53:139 FOUNDATION ENGINEERING

Civil & Environmental Engineering, The University of Iowa
Spring Semester 2002
Instructor: C.C. Swan

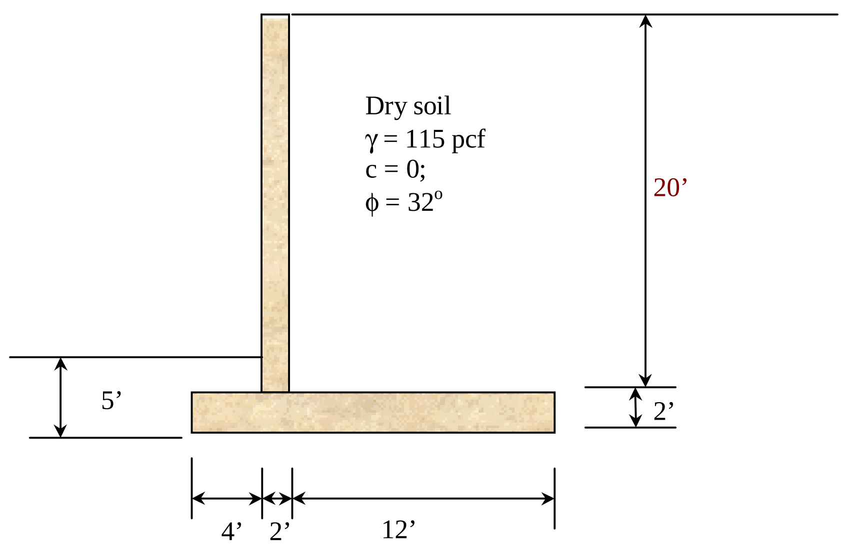
Final Exam, 2 hours, 10 questions, 200 points

<u>To receive due credit, show all of your work.</u>

Question #1: (30 points)

Consider the concrete cantilever retaining wall system below. Using a labeled free-body diagram, showing all of your work, and noting any assumptions you invoke:

- Calculate the factor of safety against overturning;
- Calculate the factor of safety against sliding.



Question #2: (15 points)

Explain the significance or physical meaning of each of the following:

a. K_o, the coefficient of earth pressure at rest $\approx 1 - \sin(\phi)$
b. K_a, Rankine’s coefficient of active earth pressure = $\tan^2(45^o - \phi/2)$
c. K_p, Rankine’s coefficient of passive earth pressure = $\tan^2(45^o + \phi/2)$

Question 3: (20 points)

An open pipe pile of outside diameter 628 mm and wall thickness of 10 mm is driven through 15 m of a normally consolidated soft undrained clay whose cohesion increases linearly with depth ($c = z * 10\ kN/m^3$). The pile bears on a thick stratum of weathered limestone [$(q_u)_{lab}$ = 128 MPa; $\phi = 15^o$]. Compute:

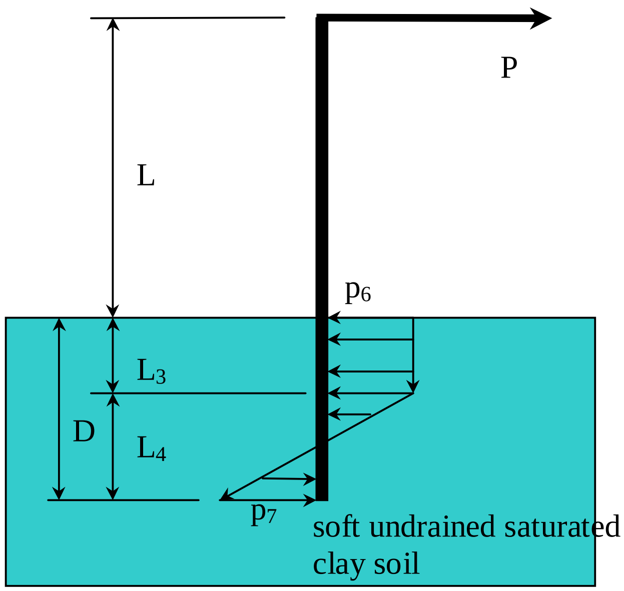
a. the net downloading capacity of the pile; and
b. the net uplift capacity of the pile.

The point bearing stress capacity of rock is: $q_p = (q_u)_{field} * \left[1 + \tan^2(45^\circ + \frac{\varphi}{2})\right]$
and the skin friction resistance between the pile and the soil can be estimated as $f(z) = \alpha\ c(z)$, where α can be taken as approximately 0.75.

Question 4: (40 points)

Consider the free cantilever sheet pile wall below shown penetrating an undrained saturated clay soil. Using limit state equilibrium considerations along with the total stress concept, and the assumed shape of the net pressure distribution on the wall as shown below:

a. Develop expressions for the net stress magnitudes p_6 and p_7.
b. Find a quadratic expression for the minimum necessary depth of embedment of the wall based on: the soil cohesion c, as well as P and L.
c. In terms of the loads shown, develop an expression for the maximum bending moment in the wall.
d. Develop an expression for the location of the maximum bending moment.



Question 5: (20 points)

a. What is the basic idea underlying most pile driving formulae that estimate the ultimate capacity of driven piles?
b. Please discuss (briefly) the pro's and cons of using pile driving formulae to estimate pile capacities.

Question 6: (25 points)

If a rigid square steel plate with edge lengths of 1m were to be used to anchor the retaining wall of Question 1, and if the center of the anchor were placed 5m beneath the ground surface of the backfill, estimate the ultimate load that could be resisted by the anchor. (Provide a sketch, and show all of your work.)

Question 7 : (15 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 measures can be taken to minimize potential damage?

Question 8 : (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 extensive answer or explanation.

a. Very loose, saturated sands are potentially vulnerable to liquefaction during earthquakes since they tend to densify 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. Pre-stressed concrete is the ideal material system for end-bearing piles that are to be driven to “refusal” in bedrock.
f. H piles are “high-displacement” piles.

g. Invariably, the larger the skin friction 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 tend to over estimate the static ultimate capacity of piles in granular, cohesionless soils.
l. The “freeze” behavior of piles driven in clay is related to thixotropic behavior.
m. The friction angle δ 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.

Question 9: (10 points)

Consider the piles described in Question 3. An industrial structure was built on a system of end bearing piles like these, passing through a soft normally-consolidated clay like that described and bearing on bedrock. At the time the structure was built, the groundwater table was very close to the ground surface but since that time, however, drainage has been added to the site, resulting in the water table dropping by approximately 3m. With the dropping water table, the structure has been undergoing gradual settlements, and even significant differential settlements that are causing increasing damage. As a foundations consultant, you've been called in to diagnose the situation. Being as specific as possible, please provide your assessment of the problem.

Question 10: (10 points)

a. Aside from your own, which of the student project presentations did you find most interesting, and why?
b. Identify one thing concerning foundations that you learned from that presentation.