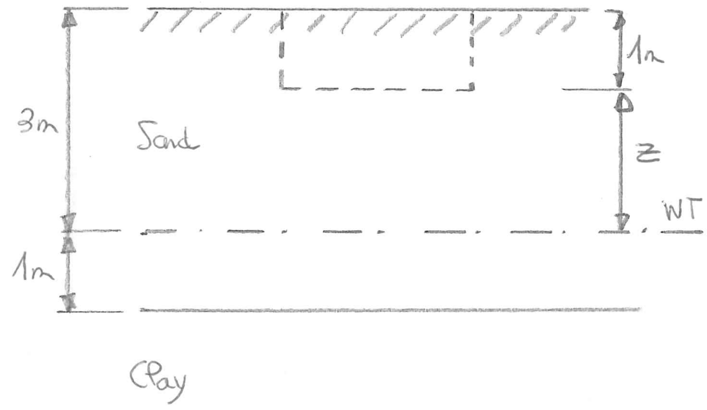
EXERCISE

$B = 2.5\,m$, $L = 3.0\,m$



Option 1, at a depth of 1m

SP, poorly graded sand

$\gamma = 17.0\ \frac{kN}{m^3}$, $\gamma_{sat} = 18.5\ kN/m^3$, $N_{SPT} = 10$

↓ chart

$\phi \approx 30°$

$S_{allow} = 25\,mm$

Granular soil (Terzaghi's expression)

$$q'_{ult} = c' \cdot N_c \cdot f_c + \sigma'_{v0} \cdot N_q \cdot f_q + \frac{1}{2} \gamma \cdot B^* \cdot N_\gamma \cdot f_\gamma$$

$c' = 0$ (granular soil) $\rightarrow c' \cdot N_c \cdot f_c = 0$

$\sigma'_{v0} = \sigma_{v0} - u_0 = \gamma \cdot H_{exc} - 0 = 17 \cdot 1 = 17\ kN/m^2$

$B^* = B = 2.5\,m$
$z = 3 - 1 = 2m$
$\Big\}\ z < B^* \Rightarrow \gamma \rightarrow \gamma' + \frac{z}{B^*}(\gamma - \gamma') = 8.7 + \frac{2}{2.5}(17 - 8.7) = 15.34\ kN/m^3$

$\gamma' = \gamma_{sat} - \gamma_w = 18.5 - 9.8 = 8.7\ kN/m^3$

$\phi = 30° \rightarrow N_q = \frac{1 + \sin 30°}{1 - \sin 30°} \cdot e^{\pi \cdot \tan 30°} = 18.4011$

$\rightarrow N_\gamma = 1.5(18.4011 - 1) \cdot \tan 30° = 15.0698$

$f_q = d_q \cdot i_q \cdot t_q \cdot s_q =$

$f_\gamma = d_\gamma \cdot i_\gamma \cdot t_\gamma \cdot s_\gamma =$

$d_q = d_\gamma = 1$ because it is not possible to assure that soil will remain over the lifespan of the structure

$i_q = i_\gamma = 1$ because load is vertical

$t_q = t_\gamma = 1$ because the ground surface is horizontal

$$S_q = 1 + 1.5 \cdot \tan 30 \cdot \frac{2.5}{3} = 1.7217 \quad ; \quad S_\gamma = 1 - 0'3 \cdot \frac{2.5}{3} = 0.75$$

Then,

$$f_q = 1 \cdot 1 \cdot 1 \cdot 1.7217 = 1.7217$$

$$f_\gamma = 1 \cdot 1 \cdot 1 \cdot 0.75 = 0.75$$

$$q'_{ult} = 0 + 17 \cdot 18.4011 \cdot 1.7217 + \frac{1}{2} \cdot 15.34 \cdot 2.5 \cdot 15.0698 \cdot 0.75 = 755.30 \text{ kN/m}^2$$

$$q_{ult} = q'_{ult} + u = 755.30 \text{ kN/m}^2$$

$$q_{nult} = q_{ult} - \sigma_{vo} = 755.30 - 17 = 738.30 \text{ kN/m}^2$$

$$q_{allow} = \frac{q_{nult}}{\gamma_R} = \frac{738.3}{3} = 246.10 \text{ kN/m}^2$$

Granular soil (SPT expression)

All the requirements to use this expression are fulfilled.

$$1 + \frac{D}{3 \cdot B^*} = 1 + \frac{1}{3 \cdot 2.5} = 1.13 < 1.3 \checkmark$$

$$B^* = 2.5 \text{ m} > 1.2 \text{ m} \Rightarrow q_{adm} = 8 \cdot N_{AVG} \cdot \left(1 + \frac{D}{3 \cdot B^*}\right) \cdot \left(\frac{S_t}{25}\right) \cdot \left(\frac{B^* + 0.3}{B^*}\right)^2 =$$

$$= 8 \cdot 10 \left(1 + \frac{1}{3 \cdot 2.5}\right) \left(\frac{25}{25}\right) \cdot \left(\frac{2.5 + 0.3}{2.5}\right)^2 = 113.73 \text{ kN/m}^2$$

$$\Rightarrow q_{allow} (\text{granular soil, SP}) = 113.73 \text{ kN/m}^2$$

Option 2, at a depth of 4m

lean clay, CL, normally consolidated

$\gamma = 21.8 \text{ kN/m}^3 \equiv \gamma_{sat}$ (below the WT)

$q_u = 145 \text{kPa}$, $\phi' = 25°$, $c' = 0$ because it is a normally consolidated clay

Long-term: $q'_{ult} = c' \cdot N_c \cdot f_c + \sigma'_{vo} \cdot N_q \cdot f_q + \frac{1}{2} \gamma \cdot B^* \cdot N_\gamma \cdot f_\gamma$

$c' = 0 \rightarrow c' \cdot N_c \cdot f_c = 0$

$\sigma'_{v0} = \sigma_{v0} - u_0 = \Sigma \gamma_i H_i - \gamma_w \cdot h_{NF} = 17.3 + 18.5 \cdot 1 - 9.8 \cdot 1 = 59.7 \ kN/m^2$

$\gamma \rightarrow \gamma' = \gamma_{sat} - \gamma_w = 21.8 - 9.8 = 12.0 \ kN/m^3$

$B^* = B = 2.5 \ m$

$\phi' = 25° \rightarrow N_q = \dfrac{1 + \sin 25°}{1 - \sin 25°} \cdot e^{\pi \cdot \tan 25°} = 10.6621$

$\rightarrow N_\gamma = 1.5 (10.6621 - 1) \cdot \tan 25° = 6.7583$

$d_q = d_\gamma = 1$
$i_\gamma = i_q = 1$
$t_q = t_\gamma = 1$
} The same reasons as in soil 1

$s_q = 1 + 1.5 \cdot \tan 25° \cdot \dfrac{2.5}{3} = 1.5829$; $s_\gamma = 1 - 0.3 \dfrac{2.5}{3} = 0.75$

Then,

$f_q = 1 \cdot 1 \cdot 1 \cdot 1.5829 = 1.5829$

$f_\gamma = 1 \cdot 1 \cdot 1 \cdot 0.75 = 0.75$

$q'_{ult} = 0 + 59.7 \cdot 10.6621 \cdot 1.5829 + \frac{1}{2} 12.0 \cdot 2.5 \cdot 6.7583 \cdot 0.75 = 1083.59 \ kN/m^2$

$q_{ult} = q'_{ult} + u = 1083.59 + 9.8 \cdot 1 = 1093.39 \ kN/m^2$

$q_{nult} = q_{ult} - \sigma_{v0} = 1093.39 - (17.3 + 18.5 \cdot 1) = 1023.89 \ kN/m^2$

$q_{allow} = \dfrac{q_{nult}}{\gamma_R} = \dfrac{1023.89}{3} = 341.30 \ kN/m^2$

<u>Short-term:</u> $q_{ult} = c_u \cdot N_c \cdot f_c + \sigma_{v0} \cdot N_q \cdot f_q$

$c_u = \dfrac{q_u}{2} = \dfrac{145}{2} = 72.5 \ kN/m^2$

$\sigma_{v0} = 17.3 + 18.5 \cdot 1 = 69.5 \ kN/m^2$

$N_c = 5.14$; $N_q = 1$

$d_q = d_\gamma = 1$
$i_q = i_\gamma = 1$ } The same reasons as before
$t_q = t_\gamma = 1$

$s_q = 1 + 1.5 \cdot tg\,0 \cdot \frac{2.5}{3} = 1.0$; $s_c = 1 + 0.2 \cdot \frac{2.5}{3} = 1.1\widehat{6}$

$f_q = 1 \cdot 1 \cdot 1 \cdot 1.0 = 1.0$

$f_c = 1 \cdot 1 \cdot 1 \cdot 1.1\widehat{6} = 1.1\widehat{6}$

$q_{ult} = 72.5 \cdot 5.14 \cdot 1.1\widehat{6} + 69.5 \cdot 1 \cdot 1 = 504.26\ kN/m^2$

$q_{nult} = q_{ult} - \sigma_{v0} = 504.26 - 69.5 = 434.76\ kN/m^2$

$q_{allow} = \frac{q_{nult}}{\gamma_R} = \frac{434.76}{3} = 144.92\ kN/m^2$

$\Rightarrow$ q_{allow}(lean clay) = q_{allow}(short-term) = $144.92\ kN/m^2$

CONCLUSIONS

Most adequate option : b) at a depth of 4 m because q_{allow} is the largest.

$q_{allow} = 144.92\ kN/m^2$