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

Fall 2001 Instructor: C.C. Swan

Problem #1: (25 points)

A sand with a minimum void ratio of 0.45 and a maximum void ratio of 0.97 has a relative density of 40 percent. The average specific gravity of the minerals in the soil is 2.68, and $\gamma_w = 9.81 kN \cdot m^{-3}$.

a. Compute γ_{dry} and γ_{sat} for the sand in its present state with D_r = 40%.

b. Under vibratory loading, the sand is densified to a relative density of D_r = 75%. How much will a 3m thick stratum of this sand settle under this densification?

Problem #2: (40 points)

a. List two or three of the major differences in engineering properties between clay soils and sands/gravels. Briefly, attempt to explain why these differences exist based on physical differences between the soils.

b. Explain in a few sentences and with a sketch or two how a 1-D consolidation test can be performed on a saturated, fine-grained soil.

c. Can the permeability of the soil be estimated from such a test? If yes, briefly explain how.

d. How can the soil's C_c and C_s values be estimated from such a test?

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.)

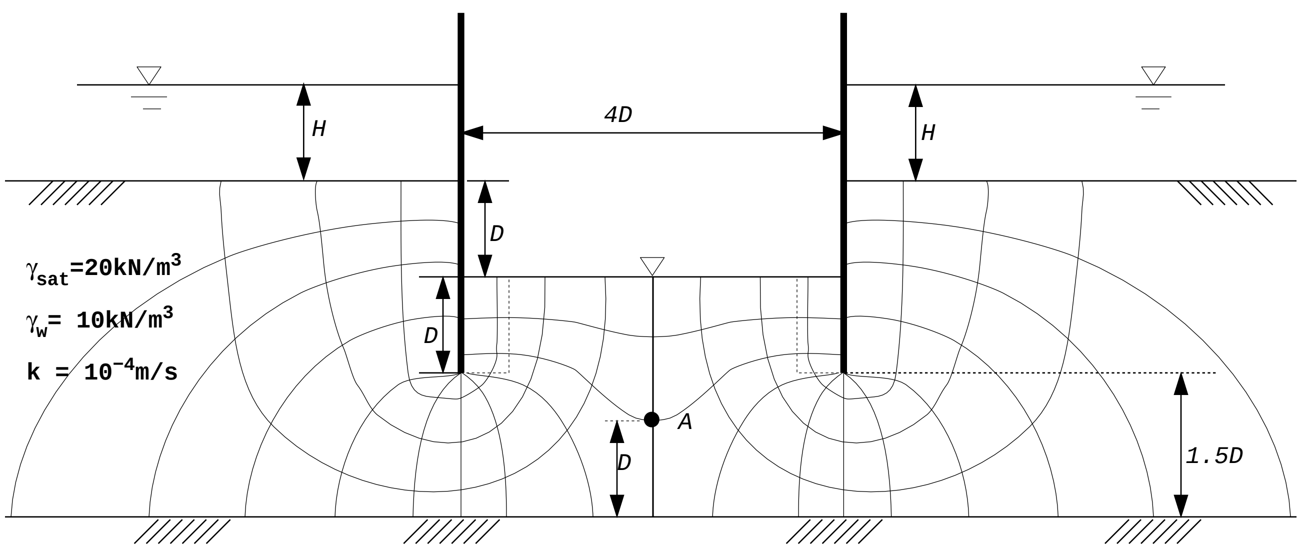

Figure 1. Seepage around sheetpile walls.

Problem #4: (40 points)

Figure 2 shows a homogeneous, saturated sandy soil deposit with a horizontal ground surface. Before the strip load is applied, the stresses at point A are as follows: vertical stress σ_v=100 kPa; horizontal stress σ_h=75kPa; pore water pressure p_w = 50kPa.

a. Compute the maximum shear stress at point A before the surface pressure is applied.

b. Using the information provided in Figure 3, estimate (compute) the maximum shear stress at point A after the uniform strip load is applied.

c. Estimate (compute) the intensity of the strip surface pressure q required to cause shear failure in the soil at point A. Assume that the sand features a drained behavior, such that any excess pore pressures due to the applied load are dissipated quickly.

d. What are the orientations of the failure planes at point A when shear failure is reached by increasing the surface pressure.

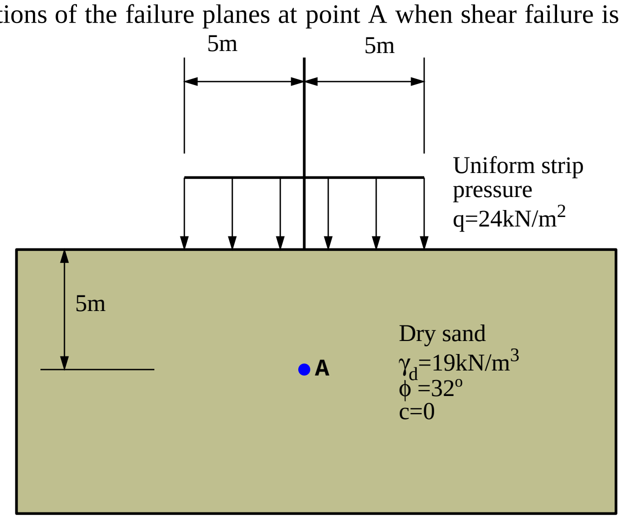

Figure 2. Uniform strip load applied to a dry soil deposit.

Figure 3. Principal stress increases under strip loading

<u>Problem #5</u>: (45 points)

A wastewater treatment aeration tank of diameter 40m and gross weight 286.5 MN is to be constructed on the site shown below in Figure 4a. To construct the tank, 6m of the dense sand layer will be excavated, and the tank will be built as shown in Figure 4b. For the values provided in Figure 4:

a. Compute the increased average vertical stress in the silty clay layer directly beneath the center of the tank.

b. Calculate the ultimate consolidation settlements that will occur at the center of the tank due to compression of the silty clay layer.

c. How long will it take for 90% of this consolidation settlement to occur? (Use one-dimensional consolidation theory to answer this question.) The non-dimensional time constant for 90% consolidation is T_{90} = 0.848.

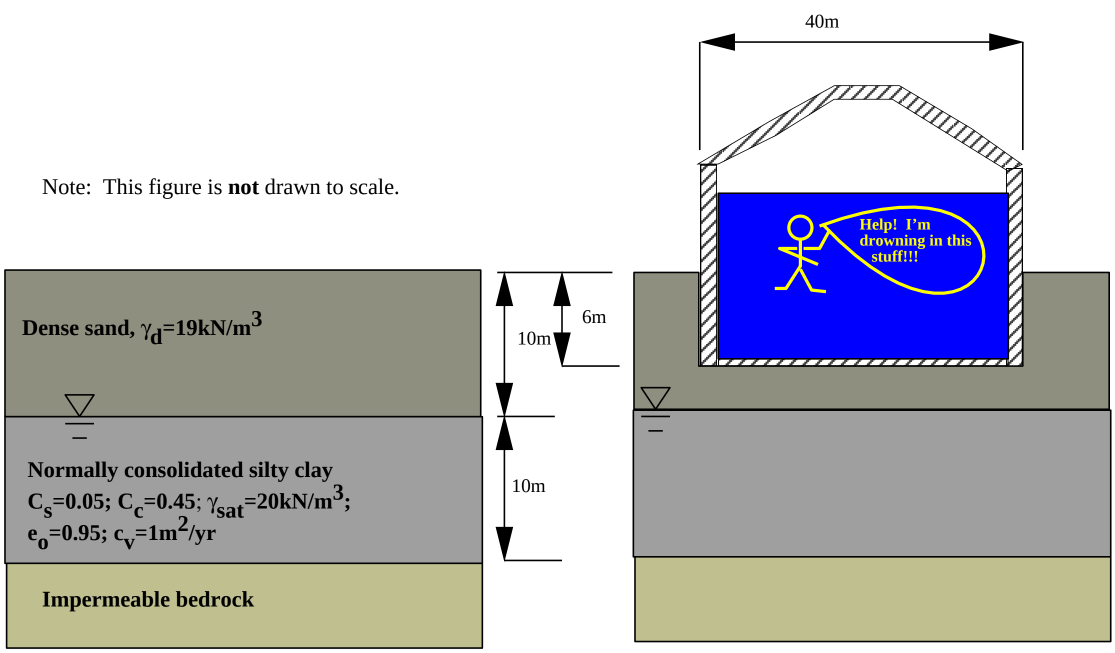

Figure 4a

Figure 4b

Figure 4. a) Existing site configuration; and b) Proposed configuration after construction.

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

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

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