

Freehaul, Overhaul, and Mass Haul Diagram:

Normally, cost of excavation includes; cost of transporting of material (unwanted soil) from either cut or fill for a maximum distance called the freehaul distance (F.H.D.), but transporting of material for a distance greater than freehaul is called overhaul distance (O.H.D.).

Definitions:

Overhaul: Is the number of cubic meters (yards) of overhauled material multiplied by the overhaul distance, this distance is measured between the center of gravity of cut and fill (i.e. $m^3 \cdot \text{station}$ or $yd^3 \cdot \text{mile}$).

- **Haul = volume of earthwork * distance moved**

- **Limit of Economic Haul (L.E.H.) =**

Freehaul Distance (F.H.D.) + Economic Overhaul Distance(Limit) (O.H.D.)

- **Economic Overhaul Distance = Cost of Borrow / Cost of Overhaul**

- Freehaul: Distance with which there is a fixed price for excavating, hauling, and dumping regardless of the distance moved.

- Mass Haul Diagram:

It is a diagram provides a suitable means for studying haul and overhaul to compute the total payment. It's x-axis represents the distance in stations, while the y-axis represents the cumulative volume (the algebraic sum of excavations and embankment between any selected points) after correction due to soil condition.

- Shrinkage or swell factor: It is well known that one cubic meter of excavation on amount will not occupies exactly $1 m^3$ of space in the fill, so adjusting is required. This can be done by using the shrinkage or swell factor.

- Borrow: It is the location away from the Right of Way (R.O.W.) and it is chosen by the Engineer. The borrow pits soil should be comply with the followed specification (preferably out of R.O.W.).

Note: there is a problem in urban areas because of borrow cost.

- Waste: It is the unwanted excavation material which should be disposed out of R.O.W.

Characteristics of Mass Curve:

- 1- Rising sections of the mass curve indicates areas where excavating exceeds fill, whereas falling sections indicate where fill exceeds excavation.
- 2- Steep slopes reflect heavy cuts & Fills, while flat slopes indicate areas from small amount of earthwork.
- 3- The difference in ordinates between any two points indicate net excess of excavation over embankment or vice versa.

- 4- Any horizontal line down to intersect two points within the same curve indicates a balance of excavation (cut) and embankment (fill) quantities between the two points.
- 5- Points of zero slope represent points where roadway goes from cut to fill or from fill to cut.
- 6- The highest or the lowest points of the mass haul diagram represents the crossing points between the grade line (roadway level) and natural ground level.

Calculation of total cost of earthworks:

- 1- Cost of freehaul = cost of freehaul per m^3 * Volume of freehaul.
- 2- Cost of borrow = cost of borrow per m^3 * Volume of borrow.
- 3- Cost of waste = cost of waste per m^3 * Volume of waste.
- 4- Cost of overhaul = [cost of freehaul per m^3 * volume of overhaul] + [cost of freehaul per m^3 .station * volume of overhaul * {average hauling distance-free haul distance}].

Example: Given the following end areas for cut & fill, complete the earthwork calculation using a shrinkage of 10%. Then draw the M.H.D. and the longitudinal profile of the earthworks & find the following:

- a) Limit of Economic Haul (L.E.H.).
- b) Freehaul volume (F.H.V.).
- c) Overhaul volume (O.H.V.).
- d) Waste volume.
- e) Borrow volume.
- f) Total cost of the earthworks.

Given that:

- Cost of overhaul = 30 ID/ m^3 .station.
- Cost of borrow = 120 ID/ m^3 .
- Cost of freehaul = 70 ID/ m^3 .
- Freehaul Distance (F.H.D.) = 200m = 2 stations.

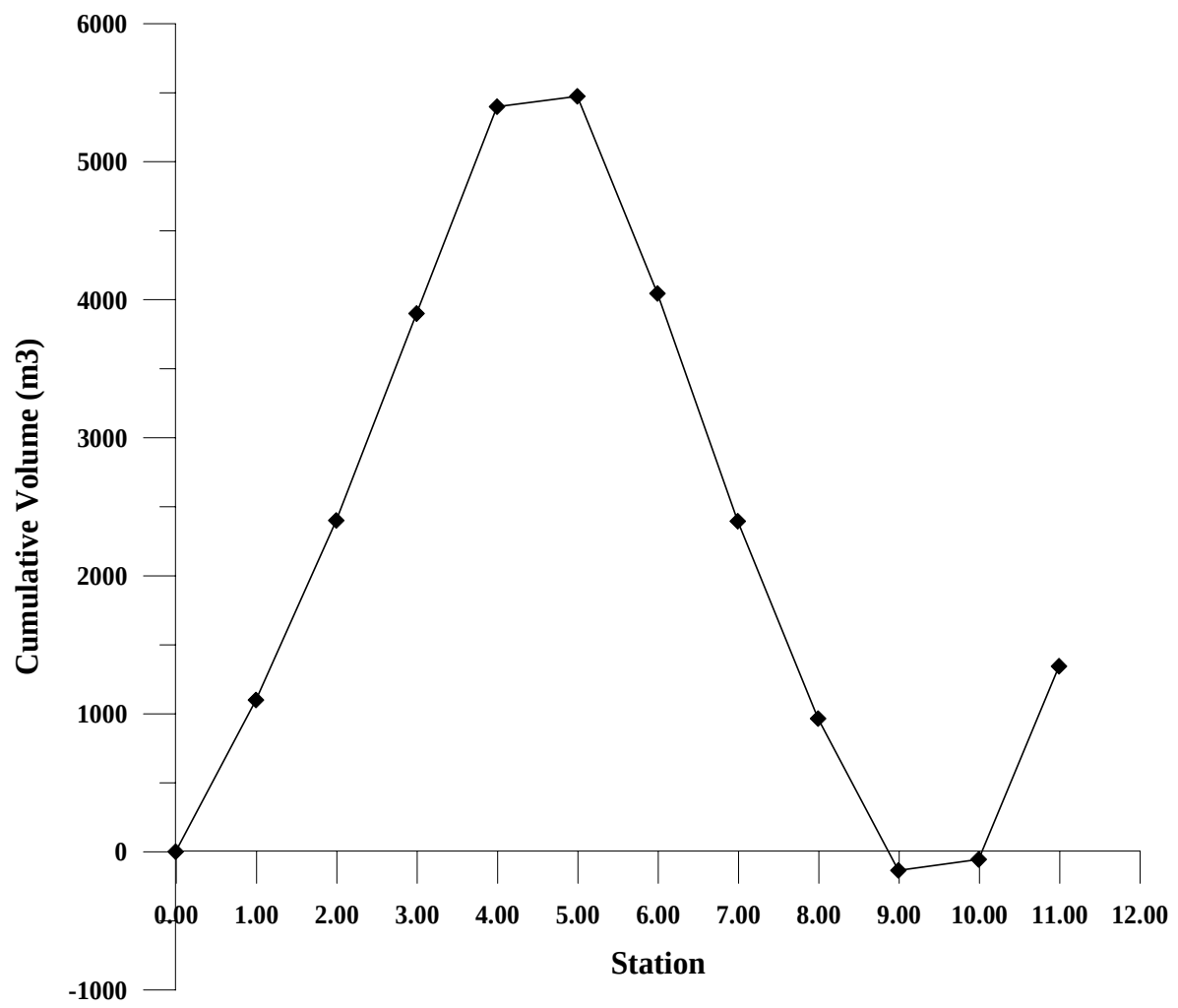
Solution:

Station	Areas (m ²)		Volumes (m ³)			Excess of (m ³)		Cumulative Volume(m ³)	Station
	Cut	Fill	Cut+	Fill-	Corrected Fill -	Cut+	Fill-		
0	10	-	<u>1100</u>	--	--	1100	--	0	0
1	12	-	1300	--	--	1300	--	+1100	1
2	14	-	1500	--	--	1500	--	+2400	2
3	16	-	1500	--	--	1500	--	+3900	3
4	14	-	<u>350</u>	250	<u>275</u>	<u>75</u>	--	+5400	4
5	-	10	--	1300	1430	--	1430	+5475	5
6	-	16	--	1500	1650	--	1650	+4045	6
7	-	14	--	1300	1430	--	1430	+2395	7
8	-	12	--	1000	1100	--	1100	+965	8
9	-	8	300	200	220	<u>80</u>	--	-135	9
10	12	-	1400	--	--	1400	--	-55	10
11	16	-						+1345	11

Notes:

- $1100 = [(10+12)/2] \times 100$ (by using average area method).
- $350 = [(14+0)/2] \times [100/2]$
- $275 = 250 \times (1.10)$ (Correction by shrinkage factor).
- $75 = 350 - 275$
- $80 = 300 - 220$

- Economic overhaul limit (L) = (cost of borrow/cost of overhaul) = (120/30) = 4 stations.
- Therefore, Limit of Economic Haul (L.E.H.) = Free haul distance + Economic overhaul limit = 2 + 4 = 6 stations.



- Freehaul volumes = (FHV1+FHV2) =

- Overhaul volumes = (OHV1+OHV2) =

- Waste volume =

- Borrow volume =

- Total cost of the earthworks =

[cost of freehaul*(FHV1+FHV2)] + [cost of waste*waste vol.] +
[cost of borrow*borrow vol.] + [cost of freehaul*(OHV1+OHV2)] + [(cost of
overhaul*OHV1*(average hauling distance1-FHD)) + (cost of
overhaul*OHV2*(average hauling distance2-FHD))] =

[70 * ()] + [70 *] + [120 *] + [70*()] +
[30 * * (- 2)) + (30 * (- 2))] = ID