Slope Stability Exercise
(Due April 5, 2002)

SHOW ALL YOUR WORK FOR THE FOLLOWING PROBLEMS

1) Solve parts 2, 3, and 4 for the attached problem. Use part 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.

2) Solve for the case of slip surface AB'C'D' on page 184-186 of Rahn using the method of slices - with one change. Assume that at the base of slice 5 there is a horizontal layer of quick clay and we've just had an earthquake. 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? You might note that the scale on Figure 6.17 of Rahn is not perfectly consistent - do the best you can. Create a table like that in Table 6.1 to show your work.

3) 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.

Comment on these three points.

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 x 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

σ_V = 27900 kN/m)/(9m x 10m) = 310 kN/m^2

3 The frictional strength of the weathered bed is:

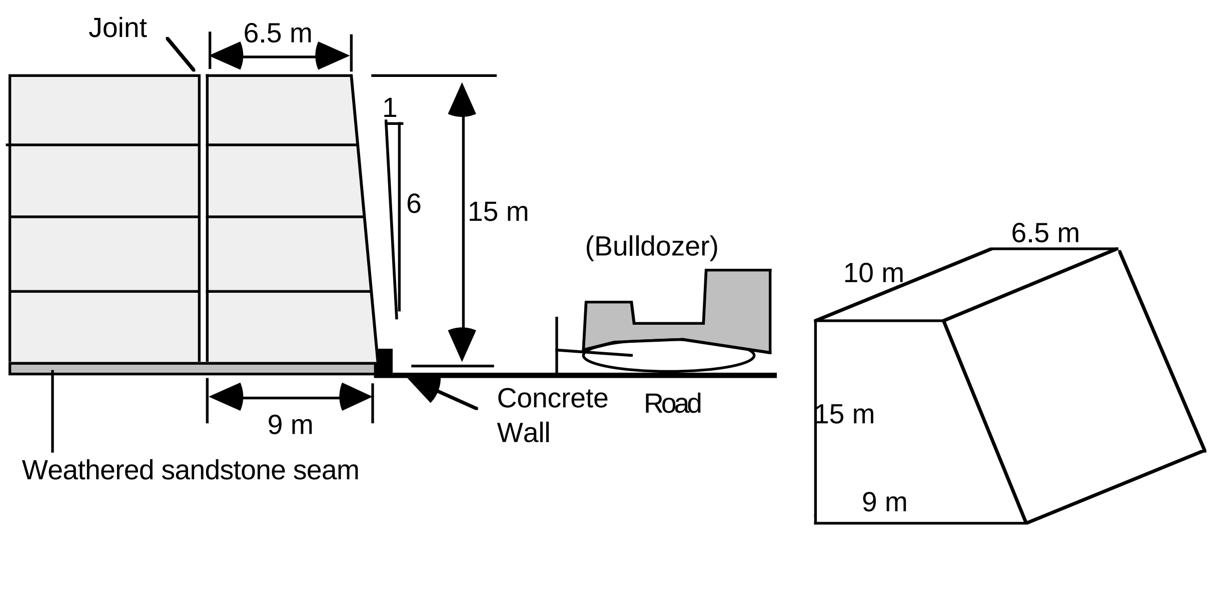
$\tau_f = \sigma_V$ tan 30° = 310kN/m^2 tan 30° = 179 kN/m^2

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: σ_V' = __________

7 The weathered bed now provides a lateral shear resistance of $\tau_f = \sigma_V'$ tan 30°:__________

9 The shear force available for resisting sliding depends on the shear strength (τ_f) 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:
F_L = (Average pressure)(wetted area of the back of the joint-bounded block)
F_L = ({pressure at top of joint + pressure at bottom}/2) x
(the part of the area of the back of the block that feels the water pressure)
F_L = ({ρ_{water} 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.

	Case 1	Case 2	Case 3	Case 4
Block.length (m)				
Block.height (m)				
Block.top.width (m)				
Block.bottom.width (m)				
Block.volume				
Block.density (kg/m^3)				
Unit.weight (N/m^3)				
Block.weight (N)				
Basal.area (m^2)				
Total.basal.normal.stress (Pa)				
Water.height (m)				
Basal.water.pressure (Pa)				
Effective.basal.normal.stress (Pa)				
Basal.cohesion (Pa)				
Friction angle (phi), (deg)				
Coefficient of friction (mu)				
Shear.resisting.stress (Pa)				
Basal.area (m^2)				
Shear.resisting.force (N)				
Water.pressure.top (Pa)				
Water.pressure.bottom (Pa)				
Average.water.pressure (Pa)				
Wetted.area.of.back (m^2)				
Driving.force (N)				
Factor.of.safety				