THE UNIVERSITY OF IOWA
Department of Civil & Environmental Engineering
FOUNDATION ENGINEERING 53:139
Final Exam: 2.0 Hours – 100 points + 10 Bonus points

Spring 1998 Instructor: C.C. Swan

Question #1: (25 points)

Assume that you are designing a cantilever retaining wall to support a granular, cohesionless backfill soil that slopes at an angle α with the horizontal:

a. Draw a sketch of such a wall system, and draw a **neat and clearly labeled** free-body diagram you would use to assess the overturning stability of the system.
b. Which method would you use to compute the overturning force exerted by the soil on the wall system?
c. Aside from overturning, what other standard checks would you perform to assure that your design is adequate?
d. Assume that in performing these design checks, you find that the wall you've designed has **inadequate** factors of safety. Please identify specific measures could you take with respect to each item checked to improve the factor of safety of your cantilever retaining wall system?
e. To mitigate possible water and/or freeze-thaw damage to the wall system, what measures would you take in designing the wall?

Question #2: (10 points)

The following simple equation gives the end-bearing capacity q_p of deep foundations in granular, cohesionless soils:

$$q_p = q' N_q^*,$$

where $N_q^* = N_q^*(\phi)$ and q' is the ambient vertical effective stress at the end bearing depth. This equation suggests that the end bearing capacity of a pile increases indefinitely with the depth of embedment. Is this realistic? If not, please explain why, in terms of a granular soil's **realistic** Mohr-Coulomb shear failure envelope.

Question #3: (15 points)

An open pipe pile of outside diameter 500mm and wall thickness of 7mm is driven through 28m of a normally consolidated soft clay (ϕ = 0; c_u=200kPa) to bear on a layer of Bedford limestone (q_u(lab) = 100 MPa; ϕ = 40°). Compute:

a. the net downloading capacity of the pile; and
b. the net uplift capacity of the pile.

The point bearing stress capacity of rock is:

$$q_p = q_u(\text{field}) * \left[1 + \tan^2\left(45° + \frac{\phi}{2}\right)\right]$$

and the skin friction resistance between the pile and the soil can be estimated as $f = \alpha c_u$, where α can be taken as approximately 0.75.

Question #4: (25 points)

Consider the free cantilever sheet pile wall of Figure 2 shown penetrating an undrained saturated clay soil. Using limit state equilibrium considerations along with the **total stress** $\phi = 0$ **concept**, and the assumed shape of the net pressure distribution on the wall as shown in Figure 1:

a. Compute expressions for the net stress magnitudes p_6 and p_7.

b. Using equilibrium arguments, find a quadratic expression for the minimum necessary depth D of embedment of the wall based on: the soil cohesion c, as well as P and L.

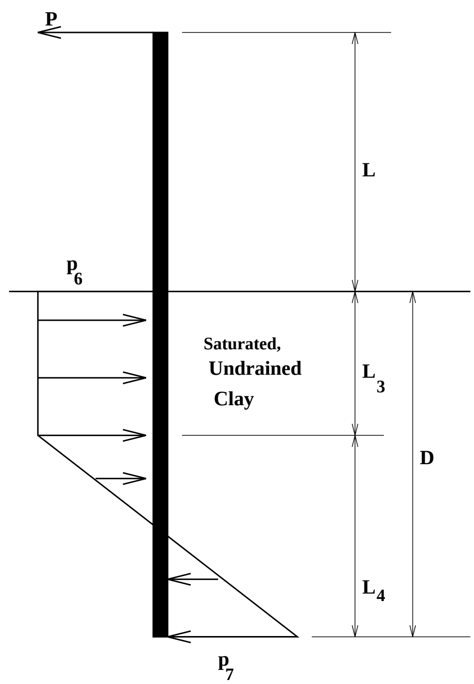

Figure 1.

Question #5: (10 points)

a. What is a hydro-collapsible soil?

b. What tests might you perform on a soil sample to test for hydro-collapse potential?

c. When designing/building shallow foundations on such collapsible soils, what preventative measures can be taken to minimize damage?

Question #6: (15 points)

The following are true/false questions. To answer each, just enter "T" or "F" for each in your test booklet. If you find a question ambiguously worded, you may provide a more extended answer or explanation.

a. Very loose, saturated sands are highly vulnerable to liquefaction during earthquakes since they tend to compact (contract volumetrically) when sheared.

b. Shallow footings for retaining walls and shallow strip footings in general should always be placed as close to the existing ground surface level as possible.

c. When designing deep foundations to resist uplift loads, it is standard practice to use a factor of safety against uplift failure that is larger than the standard factor of safety against downward loading failure.

d. General shear failures tend to occur in dense, well-compacted soils whereas local punching failures are likely to occur in loose soils of low relative density.

e. Three semi-empirical methods of computing the end-bearing capacity of deep foundations bearing on soils are Meyerhoff's, Vesic's, and Janbu's methods. Of these, only Meyerhoff's method accounts for the possibility of local punching failure at the pile or pier tip.

f. H piles are "high-displacement" piles.

g. Invariably, the larger the shear capacity between the soil and the pile, the better.

h. Piles are generally driven in groups and structurally integrated through either grade beams or pile caps.

i. Iowa loess is highly expansive.

j. Expansive soils are those which exist in loose "cemented", semi-dry states and which expand when the cemented bonds disintegrate in the presence of water.

k. A commonly observed rate effect in granular, cohesionless soils is that they show higher strength when loaded rapidly as opposed to quasi-statically. This means that pile driving formula methods to estimate the ultimate capacity of piles in granular, cohesionless soils systematically **over predict** the quasi-static capacity of the piles.

l. The "freeze" behavior of piles driven in clay is related to thixotropic behavior.

m. The friction angle between soil and steel piles is generally less than that of a soil's internal angle of friction ϕ.

n. In general, sheetpile wall anchors can be safely placed a distance of 3.5h away from the wall, where h is the height of the anchor.

o. A high liquid limit(LL) and plasticity index (PI) are strong indicators of a highly expansive soil.

Bonus Question #7: (10 extra points!!)

Consider the situation described in problem #3. A structure was built on a system of end bearing piles passing through a soft clay like that described. At the time the structure was built, the groundwater table was very close to the ground surface, but drains were added to the overall development and resulted in the water table dropping by approximately 10m. Since the time of construction, the structure has been undergoing gradual, unexpected differential settlements which are causing increasing damage. As a foundations consultant, you've been called in to diagnose the situation. What is your assessment of the problem? Please be as specific as possible.