Foundations Ch 5 problems 1a, 1b(assume poisson ratio= 0 and 0.3), 2, 4-7

5.1 A flexible circular area is subjected to a uniformly distributed load of 150 kN/m². The diameter of the loaded area is 2 m. Determine the stress increase in a soil mass at a point located 3 m below the center of the loaded area.
a. by using Eq. (5.3)
b. by using Eq. (5.28). Use $\mu_s = 0$

GIVEN $qo := 150 \ \frac{kN}{m^2}$ $B := 2 \ m$ $z := 3 \ m$

FIND 1. Stress Increase in a soil mass at a point located 3 m below

METHOD 1. Using Boussinesq Eq 5.3
2. Using Westergaard Eq 5.28 $\mu s := 0$

SOLUTION 1. $\Delta\sigma := qo\cdot\left[1 - \frac{1}{\left[1 + \left(\frac{B}{2z}\right)^2\right]^{\frac{3}{2}}}\right] = 21.928$

2. $\eta := \sqrt{\frac{(1 - 2\mu s)}{(2 - 2\cdot\mu s)}} = 0.707$ EQ 5.25

$\Delta\sigma := qo\cdot\left[1 - \frac{\eta}{\left[\eta^2 + \left(\frac{B}{2z}\right)^2\right]^{\frac{1}{2}}}\right] = 14.32$

5.2 Refer to Figure 5.4, which shows a flexible rectangular area. Given: $B_1 = 4$ ft, $B_2 = 6$ ft, $L_1 = 8$ ft, and $L_2 = 10$ ft. If the area is subjected to a uniform load of 3000 lb/ft², determine the stress increase at a depth of 10 ft located immediately below point O.

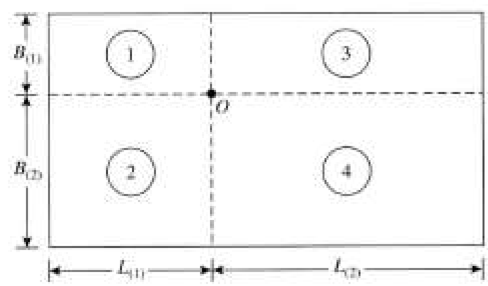

Figure 5.4 Stress below any point of a loaded flexible rectangular area

GIVEN $w := 3000 \ \frac{lb}{ft^2}$ $z := 10 \ m$ $B1 := 4 \ ft$ $B2 := 6 \ ft$
$L1 := 8 \ ft$ $L2 := 10 \ ft$

FIND 1. Stress Increase at 10 ft below point O

METHOD 1. Use Eq 5.7 and 5.8 for m and n
2. Use Eq 5.6 for each rectangle to determine the influence factor I
3. Use Eq 5.5 and 5.9 to determine stress

SOLUTION For rectangle 1: $B := 4$ $L := 8$ $m := \frac{B}{z} = 0.4$ $n := \frac{L}{z} = 0.8$

$$I1 := \frac{1}{4\cdot\pi}\cdot\left[\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 + m^2\cdot n^2 + 1}\right)\cdot\left[\frac{\left(m^2 + n^2 + 2\right)}{\left(m^2 + n^2 + 1\right)}\right] + \operatorname{atan}\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 - m^2\cdot n^2 + 1}\right)\right] = 0.093$$ EQ 5.6

For rectangle 2: $B := 6$ $L := 8$ $m := \frac{B}{z} = 0.6$ $n := \frac{L}{z} = 0.8$

$$I2 := \frac{1}{4\cdot\pi}\cdot\left[\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 + m^2\cdot n^2 + 1}\right)\cdot\left[\frac{\left(m^2 + n^2 + 2\right)}{\left(m^2 + n^2 + 1\right)}\right] + \operatorname{atan}\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 - m^2\cdot n^2 + 1}\right)\right] = 0.125$$

For rectangle 3: $B := 4$ $L := 10$ $m := \frac{B}{z} = 0.4$ $n := \frac{L}{z} = 1$

$$I3 := \frac{1}{4\cdot\pi}\cdot\left[\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 + m^2\cdot n^2 + 1}\right)\cdot\left[\frac{\left(m^2 + n^2 + 2\right)}{\left(m^2 + n^2 + 1\right)}\right] + \operatorname{atan}\left(\frac{2m\cdot n\cdot\sqrt{m^2 + n^2 + 1}}{m^2 + n^2 - m^2\cdot n^2 + 1}\right)\right] = 0.101$$

For rectangle 2: $B := 6$ $\quad L := 10$ $\quad m := \frac{B}{z} = 0.6$ $\quad n := \frac{L}{z} = 1$

$$I4 := \frac{1}{4 \cdot \pi} \cdot \left[\left(\frac{2m \cdot n \cdot \sqrt{m^2 + n^2 + 1}}{m^2 + n^2 + m^2 \cdot n^2 + 1} \right) \cdot \left[\frac{\left(m^2 + n^2 + 2\right)}{\left(m^2 + n^2 + 1\right)} \right] + \operatorname{atan}\left(\frac{2m \cdot n \cdot \sqrt{m^2 + n^2 + 1}}{m^2 + n^2 - m^2 \cdot n^2 + 1} \right) \right] = 0.136$$

$$\Delta\sigma := w \cdot (I1 + I2 + I3 + I4) = 1.366 \times 10^3 \frac{lb}{ft^2} \qquad \text{EQ 5.9}$$

5.4 Using Eq. (5.10), determine the stress increase ($\Delta\sigma$) at $z = 10$ ft below the center of the area described in Problem 5.2.

GIVEN $\quad w := 3000 \frac{lb}{ft^2}$ $\quad z := 10$ m $\quad B1 := 4$ ft $\quad L1 := 8$ ft $\quad B2 := 6$ ft $\quad L2 := 10$ ft $\quad B := B1 + B2 = 10$ ft $\quad L := L1 + L2 = 18$ ft

FIND 1. Stress Increase at 10 ft below point O using Eq 5.10

METHOD
1. Use Eq 5.12 and 5.13 for m1 and n1
2. Use Eq 5.11 to determine the influence factor Ic
3. Use Eq 5.10 to determine stress

SOLUTION $\quad m := \frac{L}{B} = 1.8$ EQ 5.12 $\qquad n := \frac{z}{\left(\frac{B}{2}\right)} = 2$ EQ 5.13

$$Ic := \frac{2}{\pi} \left[\operatorname{asin}\left[\frac{m}{\left(\sqrt{m^2 + n^2}\right) \cdot \left(\sqrt{1 + n^2}\right)} \right] + \left[\frac{(m \cdot n)}{\sqrt{1 + m^2 + n^2}} \right] \frac{\left(1 + m^2 + 2 \cdot n^2\right)}{\left(1 + n^2\right) \cdot \left(m^2 + n^2\right)} \right] = 0.463 \qquad \text{EQ 5.11}$$

$$\Delta\sigma := w \cdot Ic = 1.39 \times 10^3 \frac{lb}{ft^2} \qquad \text{EQ 5.10}$$

5.5 Refer to Figure P5.5. Using the procedure outlined in Section 5.5, determine the average stress increase in the clay layer below the center of the foundation due to the net foundation load of 900 kN.

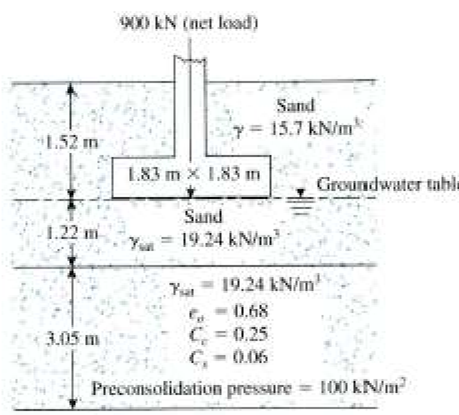

Figure P5.5

GIVEN $\quad Qnet := 900$ kN $\quad Df := 1.52$ m $\quad zs := 1.22$ m $\quad zc := 3.05$ m $\quad B1 := 1.83$ m $\quad L1 := 1.83$ m

FIND 1. Average stress increase in the clay layer due to the Qn foundation

METHOD
1. Refering to Figure 5.9, the foundation base can be divided into four rectangular areas, each measuring:
$L := \frac{L1}{2} = 0.915$ $\quad B := \frac{B1}{2} = 0.915$
2. For the sandy layer: $H1 := zs = 1.22$ m
clay layer: $H2 := zs + zc = 4.27$ m
3. Determine m and n, for each one of the heights above, and Ia(H2) and Ia(H1), using Figure 5.7
4. Determine qo given Qnet and the area of the foundation 5. Determine Δσavg using Eq 5.19

SOLUTION For top of the layer, at height H1: $\quad m := \frac{B}{H1} = 0.75$ $\quad n := \frac{L}{H1} = 0.75$ $\quad IaH1 := 0.205$

For bottom of the layer, at height H2: $\quad m := \frac{B}{H2} = 0.214$ $\quad n := \frac{L}{H2} = 0.214$ $\quad IaH2 := .105$

$$qo := \frac{Qnet}{B1^2} = 268.745\ \text{kN} \qquad \Delta\sigma avg := 4\cdot qo\cdot\frac{(H2\cdot IaH2 - H1\cdot IaH1)}{H2 - H1} = 69.874\ \frac{kN}{m^2}$$

5.6 Solve Problem 5.5 using the 2:1 method [Eqs. (5.14) and (5.84)].

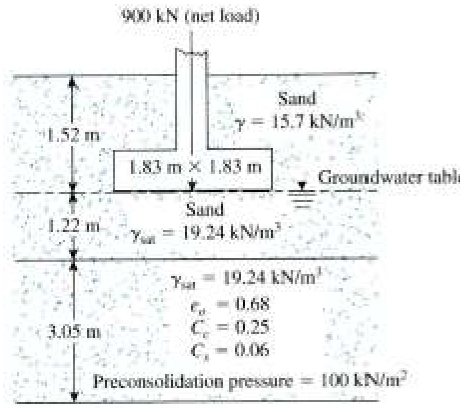

Figure P5.5

GIVEN $Qnet := 900\ \text{kN}$ $Df := 1.52\ \text{m}$ $zs := 1.22\ \text{m}$ $zc := 3.05\ \text{m}$ $B := 1.83\ \text{m}$ $L := 1.83\ \text{m}$

FIND 1. Average stress increase in the clay layer due to the Qn foundation

METHOD 1. Solve using 2:1 method Eq. 5.14 and 5.84

SOLUTION $z1 := zs = 1.22$ $\quad z2 := zs + \frac{zc}{2} = 2.745$ $\quad z3 := zs + zc = 4.27$

$$\Delta\sigma1 := \frac{(Qnet)}{(B + z1)\cdot(L + z1)} = 96.748 \qquad \Delta\sigma2 := \frac{(Qnet)}{(B + z2)\cdot(L + z2)} = 42.999$$

$$\Delta\sigma3 := \frac{(Qnet)}{(B + z3)\cdot(L + z3)} = 24.187 \qquad \Delta\sigma'avg := \frac{(\Delta\sigma1 + 4\cdot\Delta\sigma2 + \Delta\sigma3)}{6} = 48.822\ \frac{kN}{m^2}$$

EQ 5.84

5.7 Figure P5.7 shows an embankment load on a silty clay soil layer. Determine the stress increase at points *A*, *B*, and *C*, which are located at a depth of 5 m below the ground surface.

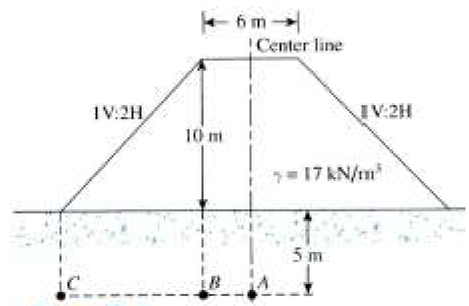

Figure P5.7

GIVEN $w := 3000\ \frac{lb}{ft^2}$ $\quad z := 5\ \text{m}$ $\quad B1 := 4\ \text{ft}$ $\quad L1 := 8\ \text{ft}$ $\quad B2 := 6\ \text{ft}$ $\quad L2 := 10\ \text{ft}$

FIND 1. Stress increase at A, B and C

METHOD 1. Solve using 2:1 method Eq. 5.14 and 5.84

SOLUTION