3.8

$$B' = B - 2\ e = 1.5 - (2 \cdot .1) = 1.3\ m$$

$$L' = L = 1.5\ m$$

$c' = 0$ No load inclination

$$\therefore\ q'_u = q \cdot N_q \cdot F_{qs} \cdot F_{qd} + \frac{1}{2} \cdot \gamma \cdot B \cdot N_\gamma \cdot F_{\gamma s} \cdot F_{\gamma d}$$ [Eq. 3.40]

$\phi' = 32\ ^\circ \quad \therefore\ N_q = 23.18$

$N_\gamma = 30.22$ [Tbl. 3.3]

$$F_{qs} = 1 + \left(\frac{B'}{L'}\right) \cdot tan(\phi') = 1 + \left(\frac{1.3}{1.5}\right) \cdot tan(32) = 1.54$$ [Tbl. 3.4]

$$F_{qd} = 1 + 2 \cdot tan(\phi')\ (1 - sin\phi')^2 \cdot \left(\frac{D_f}{B}\right) = 1 + 2 \cdot tan(32) \cdot (1 - sin(32))^2 \cdot \left(\frac{.8}{1.5}\right) = 1.147$$

$$F_{\gamma s} = 1 - .4 \cdot \left(\frac{B'}{L'}\right) = 1 - .4 \cdot \left(\frac{1.3}{1.5}\right) = .653$$

$$F_{\gamma d} = 1$$

$$\therefore q'_u = (.8 \cdot 17) \cdot 23.18 \cdot 1.54 \cdot 1.147 + \frac{1}{2} \cdot 17 \cdot 1.3 \cdot 30.22 \cdot .653 \cdot 1 = 774.91\ \frac{kN}{m^2}$$

$$Q_{all} = \frac{q'_u \cdot B' \cdot L'}{FS} = \frac{774.91 \cdot 1.3 \cdot 1.5}{4} = 377.8\ kN$$

$Q_{all} = 377.8$ kN

3.12

$$e = \frac{M}{Q} = \frac{70\ kN \cdot m}{450\ kN} = .156m \qquad c' = 0 \qquad B = L \because$$ Square Foundation

$$\therefore Q_{ult} = B^2 \cdot \left(q \cdot N_{q(e)} \cdot F_{qs(e)} + \frac{1}{2} \cdot \gamma' \cdot B \cdot N_{\gamma(e)} \cdot F_{\gamma s(e)}\right)$$ [Eq. 3.43]

$$Q_{ult} = 450\ kN \cdot FS = 450\ kN \cdot 6 = 2700\ kN$$

$$q = \gamma \cdot D_f = 16\ \frac{kN}{m^3} \cdot 1.3\ m = 19.2\ \frac{kN}{m^2}$$

$$\gamma' = \gamma_{sat} - \gamma_w = 19\ \frac{kN}{m^3} - 9.81\ \frac{kN}{m^3} = 9.19\ \frac{kN}{m^3}$$

$F_{qs(e)} = 1$ [Eq. 3.45]

$$F_{\gamma s(e)} = 1 + \left(\frac{2 \cdot e}{B} - .68\right) \cdot \frac{B}{L} + \left(.43 - \frac{3}{2} \cdot \frac{e}{B}\right) \cdot \left(\frac{B}{L}\right)^2 \quad \text{[Eq. 3.46]}$$

$$= 1 + \left(\frac{2 \cdot .156}{B} - .68\right) \cdot 1 + \left(.43 - \frac{3}{2} \cdot \frac{.156}{B}\right) \cdot 1^2 = .75 + \frac{.078}{B}$$

$$\therefore 2700 = B^2 \cdot \left(19.2 \cdot N_{q(e)} \cdot 1 + \frac{1}{2} \cdot 9.19 \cdot B \cdot N_{\gamma(e)} \cdot \left(.75 + \frac{.078}{B}\right)\right)$$

Iterative procedure using trial and error:
Try B=2.5m

$$\frac{e}{B} = \frac{.156}{2.5} = .0624 \qquad \phi' = 30\ ^\circ \qquad \therefore\ N_{q(e)} = 17 \quad \text{[Fig. 3.16]}$$
$$N_{\gamma(e)} = 16 \quad \text{[Fig. 3.17]}$$

$$\therefore\ 2.5^2 \cdot \left(19.2 \cdot 17 \cdot 1 + \frac{1}{2} \cdot 9.19 \cdot 2.5 \cdot 16 \cdot \left(.75 + \frac{.078}{2.5}\right)\right) = 2937.4\ kN$$

$2937.4 > 2700$ [OK]

Use B=2.5m

3.13

$$\frac{e_L}{L} = \frac{.36}{1.8} = .2 > \frac{1}{6} < .5 \qquad e_B = \frac{.12}{1.2} = .1 < \frac{1}{6} < .5 \qquad \therefore \text{ Case II}$$

$$\frac{L_1}{L} = .865 \quad \frac{L_2}{L} = .22 \qquad \text{[Fig. 3.21]}$$

$$\therefore\ L_1 = .865 \cdot 1.8\ m = 1.557\ m \qquad L_2 = .22 \cdot 1.8\ m = .396m$$

$$A' = \frac{1}{2} \cdot (L_1 + L_2) \cdot B = \frac{1}{2} \cdot (1.577 + .396) \cdot 1.2\ m = 1.172\ m^2 \qquad \text{[Eq. 3.58]}$$

$$B' = \frac{A'}{L_1} = \frac{1.172}{1.557} = .753m \quad \text{[Eq. 3.59]}$$

$L' = L_1 = 1.557\ m$ [Eq. 3.59]

$c' = 0$ No load inclination

$\therefore\ q'_u = q \cdot N_q \cdot F_{qs} \cdot F_{qd} + \frac{1}{2} \cdot \gamma \cdot B \cdot N_\gamma \cdot F_{\gamma s} \cdot F_{\gamma d}$ [Eq. 3.40]

$\phi' = 35\ ^\circ \quad \therefore\ N_q = 33.3$

$N_\gamma = 48.03$ [Tbl. 3.3]

$q = \gamma \cdot D_f = 17\ \frac{kN}{m^3} \cdot 1\ m = 17\ \frac{kN}{m^2}$

$F_{qs} = 1 + \left(\frac{B'}{L'}\right) \cdot tan(\phi') = 1 + \left(\frac{.753}{1.557}\right) \cdot tan(35) = 1.339$ [Tbl. 3.4]

$F_{qd} = 1 + 2 \cdot tan(\phi')\ (1 - sin\phi')^2 \cdot \left(\frac{D_f}{B}\right) = 1 + 2 \cdot tan(35) \cdot (1 - sin(35))^2 \cdot \left(\frac{1}{1.2}\right) = 1.212$

$F_{\gamma s} = 1 - .4 \cdot \left(\frac{B'}{L'}\right) = 1 - .4 \cdot \left(\frac{.753}{1.557}\right) = .806$

$F_{\gamma d} = 1$

$\therefore \quad q'_u = (17 \cdot 1) \cdot 33.3 \cdot 1.339 \cdot 1.212 + \frac{1}{2} \cdot 17 \cdot .753 \cdot 48.03 \cdot .806 \cdot 1 = 1166.49\ \frac{kN}{m^2}$

$Q_{all} = \frac{q'_u \cdot B' \cdot L'}{FS} = \frac{1166.49 \cdot .753 \cdot 1.557}{3} = 455.87\ kN$

$Q_{all} = 455.87$ kN

4.1

$q_u = q \cdot N^\circ_q \cdot F^\circ_{qs} + \frac{1}{2} \cdot \gamma \cdot B \cdot N^\circ_\gamma \cdot F^\circ_{\gamma s}$ [Eq. 4.3]

$\frac{H}{B} = \frac{2\ ft}{3\ ft} = .67 \quad \phi' = 40\ ^\circ$

$\therefore \quad N^\circ_q = 230$ [Fig. 4.4] $\quad m_1 = .4$ [Fig. 4.6]

$N^\circ_\gamma = 170$ [Fig. 4.5] $\quad m_2 = .45$ [Fig. 4.6]

$F^\circ_{qs} = 1 - m_1 \cdot \frac{B}{L} = 1 - .4 \cdot \frac{3}{6} = .8$ [Eq. 4.4]

$$F^{\circ}_{\gamma s} = 1 - m_2 \cdot \frac{B}{L} = 1 - .45 \cdot \frac{3}{6} = .775 \quad \text{[Eq. 4.5]}$$

$$q = \gamma \cdot D_f = 115\ pcf \cdot 3\ ft = 345\ psf$$

$$q_u = 345 \cdot 230 \cdot .8 + \frac{1}{2} \cdot 115 \cdot 3 \cdot 170 \cdot .775 = 86206.88\ psf$$

$$Q_{all} = \frac{q_u \cdot B \cdot L}{FS} = \frac{86206.88 \cdot 3 \cdot 6}{4} = 387930.94\ lbs = 387.93\ kips$$

$$Q_{all} = 387.93\ kips$$

4.6

Special Case #3:

$$\frac{B}{L} = \frac{.92m}{1.22\ m} = .754 \qquad \frac{c_2}{c_1} = \frac{43\ \frac{kN}{m^2}}{72\ \frac{kN}{m^2}} = .597$$

$$\frac{c_a}{c_1} = .975 \quad \text{[Fig. 4.10]}$$

$$\therefore$$

$$c_a = .975 \cdot c_1 = .975 \cdot 72 = 70.2\ \frac{kN}{m^2}$$

[Eq. 4.29,4.30]

$$q_u = \left(1 + .2 \cdot \frac{B}{L}\right) \cdot 5.14 \cdot c_2 + \left(1 + \frac{B}{L}\right) \cdot \frac{2 \cdot c_a \cdot H}{B} + \gamma_1 \cdot D_f \leq \left(1 + .2 \cdot \frac{B}{L}\right) \cdot 5.14 \cdot c_1 + \gamma_1 \cdot D_f$$

$$= \left(1 + .2 \cdot \frac{.92}{1.22}\right) \cdot 5.14 \cdot 43 + \left(1 + \frac{.92}{1.22}\right) \cdot \frac{2 \cdot 70.2 \cdot .76m}{.92} + 17 \cdot .92m$$

$$\leq \left(1 + .2 \cdot \frac{.92}{1.22}\right) \cdot 5.14 \cdot 72 + 17 \cdot .92$$

$$q_u = 473.44\ \frac{kN}{m^2} \leq 441.54\ \frac{kN}{m^2}$$

$$Q_u = q_u \cdot B \cdot L = 441.54 \cdot .92 \cdot 1.22 = 495.58\ kN$$

$Q_u = 495.58$ kN

4.8

$c' = 0$

$\therefore\ q_t = \gamma_1 \cdot D_f \cdot N_{q(1)} \cdot F_{qs(1)} + \frac{1}{2} \cdot \gamma_1 \cdot B \cdot N_{\gamma(1)} \cdot F_{\gamma s(1)}$ [Eq. 4.33]

$\phi'_1 = 30\ ^\circ \qquad \therefore\ N_{q(1)} = 18.4$ [Tbl. 3.3]

$N_{\gamma(1)} = 22.4$

$F_{qs(1)} = 1 + \left(\frac{B}{L}\right) \cdot tan\left(\phi'_1\right) = 1 + \left(\frac{4\ ft}{6\ ft}\right) \cdot tan(30) = 1.385$ [Tbl. 3.4]

$F_{\gamma s(1)} = 1 - .4 \cdot \frac{B}{L} = 1 - .4 \cdot \frac{4}{6} = .733$

$q_t = 98\ pcf \cdot 3\ ft \cdot 18.4 \cdot 1.385 + \frac{1}{2} \cdot 98 \cdot 4 \cdot 22.4 \cdot .733 = 10711.5\ psf$

$q_b = \gamma_2 \cdot D_f \cdot N_{q(2)} \cdot F_{qs(2)} + \frac{1}{2} \cdot \gamma_2 \cdot B \cdot N_{\gamma(2)} \cdot F_{\gamma s(2)}$ [Eq. 4.34]

$\phi'_2 = 38\ ^\circ \qquad \therefore\ N_{q(2)} = 48.93$ [Tbl. 3.3]

$N_{\gamma(2)} = 78.03$

$F_{qs(2)} = 1 + \left(\frac{B}{L}\right) \cdot tan\left(\phi'_1\right) = 1 + \left(\frac{4\ ft}{6\ ft}\right) \cdot tan(38) = 1.52$ [Tbl. 3.4]

$F_{\gamma s(2)} = 1 - .4 \cdot \frac{B}{L} = 1 - .4 \cdot \frac{4}{6} = .733$

$q_b = 108\ pcf \cdot 3 \cdot 48.93 \cdot 1.521 + \frac{1}{2} \cdot 108 \cdot 4 \cdot 78.03 \cdot .733 = 36467.2\ psf$

$q_u = q_t + \left(q_b - q_t\right) \cdot \left(\frac{H}{D}\right)^2$ [Eq. 4.32]

Sand $\therefore\ D = B$

$q_u = 10711.5 + \left(36467.2 - 10711.5\right) \cdot \left(\frac{2}{4}\right)^2 = 17150.4\ psf$

$Q_{all} = \frac{q_u \cdot B \cdot L}{FS} = \frac{17150.4 \cdot 4 \cdot 6}{4} = 102902.6\ lbs = 102.9\ kips$

Qall=102.9 kips

4.12

$$\frac{D_f}{B} = \frac{5\ ft}{4\ ft} = 1.25 \qquad \phi' = 35\ ^\circ$$

$$\left(\frac{D_f}{B}\right)_{cr} = 5$$ [Tbl. 4.3] $\therefore$ Shallow foundation

$m = .25$

$K_u = .936$

$$F_q = 1 + 2\left(1 + m \cdot \frac{D_f}{B}\right) \cdot \frac{D_f}{B} \cdot K_u \cdot tan(\phi')$$ [Eq. 4.53]

$$= 1 + 2\left(1 + .25 \cdot \frac{5}{4}\right) \cdot \frac{5}{4} \cdot .936 \cdot tan(35) = 3.15$$

$$Q_u = F_q \cdot A \cdot \gamma \cdot D_f$$ [Eq. 4.52]

$$= 3.15 \cdot 4\ ft \cdot 4\ ft \cdot 112\ pcf \cdot 5 = 28224\ lbs = 28.22\ kips$$

Qu=28.22 kips

5.8

$$S_e = q_0 \cdot (\alpha \cdot B') \cdot \frac{1 - {\mu_s}^2}{E_s} \cdot I_s \cdot I_f$$ [Eq. 5.33]

$$q_0 = 210\ \frac{kN}{m^2} \qquad \alpha = 4 \qquad B' = \frac{B}{2} = \frac{2\ m}{2} = 1\ m \qquad E_s = 8500\ \frac{kN}{m^2}$$

$$\mu_s = .3 \qquad m' = \frac{L}{B} = \frac{3.2\ m}{2\ m} = 1.6 \qquad n' = \frac{H}{\left(\frac{B}{2}\right)} = \frac{\infty}{\left(\frac{2\ m}{2}\right)} = \infty$$

$F_1 = .697$ [Tbl. 5.8]

$F_2 = 0$ [Tbl. 5.9]

$$I_s = F_1 + \frac{1 - 2 \cdot \mu_s}{1 - \mu_s} \cdot F_2 = .697 + \frac{1 - 2 \cdot \mu_s}{1 - \mu_s} \cdot 0 = .697$$ [Eq. 5.34]

$$\frac{D_f}{\ } = \frac{1.6\ m}{\ } = .8 \qquad \frac{B}{\ } = \frac{2\ m}{\ } = .625$$

$B \quad 2\ m \qquad\qquad L \quad 3.2\ m$

$\therefore \quad I_f = .73$ [Tbl. 5.10]

$$\therefore \quad S_e = 210 \cdot 4 \cdot 1 \cdot \frac{1-.3^2}{8500} \cdot .697 \cdot .73 = .04576m = 45.76\ mm$$

S_e=45.76mm

5.13

$$B_e = \sqrt{\frac{4 \cdot B \cdot L}{\pi}} = \sqrt{\frac{4 \cdot 2\ m \cdot 1\ m}{\pi}} = 1.56\ m \qquad \text{[Eq. 5.43]}$$

$$\beta = \frac{E_0}{k \cdot B_e} = \frac{9000\ \frac{kN}{m^2}}{500\ \frac{\frac{kN}{m^2}}{m} \cdot 1.56} = 11.54$$

$$\frac{H}{B_e} = \frac{2}{1.56} = 1.28$$

$\therefore I_G = .68$ [Fig. 5.18] $\qquad q_0 = 190\ \frac{kN}{m^2}$

$$I_F = \frac{\pi}{4} + \frac{1}{4.6 + 10\left(\frac{E_f}{E_0 + \frac{B_e}{2} \cdot k}\right) \cdot \left(\frac{2 \cdot t}{B_e}\right)^3} \qquad \text{[Eq. 5.47]}$$

$$= \frac{\pi}{4} + \frac{1}{4.6 + 10\left(\frac{15000000\ \frac{kN}{m^2}}{9000\ \frac{kN}{m^2} + \frac{1.56}{2} \cdot 500}\right) \cdot \left(\frac{2 \cdot .23m}{1.56}\right)^3} = .788$$

$$I_E = 1 - \frac{1}{3.5 \cdot e^{1.22 \cdot \mu_s - .4}\left(B_e + 1.6\right)} \qquad \text{[Eq. 5.48]}$$

$$3.5 \cdot e \qquad \cdot \left(\frac{}{D_f} + 1.6\right)$$

$$= 1 - \frac{1}{3.5 \cdot e^{1.22 \cdot .4 - .4} \cdot \left(\frac{1.56}{1\ m} + 1.6\right)} = .917$$

$$S_e = \frac{q_0 \cdot B_e \cdot I_G \cdot I_F \cdot I_E}{E_0} \cdot \left(1 - \mu_s{}^2\right) \text{ [Eq. 5.46]}$$

$$= \frac{190 \cdot 1.56 \cdot .68 \cdot .788 \cdot .917}{9000} \cdot \left(1 - .4^2\right) = .01359m = 13.59\ mm$$

$S_e = 13.59mm$

5.14

$$B_e = \sqrt{\frac{4 \cdot B^2}{\pi}} = \sqrt{\frac{4 \cdot 3^2\ m}{\pi}} = 3.385\ m \qquad \text{[Eq. 5.43]}$$

$$\beta = \frac{E_0}{k \cdot B_e} = \frac{16000\ \frac{kN}{m^2}}{400\ \frac{\frac{kN}{m^2}}{m} \cdot 3.385} = 11.54$$

$$\frac{H}{B_e} = \frac{20\ m}{3.385} = 5.91$$

$\therefore\ I_G = .89$ [Fig. 5.18] $\qquad q_0 = 150\ \frac{kN}{m^2}$

$$I_F = \frac{\pi}{4} + \frac{1}{4.6 + 10\left(\frac{E_f}{E_0 + \frac{B_e}{2} \cdot k}\right) \cdot \left(\frac{2 \cdot t}{B_e}\right)^3} \text{ [Eq. 5.47]}$$

$$= \frac{\pi}{4} + \frac{1}{4.6 + 10\left(\frac{15000000\ \frac{kN}{m^2}}{\qquad}\right)\left(2 \cdot .25m\right)^3} = .815$$

$$4.6+10\left(\frac{}{9000\ \frac{kN}{m^2}+\frac{3.385}{2}\cdot 400}\right)\cdot\left(\frac{}{3.385}\right)$$

$$I_E = 1-\frac{1}{3.5\cdot e^{1.22\cdot\mu_s-.4}\cdot\left(\frac{B_e}{D_f}+1.6\right)}$$ [Eq. 5.48]

$$= 1-\frac{1}{3.5\cdot e^{1.22\cdot .3-.4}\cdot\left(\frac{3.385}{1.5\ m}+1.6\right)} = .923$$

$$S_e = \frac{q_0\cdot B_e\cdot I_G\cdot I_F\cdot I_E}{E_0}\cdot\left(1-\mu_s{}^2\right)$$ [Eq. 5.46]

$$= \frac{150\cdot 3.385\cdot .89\cdot .815\cdot .923}{16000}\cdot\left(1-.3^2\right) = .01933m = 19.33\ mm$$

S_e=19.33mm

5.16

$$q = \gamma\cdot D_f = 18\ \frac{kN}{m^3}\cdot 1.5\ m = 27\ \frac{kN}{m^2}$$

Continuous foundation $\therefore\ z_1 = B$
$z_2 = 4\cdot B$

$$q'_{z(1)} = \left(D_f+z_1\right)\cdot\gamma = \left(1.5+2.5\right)\cdot 18 = 72\ \frac{kN}{m^2}$$

$$I_{z(m)} = .5+.1\cdot\sqrt{\frac{\hat{q}-q}{q'_{z(1)}}} = .5+.1\cdot\sqrt{\frac{195-27}{72}} = .653$$ [Eq. 5.50]

See attached for strain influence factor Diagram and Table

$$C_1 = 1-.5\cdot\left(\frac{q}{\hat{q}-q}\right) = 1-.05\cdot\left(\frac{27}{195-27}\right) = .92$$

$$C_2 = 1+.2log\left(\frac{t(years)}{.1}\right) = 1+.2log\left(\frac{10}{.1}\right) = 1.4$$

$$S_e = C_1\cdot C_2\cdot\left(\hat{q}-q\right)\cdot\Sigma\ \frac{I_z}{E_s}\cdot\Delta z$$ [Eq. 5.49]

$$= .92 \cdot 1.4 \cdot (195 - 27) \cdot .0003517 = .07611m = 76.11\ mm$$

Se=76.11mm

5.18

$$z' = 1.4 \cdot B_R \left(\frac{B}{B_R}\right)^{.75}$$ [Eq. 5.69] Units are meters $\therefore\ B_R = .3$

$$z' = 1.4 \cdot .3 \cdot \left(\frac{1.2\ m}{.3}\right)^{.75} = 1.188\ m$$

$$\frac{S_e}{B_R} = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \left(\frac{1.25 \cdot \frac{L}{B}}{.25 + \frac{L}{B}}\right)^2 \cdot \left(\frac{B}{B_R}\right)^{.7} \cdot \frac{q'}{p_a}$$ [Eq. 5.70]

Normally consolidated sand:

$\therefore\quad \alpha_1 = .14$ [Tbl. 5.12]

$$\alpha_2 = \frac{1.71}{(N'_{60})^{1.4}} = \frac{1.71}{11^{1.4}} = .06$$

$$\alpha_3 = 1$$

$$q' = 210\ \frac{kN}{m^2}$$

$$\therefore\quad S_e = .3 \cdot \left(.14 \cdot .06 \cdot 1 \cdot \left(\frac{1.25 \cdot \frac{4.2}{1.2}}{.25 + \frac{4.2}{1.2}}\right)^2 \cdot \left(\frac{1.2}{.3}\right)^{.7} \cdot \frac{210}{100}\right) = .01901m = 19.01\ mm$$

S_e=19.01mm