EARTHWORK EXCAVATION FOR ROADWAY

1. Calculation of Volume

There are three methods generally adopted for computation of earthwork volume (according to the formation of the solid). They are:

a. From cross sections: Measurement from cross section is a universally applicable method.

b. From spot levels: measurement from spot levels are applied sometime for large excavation.

c. From contours: Rough estimates of volume may be made by treatment of the contour line and not much used in practice.

2. Measurement from Cross Sections.

The cross sectional area along the line is first calculated by standard formulae and the volumes of the prismoids between successive cross-sections are then calculated by following methods:

a. Formulae of Mid-section method/ Average height method.

b. Formulae of Trapezoidal method/ Average end area method/ mean-sectional area method.

c. Formulae of prismoidal method according to Simpson’s one-third rule.

3. Terms and Abbreviations.

EGL (Existing Ground Level) or GL (Ground Level): The existing earth surface

FL (Formation Level): The proposed level of roadway.

RL (Road Level): A level stated in relation to a known bench mark or datum.

Longitudinal Slope/ Gradient: Gradient may be defined as the rate of rise or fall along the length of highway.

Side Slope: Side slope is defined as the rate of rise or fall of the shoulders of the pavement. It depends on the soil characteristics and geographic location of the highway.

4. **Mid-section formulae (Average Height Method)**

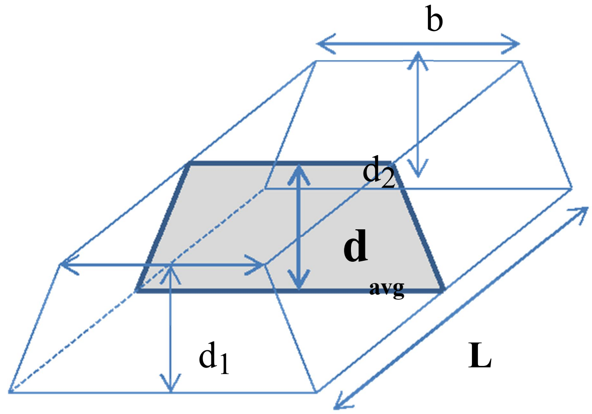

Figure 1: Cross Section of a Trapezoidal Section for Average Height Method

Depth section (1) = d_1 (note that d_1 is the difference between GL & FL)

Depth section (2) = d_2 (note that d_2 is the difference between GL & FL)

Average depth, $d_{avg} = (d_1 + d_2)/2$

Width of section = b

Side slope = 1: s (vertical: horizontal)

Area of mid-section, $A_{mid} = bd_{avg} + (1/2)\, sd_{avg}^2 +$

$(1/2)\, sd_{avg}2$ $A_{mid} = (b+sd_{avg}) \times d_{avg}$

Length between two consecutive sections (between section (1) & (2)) = L_{1-2}

Volume of earthwork between these two consecutive sections (between section (1) & (2)), $V_{1-2} = A_{avg} \times L$

$V_{1-2} = (b+sd_{avg}) \times d_{avg} \times L$ (may be cut or fill)

5. **Trapezoidal Formula/ Average End Area Method / Mean-Sectional Area Method**

Depth section (1) = d_1 (note that d_1 is the difference between GL & FL)

Depth section (2) = d_2 (note that d_2 is the difference between GL & FL)

Area at end 1, $A_1 = (b+sd_1) \times d_1$

Area at end 2, $A_2 = (b+sd_2) \times d_2$

Mean sectional area, $A_{mean} = (A_1+A_2)/2$

Width of section = b

Side slope = 1: s (vertical: horizontal)

Length between two consecutive sections (between section (1) & (2)) = L

Volume of earthwork between these two consecutive sections (between section (1) & (2)), V_{1-2} = A_{mean} x L

$V_{1-2} = A_{mean} \times L$ (may be cut or fill)

6. **Prismoidal formula.**

Depth section (1) = d_1 (note that d_1 is the difference between GL & FL)

Depth section (2) = d_2 (note that d_2 is the difference between GL & FL)

Area at end 1, $A_1 = (b+sd_1) \times d_1$

Area at end 2, $A_2 = (b+sd_2) \times d_2$

Mean sectional area, $A_{mean} = (A_1+A_2)/2$

Width of section = b

Side slope = 1: s (vertical: horizontal)

Length between two consecutive sections (between section (1) & (2)) = L

Volume of earthwork between these two consecutive sections (between section (1) & (2)),

$V_{1-2} = (A_1 + 4A_m + A_2)/6 \times L$ (may be cut or fill)

7. **Worked Out Problem.**

A 1 km road is to be constructed in existing ground level having reduced levels 54.1, 53.8, 53.5, 53.5, 54.3, 54.6, 54.9, 54.5, 54.7 and 54.3 meters at 100 m intervals. A required reduced level at station 1 is 55 meter and the downward gradient is 1 in 1000. The width of the road at formation level is 8 meter. Slopes to be maintained at cutting and filling are 1:2 (V: H) and 1:3 (V: H) respectively. Calculate the volume of Earthwork.

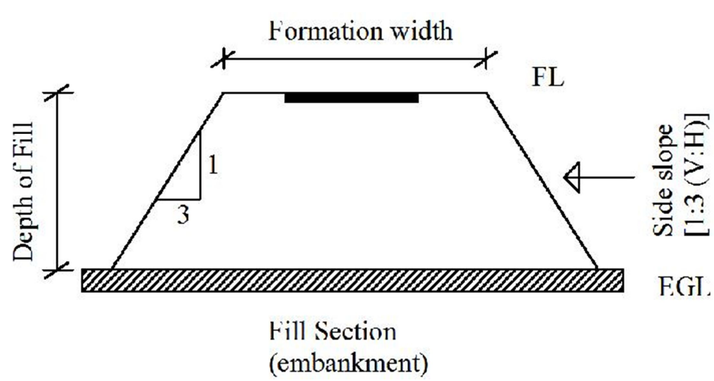

Figure 6-2: Typical Fill Section

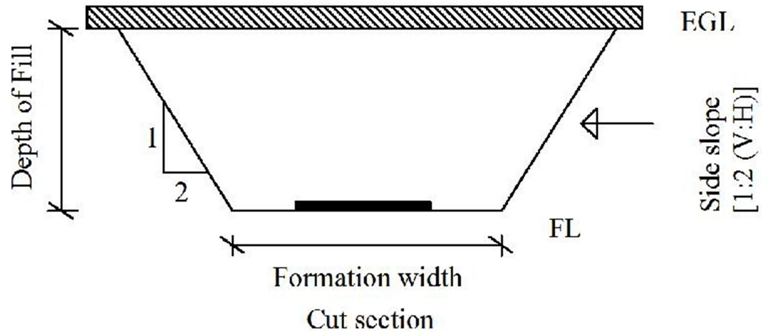

Figure 6-3: Typical Cut Section

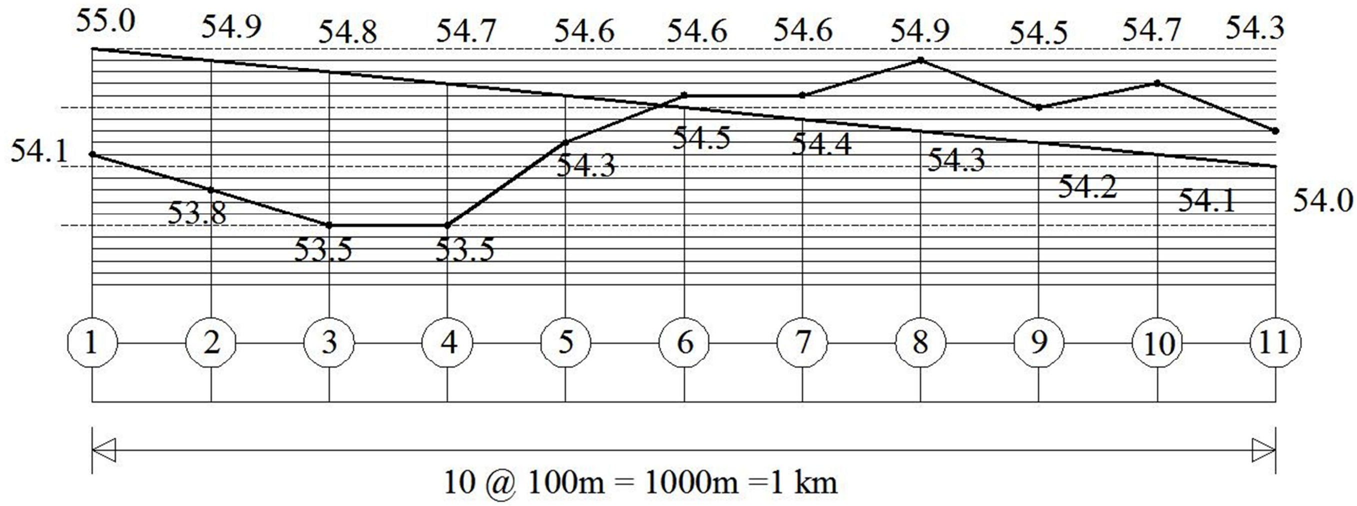

Figure 6-4: Long Section of the Road

*From figure

$$\frac{X}{0.3} = \frac{100-X}{0.1} \Rightarrow X = 75'$$

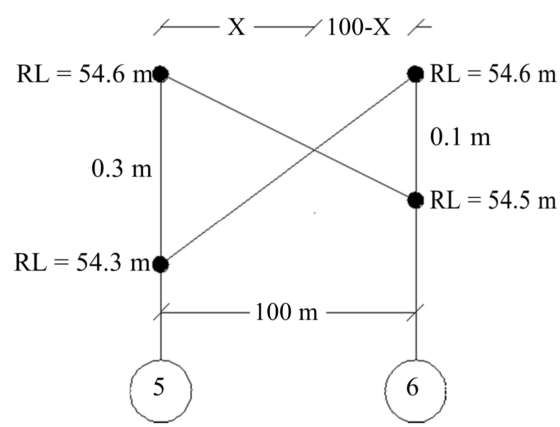

Figure 6-5: Length of Cut and Fill between station 5 & 6.

Table1: Earthwork Computation Table (Mid-section / average height method)

Station	FL (m)	EGL (m)	Depth, d= EGL ~ FL (m)	Average depth, d_{avg} (m)	Area, $A=(b+sd_{avg})d_{avg}$ (m^2)	Length, L (m)	Volume, V = A x L (m^3)	Remark
1	55.0	54.1	0.9					
				1	(8+3X1)X1 = 11	100	1100.00	Fill
2	54.9	53.8	1.1					
				1.2	(8+3 X 1.2) X 1.2 = 13.92	100	1392.00	Fill
3	54.8	53.5	1.3					
				1.25	(8+3 X 1.25) X 1.25 = 14.68	100	1468.00	Fill
4	54.7	53.5	1.2					
				0.75	(8+3 X 0.75) X 0.75 = 7.68	100	768.00	Fill
5	54.6	54.3	0.3					
				0.15	(8+3 X 0.15) X 0.15 = 1.26	75*	95.06	Fill
0	x	x	0					
				0.05	(8+2 X 0.05) X 0.05 = 0.40	25*	10.18	Cut
6	54.5	54.6	0.1					
				0.15	(8+2 X 0.15) X 0.15 = 1.245	100	124.50	Cut
7	54.4	54.6	0.2					
				0.4	(8+2 X 0.4) X 0.4 = 3.52	100	352.00	Cut
8	54.3	54.9	0.6					
				0.45	(8+2 X 0.45) X 0.45 = 4.01	100	400.50	Cut
9	54.2	54.5	0.3					
				0.45	(8+2 X 0.45) X 0.45 = 4.01	100	400.50	Cut
10	54.1	54.7	0.6					
				0.45	(8+2 X 0.45) X 0.45 = 4.01	100	400.50	Cut
11	54.0	54.3	0.3					

Volume of total cutting = 1688.18 m^3

Volume of total filling = 4824.56 m^3

Calculate the volume of cutting and filling for the previous worked out problem using the trapezoidal method.

Hints

Table 6-2: Earthwork Computation Table (Trapezoidal formula/Average End Area Method)

Station	FL(m)	EGL(m)	Depth, d=EGL-FL (m)	Area , A = (b+sd)d	Avg. Area A_{mean} (m^2)	Length, L (m)	Volume $V=A_{mid} x L$ (m^3)	Remarks
1	55	54.1	0.9					
2	54.9	53.8	1.1					
3	54.8	53.5	1.3					
4	54.7	53.5	1.2					
5	54.6	54.3	0.3					
0	-	-	0					
6	54.5	54.6	0.1					
7	54.4	54.6	0.2					
8	54.3	54.9	0.6					
9	54.2	54.5	0.3					
10	54.1	54.7	0.6					
11	54	54.3	0.3					

Calculate the volume of cutting and filling for the previous worked out problem using the prismoidal method.

Hints

Table 6-3: Earthwork Computation Table (Prismoidal formula)

		GL(m)	~ m)	Area(A)	avg	avg mid 2(m)	Length,L(m)	**Volume** **V=(A1 +4 Amid + A2) x L /6** **(m^3)**	marks
1	55	54.1	0.9	A_1					
						A_{1-2}			
2	54.9	53.8	1.1	A_2					
						A_{2-3}			
3	54.8	53.5	1.3	A_3					
						A_{3-4}			
4	54.7	53.5	1.2	A_4					
						A_{4-5}			
5	54.6	54.3	0.3	A_5					
						A_{5-0}			
0	-	-	0	0					
						A_{0-6}			
6	54.5	54.6	0.1	A_6					
						A_{6-7}			
7	54.4	54.6	0.2	A_7					
						A_{7-8}			
8	54.3	54.9	0.6	A_8					
						A_{8-9}			
9	54.2	54.5	0.3	A_9					
						A_{9-10}			
10	54.1	54.7	0.6	A_{10}					
						A_{10-11}			
11	54	54.3	0.3	A_{11}					

Calculate the volume of earth filling for the ditch. Given, reduced level of filling plane is 100 m.

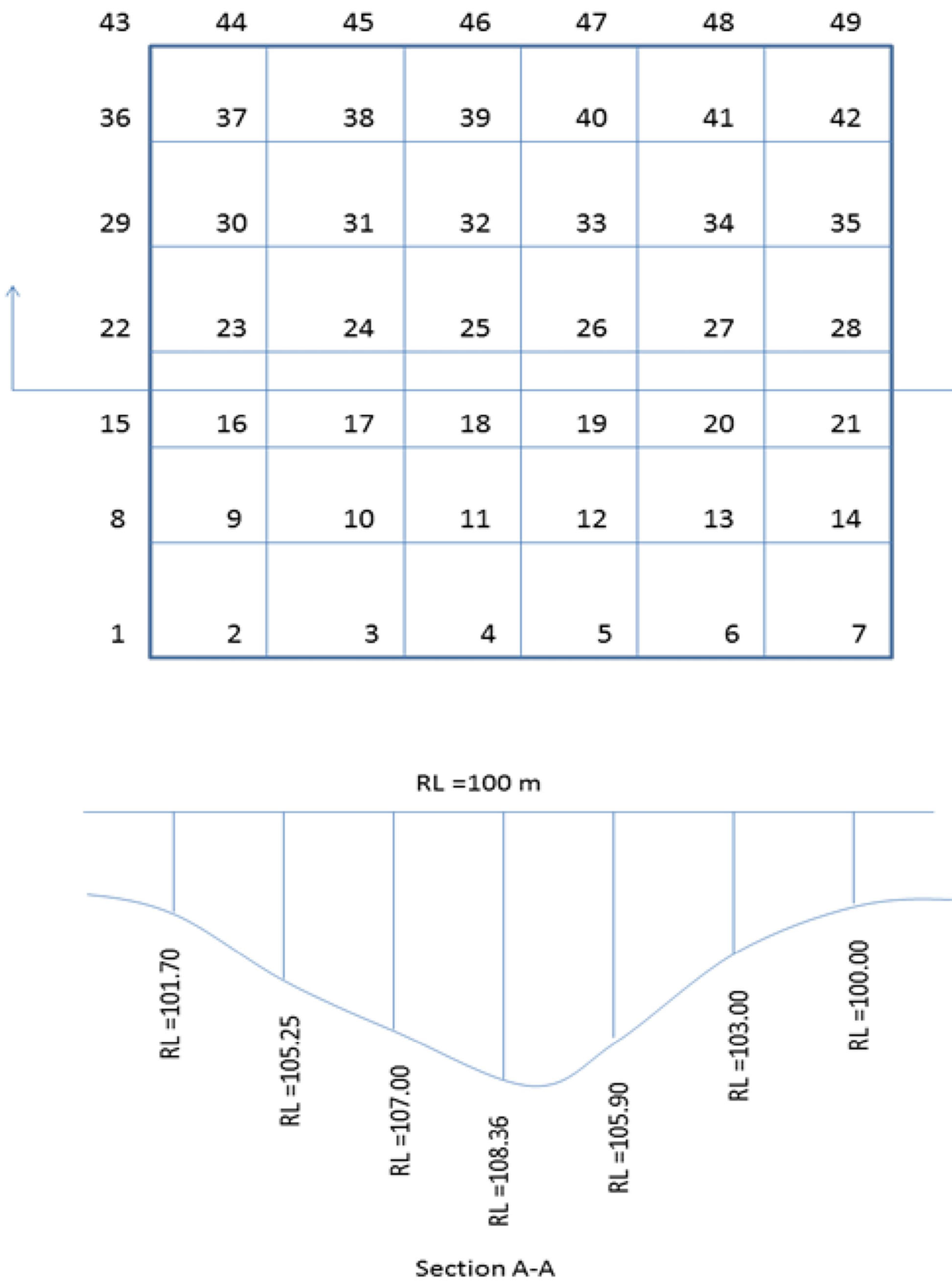

Figure 6-6: Section A-A of Ditch for Assignment 3

Reduced levels (RL) of different stations are given as follows

Table 4: Reduced levels (RL) of Different Stations for Assignment 3

Station	RL (m)	Station	RL (m)	Station	RL (m)	Station	RL (m)	Station	RL (m)
1	101.00	**12**	103.20	**23**	105.25	**34**	104.14	**45**	101.00
2	102.00	**13**	103.90	**24**	107.00	**35**	100.00	**46**	103.20
3	101.70	**14**	101.30	**25**	108.36	**36**	101.10	**47**	101.10
4	102.00	**15**	100.16	**26**	105.90	**37**	104.80	**48**	102.15
5	101.00	**16**	104.15	**27**	103.00	**38**	105.60	**49**	102.00
6	100.60	**17**	106.85	**28**	100.00	**39**	103.00		
7	100.10	**18**	107.65	**29**	101.70	**40**	107.80		
8	100.60	**19**	105.90	**30**	104.80	**41**	104.14		
9	106.00	**20**	104.00	**31**	105.60	**42**	101.00		
10	107.50	**21**	102.00	**32**	103.00	**43**	100.10		
11	105.10	**22**	101.70	**33**	107.8	**44**	102.30		

Hints:

1. Calculate depth to be filled at each station.
2. Calculate volume of each grid to be filled (i.e. V 1-2-8-9 = 1/4 x (d1 + d2 + d8 + d9) x A 1-2-8-9).
3. Sum up all to get total volume (Total volume = V 1-2-8-9 + V 2-3-9-10 + …………….).