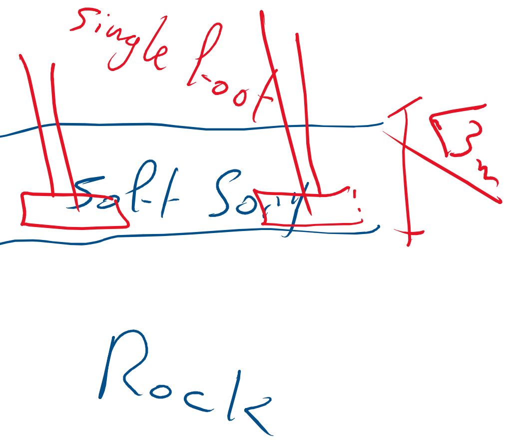
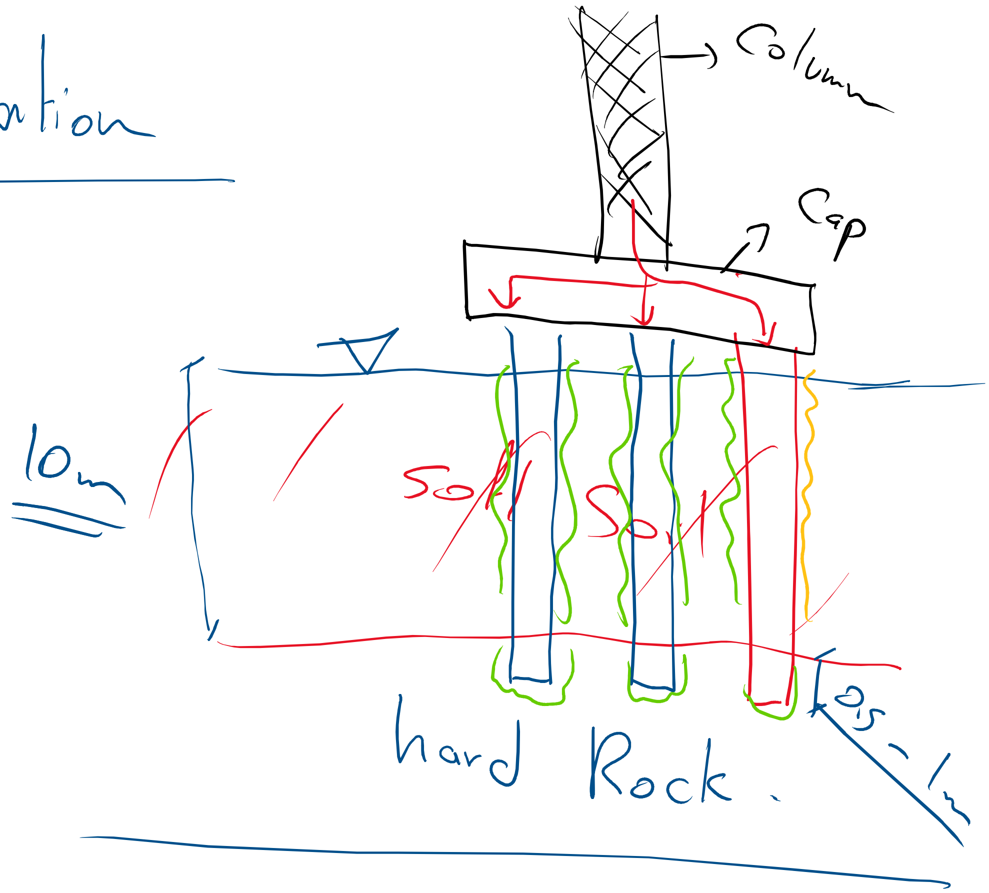
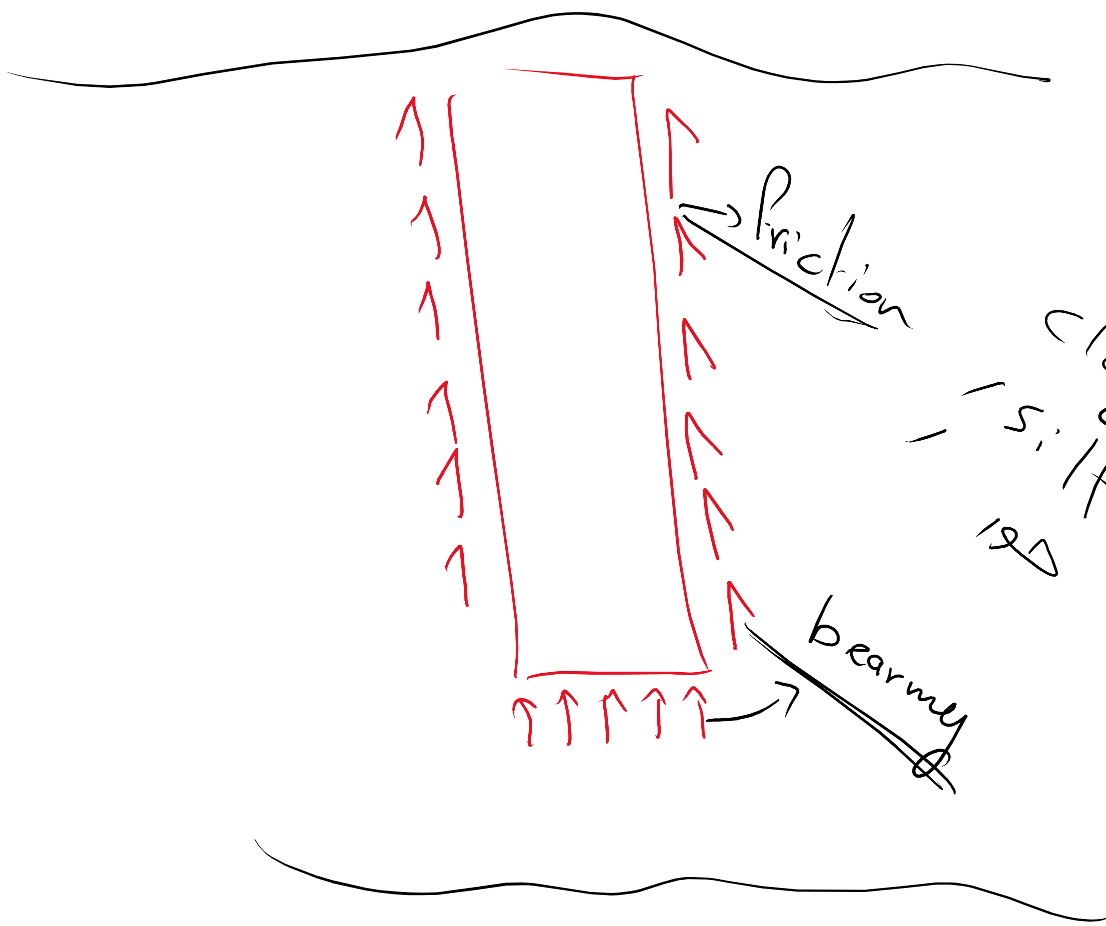
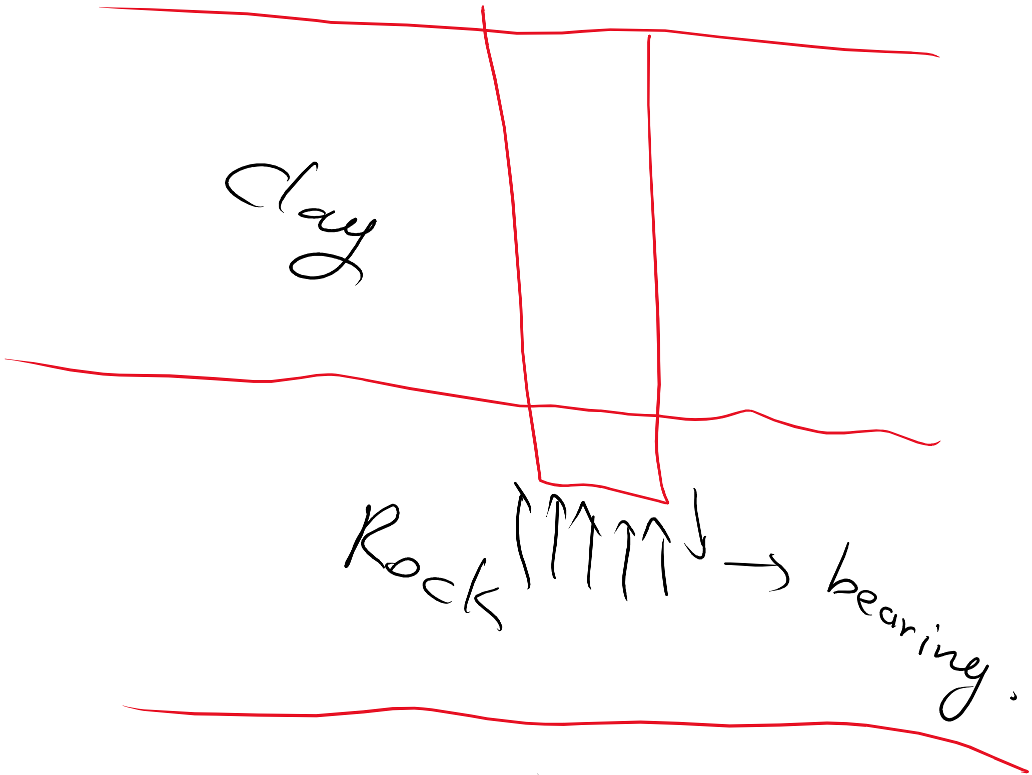
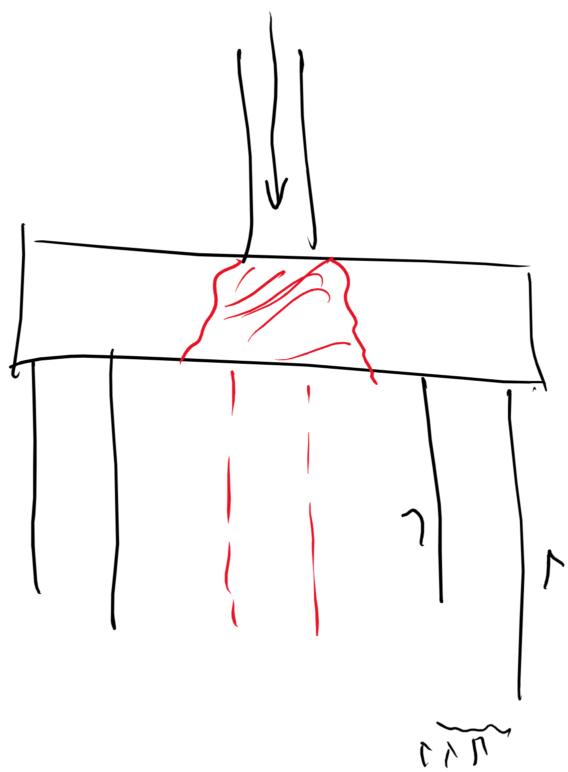
Pile foundation








Clay
Rock
bearing.



Design Steps

① number of Pile required.

example of soil report

Length	Pile Dia	Capacity.
5 m	50	1000 kN.
	60	1100
	70	1200
	80	1300
	100	1400

② Cap thickess, Dimension

③ Cap reinforcemt

④ Pile design

number of required piles

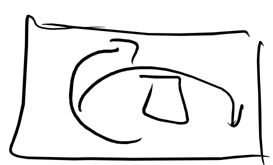
① case I : no moment

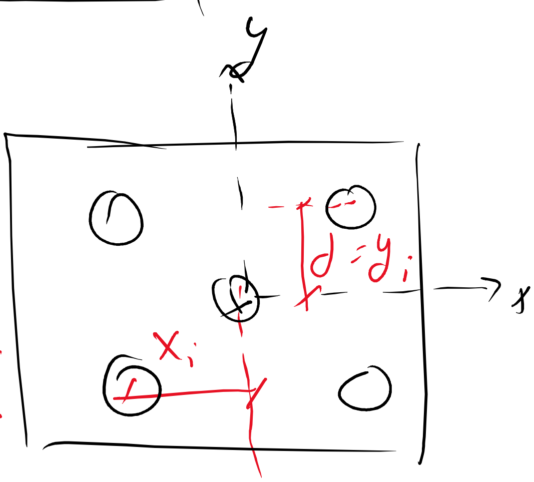
$$\# \text{Piles} = \frac{\text{total service load}}{\text{Pile Capacity}}$$

② with moment

$$\sigma_{max} = \frac{P}{A} + \frac{M_x C_x}{I_x} + \frac{M_y C_y}{I_y}$$

($C_x \rightarrow y_{max}$, $C_y \rightarrow x_{max}$)





$$I_x = \sum I_{x_i}$$

$$= \sum \left(I_{x_0} + A_i d_i^2 \right) = \sum A_i y_i^2$$

(I_{x_0}: small)

$$I_y = \sum A_i x_i^2$$

$$\sigma_{max} = \frac{P}{\sum A_i} + \frac{M_x\, y_{max}}{\sum A_i y_i^2} + \frac{M_y \times X_{max}}{\sum A_i x_i^2}$$

→ if A_i constant (in most cases)

$$A_i = A_p$$

$$\sigma_{max} = \frac{P}{N \times A_p} + \frac{M_x\, y_{max}}{A_p \sum y_i^2} + \frac{M_{y} \times X_{max}}{A_p \sum x_i^2}$$

→ stress

→ Load

R_{max} (reaction on Pile)

$$R_{max} = \sigma_{max} \times A_p = \left(\frac{P_s}{N} + \frac{M_x\, y_{max}}{\sum y_i^2} + \frac{M_y \times X_{max}}{\sum X_i^2} \right)$$

↓ for single pile.

$R_{max} < Q_{all}$

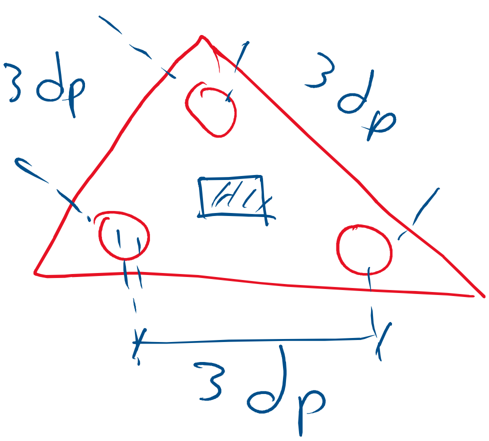
Notes

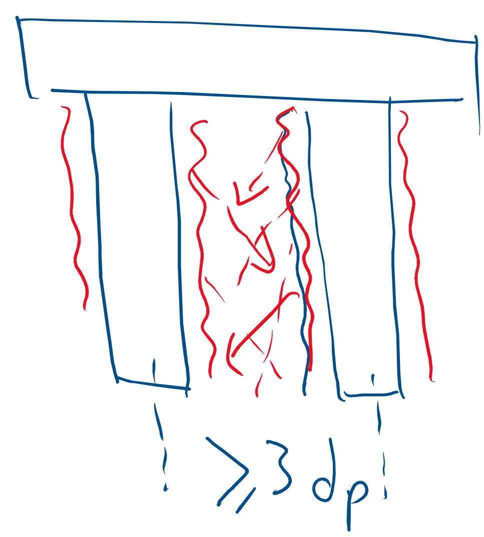
① Piles Center to Center placement $\geq 3\,d_p$

② $R_{max} = \frac{P}{N}$ if no moment on Colum.

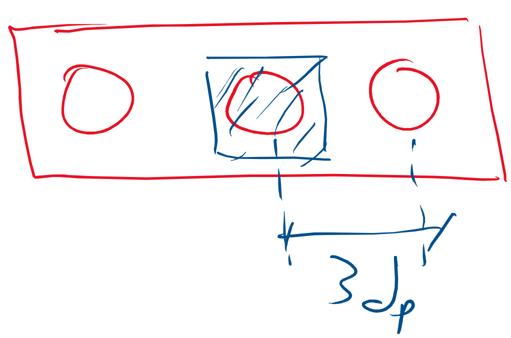
N ← عدد البايلز

③ 3 piles

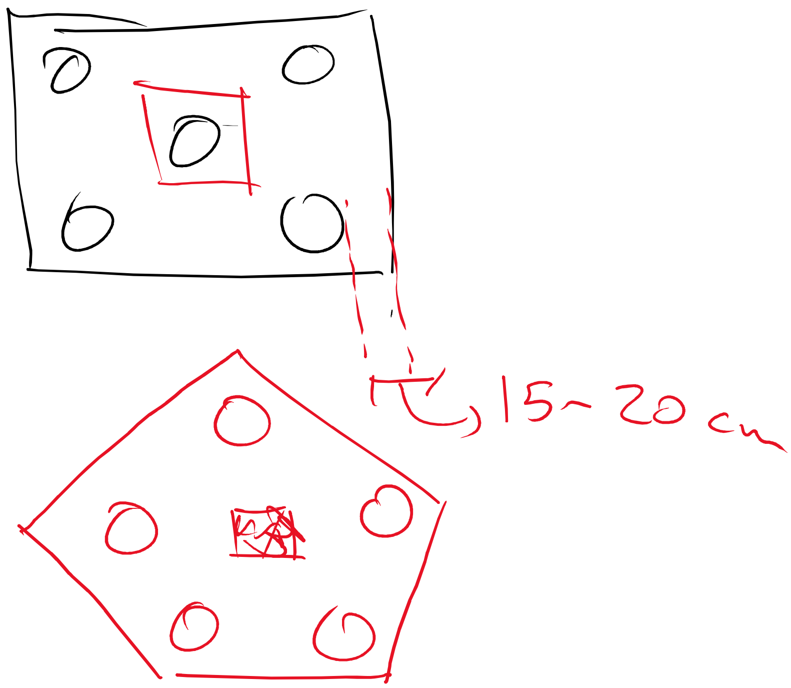




3 piles



5 pile



④ incase of tension Load on Pile (from load or moment)

$$R_{min} = \frac{P}{N} - \frac{M_x\, y_{max}}{\sum y_i^2} - \frac{M_y\, x_{max}}{\sum x_i^2} \geq Q_{all} \text{ in tension}$$

→ Pile Capacity in Comprission Q_{all_C}

→ Pile Capacity in tension Q_{all_T}

Thickness (Cap)

→ Punching Shear

→ Punching of Column on Cap

→ Punching of Pile on Cap

→ Column subjected to moment

Punching load

in Pile → $V_u = R_{max} \times N$

→ no moment on Column but eccentricity exist → normall Calculation.

→ Pile diameters → 50 cm, 60, 80, 100 cm

Eample Draw the pile Cap Showing all dimensions for pile footing supporting

$P_D = 5000$ kN $M_D = 600$ kN.m in X
$P_L = 2500$ kN $M_L = 300$ kN.m in X

$Q_{all} = 1500$ kN / Pile Diamter = 0.8m

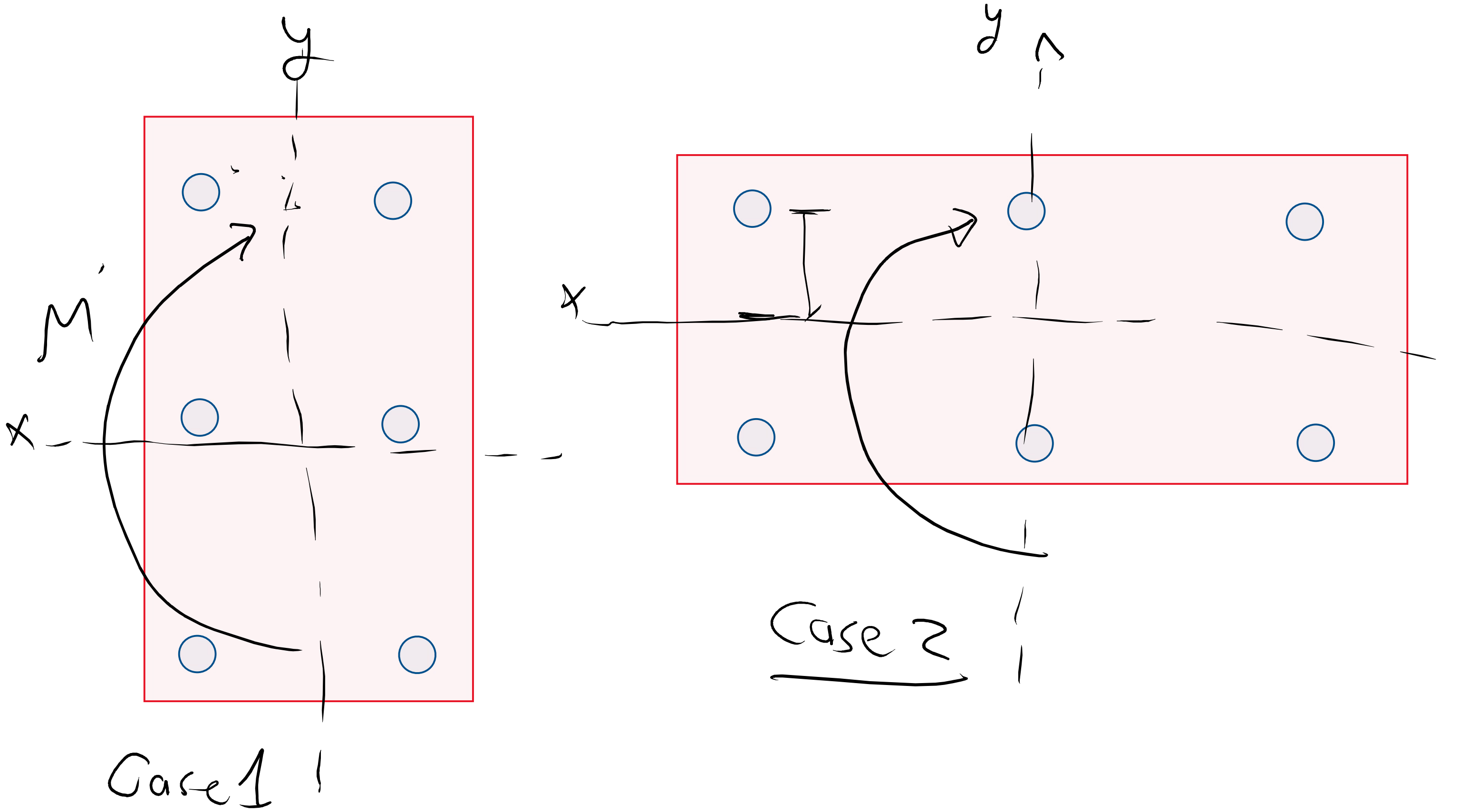
→ $P_{service} = 7500$ kN

$M_s = 9000$

→ # of Pile

if no moment → $N = \frac{7500}{1500} = 5$

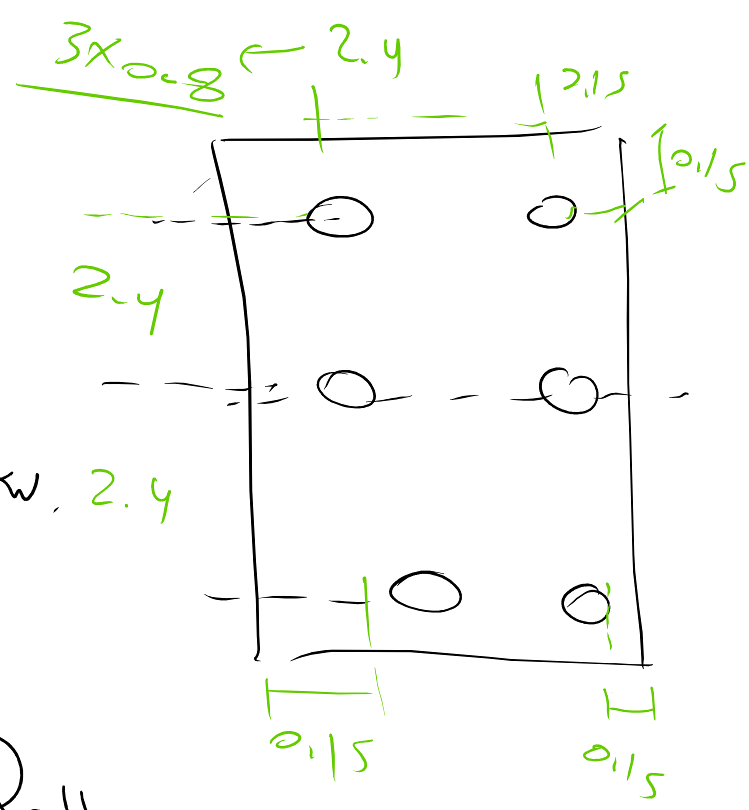
Because of moment try 6 Pile.



arrangement 1 is the stronger.

$$R_{max} = \frac{7500}{6} + \frac{\overset{M_x}{900 \times 2.4}}{4 \times 2.4^2 + 2 \times 0^2}$$

$= 1344\ kN < Q_{all} = 1500\ kN.$



for Case 2 $R_{max} > Q_{all}$

Example2

Design a pile footing for Column Carrying $P_D = 3000$ kN

$P_L = 1250$ kN, $f'_c = 40$ MPa, $Q_{all} = 1000$ kN

Column : 600x600, Pile Diameter = 0.6m

ignore weight of footing.

Solu:

no moment

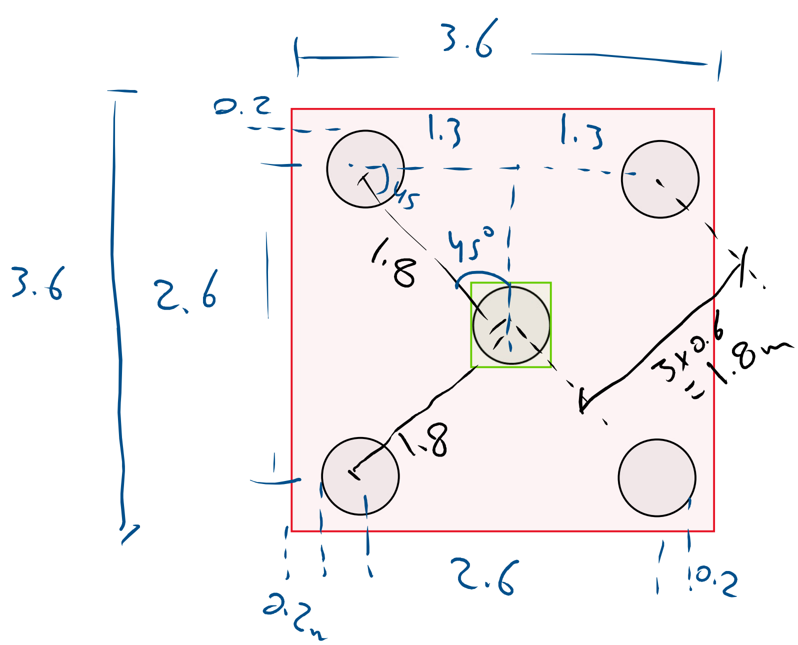
$$\rightarrow R_{max} = \frac{P_{service}}{N} = \frac{3000+1250}{N} \leq Q_{all} = 1000$$

$$N \simeq 5 \text{ piles}.$$

spacing

3dp

$$X \rightarrow 1.8 \times \sin 45 = 1.3\ m$$



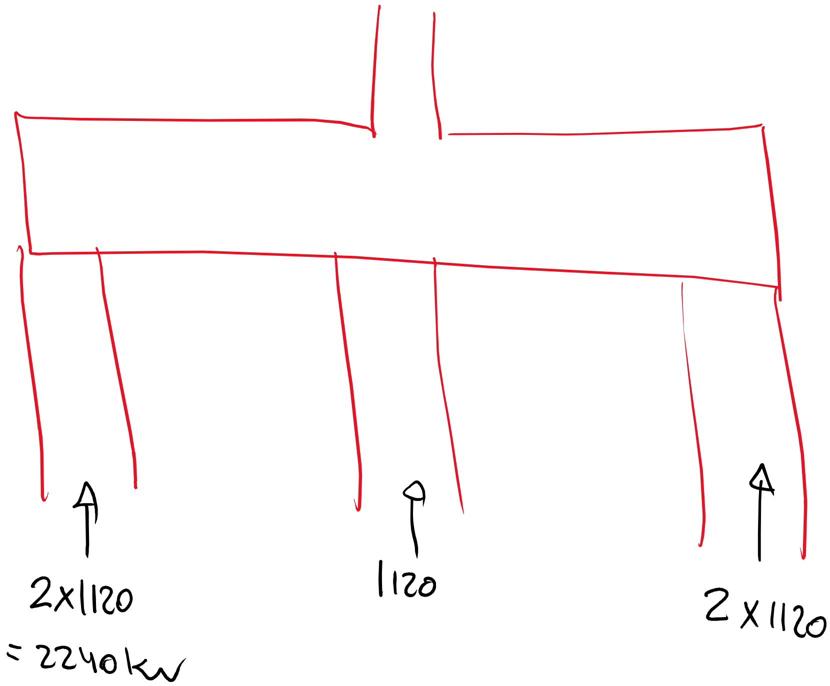
thickness

$$P_u = 1.2 \times 3000 + 1.6 \times 1250 \text{ kN}$$

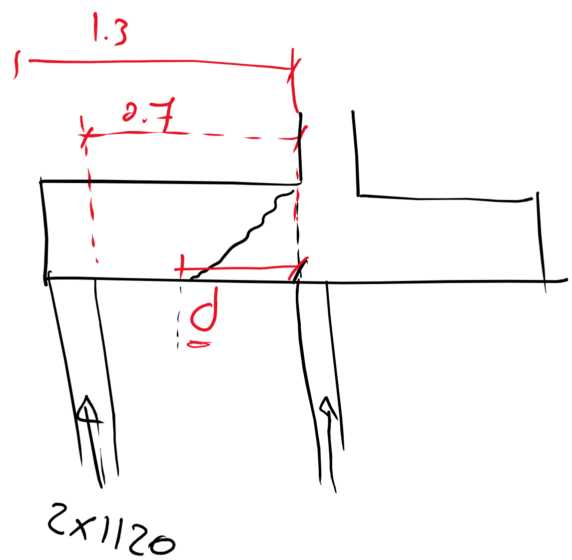
$$= 5600 \text{ kN}$$

$$R_{max_u} = \frac{P_u}{5} = 1120 \text{ kN}$$

ultimate



→ Wide Beam Shear (one way shear)

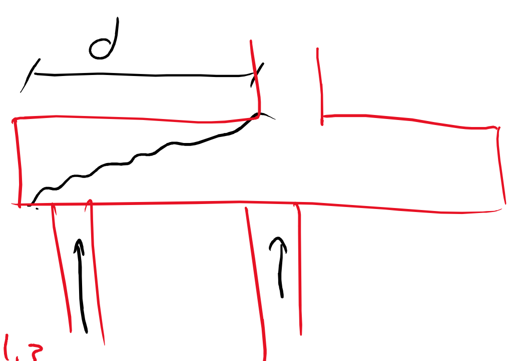


Case 1

$d \leq 0.7m$ (for this question)

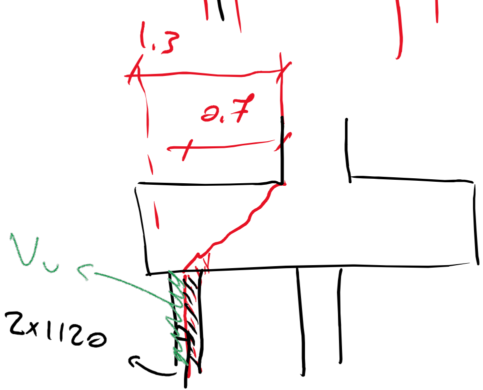
($d \leq$ distance from face of column to face of edge pile.)

$V_u = 2240$



Case 2

$V_u = \text{zero}$



Case 3

$(0.7 < d < 1.3)$

$$V_u = 2240 - \left(\frac{\frac{d}{1000} - 0.7}{1.3 - 0.7}\right) 2240$$

its either Case 1 or Case 3

→ assume Case 1 (gives the largest shear)

$V_u = 2240 = \phi V_c$

$$\phi V_c = 0.75 \times \left(\frac{1}{6}\right) \sqrt{40} \times \frac{d \times \overset{b}{(3600)}}{1000} = V_u$$

$d = 787\,mm$

$0.7 < d = 0.787 < 1.3$ → the true Case is **Case 3**

$\phi V_c = V_u$

$$0.75 \times \frac{1}{6} \sqrt{40} \times \frac{d \times 3600}{1000} = 2240 - \left(\frac{\frac{d}{1000} - 0.7}{1.3 - 0.7}\right) \times 2240$$

$d = 738\,mm$ → use $d = 790\,mm$

→ $h = 950\,mm$.

use Cover in pile Cap

√ (150) 250 mm

① = ② = ③ = ④

Case 1 or 2 or 3

Case 3 in example