14.531 ADVANCED SOIL MECHANICS
FINAL EXAM (TAKE HOME): DUE THURSDAY, DECEMBER 19, 2013 @ 6PM.

Problem #1. Field load tests on strip footings yielded the test data provided below in Figure 1 and Table 1 (from Ladd, 1979). Based on these test results, estimate the following quantities for a strip footing with $B = 4m$ and $d = 2m$.

a. The ultimate bearing capacity of the strip footing
b. The settlement at $\Delta q = 20$ tonnes per square meter (TSM). Assume that settlement is proportional to $\log B$.

\[ q = \text{Total Applied Stress} \]
\[ \Delta q = \text{Net Applied stress} = q - \gamma d \]

\[ \gamma = 1.50 \text{ TCM (above footing)} \]
\[ \gamma = 2.00 \text{ TCM (above footing)} \]

Figure 1. Test Conditions for Strip Footing.

Table 1. Test Data for Problem #1.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>B (m)</th>
<th>d (m)</th>
<th>$q_{ult}$ (TSM)</th>
<th>$\rho$ (cm) at $\Delta q = 10$ TSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
<td>42</td>
<td>0.400</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>1</td>
<td>105</td>
<td>0.300</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>1</td>
<td>147</td>
<td>0.525</td>
</tr>
</tbody>
</table>
Problem #2. Your company plans to test load a 150 ft diameter oil tank with water. The stress increase at the ground surface ($\Delta q$) will be 3,000 psf. The tank rests on the surface of 60 ft of dry sand with the properties shown in Figure 2. Using the provided information, do the following:

a. Estimate the settlement of the center of the tank using the “stress path” method (and the data provided in Figure 2) to plot $\Delta \sigma'/\sigma'_{vo}$ and $\Delta K$ vs. depth and compute the vertical strains at depth (d) of 10, 20, 30, 40, and 50 ft.

b. Estimate the settlement of the center of the tank using “corrected” SPT N values that averaged 40 to 50 blows per foot.

c. Back calculate a value of modulus of elasticity (E) that yields the same settlement obtained with the stress path method using equations 14.15 and 14.21 in L&W.

d. Compare your answer for part c with the value of E obtained from Figure 2, assuming that $\sigma'_{vo} = 2,000$ psf, $\Delta \sigma'_{vo} = 2,000$ psf, and $\Delta K = K_o = 0.35$. See Example 12.2 for calculation of E.

Assume the following stress distribution provided in Table 2 and an elastic half space with $\nu = 0.30$.

Table 2. Stress Distribution for Problem #2.

<table>
<thead>
<tr>
<th>z (ft)</th>
<th>$\Delta \sigma_v$ (psf)</th>
<th>$\Delta \sigma_h$ (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3000</td>
<td>2400</td>
</tr>
<tr>
<td>7.5</td>
<td>3000</td>
<td>2010</td>
</tr>
<tr>
<td>10</td>
<td>3000</td>
<td>1890</td>
</tr>
<tr>
<td>20</td>
<td>2950</td>
<td>1445</td>
</tr>
<tr>
<td>30</td>
<td>2850</td>
<td>1025</td>
</tr>
<tr>
<td>40</td>
<td>2700</td>
<td>729</td>
</tr>
<tr>
<td>50</td>
<td>2450</td>
<td>490</td>
</tr>
</tbody>
</table>
Figure 2. Stress-Strain as a Function of $\Delta K$ for Problem 2.
Problem #3. Lambe and Whitman Problem 16.3.

Problem #4. Calculate the theoretical height of capillary rise and the capillary pressure in a clay soil with $D_{10} = 0.1 \mu m$.

Problem #5. An inclined permeameter tube filled with three layers of soil of different permeabilities as shown below in Figure 3. Express the total head at Points A, B, C, and D (with respect to the indicated datum) in terms of the given dimensions and permeabilities. Plot the total heads and the seepage velocity versus distance along the line A-D for the case where $3k_1 = k_2 = 2k_3$. Assume $n_1 = 0.25$, $n_2 = 0.4$, and $n_3 = 0.35$.

![Figure 3. Inclined Permeameter Tube for Problem #5.](image)


Problem #7. Figure 4 shows a double sheet pile wall system for construction dewatering. A steady-state 2D flow of water occurs into the inside of the excavation between the two walls. For this problem, do the following:

a. Draw the flow net for this problem. You may use computer programs if they are available to you.
b. Compute the rate of flow per foot of wall length.
c. Determine the maximum exit gradient and the factor of safety against liquefaction.
d. Plot the pore water pressure against both sides of the sheet pile wall.
Sand
\[ \gamma_t = 124.8 \text{ pcf} \]
\[ k = 2 \times 10^{-4} \text{ cm/sec} \]

**Figure 4.** Double Sheet Pile Wall Layout for Problem #8 (Not To Scale).