Homework 8 Solution

1. gross foundation pressure: q_{gross} = 288000/(20x32) = ***450 kPa***
σ_{vo} = (5x16+5x20) = 180 kPa
net foundation pressure: $q_{net} = q_{gross} - \sigma_{vo}$ = 450 – 180 = ***270 kPa***

2. z is the depth from foundation level.

sublayer 1: Clay 1, z = 0 to 5 m,

midpoint z = 2.5 m $\Rightarrow$ σ_{vo}' = 5x16 + (5+2.5).(20-10) = 155 kPa

$$\Delta\sigma = \frac{q_{net} \cdot B \cdot L}{(B + 2tan30^\circ \cdot z).(L + 2tan30^\circ \cdot z)} = \frac{q_{net} \cdot 20 \cdot 32}{22.89 \times 34.89} = 0.802 \times q_{net} = 216kPa$$

$$S = H_o \cdot \left[\frac{C_r}{1+e_o} \cdot log \frac{\sigma_p'}{\sigma_{vo}'} + \frac{C_c}{1+e_o} \cdot log \frac{\sigma_{vo}'+\Delta\sigma}{\sigma_p'} \right] =$$

$$= 5000 \cdot \left[\frac{0.01}{1+0.8} \cdot log \frac{230}{155} + \frac{0.045}{1+0.8} \cdot log \frac{155+216}{230} \right] = 30.8mm$$

sublayer 2: Clay 1, z = 5 to 10 m,

midpoint z = 7.5 m $\Rightarrow$ σ_{vo}' = 5x16 + (5+7.5).(20-10)= 205 kPa

$$\Delta\sigma = \frac{q_{net} \cdot 20 \cdot 32}{(20 + 1.155 \times 7.5).(32 + 1.155 \times 7.5)} = 0.549 \times q_{net} = 148kPa$$

$$S = 5000 \cdot \left[\frac{0.01}{1+0.8} \cdot log \frac{230}{205} + \frac{0.045}{1+0.8} \cdot log \frac{205+148}{230} \right] = 24.7mm$$

sublayer 3: Clay 2, z = 10 to 15 m,

midpoint z = 12.5 m $\Rightarrow$

$$\Delta\sigma = \frac{q_{net} \cdot 20 \cdot 32}{(20 + 1.155 \times 12.5).(32 + 1.155 \times 12.5)} = 0.4 \times q_{net} = 108kPa$$

$$S = H_o \cdot m_v \cdot \Delta\sigma = 5000 \cdot 4 \times 10^{-5} \cdot 108 = 21.6mm$$

sublayer 4: Clay 2, z = 15 to 20 m,

midpoint z = 17.5 m $\Rightarrow$

$$\Delta\sigma = \frac{q_{net} \cdot 20 \cdot 32}{(20 + 1.155 \times 17.5).(32 + 1.155 \times 17.5)} = 0.305 \times q_{net} = 82kPa$$

$$S = H_o \cdot m_v \cdot \Delta\sigma = 5000 \cdot 4 \times 10^{-5} \cdot 82 = 16.5mm$$

Summing up settlements of all layers: 30.8 + 24.7 + 21.6 + 16.5 = ***93.5 mm***

3. $k = \frac{q}{S} = \frac{450kPa}{93.5mm} = \frac{0.45MPa}{0.0935m} =$ ***4.81 MN/m³***

4. Short term ⇒ clay behaves undrained ⇒ Skempton's bearing capacity

$q_{ult} = s_c \,.\, Nc_{square} \,.\, c_u + \sigma_{vo} = 0.94$x 7.1 x 50 + 180 = ***514 kPa***

$s_c = 0.84 + 0.16$ x 20/32 = 0.94 from Skempton's chart for square, $D_f/B=5/20$, where D_f is the depth of foundation <u>in clay</u>.

Long term ⇒ drained parameters $s_c = 1 - 0.2$ x 20/32 = 0.875

$q_{ult} = s_c \,.\, Nc_{strip} \,.\, c' + s_\gamma \,.\, N\gamma_{strip} \,.\, \gamma'.B/2 + N_q \,.\, \sigma_{vo}'$

= 1.125x15x5 + 0.875x3.2x(20-10)x20/2 + 6.4x130 = ***1196 kPa***

using $\phi'=20°$ from Terzaghi's chart

Short term is more critical (as it shows a lower capacity).

5. $q_{net.ult} = q_{ult} - \sigma_{vo}$ = 514 – 180 = ***334 kPa***

6. $q_{net.safe} = q_{net.ult}$ / FS = 334/2 = ***167 kPa***

7. $q_{safe} = q_{net.safe} + \sigma_{vo}$ = 167 + 180 = ***347 kPa***

8. Repeating question 2 with a trial and error procedure, or solving for q_{net} from:

$$S = 100 = 5000 \cdot \left[\frac{0.01}{1+0.8} \cdot \left(log \frac{230}{155} + log \frac{230}{205} \right) + \frac{0.045}{1+0.8} \cdot \left(log \frac{155 + 0.802 q_{net}}{230} + log \frac{205 + 0.549 q_{net}}{230} \right) + 4 \times 10^{-5} \cdot (0.4 + 0.305) \cdot q_{net} \right]$$

q_{net} that would cause 100mm settlement can be calculated as 289 kPa.

$q_{gross} = q_{net} + \sigma_{vo}$ = 289 + 180 = ***469 kPa***

9. q_{all} = min(347, 469) = ***347 kPa*** < 450 kPa ⇒ not acceptable for FS=2 and S_{all}=10cm (here settlement criterion is satisfied but bearing capacity is not, so reinforcing the soil is necessary)