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ENCE 4340 Foundation Engineering Fall 2011 Class Test # 1 (10-12-2011)

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Problem #1 : A mat foundation on a saturated clay has dimensions of 20m x 20m. Given :

dead load and live load = 48 MN, $c_u = 30\ kN/m^2$, $\gamma_{clay} = 18.5\ kN/m^3$.

(*a*) Find the depth, D_f, of the mat for a fully compensated foundation

(b) What will be the depth of the mat (D_f) for a factor of safety of 2 against bearing capacity failure?

$Q = 48\ MN$

a) $D_f = \frac{Q}{A\gamma} = \frac{48\ MN}{400\ m^2(18.5\ KN/m^3)} = \frac{48000\ KN}{400(18.5)} = \boxed{6.48\ m}$ ✓

b) $2 = FS = \frac{5.14\ c_u\left(1+\frac{0.195\ B}{L}\right)\left(1+0.4\frac{D_f}{B}\right)}{\frac{Q}{A}-\gamma D_f} = \frac{5.14(30\ KN/m^2)\left(1+\frac{0.195(20)}{20}\right)\left(1+0.4\frac{D_f}{20}\right)}{\frac{48000}{400}-18.5(D_f)}$

$2 = \frac{184.269\left(1+0.4\frac{D_f}{20}\right)}{120-18.5\ D_f} \Rightarrow \boxed{D_f = 1.37\ m}$ ✓

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5.33
5.41

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Problem #2 : Refer fo Figure 5.16 where a foundation of size 1.8m x 1.8m is resting on sand.

Given : $q_0 = 190\ kN/m^2$; $D_f = 1.0m$; $H = 15m$; $\mu_s = 0.4$; $E_s = 15400\ kN/m^2$; and $\gamma = 17\ kN/m^3$

Assuming that the foundation is rigid, determine the elastic settlement the foundation would undergo.

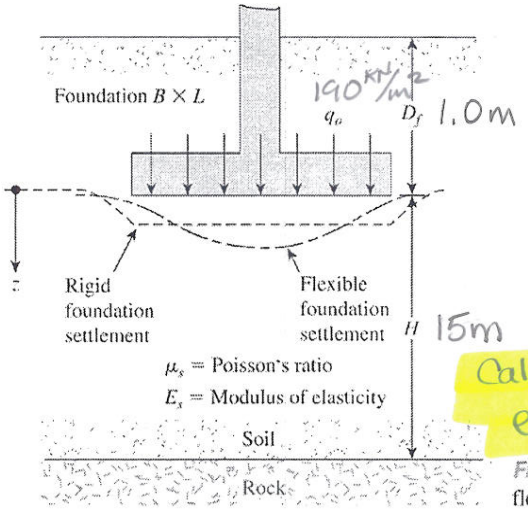

Figure 5.16 Elastic settlement of flexible and rigid foundations

$$S_e = q_0 (\alpha B') \frac{1-\mu_s^2}{E_s} I_s I_f$$

$B' = \frac{B}{2} = \frac{1.8}{2} = 0.9$

$\alpha = 4$ (center)

$I_s = F_1 + \frac{1-2\mu_s}{1-\mu_s} F_2$

$m' = \frac{L}{B} = 1 \qquad n' = \frac{H}{\frac{B}{2}} = \frac{15}{\frac{1.8}{2}} = 16.67$

$F_1 \simeq \frac{0.529 - 0.498}{2} = 0.5135$

$F_2 \simeq 0.012$

$= 0.5135 + \frac{1-2\times0.4}{1-0.4}(0.012)$

Calculation error → $I_s = 0.003762$ ← 0.515

$\frac{D_f}{B} = \frac{1}{1.8} = 0.56$

$\frac{B}{L} = 1$

$I_f \simeq 0.78$

$$S_{e,flex} = 190\,(4\times0.9)\frac{1-0.4^2}{15400}(0.003762)(0.78) = 1.095\times10^{-4}\ m$$

0.01499 m

$$S_{e,rigid} \simeq 0.93\, S_{e,flex} = 1.018\times10^{-4}\ m$$

0.0139 m

= 13.94 mm

$S_{e\,rigid} = 14.3$ mm

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Problem #3: Refer fo Figure 4.11. For a rectangular foundation on layered sand, given :

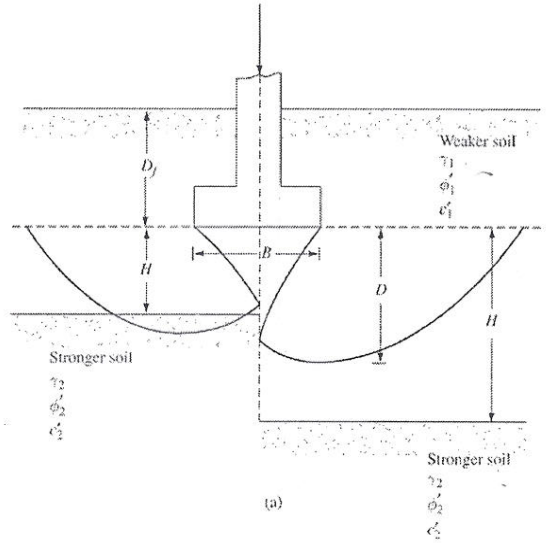
$B = 4\text{ ft}, L = 6\text{ ft}, H = 2\text{ ft}, D_f = 3\text{ ft}$

$\gamma_1 = 98\text{ lb/ft}^3, \phi_1' = 30^0, c_1' = 0$ $\quad N_{c1} = 30.14 \quad N_{q1} = 18.4 \quad N_\gamma = 22.40$

$\gamma_2 = 108\text{ lb/ft}^3, \phi_2' = 38^0, c_2' = 0$ $\quad N_{c2} = 61.35 \quad N_{q2} = 48.93 \quad N_\gamma = 78.03$

$q_{all} = \frac{q_u}{FS}$

Using a factor of safety of 4, determine the gross allowable load the foundation can carry.



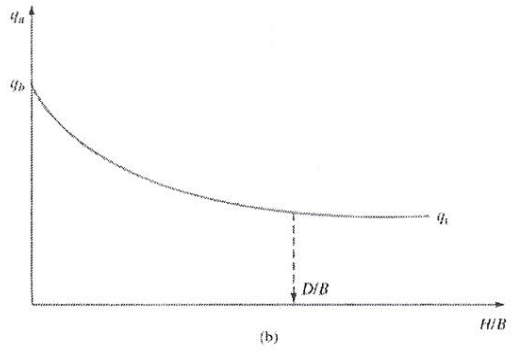


Figure 4.11 (a) Foundation on weaker soil layer underlain by stronger sand layer, (b) Nature of variation of q_u with H/B

$q_1 = c_1'(N_{c1}) = 0$

$q_2 = \text{"} = 0$

$q_u = q_t + (q_b - q_t)\left(\frac{H}{D}\right)^2$

$q_t = \left(1 + 0.2\frac{B}{L}\right)^{\to 0} N_{c1} c_1 + \gamma_1 D_f = 0 + 98(3\text{ ft}) = 294\ \frac{\text{lb}}{\text{ft}^2}$

$q_b = \left(1 + 0.2\frac{B}{L}\right)^{\to 0} N_{c2} c_2 + \gamma_2 D_f = 0 + 108(3) = 324$

$q_u = 294 + (324 - 294)\left(\frac{2}{3}\right)^2 = 144\ \frac{\text{lb}}{\text{ft}^2}$

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$q_{all} = \frac{144}{4} = \boxed{36\ \frac{\text{lb}}{\text{ft}^2}}$

$Q_{all} = 102.84$ kips

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Problem #4 : Determine the allowable gross vertical load bearing capacity of a continuous foundation using the General Bearing capacity equation.

Given : $B = 4\text{ft}, D_f = 3\text{ ft}, \phi' = 25^0, c' = 600\text{ lb/ft}^2, \gamma = 110\text{ lb/ft}^3$, Factor of safety $= 4$.

for $\phi' = 25^\circ$

$N_c = 20.72 \quad N_q = 10.66 \quad N_\gamma = 10.88$

$q = \gamma D_f = 110(3) = 330$

$q_u = c' N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qi} + \frac{1}{2}\gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i}$ 8/10

Because we are considering cont. found.

$F_{cs} = F_{qs} = F_{\gamma s} = 1$

Calc error →

$F_{qd} = 1 + 2\tan\phi'(1-\sin\phi')^2\left(\frac{D_f}{B}\right) = 1 + 2\tan 25(1-\sin 25)^2\left(\frac{3}{4}\right) = 0.483$

$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'} = 0.483 - \frac{1 - 0.483}{20.72\tan 25} = 0.4295$

1.23 ← 1.23 corrected

1.23 ↑ 1.23

C 1.26

$F_{\gamma d} = 1$

$F_{ci} = F_{qi} = F_{\gamma i} = 1$

$q_u = 600(20.72)(1)(0.4295)(1) + 330(10.66)(1)(0.483)(1)$

$+ 0.5(110)(4)(10.88)(1)(1)(1) = 9432.24\ \text{lb/ft}^2$

1.26 ↑ 1.23 ↑ 22384 ↑ 5596

$q_{all} = \frac{q_u}{FS} = \frac{9432.24}{4} \simeq 2360\ \frac{\text{lb}}{\text{ft}^2}$ $q_{all} = 5278\ \text{lb/ft}^2$

$Q = 2360\ B^2 = 2360(4)^2 = \boxed{37760\text{ lbs}}$

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Problem #5 : The laboratory test results of a soil is given in the following table. Classify the soil by : (a) AASHTO soil classification system, and (b) Unified Soil Classification system.

Sieve No.	Percent Passing
4	92
10	48
40	28
200	13

$PI = LL - PL = 31 - 26 = 5$

Liquid Limit = 31, Plastic Limit = 26

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a) Granular materials < 35% pass No. 200

A-1-a

a) A-1-a(0)

b) Coarse grained soils > 50% retained on No. 200

- Sands > 50% pass No. 4
- Gravels w/ Fines more than 12% fines
- Fines ~~clay~~ plot above A-line (CH)

b) SM silty Sand

Symbol GC

Clayey-Gravel