The University of Iowa
Department of Civil & Environmental Engineering
SOIL MECHANICS 53:030
Final Examination
2 Hours, 200 points

Fall 1998 **Instructor: C.C. Swan**

Problem #1: (25 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: (25 points)

An embankment for a highway will use a 30m 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 15 percent, and its void ratio is 0.69. The specification requires the soil in the embankment be compacted to a dry unit weight of 18kN/m^3. For 1 km length of embankment, determine:

a. the weight of sandy soil from the borrow pit required to construct the 30m by 1.5m layer in the embankment;
b. the number of 5.0m^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 15 percent.

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

Problem #3: (50 points)

To build an underwater foundation, a temporary sheetpile wall system has been constructed as shown in Figure 1, and the soil has been excavated to a depth of D=4m. The water level H on the back side of sheetpile is 3m. The corresponding flownet for this problem is also shown in Figure 1.

a. At what rate is water being pumped out of the excavation to maintain the water level shown?

b. What is the vertical effective stress at point A?

c. What is the factor of safety against heaving in the critical regions around the sheetpiles?

d. How high H would water have to be on the back side of the sheetpile wall to create an unstable situtation in the critical regions? (Assume that the water level in the excavation remains as shown in Figure 1.)

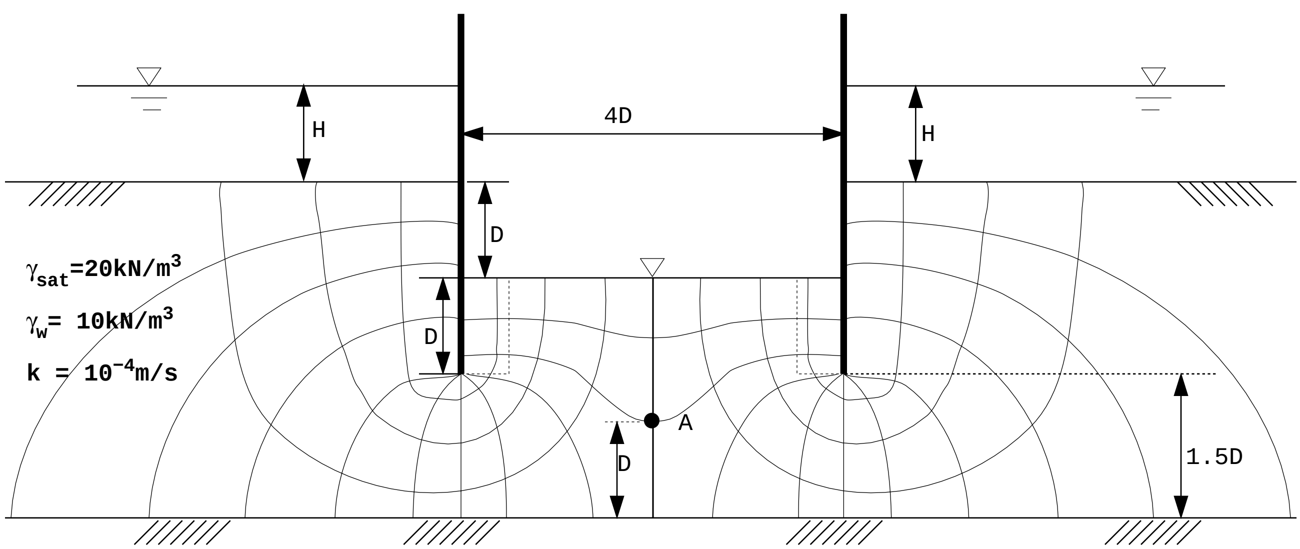

Figure 1. Seepage around sheetpile walls.

Problem #4: (50 points)

Figure 2a shows a two-layered soil system in which a dry sandy soil overlies a normally consolidated silty-clay soil, which in turn overlies a layer of low-permeability, undrained bedrock. A strip foundation load of 150 kPa is to be applied to the soil as shown in Figure 2b.

a. What is the *average vertical stress increase* in the silty clay layer directly beneath the centerline of the strip loading?

b. Neglecting any and all deformations in the sand layer, compute the settlement beneath the center of the strip foundation due to primary consolidation of the clay layer at times of:

   1. 1 year;
   2. 10 years; and
   3. 50 years.

c. Assuming that the silty clay soil had been significantly over-consolidated before the foundation load was applied, how would your computed settlements have changed? (There is no need for a detailed computation here; just explain briefly what difference you would expect, and why.)

For all computations, assume $\gamma_{water} = 10 kN \cdot m^{-3}$.

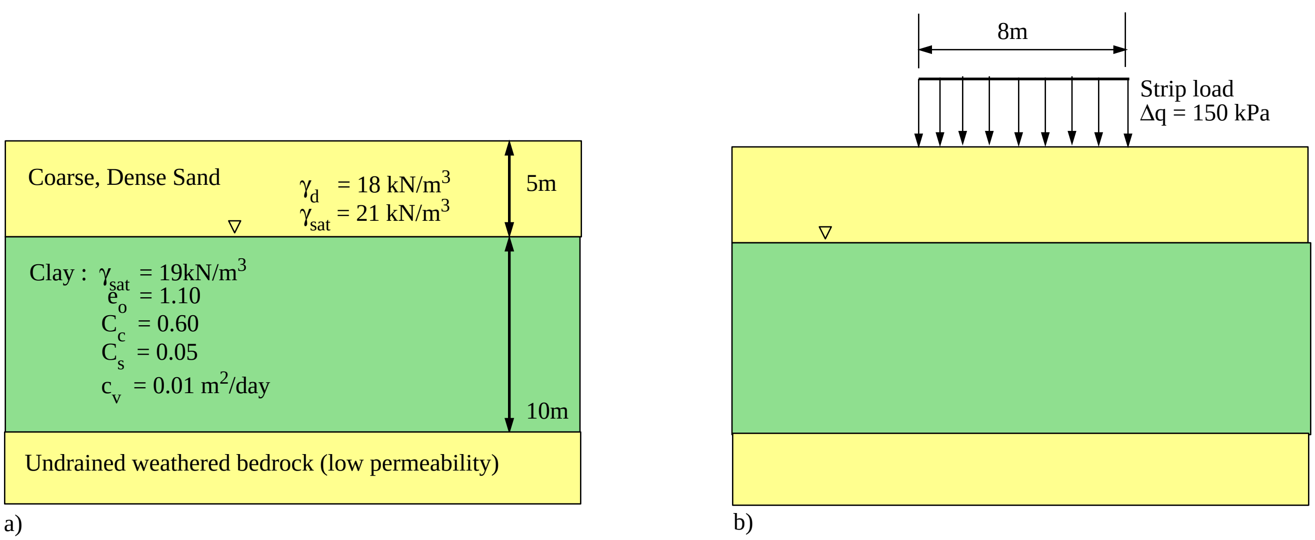

Figure 2: a. Two-layered soil system before load is applied; and b. Strip load applied to the soil system.

Problem #5: (50 points)

A sheetpile retaining wall is shown in Figure 3a, and the state of total stresses in the silty-sandy soil at point A are as shown. As part of a construction operation, a bracing force is pushing on the sheetpile wall as shown in Figure 3b, and this force leads to an increase in lateral stress σ_h in soil behind the retaining wall, while the vertical stress in the soil σ_v remains essentially constant.

a. For the original conditions shown in Figure 3a, what is the maximum shear stress at point A?

b. For the conditions shown in Figure 3b, how large would the lateral stress need to become at point A to cause shear failure?

c. At shear failure at point A, what would be the orientation of the plane(s) on which shear failure occurs? (Use the pole method.)

d. What are the effective shear and normal stresses on the failure plane passing through point A?

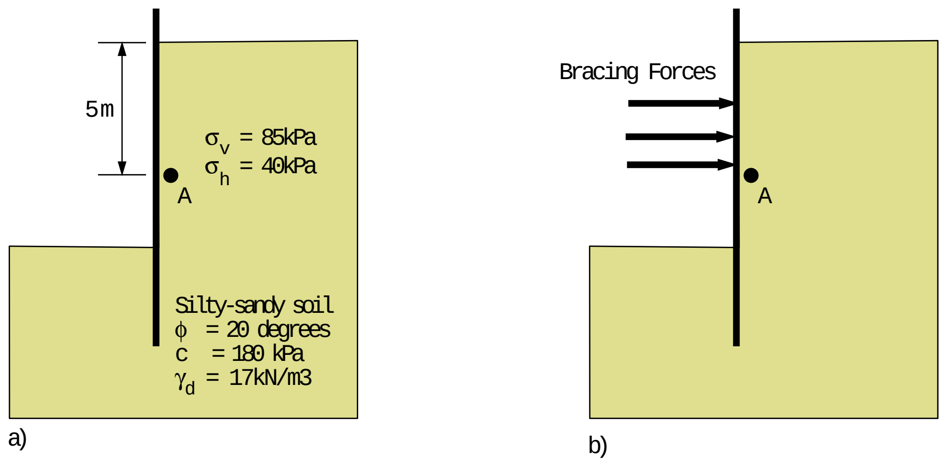

Figure 3: a. Sheetpile wall to retain a dry silty-sandy soil, with the initial stress at point A; and b. Force exerted on the wall leading to increased horizontal stress at point A.