## 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:

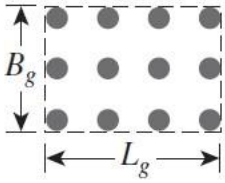
1- Let the depth of embedment of the piles be L. The group is subjected to a total load of $Q_g$ If the pile cap is below the original ground surface, $Q_g$ equals the total load of the superstructure on the piles, minus the effective weight of soil above the group piles removed by the excavation.

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:

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

$$p_1 = p_o + \delta p$$



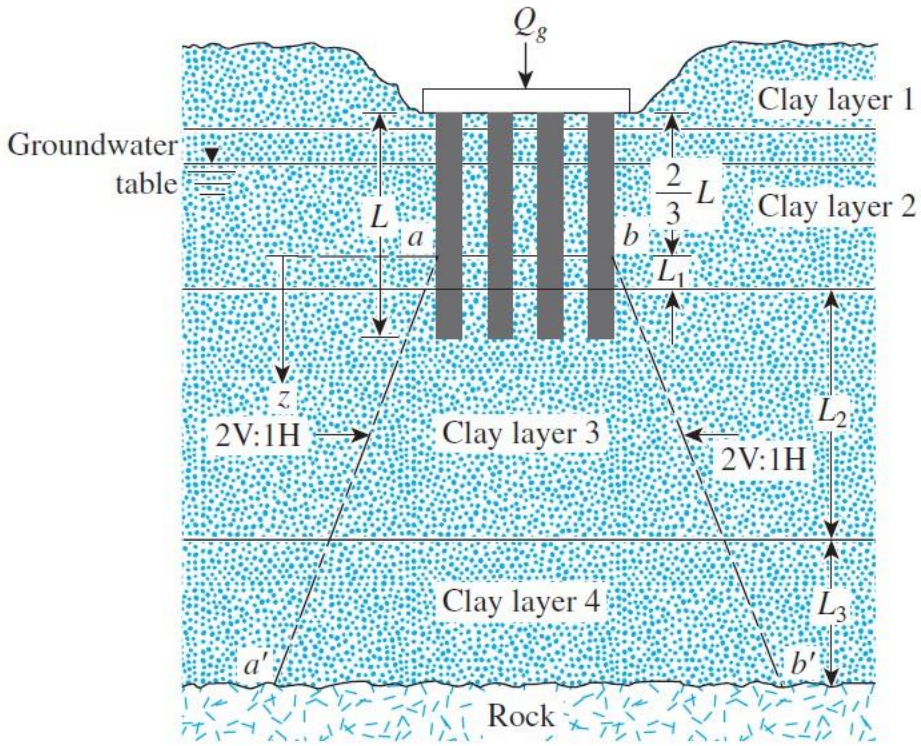




Fig.1 Consolidation settlement of group piles

$\Delta\sigma_i^{'}$ : increase in effective stress in the middle of layer i.

$L_g \; and \; B_g$ : Length and width of the planned group pyhile.

$Z_i$: 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

$$S_C = \frac{C_C H}{1 + e_o} log(\frac{\sigma + \Delta\sigma}{\sigma})$$

The total consolidation settlement of the piles group 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.

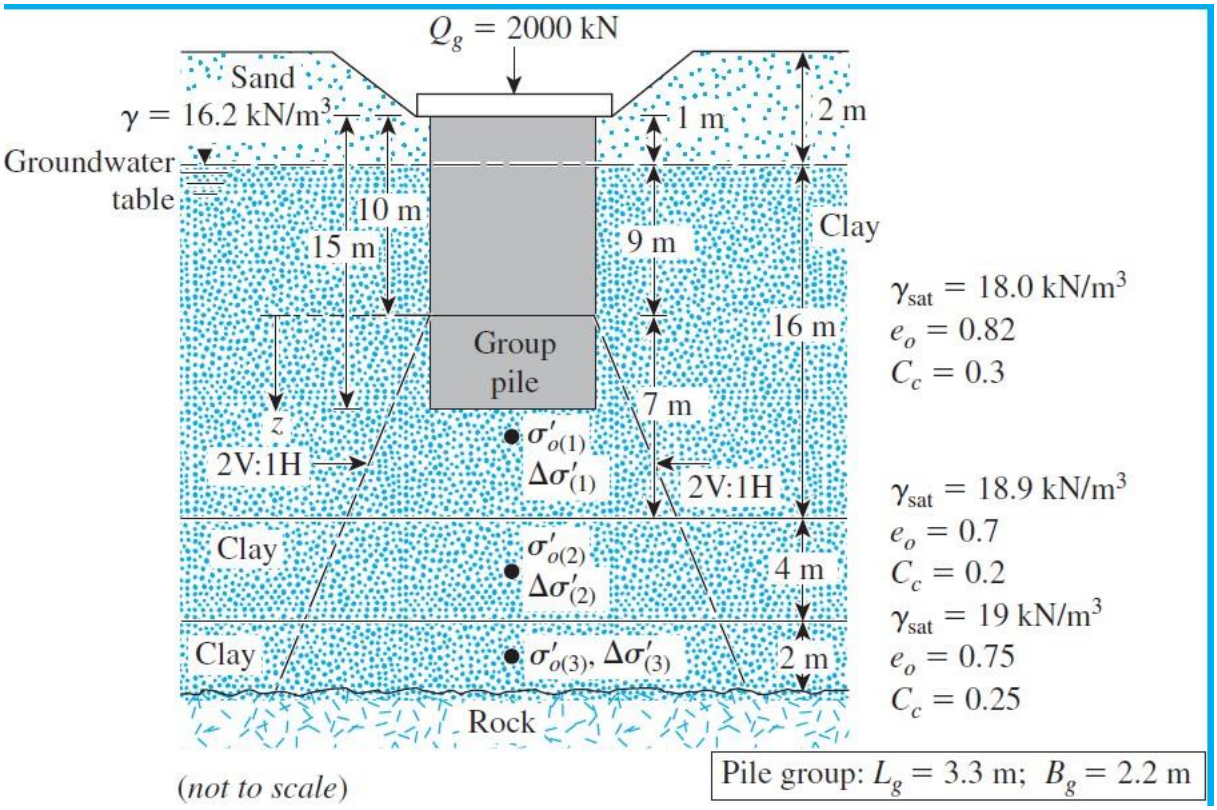



Fig.2

## 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 $Q_g = 2000KN$.

Calculation of Settlement of Clay Layer 1

For normally consolidated clays,

$$S_i = \frac{C_C H}{1 + e_o} log \frac{P_1}{P_O}$$

**Layer 1**

$$\Delta\sigma = \frac{Q_g}{(B_g + Z_i)(L_g + Z_i)}$$

$$\Delta\sigma 1 = \frac{2000}{(2.2 + 3.5)(3.3 + 3.5)} = 51.6\ KN/m2$$

$$\sigma = 16.2 * 2 + 12.5 * 8 = 132.4\ KN/m2\ ,$$

$$S_i = \frac{C_C H}{1 + e_o} log \frac{\sigma + \Delta\sigma}{\sigma}$$

$$S_1 = \frac{0.3*7}{1+0.82} log \frac{51.6+132.4}{132.4} = 164\ mm$$

**Layer 2**

$$\Delta\sigma = \frac{2000}{(3.3 + 9)(2.2 + 9)} = 14.518KN/m2$$

$$\sigma 2 = 16.2 * 2 + 16 * 8 + 8.9 * 2 = 158.2KN/m2\ ,$$

$$S_i = \frac{C_C H}{1 + e_o} log \frac{\sigma + \Delta\sigma}{\sigma}$$

$$S_2 = \frac{0.2*4}{1+0.7} log \frac{158.2+14.518}{158.2} = 17.9mm$$

**Layer3**

$$\Delta\sigma 3 = \frac{2000}{(3.3 + 12)(2.2 + 12)} = 9.2KN/m2$$

$$\sigma 3 = 16.2 * 2 + 16 * 8 + 8.9 * 2 + 9 * 1 = 167.2KN/m2\ ,$$

$$S_i = \frac{C_C H}{1 + e_o} log \frac{\sigma + \Delta\sigma}{\sigma}$$

$$S_3 = \frac{0.25*2}{1+0.75} log \frac{9.2}{167.2} = 6.64mm$$

$$S_t = 186.8mm$$

**Problem**

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