Sectional Area Method**

Chainage (mt.)	G.L. (mt.)	F.L. (mt.)	depth (m)	Mean depth	Area (b+zd)d	L (m)	Vol = AxL Cutting
			FL-GL				
0	117.50	115.00	-2.50	-1.875	18.515	50	925.75
50	116.25	115.00	-1.25	-1.10	10.01	50	500.5
100	115.95	-11-	-0.95	-1.30	12.09	50	604.90
150	116.65	-11-	-1.65	-1.925	19.10	50	955
200	117.20	-11-	-2.20	-2.525	26.57	50	1328.5
250	117.85	-11-	-2.85	-1.80	17.640	50	882
300	115.75	-11-	-0.75				

Total - 5196.6 Cu.mt

Area = (b + Z d) d = { 8 + (1 x 1.875) } x 1.875 = 18.515 Sq.mt.

Area = (b + Z d) d = { 8 + (1 x 1.10) } x 1.10 = 10.01 Sq.mt.

Area = (b + Z d) d = { 8 + (1 x 1.30) } x 1.30 = 12.09 Sq.mt.

Area = (b + Z d) d = { 8 + (1 x 1.925) } x 1.925 = 19.10 Sq.mt.

Area = (b + Z d) d = { 8 + (1 x 2.525) } x 2.525 = 26.57 Sq.mt.

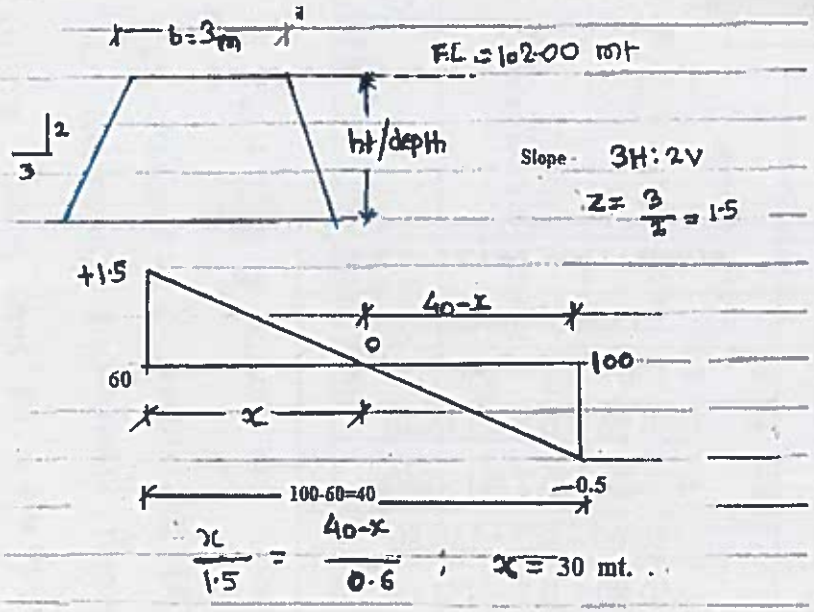
Area = (b + Z d) d = { 8 + (1 x 1.800) } x 1.800 = 17.640 Sq.mt.

Problem :- The ground level along the center line of the road ig given below :

Chainage (m) -	30	60	100	150	210
G.L. (m) -	101.00	100.50	102.5	102.8	103.0

It is proposed that the formation level of RL 102.00 should be kept constant of starting from the chainage 'ZERO'. The formation width of the road is 2 mt. And the side slope is 3 : 2.

Answer :-



∴ at Chainage 60+30=90 mt. the depth is 0 mt.

By Mid Sectional Area Method :

Chain	ht. (FL-GL)	Mean ht. (mt)	Area (b+zd)d	L (mt)	Vol^m = A×L (m3) Cutting	Filling
30	+1.0					
		+1.25	(3+1.5×1.25)×1.25 = 6.0 33	30		182.79
60	+1.5	+0.75	(3+1.5×0.75)×0.75 = 3.093	30		92.79
90	0.00	-0.25	(3+1.5×0.75)×0.25 = 0.8437	10	8.430	
100	-0.5					
		-0.65	(3+1.5×0.65)×0.65 = 2.583	50	129.15	
150	-0.8					
		-0.90	(3+1.5×0.90)×0.90 = 3.915	60	234.90	
210	-1.00					
					Σ = 372.48	275.50

Volume in Cutting = 372.48 Cu.mt

Volume in Filling = 275.50 Cu.mt

-ve sign in mean depth shows the section & Vol. is in cutting

Note :- The - ve sign in mean depth shows that the section and volume is in cutting and

The + ve sign in mean depth shows that the section and volume is in Banking.

Problem :- The ground level along the center line of the road is given below :

Chainage (m) -	0	40	80	120	160	200	240
G.L. (m) -	152.60	151.90	149.0	150.90	151.50	152.45	151.20

It is proposed that the formation level of starting station is of RL 150.00 mt.. The formation width of the road is 8 mt. And the side slope is 2 : 1 in Banking and 1.5 : 1 in cutting. The road is in Rising gradient of 1 : 200.

Answer :-

Rising gradient per 40 mt. :- $\frac{200}{1} = \frac{40}{Y}$; Y = 0.2 Mt

CHAINAGE (Mt)	G.L. (Mt)	FORMATION LEVEL (F.L.)
0	152.60	***150.00 (given)***
40	151.90	150 + 0.2 = 150.20
80	149.0	150.20 + 0.2 = 150.40
120	150.90	150.40 + 0.2 = 150.60
160	151.50	150.60 + 0.2 =150.80
200	152.45	150.80 + 0.2 = 151.00
240	151.20	151.00 + 0.2 = 151.20

For Banking : Side slope = 2 H : 1 V

$Z = \frac{2}{1} = 2$

For Cutting : Side slope = 1.5 H : 1 v

$Z = \frac{1.5}{1} = 1.5$

Prob:- Estimate Quantity of Earthwork for road of 400 mt. length from following data:-

1) Formation width = 10 mt 2) Side slope = 2:1 in banking & 1.5:1 in cutting

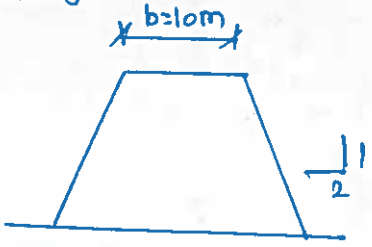
3] The road is having downward Gradient of 1 in 200

4] Formation level for station 1 is 52.00 mt.

Ans:- Falling Gradient per 40 mt $\Rightarrow \frac{200}{1} = \frac{40}{y}$ $\therefore y = 0.2$

Chainage (mt)	R.L. of Ground (GL) in mt	Formation level (FL)	Chain (m)	ht./depth (FL-GL)	Mean depth (d)	Area = (b+zd)d m^2	L (m)	Vol = A×L in cum: Cutting	Vol = A×L in cum: Filling
00	51.00	52.00	0	+1.0					
40	50.30	52−0.2=51.80	40	+0.9	+0.95	(10+2×0.95)0.95 = 11.305	40		452.20
80	50.50	51.8−0.2=51.60	80	+1.10	+1.00	12	40		480.00
120	50.80	51.60−0.2=51.4	120	+0.60	+0.85	9.345 Filling z=2	40		397.80
160	50.60	51.20	160	+0.60	+0.60	6.720	40		268.80
200	50.70	51.00	200	+0.3	+0.45	4.305	40		196.20
217.14	0.00		217.14	0.00	+0.15	1.845	17.14		26.48
240	51.20	50.80	240	−0.40	−0.20	2.06	22.86	47.091	
280	51.40	50.60	280	−0.80	−0.60	6.54	40	261.60	
320	51.90	50.40	320	−0.90	−0.85	9.583 Cutting z=1.5	40	383.20	
360	51.00	50.20	360	−0.80	−0.85	9.583	40	383.20	
400	50.6	50.00	400	−0.60	−0.70	7.735	40	303.40	
		Falling Gradient 1 in 200						Σ = 1384.43 Cum.	Σ = 1821.48 Cum

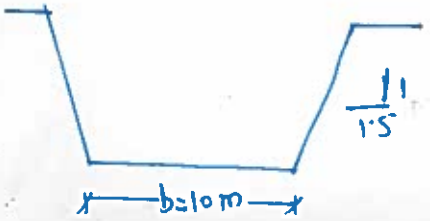
Banking :-



z for Filling 2H:1V

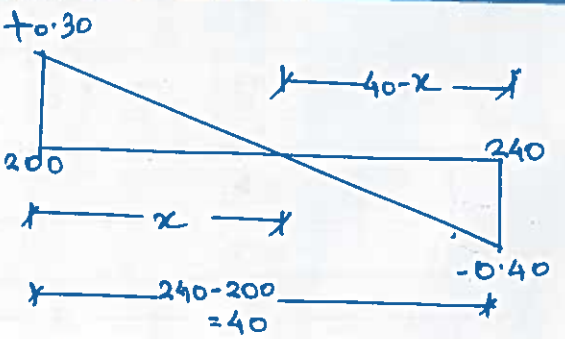
$z = 2/1 = 2$

Cutting :-



z = 1.5H:1V

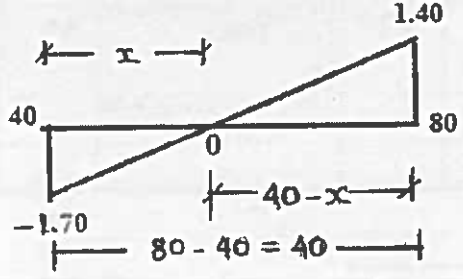
$\therefore z = \frac{1.5}{1} = 1.5$



$\frac{x}{0.3} = \frac{40-x}{0.40}$

$\therefore x = 17.14$ mt

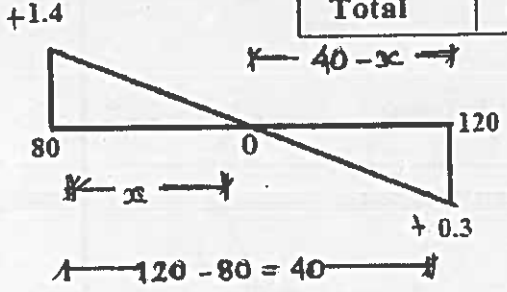
CHAINAGE (Mt)	Height / depth in Mt. = (F.L. – G.L.)	Mean depth (h) in mt.	Area = (b + Zd) d in Sq.mt	L in mt.	Volume in Cu.mt. = (A x L)	
					Cutting	filling
0	-2.60	$= \frac{-2.6 - 1.7}{2} = -2.15$ (cutting)	[8 + (1.5 x 2.15)] 2.15 = 24.133	40 – 0 = 40	965.32	
40	-1.70	$= \frac{-1.7 + 0}{2} = -0.85$ (cutting)	[8 + (1.5 x 0.85)] 0.85 = 7.88	61.93 - 40 = 21.93	172.80	
61.93	0	$= \frac{0 + 1.40}{2} = +0.7$ (filling)	[8 + (2 x 0.70)] 0.70 = 6.58	18.07		118.90
80	+ 1.40	$= \frac{0 + 1.40}{2} = +0.7$ (filling)	[8 + (2 x 0.70)] 0.70 = 6.58	32.94		216.74
112.94	0	$= \frac{0 - 0.30}{2} = -0.15$ (cutting)	[8 + (1.5 x 0.15)] 0.15 = 1.233	7.06	8.704	
120	-0.30	$= \frac{0.30 - 0.70}{2} = -0.5$ (cutting)	[8 + (1.5 x 0.5)] 0.5 = 4.375	40	175	
160	-0.70	$= \frac{-0.7 - 1.45}{2} = -2.15$ (cutting)	[8 + (1.5 x 2.15)] 2.15 = 24.133	40	965.32	
200	-1.45	$= \frac{-1.45 + 0}{2} = -0.725$ (cutting)	[8 + (1.5 x 0.725)] 0.725 = 6.588	40	263.52	
240	0.00			Total	2550.664	335.645



$$\frac{x}{1.70} = \frac{40 - x}{1.40}$$

$x = 21.93$ mt.

At the chainage 40 + 21.93 = 61.93 mt. ; the depth will be zero.



$$\frac{x}{1.40} = \frac{40 - x}{0.39}$$

$x = 32.94$ mt.

At the chainage 80 + 32.94 = 112.94 mt. ; the depth will be zero.

problem - Calculate Quantity of Earthquake in Cu.mt. required for Road Embankment (Banking / Filling) from following data

Formation Width = 9 mt.

Side slope = 2 : 1

Distance (mt.)	Height of Bank in mt.	Side Slope of Original Ground
0	3.00	1 in 10
30	3.60	1 in 8
60	3.80	1 in 12

Answer :

Side slope = 2 : 1 (2 H : 1 V)

$\therefore z = \frac{2}{1} = 2$

Remember, $$A = \frac{zb^2 + r^2[2bh + zh^2]}{r^2 - z^2}$$

Where, r - Transverse slope

$b = \frac{9}{2} = 4.5$ mt

Chainage	Depth in mt (h)	Transverse Slope (r)	Area in Sq. mt	Mean Area (m^2)	L (mt)	Volume (AxL) in Cu. mt
0	+ 3.00	1 in 10	$\frac{(2\times4.5^2) + 10^2[(2\times4.5\times9)+(2\times3^2)]}{10^2-2^2} = 47.296$	$\frac{47.296+62.88}{2} = 55.088$	0-30=30	$55.088\times30 = 1652.64$
30	+ 3.60	1 in 8	$\frac{(2\times4.5^2) + 8^2[(2\times4.5\times3.6)+(2\times3.6^2)]}{8^2-2^2} = 62.883$	$\frac{62.883+65.171}{2} = 64.025$	60-30=30	$64.025\times30 = 1920.765$
60	+ 3.80	1 in 12	$\frac{(2\times4.5^2) + 12^2[(2\times4.5\times3.8)+(2\times3.8^2)]}{12^2-2^2} = 65.171$			

Total = 3573.36 cu. mt

problem - Calculate Quantity of Earthquake in Cu.mt. required for Road in Cutting from following data
Formation Width =10mt.
Side slope = 1 : 1

Distance (mt.)	Height of Bank in mt.	Side Slope of Original Ground
0	1.00	1 in 10
50	2.00	1 in 5
100	1.50	1 in 8

Answer :

Side slope = 1 : 1 (H : 1 V)

$z = \frac{1}{1} = 1$

Remember, $A = \frac{zb^2 + r^2[2bh + zh^2]}{r^2 - z^2}$

Where, r - Transverse slope

$b = \frac{10}{2} = 5$ mt.

Chainage	Depth in mt (h)	Transverse Slope (r)	Area in Sq. mt	Mean Area (m^2)	L (mt)	Volume (A x L) in Cu. mt
0	1.00	1 in 10	$= \frac{(1\times5^2) + 10^2[2\times5\times1 + 1\times1^2]}{10^2 - 1^2} = 11.363$	$\frac{11.363 + 26.041}{2}$ = 18.701	0 – 50 = 50	17.701 x 50 = 935.05
50	2.00	1 in 5	$= \frac{(1\times5^2) + 5^2[2\times5\times2 + 1\times2^2]}{5^2 - 1^2} = 26.041$	$\frac{26.041 + 17.92}{2}$ = 21.980	100 – 50 = 50	21.980 x 50 = 1099
100	1.500	1 in 8	$= \frac{(1\times5^2) + 8^2[2\times5\times1.5 + 1\times1.5^2]}{8^2 - 1^2}$ = 17.92			

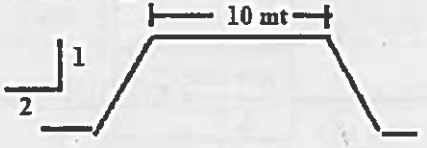
Total = 2034.05 cu. mt

Problem :- A road is to be constructed in Hilly areas with formation width 10 mt. in banking and 8 mt. in cutting. Side slope in banking is 2 : 1 and in cutting is 1.5 : 1. The heights of filling and depth of cutting at the center line of the road and the cross slope (transverse) of the ground at the interval of 30 mt are given below – Calculate the Quantity of Earthwork for the length of 210 mt.

Chainage in mt.	Ht. of bank in mt.	Depth in cutting mt.	Transverse slope
0	0.7		10 : 1
30	0.7		12 : 1
60	0.5		15 : 1
90	0.4		12 : 1
120		0.7	10 : 1
150		0.6	15 : 1
180		0.8	12 : 1
210		0.9	10 : 1

Answer :

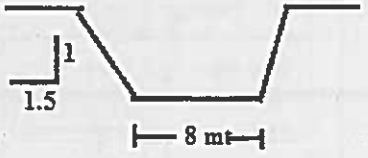
For Banking



1) $Z = \frac{2}{1} = 2$

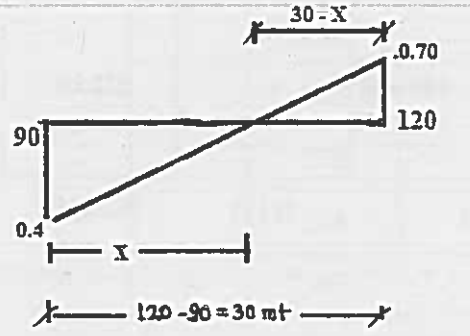
2) $b = \frac{10}{2} = 5$ mt.

For Cutting



1) $Z = \frac{1.5}{1} = 1.5$

2) $b = \frac{8}{2} = 4$ mt.



$$\frac{x}{0.4} = \frac{30 - x}{0.70}$$

$x = 10.90$ mt.

$= 11$ mt.

Mean harmonic slope (r_0) $= \frac{2\, r_1 r_2}{r_1 + r_2} = \frac{2 \times 12 \times 10}{12} = 10.9 = 11$ mt

where , r_1 - Transverse slope Before 0 Value

r_2 - Transverse slope After 0 Value

Means : At chainage of 90 + 11 = 101 mt. ; the depth is ZERO

Chainage in mt.	Ht./Depth (h) in mt.	Transverse slope (r)	Area in Sq.mt $= \frac{Z b^2 + r^2 [2 b h + Z h^2]}{r^2 - z^2}$	Mean Area in Sq.mt	Length in mt.	Volume in Cu.mt (A x L)	
						Cutting	Filling
0	- 0.7	10	$\frac{(1.5 \times 4^2) + 10^2 [(2 \times 4 \times 0.7) + (1.5 \times 0.7^2)]}{10^2 - 1.5^2} = 6.726$	$\frac{6.726 + 6.604}{2} = 6.665$	0 - 30 = 30	199.95	
30	- 0.7	12	$\frac{(1.5 \times 4^2) + 12^2 [(2 \times 4 \times 0.7) + (1.5 \times 0.7^2)]}{12^2 - 1.5^2} = 6.604$	5.565	60 - 30 = 30	166.95	
60	- 0.5	15	$\frac{(1.5 \times 4^2) + 15^2 [(2 \times 4 \times 0.5) + (1.5 \times 0.5^2)]}{15^2 - 1.5^2} = 4.527$	4.033	90 - 60 = 30	122.80	
90	- 0.4	12	$\frac{(1.5 \times 4^2) + 12^2 [(2 \times 4 \times 0.4) + (1.5 \times 0.4^2)]}{10^2 - 1.5^2} = 3.663$	$\frac{3.663 + 0.842}{2} = 2.252$	101 - 90 = 11	24.772	
101	0	$r_0 = 11$	In Cutting : $A_0 = \frac{1}{2}[\frac{b^2}{r_0 - z}] = \frac{1}{2}[\frac{4^2}{11 - 2}] = 0.842$ In Filling : $A_0 = \frac{1}{2}[\frac{b^2}{r_0 - z}] = \frac{1}{2}[\frac{5^2}{11 - 2}] = 1.40$	$\frac{1.40 + 1.833}{2} = 5.116$	120 - 101 = 19		97.204
120	–0.7	10	$\frac{(2 \times 5^2) + 10^2 [(2 \times 5 \times 0.7) + (2 \times 0.7^2)]}{10^2 - 2^2} = 8.833$	7.950	150 - 120 = 19		238.50
150	–0.6	15	$\frac{(2 \times 5^2) + 15^2 [(2 \times 5 \times 0.6) + (2 \times 0.6^2)]}{15^2 - 2^2} = 7.067$	8.483	180 - 150 = 30		254.50
180	–0.8	12	$\frac{(2 \times 5^2) + 12^2 [(2 \times 5 \times 0.8) + (2 \times 0.8^2)]}{12^2 - 2^2} = 9.9022$	10.740	210 - 180 = 30		322.20
210	–0.9	10	$\frac{(2 \times 5^2) + 10^2 [(2 \times 5 \times 0.9) + (2 \times 0.9^2)]}{10^2 - 2^2} = 11.583$				
					Total =	514.42	912.404

1] Earthwork volumen in Cutting = 514.42 Cu.mt

2] Earthwork volumen in Filling = 912.404 Cu.mt