MŰEGYETEM 1782

Budapest University of Technology and Economics

Faculty of Civil Engineering

Earthworks (BMEEOGMAT43)

Slope Stability Analysis of an Embankment and a Cut

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Part one : Slope Stability Analysis of an Embankment :

1. Initial data:

Top width of the road: 12 m

Inclination of the pavement: 3,0 %

Height of the embankment (in axis): 9,9 m

Slope of the embankment: 6/4

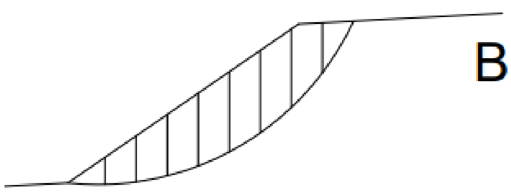
Characteristic values of soil parameters for the embankment:

Unit weight: 19,5 kN/m3

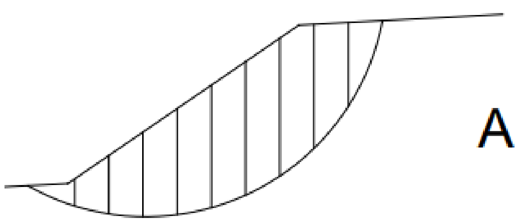
Internal friction angle: 32˚

Cohesion: 18 kPa

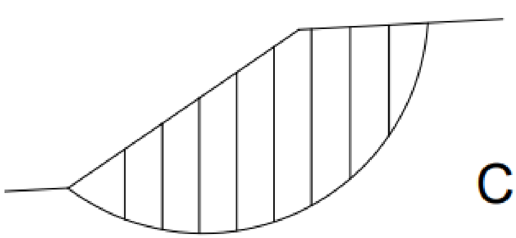
2. Three Drawn Sliding Surfaces with Slices



B



A



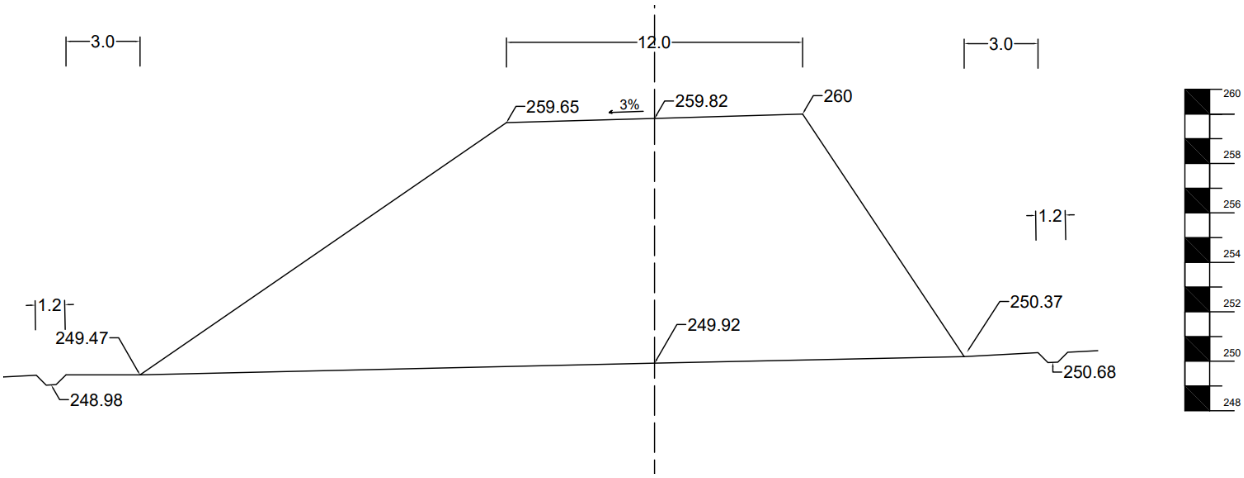
C

3. Calculation of Factor of Safety

Slice ID	A_slice [m^2]	G_i[KN/m]	alpha_i [degree]	T_i[kN/m]	N_i[kN/m]	K_i[kN/m]	S_i[kN/m]	G_i*cos(alpha_i)*tg(_d)+c_d*L_i	G_i*sin(alpha_i)
1	2.2095	43.08525	4	-32.607	-28.1624	0	-13.7893	-13.78927093	-32.607
2	4.6838	91.3341	5	-87.582	25.908	23.06667	12.6855	35.75212195	-87.582
3	6.882	134.199	11	-134.2	0.59392	39.31067	0.29081	39.60147223	-134.2
4	8.6098	167.8911	18	-126.08	110.861	52.44933	54.2815	106.730806	-126.08
5	9.823	191.5485	24	-173.46	81.2509	62.348	39.7832	102.1311885	-173.46
6	10.3749	202.3106	31	-81.741	185.062	68.62533	90.6127	159.2380145	-81.741
7	10.3333	201.4994	39	194.204	53.7284	70.62267	26.3072	96.92991271	194.204
8	8.4741	165.245	48	-126.95	-105.781	67.15333	-51.7938	15.35953446	-126.95
9	3.2112	62.6184	59	39.8715	-48.2838	42.816	-23.6414	19.1746	39.8715
10	2.2796	44.4522	23	-37.616	-23.6856	0	-11.5973	-11.59727755	-37.616
11	6.0513	118.0004	13	49.5799	107.079	23.2	52.4295	75.62954882	49.5799
12	9.8668	192.4026	5	-184.5	54.5773	50.14787	26.7229	76.87080263	-184.5
13	13.5219	263.6771	3	37.2101	-261.038	72.74648	-127.813	-55.06677004	37.2101
14	16.2041	315.98	11	-315.98	1.39843	91.15444	0.68472	91.8391587	-315.98
15	18.1424	353.7768	20	322.979	144.37	105.2597	70.6885	175.9481959	322.979
16	19.2296	374.9772	30	-370.49	57.8408	113.957	28.3208	142.2778654	-370.49
17	18.939	369.3105	39	355.94	98.474	118.4344	48.2162	166.6506182	355.94
18	14.742	287.469	51	192.67	213.346	105.2717	104.462	209.7333736	192.67
19	5.9527	116.0777	68	-104.23	51.0908	72.15465	25.0158	97.17043094	-104.23
20	8.2503	160.8809	29	-106.77	-120.348	0	-58.9265	-58.9265495	-106.77
21	13.5988	265.1766	15	172.441	-201.451	60.21318	-98.6375	-38.4243214	172.441
22	18.6394	363.4683	6	-101.56	348.991	90.95464	170.878	261.8327659	-101.56
23	22.6931	442.5155	4	-334.9	-289.247	116.1477	-141.625	-25.47768264	-334.9
24	25.7688	502.4916	13	211.13	455.984	135.997	223.266	359.2624996	211.13
25	27.718	540.501	24	-489.47	229.269	150.3223	112.258	262.5802994	-489.47
26	26.4118	515.0301	35	-220.53	-465.429	151.5349	-227.89	-76.35488019	-220.53
27	20.9172	407.8854	48	-313.36	-261.106	9.6338	-127.846	-118.2123724	-313.36
28	8.8433	172.4444	71	164.004	-53.2892	94.6771	-26.0922	68.5848754	164.004

V= -1.351732361 < 1 Embankment is insufficient against sliding

4. Detailed Documentation



Firstly, I calculated the design values and of the friction angles and the cohesion values by dividing its corresponding safety factories.   Study materials, project guides are used to calculate. Then the above cross section of embankment is drawn. After that, the simplified Bishop's (slices) method is used to determine the failure surface.

We assume the failure plane is circular. 3 different slip surfaces are considered, where arc a represents base failure, arc b is a slope failure with a positive tangent and arc c is a slope failure with a negative tangent. This method is shown in detail in part 1, section 2. Note: The earth pressures acting on a slice from the left and right are assumed to be equal. Next, the self-weight of each slice is calculated (the product of the area of the slice and the unit weight of the embankment soil). After that, the inclination of the bottom is measured. Next, the self-weight forces parallel (T_i, which causes sliding) and perpendicular (N_i) to the sliding surface are calculated for each slice. After that, the forces preventing sliding (K_i), due to cohesion, are calculated for each slice. Next, the friction from the self-weight and the friction angle (S_i) are calculated for each slice. Lastly, the factor of safety of the stability of the embankment against sliding is calculated using the following formula:

$$v = \frac{\sum(G_i * \cos\alpha_i * \tan\phi_d + c_d * L_i)}{\sum G_i * \sin\alpha_i}$$

In this project, v=-1.351732361 < 1.00 , so the embankment does not fulfill the stability resistance against sliding.

Part two: Slope Stability Analysis of a cut :

1. Initial data:

Height of the cut (in axis): 14,2 m

Slope of cut: 6/4

Characteristic values of soil parameters in cut:

Layer 1 unit weight: 19,0 kN/m3

Layer 1 internal friction angle: 28˚

Layer 1 cohesion: 5 kPa

Layer 1 height: H/4

Layer 2 unit weight: 20,0 kN/m3

Layer 2 internal friction angle: 22˚

Layer 2 cohesion: 15 kPa

Layer 2 height: 2H/3

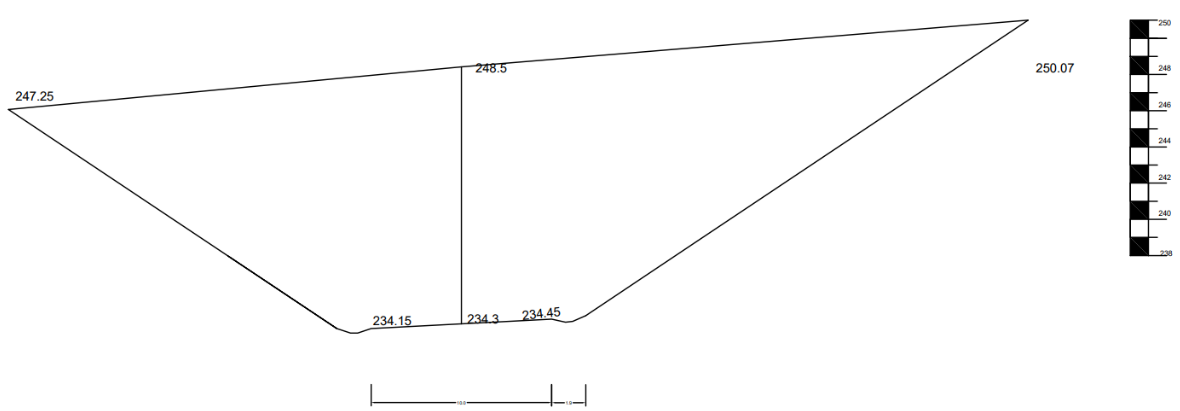
Inclination of the slip plane: 8˚

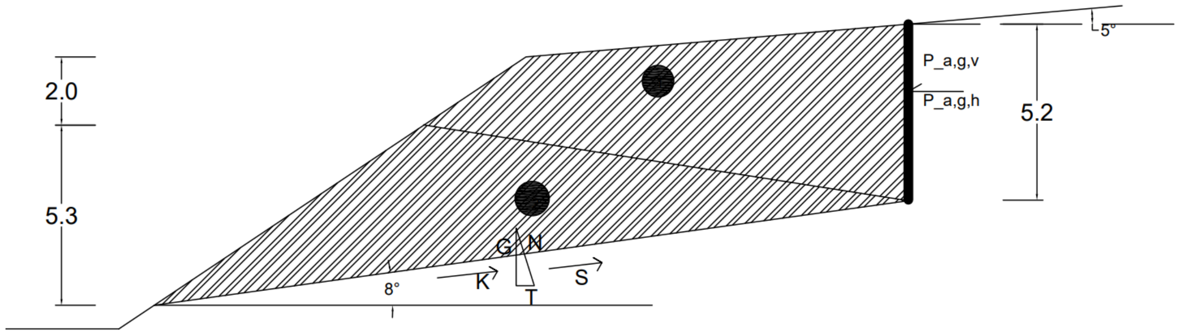
Characteristic values of shear strength on the slip surface:

Internal friction angle in the slip surface: 8˚

Cohesion in the slip surface: 7 kPa

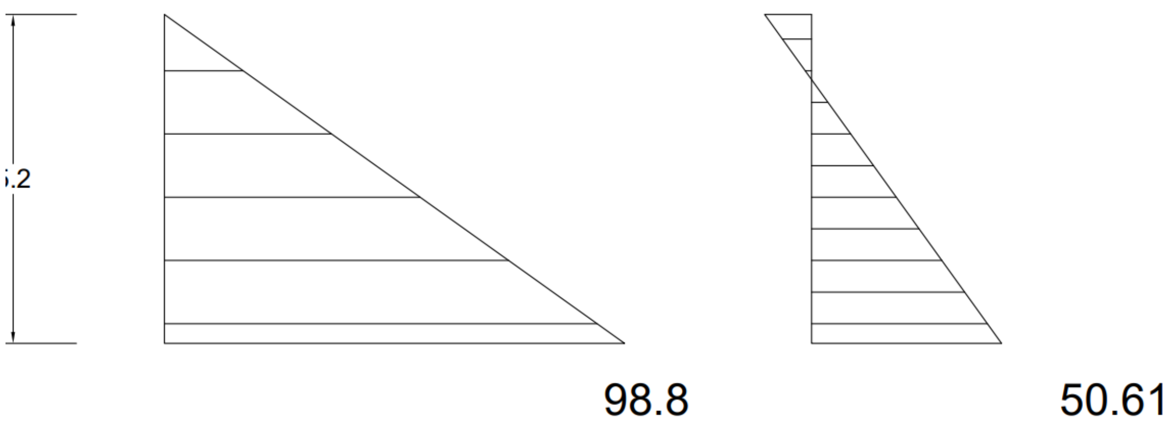
2. Drawing of the cut with the block





In the black circles the number of the layers are shown. (1,2) respectively.

3. Drawing of the Earth Pressure Diagrams



σ'_v,a, [kPa] σ'_h,a [kPa]

4. Calculation of factor of safety

H[m]- as in the presentation = 8

Height of the distribution = 5.2

β [deg] = 5

Ka [-] = 0.78046

ε [deg] = 8

σ'_h,a,1 [kPa]= -8.8344

σ'_h,a,2 [kPa]= 50.6064

P_a,g,h [kN/m]= 112.0303

P_a,g,v [kN/m] = 9.80138

P_a,g [kN/m] = 112.4582

P_a,g,N [kN/m] = -5.8856

P_a,g,T [kN/m] = 112.3041

Area_1 [m^2] = 46.6766

G [kN/m] = 886.8554

N [kN/m] = 878.2246

T [kN/m] = 123.4264

L [m] = 22.2408

S [kN/m] = 122.5992

K [kN/m] = 155.6856

v [-] = 1.1805

Factor of Safety against sliding: v = 1.1805

v > 1 Cut is sufficient against sliding

5. Detailed Documentation

Firstly , with the given parameters , the cross-section of the cut is drawn. Then, the sliding block method is used to determine the sliding surface of the cut. These drawings are illustrated I nthe previous pages. After that, the active pressure coefficient is calculated, using the simplified formula. where: β is the slope of the terrain surface, and ϕ is equal to the friction angle of the first layer. Next, the vertical and active earth pressure diagrams are drawn. After that, the earth pressure force P_a,g,h is calculated.

Then , from the horizontal component - the vertical and resultant of the earth force pressure are calculated. After that, the inclination of the sliding surface is calculated, and the earth pressure force is decomposed into normal and parallel components to the sliding surface.

Next, the self-weight of the sliding block is computed with the area of the first block and its unit weight. In the further step, the self-weight is decomposed into normal and parallel components to the sliding surface. Then, the friction on the sliding surface is calculated. After that, the cohesive force on the sliding surface is computed.

Finally, the factor of safety of the stability of the cut against sliding is calculated using the

$$v = \frac{S + K}{T + P_a, g, T}$$

given formula:

In this project, v = 1.1805 > 1.00 , so the cut does fulfill the stability resistance against sliding.