The University of Iowa
Department of Civil & Environmental Engineering
SOIL MECHANICS 53:030
Final Examination
2 Hours, 100 points

Fall 2000 Instructor: C.C. Swan

Problem #1: (20 points)

a. In a sentence or two, explain the difference between total stresses, "effective stresses", and neutral stresses in soils.

b. What is the expression for the liquidity index of a fine-grained soil?

c. If as a geotechnical engineer, you were asked to consider building a structure on a clayey soil deposit with a liquidity index of approximately one, how might you respond, and why?

d. List two or three of the major differences in engineering properties (permeabilities, strength behaviors, compressibilities, etc.) between clay soils and sands/gravels. Briefly, explain why these differences exist based on fundamental physical differences between the soil types.

e. What is the difference between a soil that is normally consolidated and one that is over-consolidated?

Problem #2: (20 points)

An embankment for a highway will use a 15m wide and 1.5m thick layer of compacted soil. The soil is to be trucked in from a borrow pit. The water content of the sandy soil in the borrow pit is 11 percent, and its void ratio is 0.74. The specification requires the soil in the embankment be compacted to a dry unit weight of $18 kN/m^3$. For a 100 meter length of embankment, determine:

a. the weight of sandy soil from the borrow pit required to construct the 15m by 1.5m layer in the embankment;

b. the number of $5.0 m^3$ truck loads of sandy soil required for construction;

c. the weight of water per truck load of sandy soil; and

d. the degree of saturation of the sandy soil in the embankment if the water content remains at 11 percent.

Assume that $\gamma_w = 9.81 kN \cdot m^{-3}$ and that G_s for the soil grains is 2.70.

<u>Problem #3</u>: (20 points)

Two rail lines lie atop a sandy-gravelly soil deposit as shown below in Figure 1. When there is no train on the track, each rail line exerts a line load force on the soil of 10 kN/m.

a. Compute the stress increases in the soil ($\Delta\sigma_{zz}, \Delta\sigma_{xx}, \Delta\tau_{xz}$) when under the rail loading;

b. What is the maximum shear stress in the soil at point A under the original soil stresses, and the increased stresses from the rail loading?

c. How large would the loads on each rail line need to be in order to cause shear failure in the soil at point A?

d. If shear failure did occur at point A, what would be the orientation of planes on which shear failure occurs. (To receive credit, show all work, and use the pole method.)

e. What would be shear and normal stresses on the shear failure planes?

$$\Delta\sigma_{zz} = \frac{2qz^3}{\pi(x^2+z^2)^2}; \qquad \Delta\sigma_{xx} = \frac{2qx^2z}{\pi(x^2+z^2)^2}; \qquad \Delta\tau_{xz} = \frac{2qxz^2}{\pi(x^2+z^2)^2}.$$

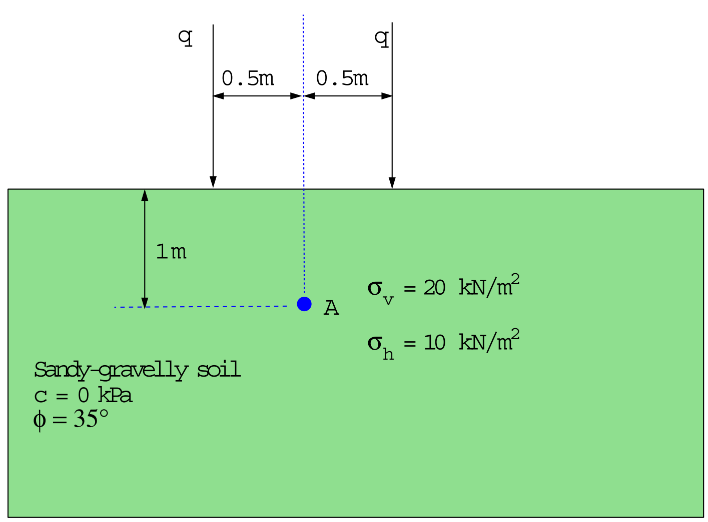

Figure 1. Soil deposit with initial stresses at point A, and line loads from rails.

Problem #4: (20 points)

Steady state upward seepage is occuring in the soil profile shown in Figure 2. Note the standpipes inserted at points B and C.

a. How high (h) is the water standing in the standpipe located at B?

b. Compute the magnitude of the hydraulic gradient in the sand layer.

c. Compute the vertical effective stress at point A in the sand layer.

d. How high (h) would the water have to stand in the standpipe at B to cause a quick (boiling) condition in the silty sand layer? (Note that the height of water in the standpipe at C will change from its original height.)

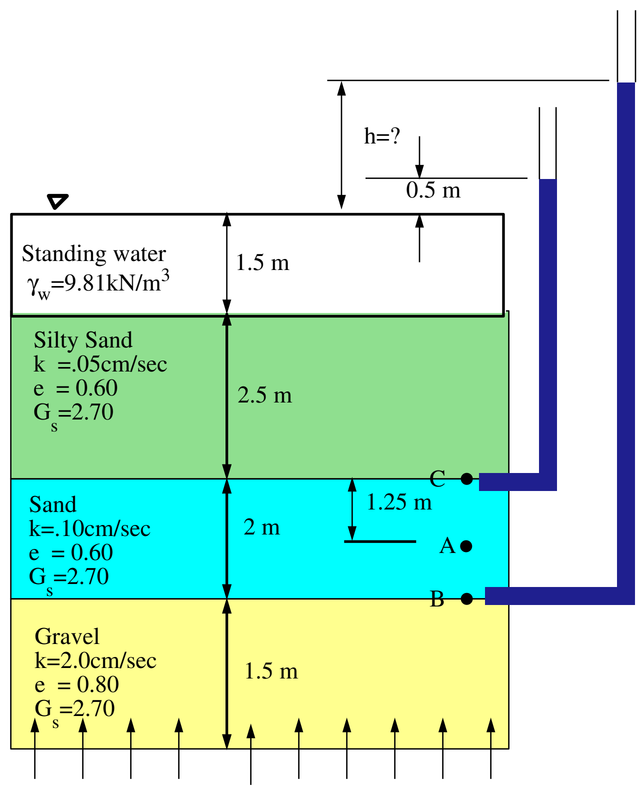

Figure 2. Uniform upward seepage in a multi-layered soil deposit.

Problem #5: (20 points)

As a consultant for an ethanol distributor, you are designing the site preparation for an ethanol storage tank. The tank will weigh 15,000 tons when full and rest on a circular flexible foundation of radius 45 feet.

i. How many feet of dry pre-loading fill (at unit weight $\gamma = 128 lbs/ft^3$) would you need to bring in to the site so that at the center of the clay layer directly under under the center of each tank $(\Delta\sigma_v)_{fill} = (\Delta\sigma_v)_{tank}$? That is, how thick should the pre-loading fill layer be?

ii. What would be the ultimate (100%) primary consolidation settlement under the fill loading?

iii. How much settlement would have occurred after 1 year?

iv. Assuming that you wanted to leave the fill in place until 90% percent consolidation is achieved before building the tank, how long would you have to wait?

iv. What would be the void ratio in the clay soil after 90% consolidation under the pre-load?

The increase in vertical stress below the center of a uniformly loaded circular flexible area is:

$$\Delta p = q \left[1 - \left[(R/z)^2 + 1 \right]^{-3/2} \right]$$

where R is the radius of the loaded region and z is the depth below the center.

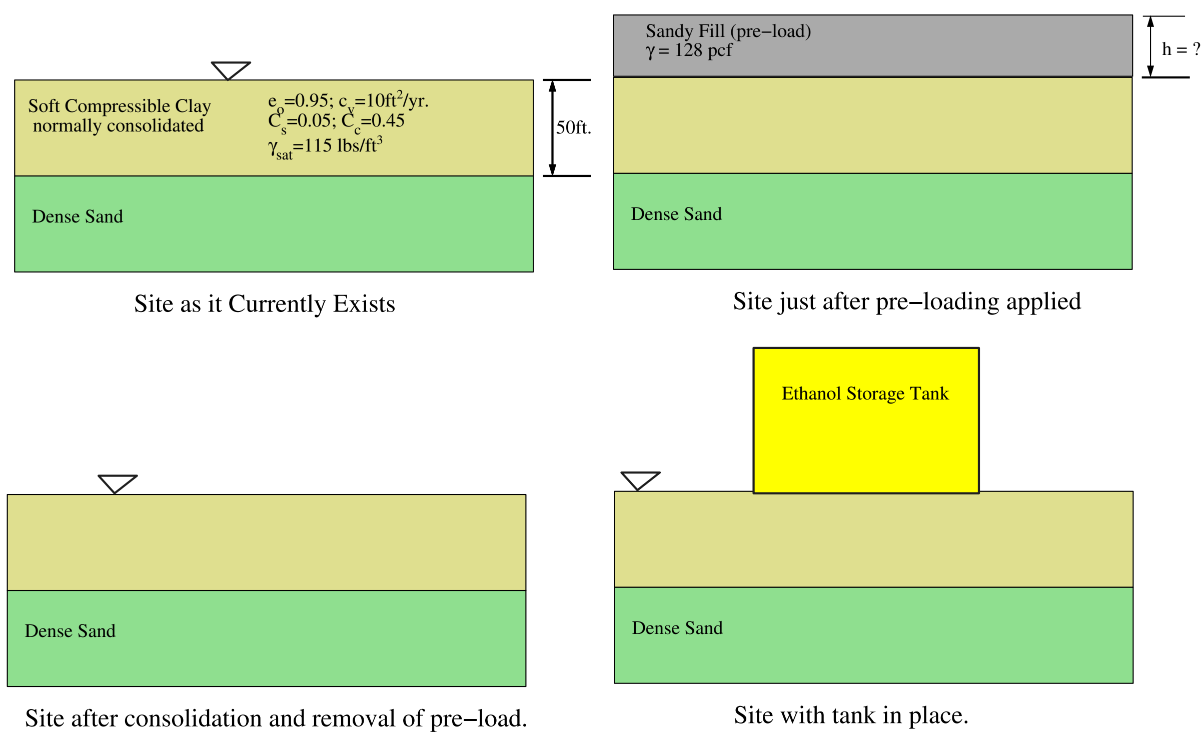

Figure 3. Existing site and proposed construction sequence.