***Highway Pavement***

***Civil Engineering Department***

***4th stage, 2nd Semester, 2019-2020***

***6th Lecture: Mass Haul Diagram , Cost estimation***

**Lecturer:**

**Dr. Maha Al-Mumaiz**

**Dr. Abeer K. Jameel**

**Free Haul Distance (F.H.D)** is the specified distance wherein an excavated material will be hauled without additional cost (there is a fixed cost for each m3 excavation hauling and dumping).

→ depends on 1) Terrain 2) Equipment

 Ex: Free haul cost = 4500 ID/m3

**Overhaul** is an authorized hauling in excess of the free haul distance.

- Units for overhaul is cubic meter-station or cubic yard-mile.

- The FHWA specifications define overhaul as the “the number of cubic yards of overhauled material multiplied by the overhaul distance”.

**Overhaul distance (O.H.D):** distance behind free haul distance with in which there is an additional cost for each 1 m3.st

Ex: Over haul cost = 1500 $\frac{ID}{m^{3}.st}$

**Balance Point (cut=fill)** anywhere the mass haul line crosses the 0 (zero) cumulative volume line on a mass haul diagram. This indicates that up to this station the cumulative cut and fill volumes are equal.

**Grade Point** transition between cut and fill on a mass haul diagram. This point coincides with a design profile intersecting the original ground profile. A “crest” on the mass haul line indicates a transition from cut to fill, and “sag” indicates a transition from fill to cut.

**Limit of economical haul (L.E.H):** F.H.D + Max over haul distance

 $=F.H.D+ \frac{Borrow cost (\frac{ID}{m^{3}})}{Over haul distance cost (\frac{ID}{m^{3}.st})}=st$

Beyond which it is more economical to use (waste + borrow) rather than to pay for over hauling.

**Borrow** it is the location away from right of way and it is chosen by the engineer.

- borrow material often must be brought into the roadway from outside the grading prism (nearby borrow pit.).

- pay for borrow usually is by cubic yard, measured in the space originally occupied in the borrow pit. Occasionally, the borrow volume is determined in the completed fill.

**Waste** it is the unwanted excavation material which should be disposed out of right way.

Waste volume: excavated and dumped away at highway section cost = 4500 $\frac{ID}{m^{3}}$



* + - * F.H.D= F.D
* F.H.V= free haul volume (m3)
* L.E.H= LH
* O.H.V= over haul volume (m3)
* X1 + X2 = max over haul distance
* K1 + K2 = average over haul distance
* Waste vol. (W. Vol) = B. Vol. (Borrow Volume)
* Total free haul cost = F.H.V \* $\frac{ID}{m^{3}}$
* Total over hauling cost = $\frac{ID}{m^{3}.st}$ \* O.H.V \* (K1 + K2)
* Total Borrow cost = $\frac{ID}{m^{3}}\*B. Vol$

**Method of Measurement**

The overhaul distance for material obtained and placed within the roadway limits will be measured along the centerline of the roadway. No allowance will be made for transverse of lateral movement to or from the centerline except materials moved to or from designated areas outside the roadway limits. If the contractor chooses to haul materials from other route which is longer than the designated source, payment will be based on the overhaul distance measured along the route designated by the engineer.

$$Cost of earthwork= \frac{ID}{m^{3}}\*m^{3}=ID$$

**Example 1:**

F.H.D= 700m =7 st

Over haul cost = 1500 $\frac{ID}{m^{3}.st}$

Waste cost = free haul distance = 4500 $\frac{ID}{m^{3}}$

Borrow cost = 6000 $\frac{ID}{m^{3}}$

Find cost for each m3, L= 5st, 9, 13 and 15st.

**Solution:**

 F.H.D =7 st

**1)** L= 5st < 7st

 Cost = free haul cost = 4500 $\frac{ID}{m^{3}}$

**2)** L= 9st> 7st

 L.E.H $=F.H.D+ \frac{Borrow cost (\frac{ID}{m^{3}})}{Over haul distance cost (\frac{ID}{m^{3}.st})}$

 $=7+ \frac{6000}{1500}=11 st$ > 9st

 Cost = 4500 + 2\*1500=7500 $\frac{ID}{m^{3}}$

**3)** L = 13st > L.E.H

 Cost = waste cost + borrow cost

 $=4500+6000=10500 \frac{ID}{m^{3}}$

**4)** L= 15st > L.E.H

Cost = 4500 + 6000 = 10500 $\frac{ID}{m^{3}}$

**Example2**: Determine the cost of total earthwork of a highway section having the cumulative volume shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Station | 0 | 5 | 9 | 13 | 15 |
| Cumm. Vol. | 0 | 250 | 350 | 220 | 0 |

Given that the overhaul cost =750 $\frac{ID}{m^{3}.st}$ , Borrow cost= 2500 $\frac{ID}{m^{3}}$, Free haul cost = 1250 $\frac{ID}{m^{3}}$, and overhaul volume =170 m3, Free haul distance = 500m

**Solution**



F.H.V = 350 -300=50 m3

L.E.H.D= 11.5 st

Waste volume = borrow volume= 130 m3

Total F.H.C = F.H.C \* F.H.V = 1250\* 50= 62500 ID

Total W.C = F.H.C \*W.V = 1250\*130=162500 ID

Total B.C = B.C \*B.V=1500\*130=195000 ID

Total O.H.C = 1250\*170+750\*170((11.5-5)/2)= 626 875 ID

Total Cost = 62500+162500+195000+626 875=1046875 ID

**Example 3**: Determine the cost of total earthwork of a highway section having the cumulative volume shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Station | 0 | 5 | 9 | 13 | 15 |
| Cum. Vol. | 0 | 250 | 350 | 220 | 0 |

Given that the overhaul cost =750 $\frac{ID}{m^{3}.st}$ , Borrow cost=2500 $\frac{ID}{m^{3}}$, Free haul cost = 1250 $\frac{ID}{m^{3}}$, Free haul volume = 100 m3



$$L.E.H.D=F.H.D+ \frac{Borrow cost (\frac{ID}{m^{3}})}{Over haul distance cost (\frac{ID}{m^{3}.st})}=7.5+\left(\frac{2500}{750}\right)=11 st$$

**Find the total cost by the same steps**

**Example 4**: Determine the cost of total earthwork of a highway section having the cumulative volume shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Station | 0 | 5 | 9 | 13 | 15 |
| Cum. Vol. | 0 | 250 | 350 | 220 | 0 |

Given that the overhaul cost =750 $\frac{ID}{m^{3}.st}$ , Borrow cost=2500 $\frac{ID}{m^{3}}$, Free haul cost = 1250 $\frac{ID}{m^{3}}$, Borrow volume = 100 m3

**Solution**



$$L.E.H.D=F.H.D+ \frac{Borrow cost \left(\frac{ID}{m^{3}}\right)}{Over haul distance cost \left(\frac{ID}{m^{3}.st}\right)}=$$

$$F.H.D=12.5-\left(\frac{2500}{750}\right)=9 st$$

**Find the total cost by the same steps**

**Example 5**: Determine the cost of total earthwork of a highway section having the cumulative volume shown in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Station | 0 | 5 | 9 | 13 | 15 |
| Cum. Vol. | 0 | 250 | 350 | 220 | 0 |

Given that the overhaul cost =750 $\frac{ID}{m^{3}.st}$ , Borrow cost= 2500 $\frac{ID}{m^{3}}$, Free haul cost = 1250 $\frac{ID}{m^{3}}$, and overhaul volume =170 m3, L.E.H.D = 17 st

**Solution:**

L.E.H.D = 17 st >15 st

L.E.H.D = 15 st

$$F.H.D=15-\left(\frac{2500}{750}\right)=11.5 st$$

Borrow volume = waste volume = zero

**Find the total cost by the same step**

**Example 6**: For the given cumulative volume measurements,

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Station | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Cum. Vol. | 0 | 1100 | 2400 | 3900 | 5400 | 5475 | 4045 | 2395 | 965 | -1635 | -255 | 1345 |

Draw the M.H.D. and the longitudinal profile of the earthworks and find the following:

a) Limit of Economic Haul (L.E.H.)

b) Free Haul Volume (F.H.V.)

c) Over Haul Volume (O.H.V)

d) Waste Volume

e) Borrow Volume

f) Total cost of the earthworks

Given that:

- Cost of overhaul = 30 ID/m3.station

-Cost of borrow = 120 ID/m3.

-Cost of free haul = 70 ID/m3.

-Free Haul Distance (F.H.D.) = 200m = 2 stations

**Solution**

F.H.V 1= 5475-4650=825

F.H.V2= 1635

$$L.E.H.D=F.H.D+ \frac{Borrow cost \left(\frac{ID}{m^{3}}\right)}{Over haul distance cost \left(\frac{ID}{m^{3}.st}\right)}=$$

$$L.E. H.D=2+\left(\frac{120}{30}\right)=6 st$$

O.H.V= 4650-=1700=2950m3

Waste volume = 1700+1345=3045 m3

Borrow volume= 1700

Free Haul Cost= 70\*(825+1635)= 172900 ID

Overhaul cost= 70\*2950+30\*2950((6-2)/2)= 383500 ID

Waste cost= 70\*3045 = 213150 ID

Borrow cost= 120\*1700= 204000 ID

Total cost = 973550 ID

