Test Cases: Schmert

Monday, June 13, 2022 10:19 AM

$$\rho = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \sum_{i=1}^{n} \frac{I_{zi}}{E_{si}} \quad \text{or} \quad \rho = \sum_{i=1}^{n} \rho_i \text{ where } \rho_i = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{zi}}{E_{si}}$$

$$C_1 = 1 - \frac{0.5\,\sigma'_{od}}{\Delta p}, \quad C_1 \geq 0.5$$

$$C_t = 1 + 0.2 \log_{10} \frac{t}{0.1}$$

$$E_{si} = \begin{cases} 2.5\,q_{ci} & \text{for rectangular footing} \\ 3.5\,q_{ci} & \text{for long strip footing} \end{cases}$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{vop}}}$$

$$I_{iz} = \begin{cases} 0.1 + \dfrac{(I_{zp} - 0.1) \cdot z}{0.5\omega} & \text{if } z \leq 0.5\omega \\ \frac{4}{3} I_{zp} - \dfrac{I_{zp}\, z}{1.5\omega} & \text{if } z > 0.5\omega \\ 0 & \text{if } z > 2\omega \end{cases}$$

These are the formulas for rectangular footing which is what the test cases will be using

$$\sigma'_{izp} = \frac{\sigma'_{vpi} + \sigma'_{vbi}}{2}$$

$$\Delta p = Q - \sigma'_{od}$$

C_1 - correction to account for strain relief from embedment

C_t - correction for time dependant increase in settlement

σ'_{od} - effective stress at bottom of foundation

Δp - net applied footing pressure

Q - applied pressure

t - time in years since construction

Δz - depth increment

I_{zi} - influence factor of soil layer i

E_{si} - elastic modulus of soil layer i

q_{ci} - cone penetration resistance of soil layer i

σ'_{vpi} - effective stress at top of layer i

σ'_{vbi} - effective stress at bottom of layer i

ρ - total settlement

ρ_i - settlement of soil layer i

Test Cases

Common values:

$\Delta z = 0.5$

$Q = 1.00$

$\sigma'_{od} = 0.119586611417$

$\Delta p = Q - \sigma'_{od} = 1.00 - 0.119586611417 = 0.880413388583$

$C_1 = 1 - \frac{0.5\,\sigma'_{od}}{\Delta p} = 0.932084946367$

$t = 10$

$C_t = 1 + 0.2 \log_{10} \frac{t}{0.1} = 1.4$

$\omega = 3.00$

Layer 7

Given:

$\sigma'_{vp7} = 0.119586611417$, $\sigma'_{vb7} = 0.139517771654$

$q_{c7} = 70.00$

$z = 0.25$

Required: ρ_7

Analysis:

$$\sigma'_{7zp} = \frac{\sigma'_{vp7} + \sigma'_{vb7}}{2}$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{7zp}}}$$

$$E_{s7} = 2.5\,q_{c7}$$

$$z \leq 0.5\omega \Rightarrow I_{7z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega}$$

$$\rho_7 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{7z}}{E_{s7}}$$

Solution:

$$\sigma'_{7zp} = \frac{\sigma'_{vp7} + \sigma'_{vb7}}{2} = \frac{0.119586611417 + 0.139517771654}{2} = 0.129552216535$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{7zp}}} = 0.760687496410$$

$$E_{s7} = 2.5\,q_{c7} = 2.5\,(70) = 175$$

$$I_{7z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega} = 0.210111460607$$

$$\rho_7 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{7z}}{E_{s7}} = \boxed{0.000689697}$$

Layer 8

Given:

$\sigma'_{vp8} = 0.139517771654$, $\sigma'_{vb8} = 0.159444881890$

$q_{c8} = 70.00$

$z = 0.75$

Required: ρ_8

Analysis:

$$\sigma'_{8zp} = \frac{\sigma'_{vp8} + \sigma'_{vb8}}{2}$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{8zp}}}$$

$$E_{s8} = 2.5\,q_{c8}$$

$$z \leq 0.5\omega \Rightarrow I_{8z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega}$$

$$\rho_8 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{8z}}{E_{s8}}$$

Solution:

$$\sigma'_{8zp} = \frac{\sigma'_{vp8} + \sigma'_{vb8}}{2} = \frac{0.139517771654 + 0.159444881890}{2} = 0.149481326772$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{8zp}}} = 0.742687828715$$

$$I_{8z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega} = 0.421343643567$$

$$E_{s8} = 2.5\,q_{c8} = 2.5\,(70) = 175$$

$$\rho_8 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{8z}}{E_{s8}} = \boxed{0.001338052}$$

Layer 9

Given:

$\sigma'_{vp9} = 0.159444881890$, $\sigma'_{vb9} = 0.179379921260$

$q_{c9} = 70.00$

$z = 1.25$

Required: ρ_9

Analysis:

$$\sigma'_{9zp} = \frac{\sigma'_{vp9} + \sigma'_{vb9}}{2}$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{9zp}}}$$

$$E_{s9} = 2.5\,q_{c9}$$

$$z \leq 0.5\omega \Rightarrow I_{9z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega}$$

$$\rho_9 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{9z}}{E_{s9}}$$

Solution:

$$\sigma'_{9zp} = \frac{\sigma'_{vp9} + \sigma'_{vb9}}{2} = \frac{0.159444881890 + 0.179379921260}{2} = 0.169412437008$$

$$I_{zp} = 0.5 + 0.1 \sqrt{\frac{\Delta p}{\sigma'_{9zp}}} = 0.728766001152$$

$$I_{9z} = 0.1 + \frac{(I_{zp} - 0.1) \cdot z}{0.5\omega} = 0.623304117627$$

$$E_{s9} = 2.5\,q_{c9} = 2.5\,(70) = 175$$

$$\rho_9 = C_1 \cdot C_t \cdot \Delta p \cdot \Delta z \cdot \frac{I_{9z}}{E_{s9}} = \boxed{0.002045984}$$