

Consolidation Settlement of Group Piles

The consolidation settlement of a group pile in clay can be estimated by using the 2:1 stress distribution method. The calculation involves the following steps:

- 1- Let the depth of embedment of the piles be L . The group is subjected to a total load of Q_g . If the pile cap is below the original ground surface, Q_g equals the total load of the superstructure on the piles, minus the effective weight of soil above the group piles removed by excavation.
- 2- Assume that the load Q_g is transmitted to the soil beginning at a depth of $\frac{2L}{3}$ from the top of the pile, as shown in the figure. The load Q_g spreads out along two vertical to one horizontal line from this depth. Lines aa' and bb' are the two 2:1 lines.
- 3- Calculate the increase in effective stress caused at the middle of each soil layer by the load Q_g . The formula is:

$$\delta p = \frac{Q_g}{(B_g + Z_i)(L_g + Z_i)}$$

$$p_1 = p_o + \delta p$$

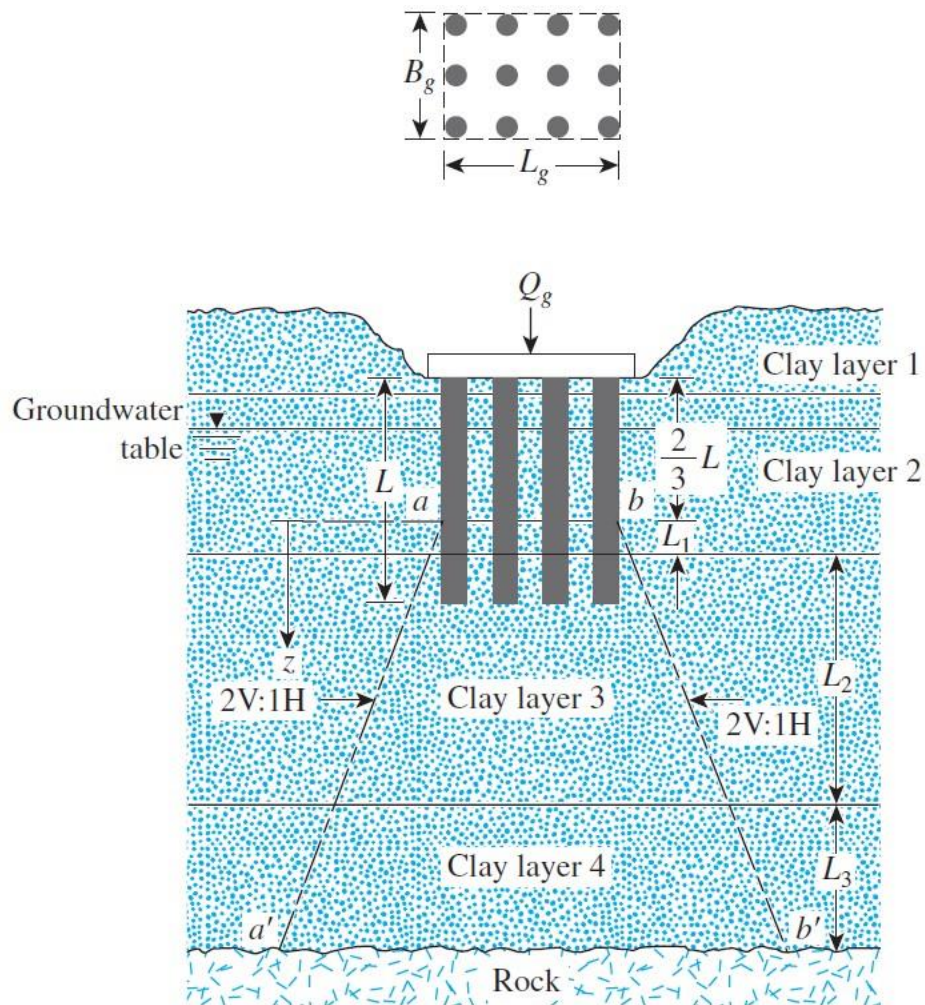


Fig.1 Consolidation settlement of group piles

$\Delta\sigma'_i$: increase in effective stress in the middle of layer i.

L_g and B_g : Length and width of the planned group pile.

Z_i : distance from $Z_i = 0$ to the middle of layer i

For an example for layer 2, $Z_1 = L_1/2$, for layer 3, $Z_2 = L_1+L_2/2$ and for layer 4, $Z_3 = L_1+L_2+L_3/2$

- 4- Calculate the consolidation settlement of each layer caused by the increased stress. The formula is

$$S_i = \frac{\delta e_i}{1 + e_o} H$$

- 5- The total consolidation settlement of the group piles is then

$$S_t = \sum S_i$$

Example : A group pile in clay is shown in Fig.2 . Determine the consolidation settlement of the piles. All clays are normally consolidated.

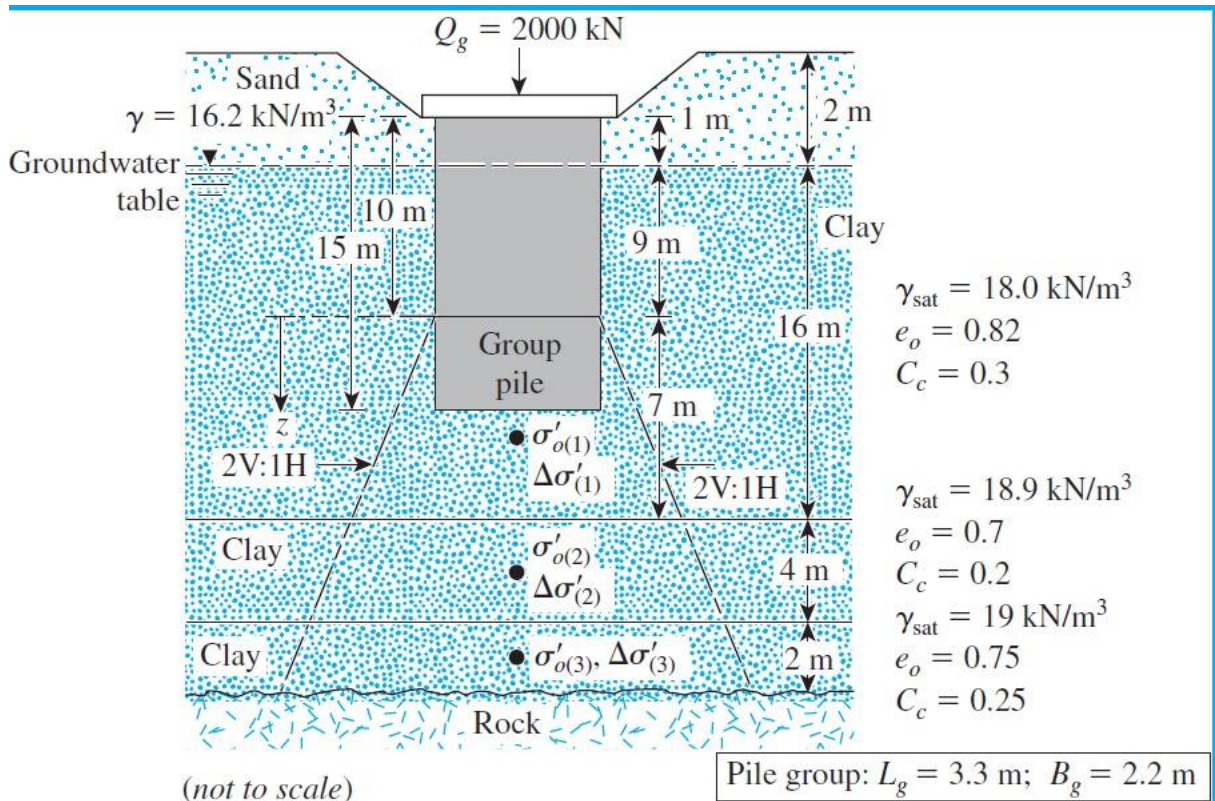


Fig.2

Solution

Because the lengths of the piles are 15 m each, the stress distribution starts at a depth of 10 m below the top of the pile. We are given that $Q_g = 2000 \text{ kN}$.

Calculation of Settlement of Clay Layer 1

For normally consolidated clays,

$$\text{Let } C_C = \frac{\delta e}{1+e_o} \log \frac{P_1}{P_o}, \text{ therefore}$$

$$S_i = \frac{C_c H}{1+e_o} \log \frac{P_1}{P_o}$$

Layer 1

$$\delta p = \frac{Q_g}{(B_g + Z_i)(L_g + Z_i)}$$

$$\delta p_1 = \frac{2000}{(3.3 + 9)(2.2 + 9)} = 51.6 \text{ KN/m}^2$$

$$P_o = 16.2 * 2 + 12.5 * 8 = 134.8 \text{ KN/m}^2, \quad P_1 = 186.375 \text{ Kn/m}^2$$

$$S_i = \frac{C_c H}{1+e_o} \log \frac{P_1}{P_o}$$

$$S_1 = \frac{0.3 * 7}{1+0.82} \log \frac{186.37}{134.8} = 162.3 \text{ mm}$$

Layer 2

$$\delta p_1 = \frac{2000}{(3.3 + 3.5)(2.2 + 3.5)} = 14.518 \text{ KN/m}^2$$

$$P_o = 16.2 * 2 + 16 * 8 + 8.9 * 2 = 158.2 \text{ KN/m}^2, \quad P_1 = 172.7 \text{ Kn/m}^2$$

$$S_i = \frac{C_c H}{1+e_o} \log \frac{P_1}{P_o}$$

$$S_1 = \frac{0.2 * 4}{1+0.7} \log \frac{172.7}{158.2} = 17.9 \text{ mm}$$

Layer 2

$$\delta p_1 = \frac{2000}{(3.3 + 12)(2.2 + 12)} = 9.2 \text{ KN/m}^2$$

$$P_o = 16.2 * 2 + 16 * 8 + 8.9 * 2 + 9 * 1 = 167.2 \text{ KN/m}^2, \quad P_1 = 176.4 \text{ Kn/m}^2$$

$$S_i = \frac{C_c H}{1+e_o} \log \frac{P_1}{P_o}$$

$$S_1 = \frac{0.25 * 2}{1+0.75} \log \frac{176.4}{167.2} = 6.64 \text{ mm}$$

$$S_t = 186.8 \text{ mm}$$

Problem

Fig.3 shows a group pile in clay. Determine the consolidation settlement of the group.

