بسم الله الرحمن الرحيم

CE 442

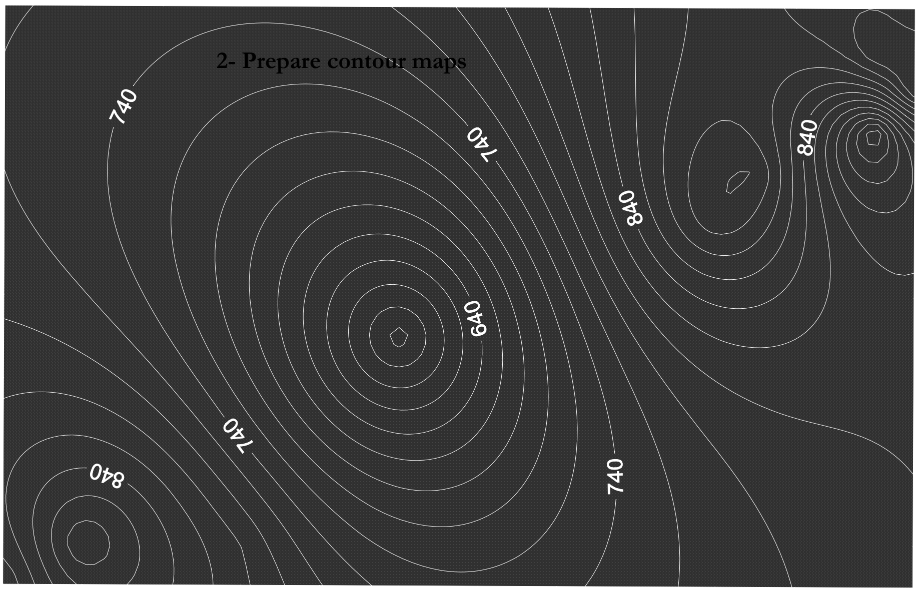
Construction and Maintenance of Highways and Airports

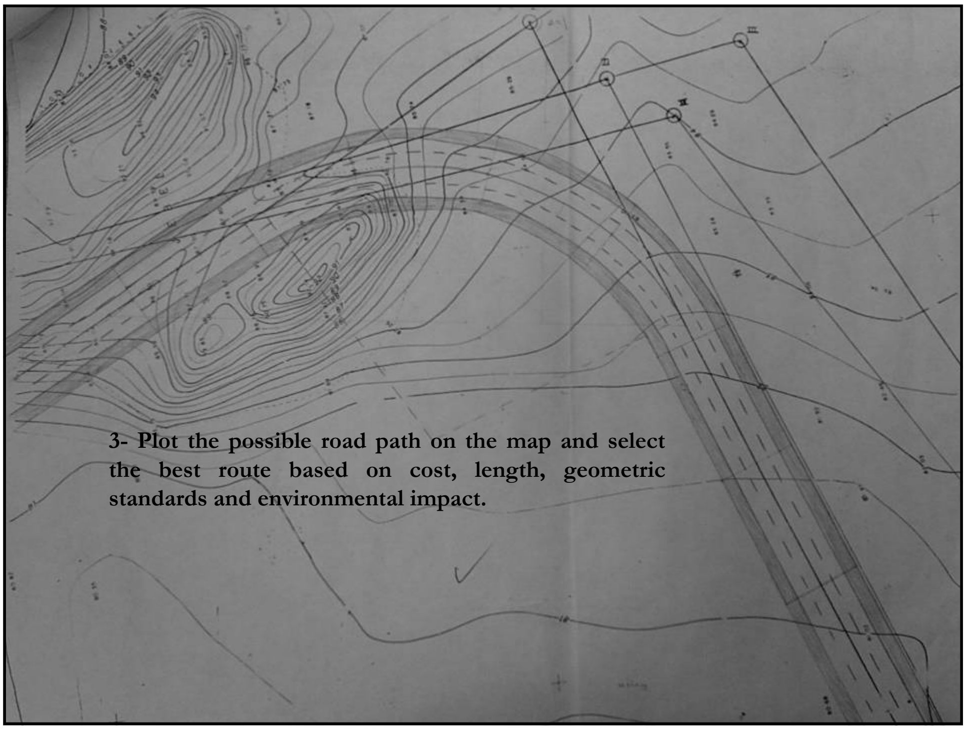
INTRODUCTION TO EARTH WORK

Mass Curve Calculation Steps :

1- Obtain Arial or ground survey maps for the route location

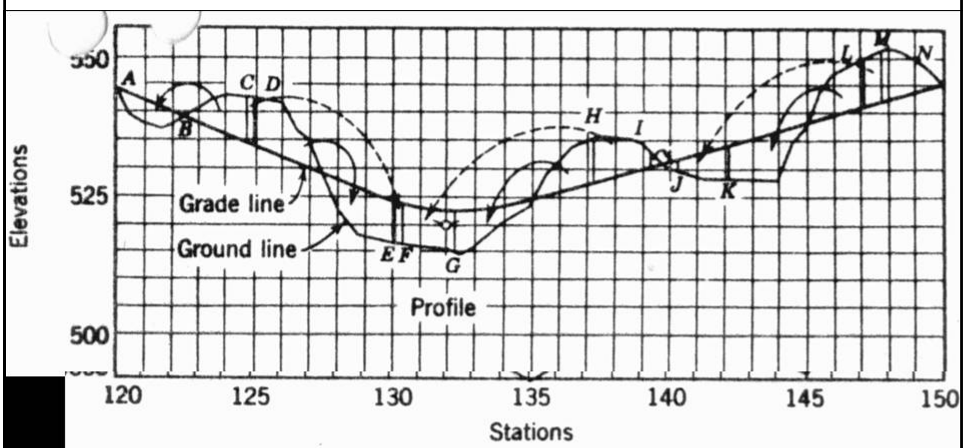
2- Prepare contour maps



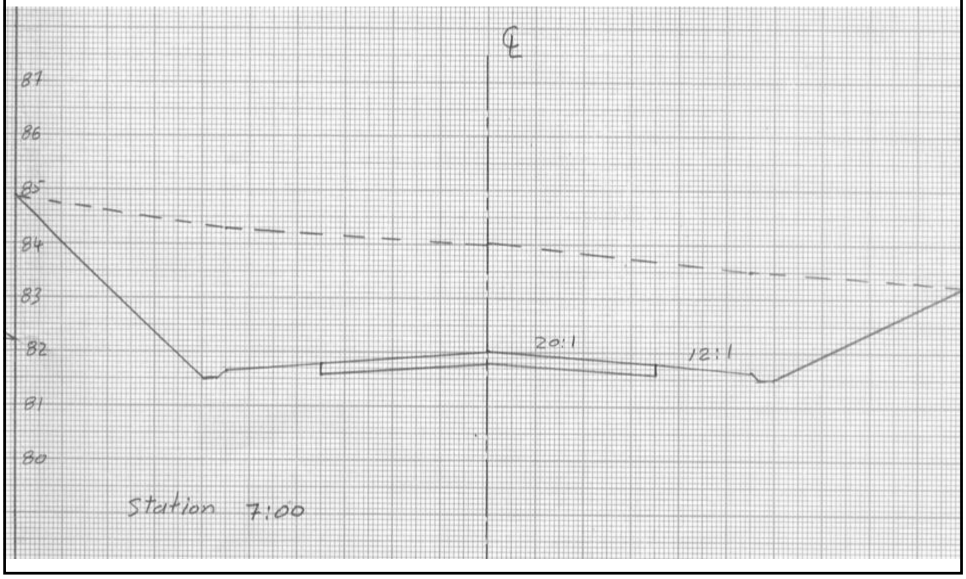


3- Plot the possible road path on the map and select the best route based on cost, length, geometric standards and environmental impact.

4- For the selected route plot ground elevation vs. designed road elevation.

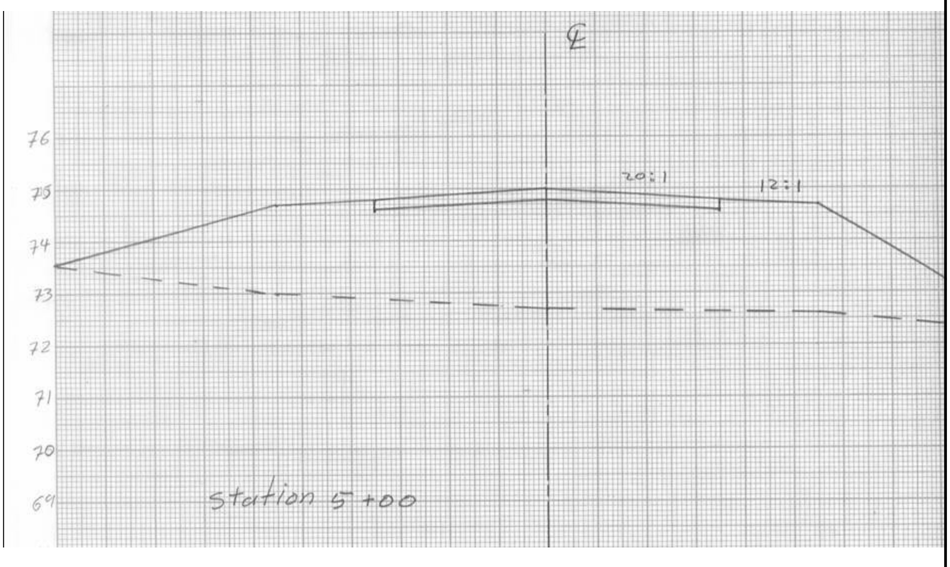


5- at each station plot road X-section with respect to natural ground and calculate the amount of cut or fill.



5- at each station plot road X-section with respect to natural ground and calculate the amount of cut or fill.

6- Calculate the volume of materials to be moved or imported (borrowed) by multiplying x-section area by the station length.



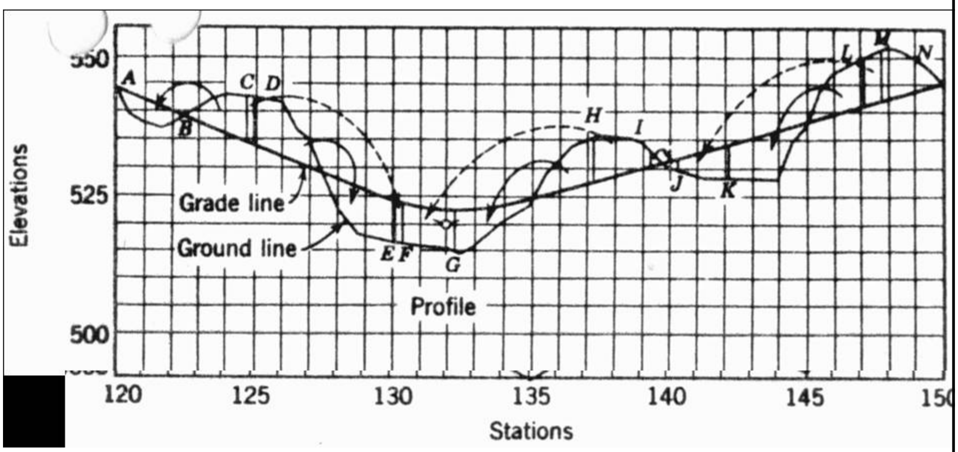
7- Tabulate the calculation results and note that soil will swell when excavated and will shrink when compacted therefore shrinkage and swilling factors must be used to correct soil volumes. Calculate mass curve.

TABLE 15–1. Typical Computations for a Mass Diagram.

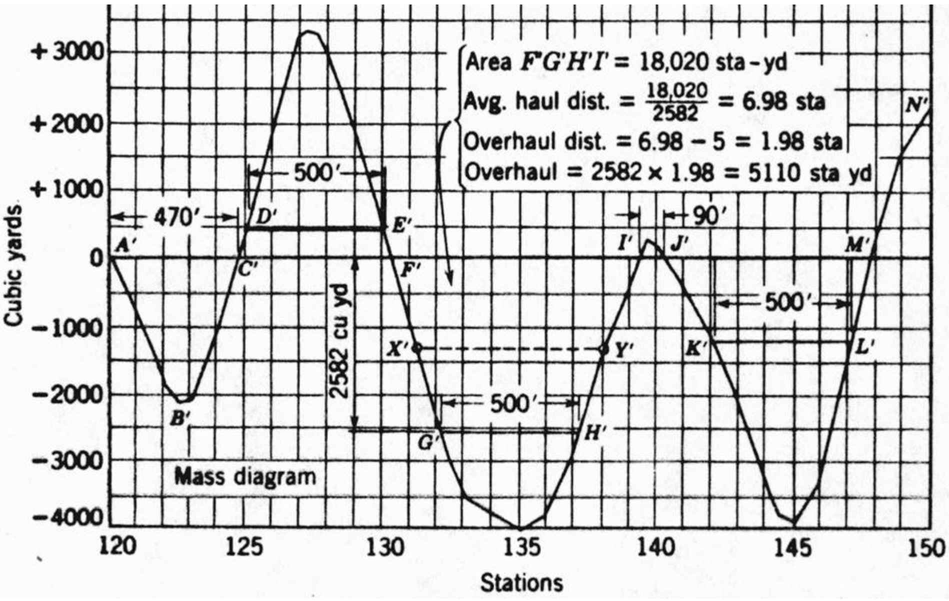
Swell or Shrinkage Factor = 0.82

Station	Excavation (yd³)	Embankment (yd³)	Embankment plus Shrinkage (yd³)	Excess material in Section (yd³) (+) Excavation	Excess material in Section (yd³) (−) Embankment	Mass Curve Ordinate (yd³)
120						0
	0	321	391	—	391	
+50						−391
	0	401	489	—	489	
121						−880
	0	483	589	—	589	
+60						−1,469
	0	318	388	—	388	
122						−1,857
	0	271	330	—	330	
+65						−2,187
	205	73	89	116	—	
123						−2,071
	421	0	0	421	—	
+50						−1,650
	593	0	0	593	—	
124						−1,057
	1,421	0	0	1,421	—	
125						+364
	1,543	0	0	1,543	—	
126						+1,907
	832	0	0	832	—	
+60						+2,739
	514	0	0	514	—	
127						+3,253
	81	12	15	66	—	
+20						+3,319
	125	153	187	—	62	
+60						+3,257
	0	241	294	—	294	
128						+2,963
	0	336	410	—	410	
+40						+2,553
	0	628	766	—	766	
129						+1,787
	0	1,123	1,370	—	1,370	
130						+417
	0	1,162	1,417	—	1,417	
131						−1,000
	0	1,141	1,391	—	1,391	
132						−2,391
	0	516	630	—	630	
+50						−3,021
	0	427	521	—	521	
133						−3,542
Totals	5,735	7,606	9,277	5,506	9,048	

8- Determine the free-hall sections (about 500 ft in length where cuts balance fill i.e. equal to fill) where no extra cost is prayed for transportation.



9- Determine the haul distance, the overhaul and the disposition of remaining excavation.



Note that:

1. A *rising* mass curve denotes excavation at that point on the roadway; a *falling* curve denotes embankment. Where the roadway lies on a sidehill, the same cross section often shows both excavation and embankment. In such cases, a rising curve indicates an excess of excavation and a falling curve an excess of embankment.
2. Steep slopes of the mass curve reflect heavy cuts or fills; flat slopes indicate small earthwork quantities.
3. Points of zero slope on the mass curve represent points where the roadway goes from cut to fill, or vice versa. These low or high points on the mass curve may not come at the exact station at which the profile goes from cut to fill. There may be a net excess of excavation or embankment at this point if the cross slope is irregular.
4. The difference in ordinate between two points on the curve represents the net excess of excavation over embankment between those points, or conversely, the net excess of embankment over excavation.
5. If a horizontal line intersects the mass curve at two points, the excavation and embankment are in balance (equal in amount) between those points.

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5- at each station plot road X-section with respect to natural ground and calculate the amount of cut or fill.
6- Calculate the volume of materials to be moved or imported (borrowed) by multiplying x-section area by the station length.
7- Tabulate the calculation results and note that soil will swell when excavated and will shrink when compacted therefore shrinkage and swilling factors must be used to correct soil volumes.
8- Determine the free-hall sections (about 500 ft in length where cuts balance fill i.e. equal to fill) where no extra cost is prayed for transportation.
9- Determine the haul distance, the overhaul and the disposition of remaining excavation.

1. Determine all the free-haul sections. (These are sections not exceeding 500 ft in length in which the cuts just balance the fills.) This is done by locating horizontal lines exactly 500 ft in length whose ends lie on the mass curve. In Fig. 15–4 these are *D'E'*, *G'H'*, *K'L'*. Also locate any sections less than 500 ft in length within which the mass curve intersects the zero ordinate twice, as lines *A'C'* and *I'J'* of Fig. 15–4. These free-haul lines must lie either on the zero ordinate of the mass curve (*A'C'* and *I'J'*) or inside the loops formed by the zero line and the mass curve (*D'E'*, *G'H'*, and *K'L'*). If the lines are drawn *outside* the loops, the completed earthmoving plans will include "cross haul," which will mean hauling material in one direction, followed later by moving material over it in the opposite direction. The actual movements of free-haul excavated material are indicated on the profile by arrows with solid lines as stems.
2. Determine the disposition of the remaining excavation. To illustrate, the mass curve shows that the excavation and embankment are in balance between *C* and *F*. Then cut *CD* should be deposited in fill *EF*. Similarly, cut *HI* makes fill *FG*, and cut *LM* makes fill *JK*, all as indicated by dotted arrows on Fig. 15–4. Any other haul plan will result in cross haul.

For this particular mass diagram, excavation within the section being considered exceeds embankment by about 2200 yd^3, as shown by the ordinate of the mass curve at station 150. This material is not needed for fill and might be wasted or used on some other section of the road. In practice, the grade line probably would be raised to secure a closer balance between cut and fill. Inclusion of waste in this illustration merely serves to indicate an added problem that is often encountered.

3. Determine the haul distance. Any *area* such as *F'G'H'I'* on the mass curve, when corrected for scale, is in station yards, which are the units for haul and overhaul. Thus, the area *F'G'H'I'* represents the station yards of haul needed to move cut *HI* into fill *FG*. Similarly, areas *C'D'E'F'* and *J'K'L'M'* give the hauls to place cuts *CD* and *LM* in fills *EF* and *JK*, respectively.

   The average haul distance is found by dividing the appropriate area on the mass curve (station yards) by its ordinate (cubic yards of excavation).[13]

4. Compute the overhaul. The overhaul distance is the haul distance less the free-haul distance. Overhaul, the pay item, is the product of overhaul distance and cubic yards of excavation. Typical calculations for overhaul for area *F'G'H'I'* are shown on