The University of Iowa
Department of Civil & Environmental Engineering
SOIL MECHANICS 53:030
Midterm Exam II
(1 Hour)

Fall 1997 Instructor: C.C. Swan

Problem #1: (50 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 1a. To construct the tank, 6m of the dense sand layer will be excavated, and the tank will be built as shown in Figure 1b. For the values provided in Figure 1:

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.

Note: This figure is **not** drawn to scale.

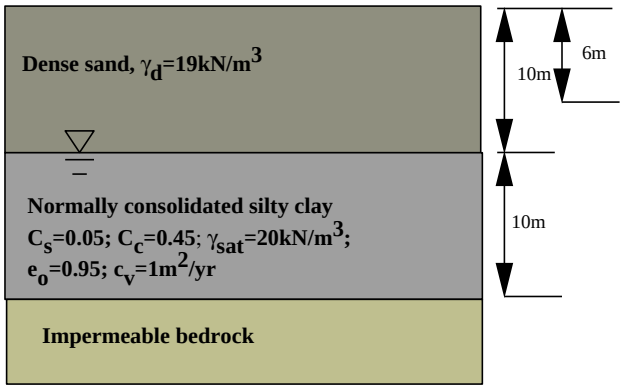

Figure 1a

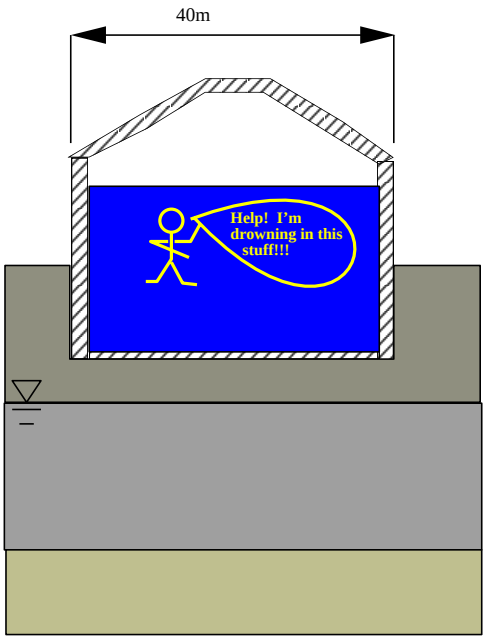

Figure 1b

Figure 1. 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.

Problem #2: (50 points)

Two consolidated, drained (CD) triaxial compression tests were performed on over-consolidated silty soil samples removed from the field. The objective of the two tests was to measure the soil's cohesion c and drained friction angle ϕ_D. The results of the two tests are as follows:

- Test 1: at failure, σ_1 = 287.94kPa; σ_3=100kPa; u = 100kPa
- Test 2: at failure, σ_1 = 491.90kPa; σ_3=200kPa; u = 100kPa

The tests were performed so slowly that the pore pressure u remained constant at 100kPa. Therefore, the tests were **drained** triaxial compression tests.

a. Using the Mohr's circle and Mohr-Coulomb failure geometry shown below in Figure 2, find a relationship between σ_1' and σ_3' at shear failure in terms of the cohesion c and friction angle ϕ_D. **To receive credit, show all work.**
b. Using this relationship, and the results of the two CD triax tests, solve for the cohesion c and drained friction angle ϕ_D for the soil.
c. During the triaxial compression tests on the soil samples, what would be the expected orientation θ of the shear failure planes in the soil samples? (Use the Pole Method, and assume that σ_1 is applied in the horizontal direction and σ_3 in the vertical direction.) **Again, show all work to receive credit.**

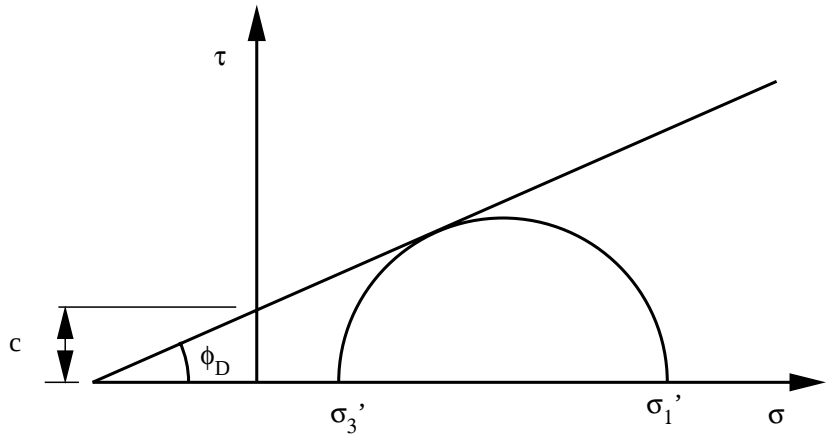

Figure 2. Mohr-Coulomb failure envelope and Mohr's circle for consolidated-drained triaxial compression tests.

Bonus Problem: (15 extra points!!!)

a. Identify three of the major assumptions used in deriving our one-dimensional soil consolidation model;
b. Briefly explain how soil grain sizes (i.e. sands versus clays) affect observed shear strength behaviors in terms of drained and undrained responses.
c. Using a sketch of "e versus log(σ_v')", briefly explain how and why pre-loading of sites is sometimes an effective method to reduce consolidation settlements under structural loads applied to clay/silt soils.