Slope Stability Exercise

SHOW ALL YOUR WORK FOR THE FOLLOWING PROBLEMS

1) Solve for the factor of safety for slip surface AB'C'D' in lecture 28 using the method of slices - with one change. Assume that at the base of slice 5 is a horizontal layer of quick clay, an earthquake just occurred, and the shear strength of the clay has gone to zero. What is the calculated factor of safety for slip surface AB'C'D'? Is it likely to fail? Fill in the second table below. Setting up a spreadsheet will help you solve the problem relatively quickly and help you gain insight into the solution.
(39 pts. for addressing the underlined points correctly)

Driving moment

Slice	Unit thickness	Width	Height	Specific weight	Force	Lever arm	Driving moment
	m	m	m	kN/m^3	kN	m	kN-m
1	1.00	3.00	2.75	18.90	155.93	16.00	2494.80
2	1.00	3.00	7.50	18.90	425.25	15.00	6378.75
3	1.00	3.50	8.50	18.90	562.28	9.00	5060.48
4	1.00	6.00	8.50	19.00	969.00	5.50	5329.50
5	1.00	6.00	7.00	19.00	798.00	0.00	0.00
6	1.00	6.00	2.50	19.00	285.00	-5.50	-1567.50
Total							17696.03

Resisting moment							
Arc	Unit thickness	Radius (lever arm)	Subtended arc angle	Arc length	Shear strength	Area of slice base	Resisting moment
	m	m	degrees	m	kN/m^2	(square meters)	kN-m
1	1.00						
2	1.00						
3	1.00						
4	1.00						
5	1.00						
6	1.00						
Total							
Factor of safety							

2) Solve cases 2, 3, and 4 for the attached problem. Use case 1 as a guide. The term γ is the unit weight, which equals the density time gravitational acceleration. Do you expect a failure for any of the steps? Comment on the results, specifically the effect of the water, the effect of cutting the slope back to a safer(?) angle, and the effect of the concrete toe wall designed to strengthen the toe of the slope. Fill out the table on the last page to make this easier for me to evaluate. **(72 points total)**

The above exercises, together with the block-on-a-slope exercise we went through in class, should provide some mechanical insight into some of the key aspects of slope failures, namely:

- Why are dip slopes of around 30° particularly susceptible to failure;
- Why rain is an important factor in triggering landslides;
- Why cutting into slopes helps trigger landslides.

Case 1 (

A highway cut is made in horizontal sandstone beds as shown below. The cut face is sloped 1(horizontal) to 6(vertical) for appearance. An open vertical joint that strikes parallel to the cut face is 9m from the cut toe. A second set of joints also exists; these vertical joints are spaced 10 m apart and extend all the way through the sandstone and strike perpendicular to the road. The joints and the bedding thus divide the sandstone into blocks. Consider the 10 m deep block shown above. Just above the base of the cut is a highly weathered cohesionless seam of silty sandstone 0.5 m thick. A small concrete wall is poured at the toe of the cut to restrain this bed. The sandstone throughout has a unit weight of 24 kN/m^3, and the angle of internal friction of the basal weathered sandstone is 30°. Case 1: No water in joint 1 The weight (i.e. force) of the upper sandstone block on the weathered bed is (See figure):

$F_w = \rho g V = \gamma V$

$F_w = \{24\ kN/m^3\}\{15m \times 10\ m\ [(9m+6.5m)]/2\} = 27{,}900\ kN$

2 The average normal vertical stress on the top of the weather bed is:

σ_v = weight / area of base

$\sigma_v = (27900\ kN/m)/(9m \times 10m) = 310\ kN/m^2$

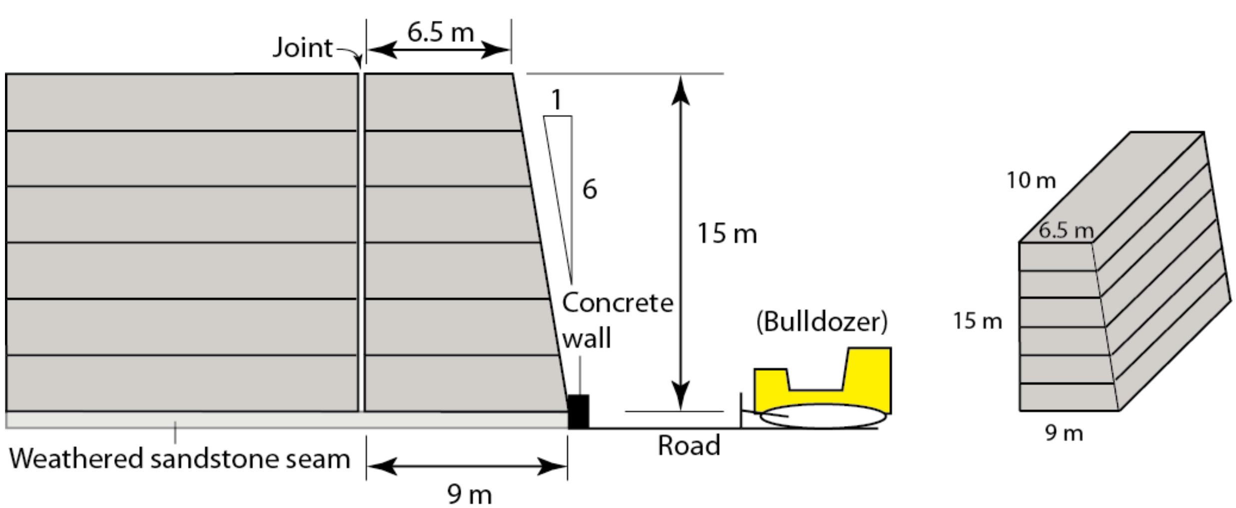
3 The frictional strength of the weathered bed is:

$\tau_f = \sigma v \tan 30° = 310 kN/m^2 \tan 30° = 179\ kN/m^2$

There is no cohesion in this case. 4 The weathered sandstone seam can resist a horizontal force of:

(τ_f)(basal area) = $(179\ kN/m^2)\ (90\ m^2) = 16{,}110\ kN$

The factor of safety is infinite because there is no driving force so far.



Case 2: Water rises to 10 m above the top of the weathered bed because the drainage in the concrete wall gets blocked.

5 Assume the pore pressure μ at the top of the weathered seam is uniform. The pore pressure μ can be determined by the height of the water column, g, and the density of the water. μ =_______________kN/m^2

6 The effective stress at the top of the weathered sandstone seam is the total stress (calculated in part 2) minus the pore pressure: σv' = __________

7 The weathered bed now provides a lateral shear resistance of τf= σv' tan 30°:__________

8 The shear force available for resisting sliding depends on the shear strength (τf) and the area of the base of the block. It is:______________

9 The 10-m-deep water in the joint produces a lateral force. This lateral force is obtained by integrating the water pressure over the height of the water column and is given by:

FL = (Average pressure)(wetted area of the back of the joint-bounded block)

FL = ({pressure at top of joint + pressure at bottom}/2) x (wetted area of the block back)

FL = ({ρwater g h}/2)(wetted area of the back of the joint-bounded block) =__________

10 The factor of safety against sliding is:________________

Case 3: Repeat steps of case 2, but assume water has risen to 14m above the top of the weathered bed.

Case 4: Assume that the slope is cut back to the top of the joint and that the water rises to 10 m above the top of the weathered bed. You will have to recalculate the weight of the block.

	Case1	Case2	Case3	Case4
Block.length (m)	10.00			
Block.height (m)	15.00			
Block.top.width (m)	6.50			
Block.bottom.width (m)	9.00			
Block.volume	1162.50			
Unit.weight (N/ m^3)	2.40E+04			
Block.weight (N)	2.79E+07			
Basal.area (m^2)	90.00			
Total.basal.normal.stress (Pa)	3.10E+05			
Water.height (m)	0.00			
Basal.water.pressure (Pa)	0.00E+00			
Effective.basal.normal.stress (Pa)	3.10E+05			
Basal.cohesion (Pa)	0.00E+00			
Friction angle (phi), (deg)	30.00			
Coefficient of friction (mu)	5.77E-01			
Shear.resisting.stress (Pa)	1.79E+05			
Basal.area (m^2)	90.00			
Shear.resisting.force (N)	1.61E+07			
Water.pressure.top (Pa)	0.00E+00			
Water.pressure.bottom (Pa)	0.00E+00			
Average.water.pressure (Pa)	0.00E+00			
Wetted.area.of.back (m^2)	0.00			
Driving.force (N)	0.00E+00			
Factor.of.safety	#DIV/0!			