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

Fall 2001 Instructor: C.C. Swan

Problem #1: (25 points)

An oil tank weighing 18,000 metric tons is to be supported on a square foundation mat 30m x 30m at a depth of 5m beneath the ground surface (see Figure 1).

(a) Plot qualitatively but neatly, the motion of point A (which is directly beneath the center of the square foundation) from the time the excavation is started until the tank has been constructed and sitting in place for several years. Briefly explain your reasoning.

(b) Calculate the average stress increase in the clay layer directly beneath point A.

(c) How much settlement will have occurred from the tank loading after a period of 5 years?

Recall that the increase in vertical stress at a depth z below the corner of a uniformly loaded flexible rectangular area is: $\Delta\sigma_v = qI_3$, where: I_3 is a function of the dimensionless parameters $m = B/z$ and $n = L/z$ and is provided the final page of this exam handout.

Relevant soil properties:
- Dense sand: $\gamma = 17.5 kN \cdot m^3$
- Clay Soil: $e_0 = 1.00$, $C_s = .05$, $C_c = 0.50$, $c_v = 0.1 m^2 \cdot day^{-1}$, $\gamma_{sat} = 19 kN \cdot m^3$.

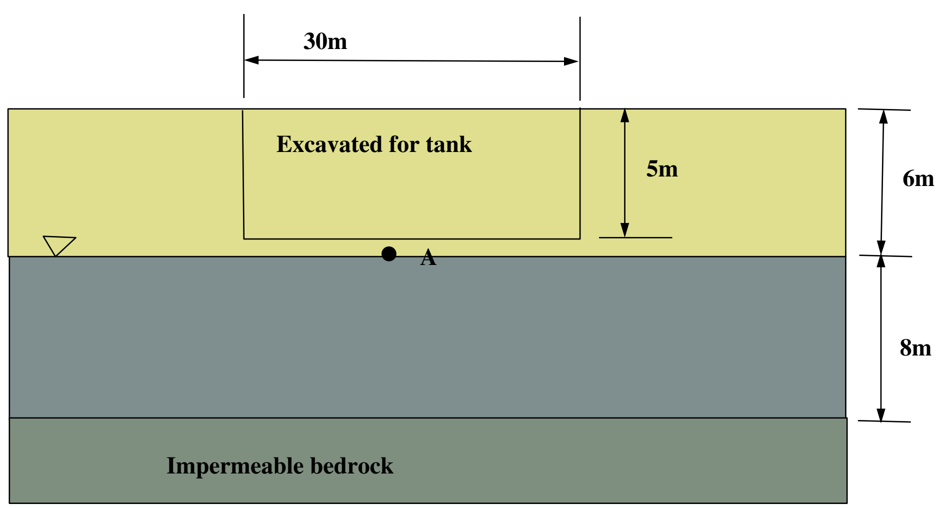

Figure 1.

Problem #2: (25 points)

Consider the soil profile shown in Figure 2. The phreatic surface now coincides with the ground surface, but a long time ago it used to be at a depth of 5 feet below the ground surface. Assume that a uniform pressure of 400 psf is to be applied over a large area:

a. Use the phreatic surface location of "a long time ago" to compute the preconsolidation vertical effective stress in the clay layer.

b. How long will it take to achieve 50% and 90% consolidation of the clay layer under the imposed loading? (Refer to the U vs. T_v curve shown on the final page of this exam handout.)

c. Estimate the ultimate settlement of the ground surface due only to consolidation in the clay layer.

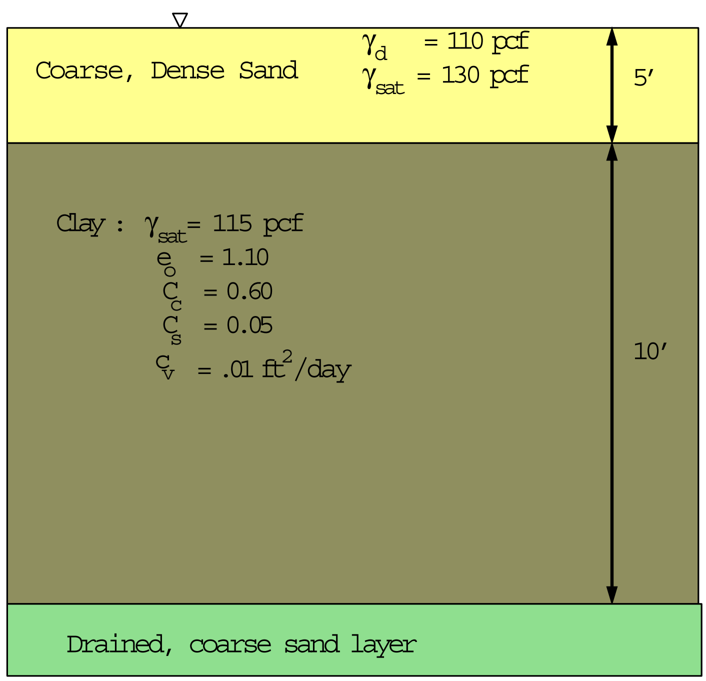

Figure 2.

Problem #3: (25 points)

Figure 3 shows a homogeneous, dry 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=95kPa; horizontal stress σ_h=47.5kPa.

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

b. Using the formulas provided, compute the changes in σ_{xx}, σ_{zz}, and τ_{xz} at point A due to the strip loading.

c. Using Mohr's circle, compute the maximum shear stress at point A after the loading is applied, and the orientation of the plane(s) on which the maximum shear stress will occur. (Use the Pole method.)

d. If the soil will fail when $\sigma_1 = 3\sigma_3$, compute the magnitude of the strip load that would create this situation at point A.

$$\Delta\sigma_{zz} = \frac{q}{\pi}[\alpha + sin(\alpha)cos(\alpha + 2\beta)] \quad \Delta\sigma_{xx} = \frac{q}{\pi}[\alpha - sin(\alpha)cos(\alpha + 2\beta)] \quad \Delta\tau_{xz} = \frac{q}{\pi}[sin(\alpha)sin(\alpha + 2\beta)]$$

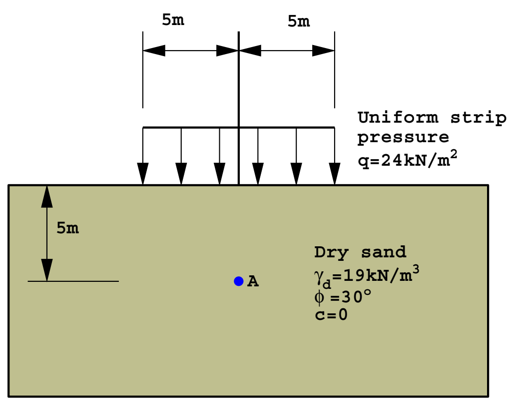

Figure 3. Uniform strip load applied to a dry soil deposit.

Problem #4: (25 points)

a. Explain some of the major assumptions involved in developing the one-dimensional soil consolidation model used in this class.

b. Discuss the relative compressibilities of the soil skeleton of clays and silts and that of water. Explain why the significance of the difference in compressibilities.

c. What factors go into determining how long it will take different soil deposits to consolidate under uniform loading of a site?

d. Explain (using a sketch of e versus log(σ'_v) how pre-loading of a site can sometimes be used to reduce consolidation settlements under foundation loads.