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

Fall 1998 Instructor: C.C. Swan

Problem #1: (30 points)

A gas company is laying small diameter plastic pipe (0.75 inches) approximately three feet beneath the ground surface as shown below in Figure 1. The pipe will crack when the difference in vertical and horizontal soil stresses acting upon it exceeds 10^4 psf (that is when $\sigma_v - \sigma_h = 10^4$ psf). If wheel loads from trucks are idealized as point loads, compute whether or not the pipe could fracture under a very large wheel load of 50,000 pounds directly over the pipe. The initial stresses in the soil in the absence of wheel loads, are shown in Figure 1. Use the following formulas to compute stress increases at the pipe location in the soil under a point load:

$$\Delta\sigma_v = \frac{3Pz^3}{2\pi R^5}; \qquad \Delta\sigma_h = \frac{P}{2\pi}\left[\frac{(1-2\nu)}{R(R+z)} - \frac{3r^2 z}{R^5}\right]$$

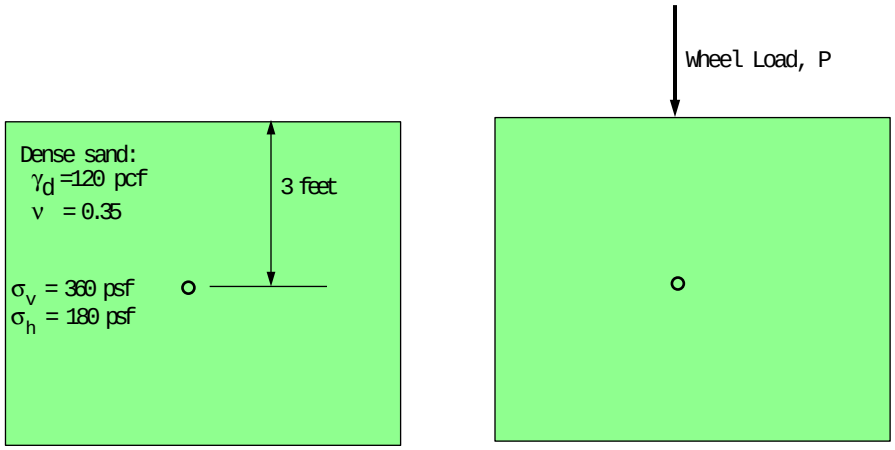

Figure 1. Wheel load and a plastic pipe 3 feet beneath the ground surface.

Problem #2: (35 points)

An enterprising engineer has a novel idea for making sand blocks for usage in construction. The idea is to wrap a dry sand in a cubical plastic liner and to then seal a vacuum pore pressure of -100 kPa in the soil. If the dry sand used to make the blocks has a friction angle of ϕ = 40°:

a. Compute the unconfined compressive strength of the sand blocks. Assume that the plastic liner (other than sealing in a negative pore pressure) has no effect on the strength of the block.

b. Using the Pole Method, predict the orientation of the plane on which shear failure would occur in the sand during the unconfined compression test shown in Figure 2b.

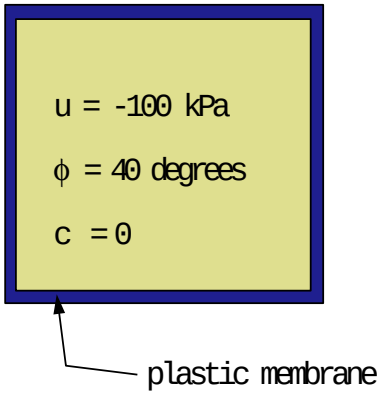

Figure 2a.

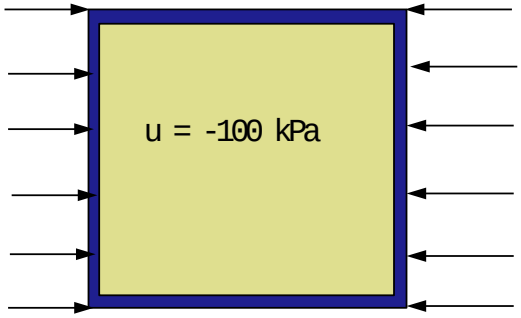

Figure 2b.

Figure 2. a) Sand block wrapped in a membrane with negative pore pressure; b) Unconfined compression test on the sand block.

Problem #3: (35 points)

Consider the soil profile shown in Figure 3. 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 page 4 of this exam handout.)

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

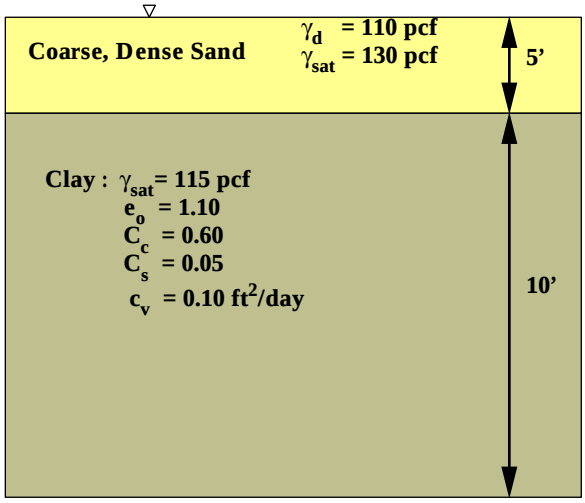

Figure 3. Two-layered soil deposit.

Bonus Problem: (10 extra points!!!)

Clearly explain how soil grain sizes (i.e. sands versus clays) affect observed shear strength behaviors in terms of drained and undrained behaviours.