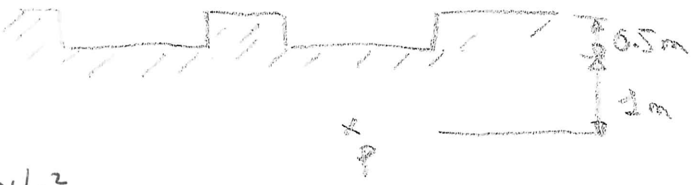
THEORETICAL QUESTIONS

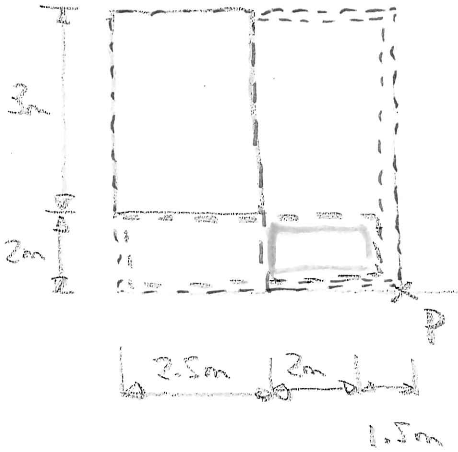
(1)



$$\Delta\sigma_V = q_{NET} \cdot I$$

$$q_{NET} = q - \gamma \cdot H_{exc} = 100 - 18 \cdot 0.5 = 91 \, kN/m^2$$

$$I = I_{BLUE} - I_{RED} - I_{BLACK} + I_{GREEN}$$



I_{BLUE} : $a = 5m, \; b = 6m, \; z = 1m$

$m = \frac{a}{z} = 5 \; ; \; n = \frac{b}{z} = 6$

$I_{BLUE} = 0.249$

I_{RED} : $a = 5m, \; b = 3.5m, \; z = 1m$

$m = \frac{a}{z} = 5, \; n = \frac{b}{z} = 3.5$

$I_{RED} = 0.247$

I_{BLACK} : $a = 2m, \; b = 6m, \; z = 1m$

$m = \frac{a}{z} = 2, \; n = \frac{b}{z} = 6$

$I_{BLACK} = 0.240$

I_{GREEN} : $a = 2m, \; b = 3.5m, \; z = 1m$

$m = \frac{a}{z} = 2, \; n = \frac{b}{z} = 3.5$

$I_{GREEN} = 0.2385$

$$\Delta\sigma_V = 91 \cdot (0.249 - 0.247 - 0.240 + 0.2385) = 91 \cdot 5 \cdot 10^{-4} = 0.0455 \, kN/m^2$$

(2)

$\sigma_V = \sum \gamma_i \cdot h_i$

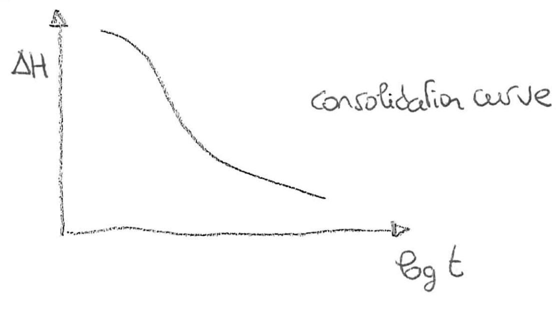
$u = \gamma_W \cdot h_{WT}$

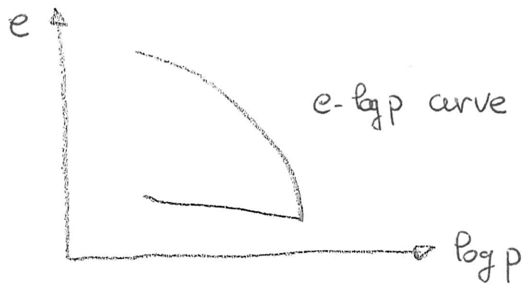
$\sigma'_V = \sigma_V - u$

$\sigma'_H = K_0 \cdot \sigma'_V$

$\sigma_H = \sigma'_H + u$

(3)





(4)

$$\left.\begin{array}{l} S_1 = 19\ mm \\ S_2 = 31\ mm \end{array}\right\} < S_{allow} = 50\ mm$$

$$\delta S_{12} = 31 - 19 = 12\ mm < 12.5\ mm$$

$$\beta_{12} = \frac{\delta S_{12}}{L_{12}} = \frac{12}{10 \cdot 10^{3}} = 1.2 \cdot 10^{-3} < \frac{1}{500} = 2 \cdot 10^{-3}$$

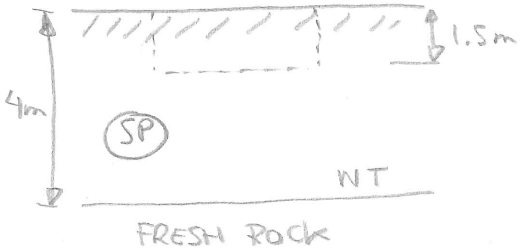
$\Rightarrow$ ALLOWABLE

EXERCISE

Viaduct → individual footings → $q = 145\ kN/m^2$

(1) SP : $\gamma = 17.5\ kN/m^3$, $N_{AVG} = 13$, $E = 12\ MN/m^2$, $B = 3.5\ m$, $L = 4\ m$, $H_{exc} = 1.5\ m$

(2) CH : $\gamma = 20.2\ kN/m^3$, $N_{AVG} = 35$, $E_u = 50\ MN/m^2$, $B = 4\ m$, $L = 6\ m$, $H_{exc} = 0\ m$
(saturated) $H = 10\ m$



Allowable settlement : 25 mm (individual footing – viaduct)

(1) $s = 1.5\ s_i = 1.5\left(f_i \cdot f_s \cdot q'_{76} \cdot B^{0.7} \cdot I_c\right) \leq 25\ mm$

$$Z_i = B^{0.75} = 3.5^{0.75} = 2.56\ m > H = 4 - 1.5 = 2.5\ m$$

$$f_i = \frac{H}{Z_i}\left[2 - \frac{H}{Z_i}\right] = \frac{2.50}{2.56}\left[2 - \frac{2.5}{2.56}\right] = 0.999 = 1.0$$

$$f_s = \left(\frac{1.25\ \frac{L}{B}}{\frac{L}{B} + 0.25}\right)^2 = \left(\frac{1.25 \cdot 4/3.5}{\frac{4}{3.5} + 0.25}\right)^2 = 1.0519$$

$$q'_{76} = 145\ \frac{kN}{m^2}$$

$$\sigma'_{V_0} = \sigma_{V_0} - u_0 = 17.5 \cdot 1'5 - 0 = 26.25\ \frac{kN}{m^2}$$

$\Rightarrow q'_{76} > \sigma'_{V_0}$

$$I_c = \frac{1.71}{N_{AVG}^{1.4}} = \frac{1.71}{13^{1.4}} = 0.0471$$

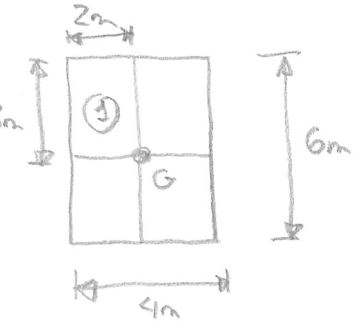
$$s = 1.5\left(1.0 \cdot 1.0519\left(145 - \frac{2}{3}\,26.25\right) \cdot 3.5^{0.7} \cdot 0.0471\right) = 22.77\ mm < 25\ mm$$ ✓

(2) $S_i = C_s \cdot q \cdot B \left(\frac{1-\nu^2}{E_u} \right)$

↳ Limited depth ($H = 10\,m$) ⇒ It is necessary to divide the rectangular area into 4 parts

$$\Rightarrow S_i = 4 \cdot S_{i(1)} = 4 \left[C_{s(1)} \cdot q \cdot B_{(1)} \cdot \left(\frac{1-\nu^2}{E_u} \right) \right]$$

0.2



$C_{s(1)}$: $\frac{L_{(1)}}{B_{(1)}} = \frac{3}{2} = 1.5$; $\frac{H}{B_{(1)}} = \frac{10}{2} = 5$ $\Rightarrow C_{s(1)} = 0.48$

0.2

$$S_i = 4 \left[0.48 \cdot 145 \cdot 2 \left(\frac{1-0.5^2}{50 \cdot 10^3} \right) \right] = 8.352 \cdot 10^{-3}\, m = 8.352\, mm$$

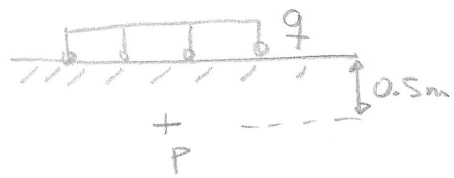
$$S_i = 0.55 \cdot S \Rightarrow S = \frac{S_i}{0.55} = \frac{8.352}{0.55} = 15.19\, mm < 25\, mm$$ ✓

Both soils satisfy the allowable settlement and any of them could be selected.

Option 1. Soil 2, because the total settlement is the smallest.

Option 2. Soil 1, because the footing is smaller.

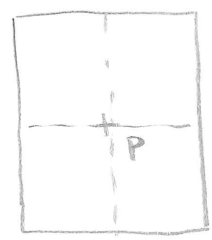
Question 2



$\Delta\sigma_v(q) = q \cdot 4 \cdot I_1$

I_1: $a = 3m$, $b = 2m$, $z = 0.5m$, $m = \frac{a}{z} = 6$, $n = \frac{b}{z} = 4$ ⇒

⇒ $I_1 = 0.248$



$\Delta\sigma_v(q) = 145 \cdot 4 \cdot 0.248 = 143.84\, kN/m^2$

$\sigma_{v0} = \gamma \cdot z_p = 20.2 \cdot 0.5 = 10.1\, kN/m^2$; $u_0 = \gamma_w \cdot h_{WT} = 9.8 \cdot 0.5 = 4.9\, \frac{kN}{m^2}$

$\sigma'_{v0} = \sigma_{v0} - u_0 = 10.1 - 4.9 = 5.2\, kN/m^2 = \sigma'_{vF}$ because at the end of the construction the pore water pressure takes all the $\Delta\sigma_v$

$\sigma_{vF} = \sigma_{v0} + \Delta\sigma_v(q) = 10.1 + 143.84 = 153.94\, kN/m^2$

$u_F = u_0 + \Delta\sigma_v(q) = 4.9 + 143.84 = 148.74\, kN/m^2$