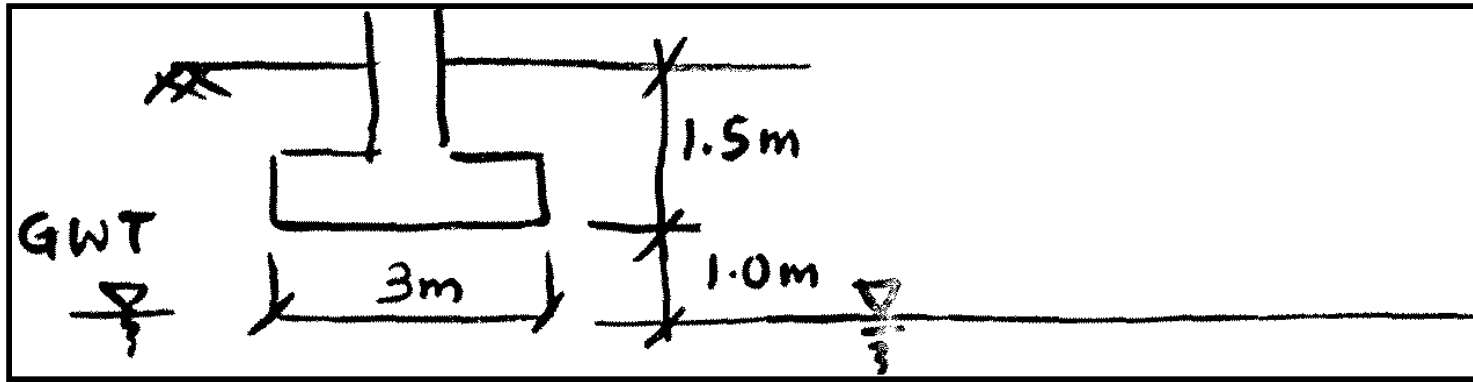


Example Problems

Bearing capacity of Foundations

Example (1)



Square Footing :

Density above GWT = $\gamma_{\text{moist}} = 16.0 \text{ kN/m}^3$; $\phi' = 35^\circ$; $c' = 0$

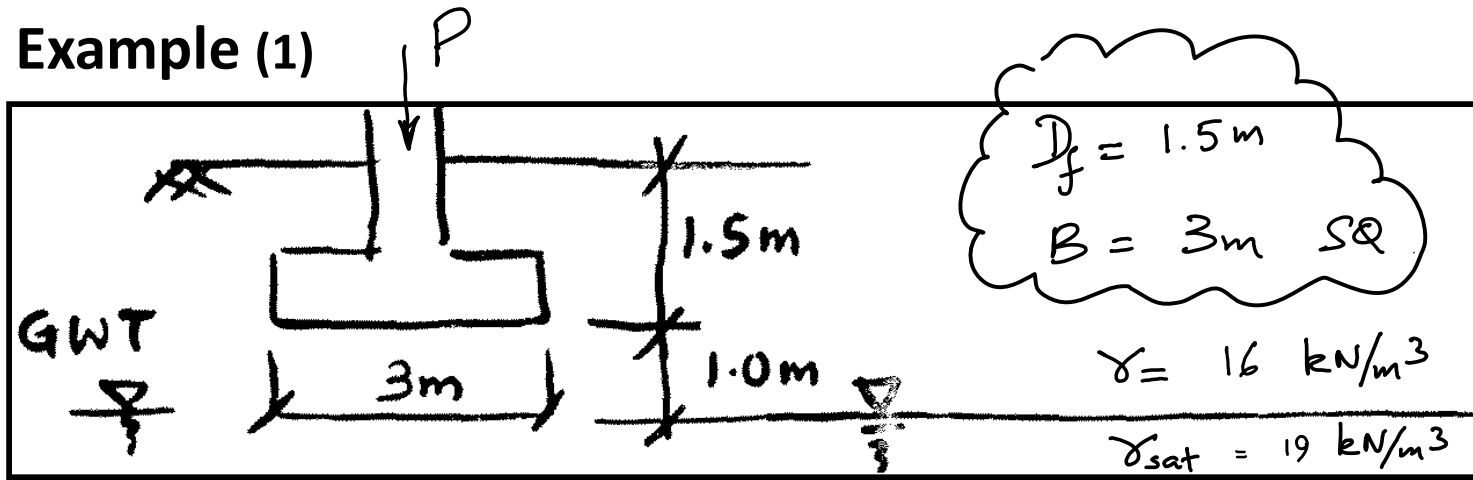
Density below GWT = $\gamma_{\text{sat}} = 19.0 \text{ kN/m}^3$; $\phi' = 35^\circ$; $c' = 0$

Find q_u , q_{ult} , and q_a

Effective Stress Analysis (ESA)

$$q_u = \gamma D_f (N_q - 1)(s_q d_q w_q) + 0.5 \gamma B' N_\gamma (s_\gamma d_\gamma w_\gamma)$$

Example (1)



$$q_u = \gamma D_f (N_q - 1)(s_q d_q w_q) + 0.5 \gamma B' N_\gamma (s_\gamma d_\gamma w_\gamma)$$

- ① Load - Vertical & centric.
- ② Square footing - Need to apply shape factors.
- ③ Embedment - Need to apply embedment factors.
- ④ Groundwater present - Need to apply groundwater factors.
- ⑤ As such, the above equation can be used.
- ⑥ Note:
 - 1st term corresponds with vertical effective stress from soils above footing level \rightarrow Use $\gamma = 16 \frac{\text{kN}}{\text{m}^3}$
 - 2nd term - use γ below water level \rightarrow Use $\gamma = 19 \text{ kN/m}^3$

Example (1) (con't)

$$\rightarrow N_q = e^{\pi \tan \phi'_p} \tan^2 \left(45^\circ + \frac{\phi'_p}{2} \right); \phi'_p \text{ in degrees}$$

$$N_q = e^{\pi \tan 35^\circ} \times \tan^2 \left(45^\circ + \frac{35^\circ}{2} \right) = \boxed{33.3}$$

$$\rightarrow N_\gamma = 0.1054 \exp(9.6 \phi'_p); \phi'_p \text{ in radians.}$$

$$N_\gamma = 0.1054 \times e^{(9.6 \times 0.61)} = \boxed{37.1}$$

Need to get B' & L' established

\rightarrow Since there is no eccentricity

$$B' = B = 3\text{m}$$

$$L' = L = 3\text{m}$$

\rightarrow Now shape factors:

$$s_q = 1 + \left(\frac{B'}{L'} \right) \tan \phi'_p = 1 + \left(\frac{3}{3} \right) \times \tan 35^\circ$$

$$= \boxed{1.7}$$

Example (1) (con't)

$$J_r = 1 - 0.4 \left(\frac{B'}{L'} \right) = \boxed{0.6}$$

→ Now, embedment factors

$$\begin{aligned} d_q &= 1 + 2 \tan \phi_p' (1 - \sin \phi_p')^2 \left(\frac{D_f}{B'} \right) \\ &= 1 + 2 \tan 35^\circ (1 - \sin 35^\circ)^2 \left(\frac{1.5}{3} \right) \\ &= \boxed{1.13} \end{aligned}$$

$$d_r = \boxed{1.0}$$

→ Next, groundwater factors

$$\left. \begin{array}{l} B = 3.0 \text{ m} \\ z = 2.5 \text{ m} \\ D_f = 1.5 \text{ m} \end{array} \right\} \begin{array}{l} 1.5 \text{ m} \\ z < \\ 4.5 \text{ m} \\ (B + D_f) \end{array}$$

This means case 2 GWT

$$\left\{ \begin{array}{l} W_q = \boxed{1} \\ W_r = \frac{z - D_f}{B} + \frac{\gamma'}{\gamma_{\text{sat}}} \left(1 + \frac{D_f}{B} - \frac{z}{B} \right) = \frac{1}{3} + \frac{19 - 9.81}{19} \left\{ 1 + \frac{1.5}{3.0} - \frac{2.5}{3} \right\} \end{array} \right.$$

$$W_r = \boxed{0.655}$$

Example (1) (con't)

$$q_u = \gamma D_f (N_q - 1)(s_q d_q w_q) + 0.5 \gamma B' N_\gamma (s_\gamma d_\gamma w_\gamma)$$

$$\begin{array}{l|l} N_q = 33.3 ; N_\gamma = 37.1 & d_q = 1.13 ; d_\gamma = 1.0 \\ s_q = 1.7 ; s_\gamma = 0.6 & w_q = 1.0 ; w_\gamma = 0.655 \end{array}$$

$$D_f = 1.5 \text{ m} ; \quad \gamma_{1\text{ST TERM}} = 16 \text{ kN/m}^3$$

$$B' = 3.0 \text{ m} ; \quad \gamma_{2\text{ND TERM}} = 19 \text{ kN/m}^3$$

$$\begin{aligned} q_u &= 16 \times 1.5 \times (33.3 - 1) \times (1.7 \times 1.13 \times 1.0) \\ &\quad + \\ &\quad 0.5 \times 19 \times 3 \times 37.1 \times (0.6 \times 1.0 \times 0.655) \\ &= 1489 + 416 \\ &= \underline{\underline{1905 \text{ kPa}}} \end{aligned}$$

Example (1) (con't)

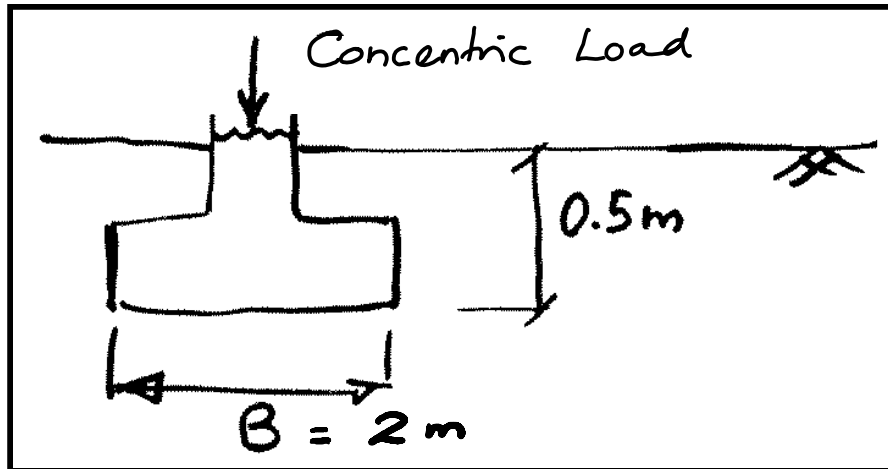
$$q_u = \boxed{1905 \text{ kPa}}$$

$$q_{ult} = q_u + \gamma D_f = 1905 + 16 \times 1.5 = \boxed{1929 \text{ kPa}}$$

$$q_a = \frac{q_u}{\text{FOS}} + \gamma D_f$$

$$= \frac{1905}{3} + 16 \times 1.5 = \boxed{659 \text{ kPa}}$$

Example (2) - Square Footing on clay.



$$\gamma = 18.5 \text{ kN/m}^3$$

$$s_u = 60 \text{ kPa}$$

Total Stress Analysis (TSA)

$$q_u = 5.14 s_u (s_c d_c)$$

$$D_f = 0.5 \text{ m}; \quad B' = L' = 2 \text{ m}$$

$$\text{Shape factor } s_c = 1 + 0.2 \left(\frac{B'}{L'} \right) = \boxed{1.2}$$

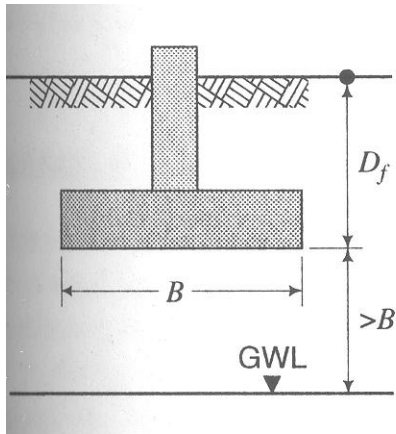
$$\text{Embedment factor } d_c = 1 + 0.33 \left(\frac{D_f}{B} \right) = 1.083$$

$$q_u = 5.14 \times 60 \times 1.2 \times 1.083 = \boxed{400 \text{ kPa}}$$

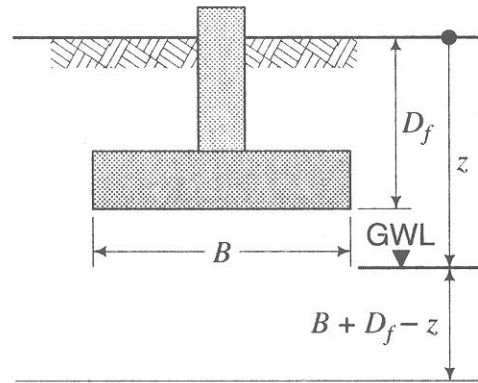
$$q_a = \frac{400}{3} + 0.5 \times 18.5 = \boxed{142 \text{ kPa}} \leftarrow$$

$$\frac{D_f}{B} = 0.25 \ll 1$$

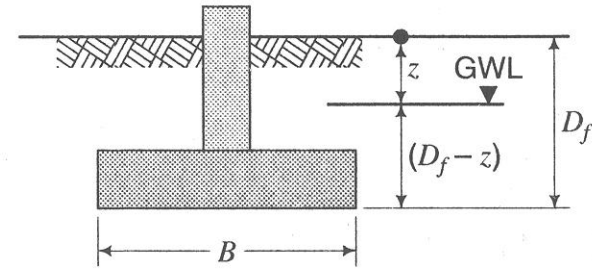
Correction for Groundwater: for ESA



Case 1



Case 2



Case 3

Case 1: $z > (B + D_f)$

$$w_q = 1; w_\gamma = 1$$

Note: z = Depth to Groundwater Table

Case 2: $(B + D_f) > z > D_f$

$$w_q = 1; w_\gamma = \frac{(z - D_f)}{B} + \frac{\gamma'}{\gamma_{sat}} \left(1 + \frac{D_f}{B} - \frac{z}{B}\right)$$

Case 3: $z < D_f$

$$w_q = \frac{z}{D_f} + \frac{\gamma'}{\gamma_{sat}} \left(1 - \frac{z}{D_f}\right); w_\gamma = \frac{\gamma'}{\gamma_{sat}}$$