Deep Foundation – static pile capacity

Capacity of individual piles

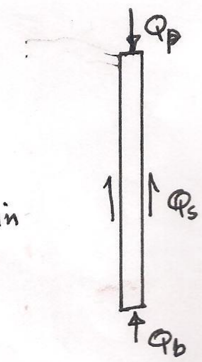
$$Q_p = Q_b + \sum Q_s - W_p$$

Q_p = ultimate capacity of pile.

Q_s = ultimate upward frictional force developed along the shaft of the pile.

Q_b = ultimate bearing base of pile.

W_p = weight of pile.



Note: the weight of pile is neglected (too small in comparison with Q_p)

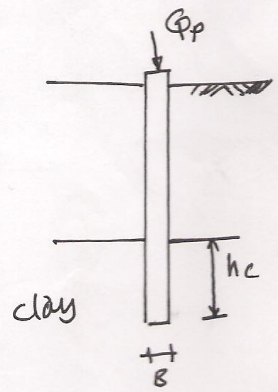
1. clay soil

$$Q_b = C\, N_c\, A_b$$

C: cohesion of soil

$N_c = 9$ for $h_c/B \geq 4$ otherwise use

h_c/B	4	3	2	1	0	X
N_c	9	8.8	8.4	7.7	6.3	X



A_b = Area of pile at tipe

$Q_s = C_a A_s$

C_a : adhesion between pile and soil.
A_s : Surface area of pile in the soil layer.

To determine C_a

a) Tomlinson method –

$C_a = \alpha C_u$

C_u = Undrain Cohesion

a-1) Bored pile $\alpha = 0.45$

a-2) Driven pile α – determine from table (7-5)

b) Meyerhof method

$C_a = \beta \bar{\sigma}_v$

$\bar{\sigma}_v$: average effective overburden pressure

b-1) For driven pile β From Fig "7-6" when $C_u < 100\ kN/m^2$

$\beta = K_s \tan\bar{\phi}$ when $C_u \geq 100\ kN/m^2$

$K_s = (1 - \sin\phi)\sqrt{R_o}$

R_o = Overconsolidation ratio

$R_o = \frac{\bar{\sigma}_p}{\bar{\sigma}_o}$,

$\bar{\sigma}_p$: max. preconsolidation pressure
$\bar{\sigma}_o$: effective stress from Ground surface to mid of clay Layer.

$R_o = 1$ For N.C. clay

b-2) Bored pile

$$\beta = K_s \tan\bar{\phi} \quad \text{For } C < 100 \text{ kN/m}^2$$

$$K_s = (1 - \sin\bar{\phi})$$

$$\beta = 0.8 \tan\bar{\phi} \quad \text{For } C \geq 100 \text{ kN/m}^2$$

c) λ method

$$C_a = \lambda(\bar{\sigma_v} + 2C_u)$$

λ From Fig. (7-7) page 334

2) pile in Sand

$$Q_b = \bar{\sigma}_{v_b} N_q A_b$$

$\bar{\sigma}_{v_b}$ = effective stress at pile base

A_b = Area of pile at tipe

N_q = from table (4-1) page 152.

$$Q_s = K_s \bar{\sigma_v} \tan\delta \, A_s$$

pile type	δ	K_s	
		loose sand	dense sand
Steel	20°	0.5	1.0
Concret	$\frac{3}{4}\phi$	1.0	2.0
timber	$\frac{2}{3}\phi$	1.5	4.0

Factor of Safety

① Compression piles

$$F.S = \frac{Q_p}{Q_{all}}, \quad Q_p = \text{ultimate capacity of pile.}$$

Q_a = allowable capacity of pile.

For driven piles $F.S \geq 2.5$, $Q_{all} \leq \frac{\sum Q_s}{1} + \frac{Q_b}{3}$

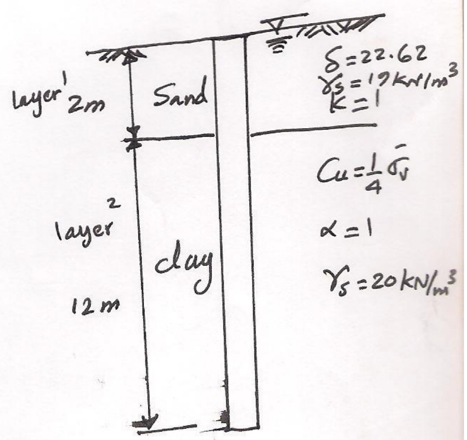
For bored piles $F.S = 2.0$

② Tension piles « Uplift force

$$Q_{all})_{uplift} = \frac{\sum Q_s + W_p}{F.S}$$

W_p = Weight of pile

Ex: For driven pile (0.3x0.3)m shown below, Calculate Q_p



$Q_b = C N_c A_b$

$C = \frac{1}{4}[2 * \bar{\gamma}\, 9 + 12 * \bar{\gamma}\, 10$

$= 34.5\ kN/m^2$

$Q_b = 34.5 * 9 * 0.3^2 = 27.9\ kN$

$Q_{s_1} = K_s \bar{\sigma}_v \tan\delta\, A_{s_1}$

$= 1 * (1*9) * \tan 22.62 * (2*4*0.3)$

$= 9\ kN$

$Q_{s2} = C_a A_{s2} = \alpha C A_{s2}$

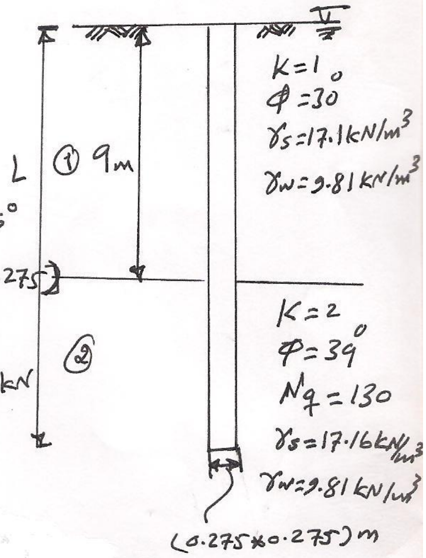
$= 1.02 * 19.5 * (12*4*0.3) = 286.4\ kN$

$Q_p = Q_b + Q_{s1} + Q_{s2} = 27.9 + 9 + 286.4 = \boxed{323.3\ kN}$ Ans

Ex: For $Q_{all})_{uplift} = 200\,kN$, $F.s = 2.5$ and $Q_p)_{all} = 400\,kN$

calculate length of pile and F.s

Sol:



$$Q_{all})_{uplift} = \frac{\sum Q_s}{F.s}$$

$$\sum Q_s = 200 * 2.5 = 500\,kN$$

$$Q_{s_1} = K_s \bar{\sigma}_v \tan\delta\, A_{s_1}, \quad \delta = \frac{3}{4} * 30 = 22.5^\circ$$

$$= 1 * [4.5(17.16 - 9.81)] \tan 22.5 * (9 * 4 * 0.275)$$

$$= 135.6\,kN$$

$$Q_{s_2} = \sum Q_s - Q_{s_1} = 500 - 135.6 = 364.4\,kN$$

$$Q_{s_2} = K_s \bar{\sigma}_v \tan\delta\, A_{s_2}$$

$$\delta = \frac{3}{4} * 39 = 29.25^\circ$$

$$364.4 = 2 * [9 * 7.35 + (\frac{L-9}{2}) * 7.35] * \tan 29.25 * (L-9) * 4 * 0.275$$

$$L^2 - 81 = 80.6 \Rightarrow L = \sqrt{161.6} = 12.7\,m$$

$$\boxed{\simeq 13\,m} \quad \text{Ans 1}$$

$$Q_b = \bar{\sigma}_{vb} * N_q * A_b$$

$$= [9 * 7.35 + 4 * 7.35] * 130 * (0.275)^2 = 939.4\,kN$$

$$Q_{all} = \frac{Q_p}{F.s} \Rightarrow F.s = \frac{500 + 939.4}{400} = \boxed{3.6} \quad \text{Ans 2}$$