Fayoum University

Faculty of Engineering

Department of Civil Engineering

CE 402: Part A

Shallow Foundation Design

Lecture No. (3): Spread Footing

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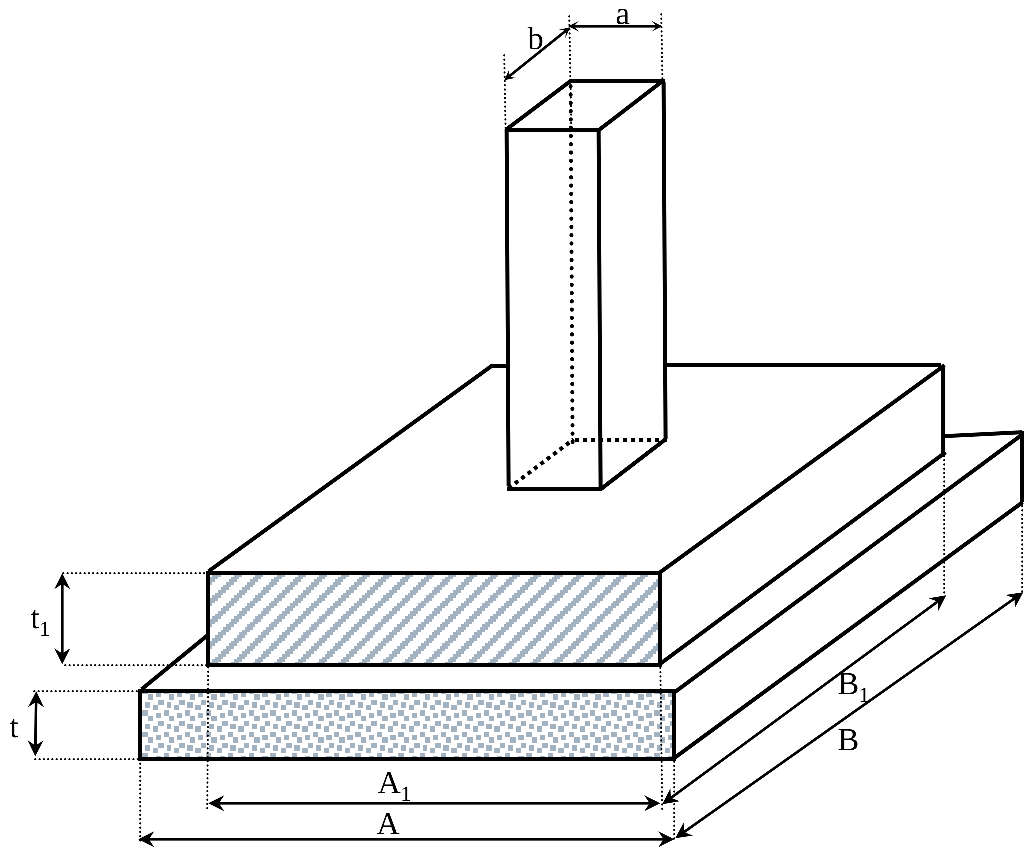
Spread Footing



Design of Spread Footing

- Plain concrete footing (P.C.)

$$Area = A * B = \frac{P_{F.L}}{q_a}$$ → Eq.(1)

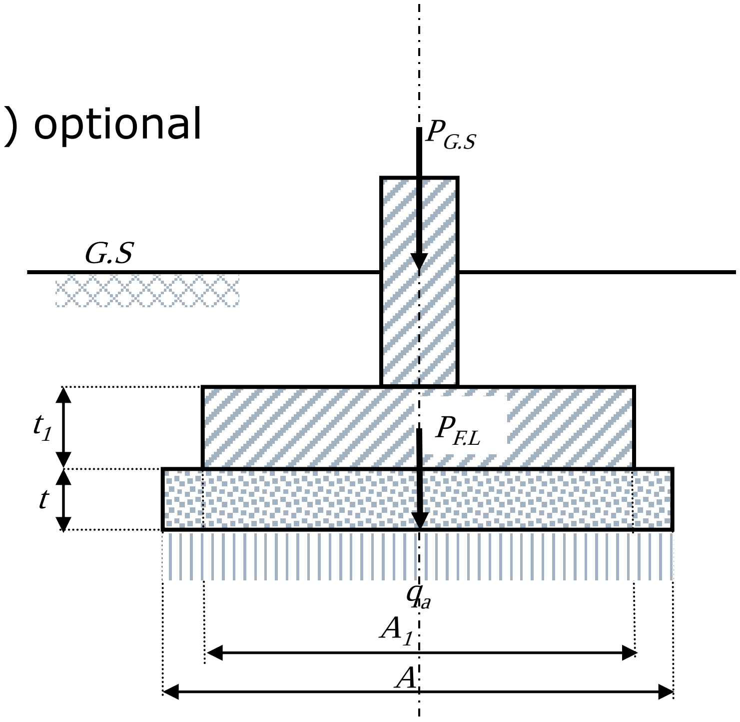
$$(A - a) = (B - b)$$ → Eq.(2) optional

Solve Eqs (1)&(2) to get A and B

Assume thickness of P.C.:

t = (0.25 to 0.50)

Dim. of P.C. = A * B * t



Design of Spread Footing

- Reinforced concrete footing (R.C.)

$$X = (0.80 \rightarrow 1.00) * t$$

$$A_1 = A - 2X \qquad B_1 = B - 2X$$

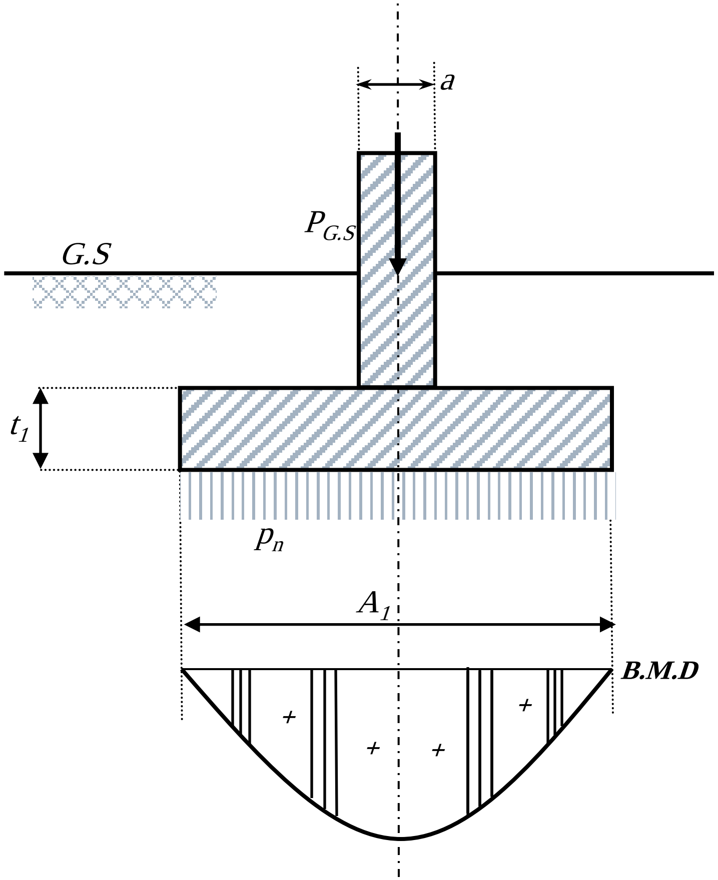
$$p_n = \frac{P_{G.s}}{A_1 * B_1}$$

$$M_I = p_n \frac{\left[(A_1 - a)/2\right]^2}{2}$$

$$d = C\sqrt{\frac{M}{b * F_{cu}}}$$

$$t_1 = d + \text{cover}$$

Steel cover=5.0 to 7.0cm



Dim. of R.C. = $A_1 * B_1 * t_1$

Design of Spread Footing

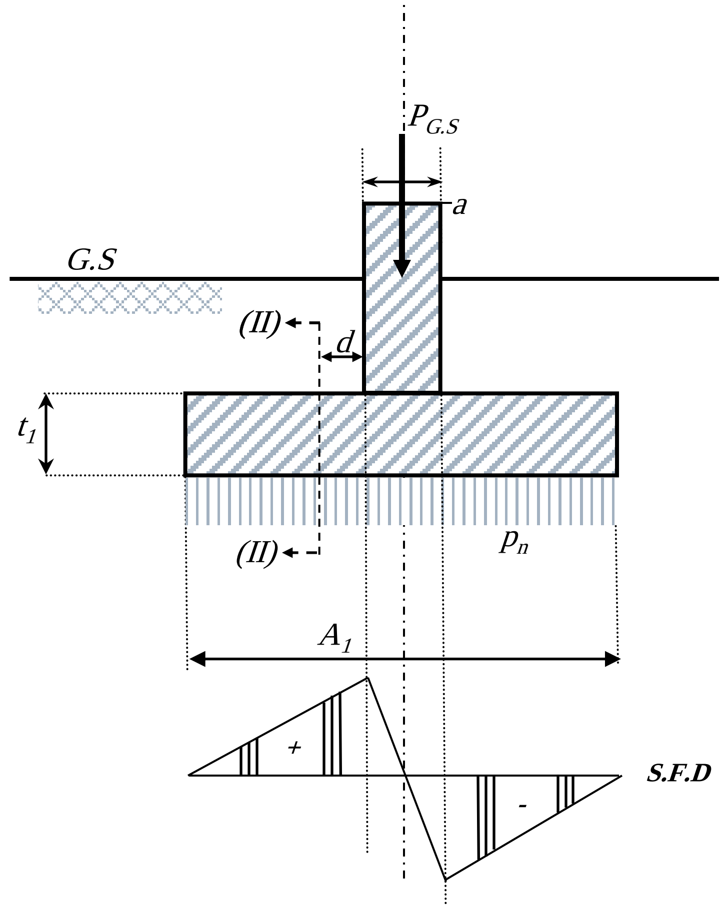
- Shear Stress:

$$Q_s = p_n * \left(\frac{A_1 - a}{2} - d \right)$$

$$q_s = \frac{Q_s}{b * d} \leq q_{su}$$

$$q_{su} = 0.75 \sqrt{\frac{f_{cu}}{\gamma_c}}$$

If $q_s > q_{su}$, *Increase d*



Notes:

•No shear RFT in Footing.

Q_s: shear force at critical sec. (II).

q_s: shear stress.

q_{su}: ultimate shear strength.

Design of Spread Footing

- Punching Stress:

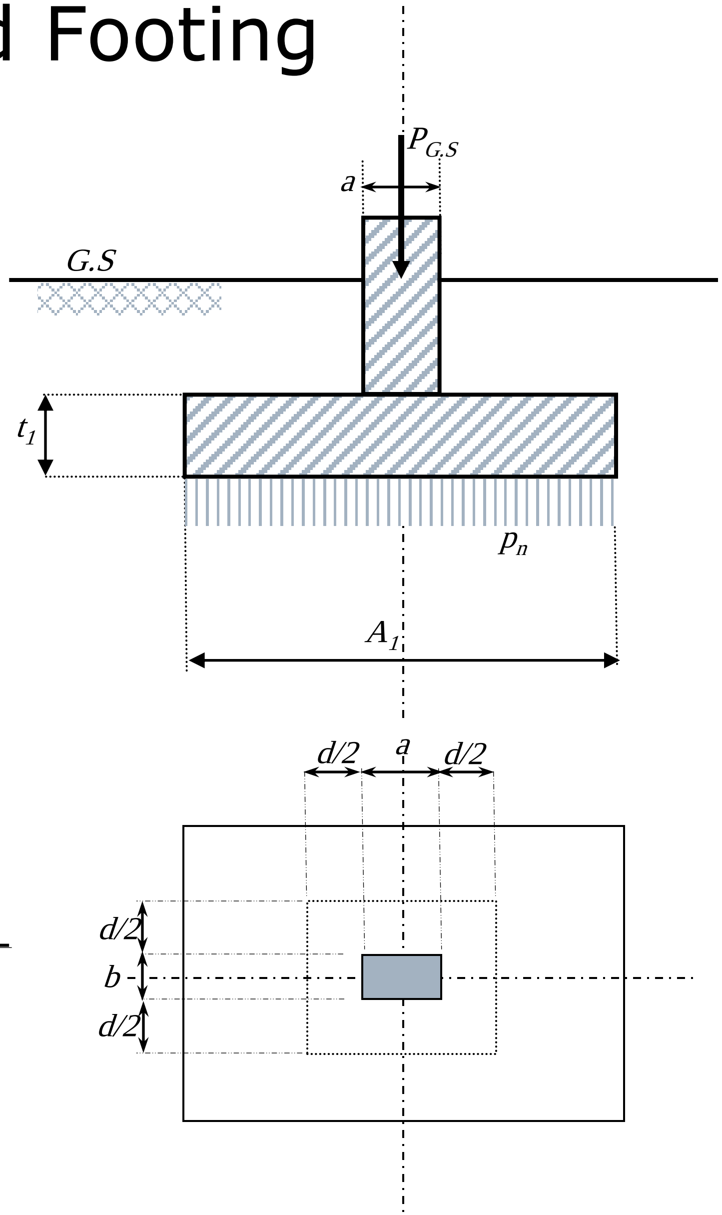
$$Q_p = P_{G.s} - p_n * [(a+d)*(b+d)]$$

$$A_p = d*2*[(a+d)+(b+d)]$$

$$q_p = \frac{Q_p}{A_p}$$

$$q_{cup} = [0.5+(a/b)]\sqrt{f_{cu}/\gamma_c} \leq \sqrt{f_{cu}/\gamma_c}$$

If $q_p > q_{cup}$, *Increase d*



Design of Spread Footing

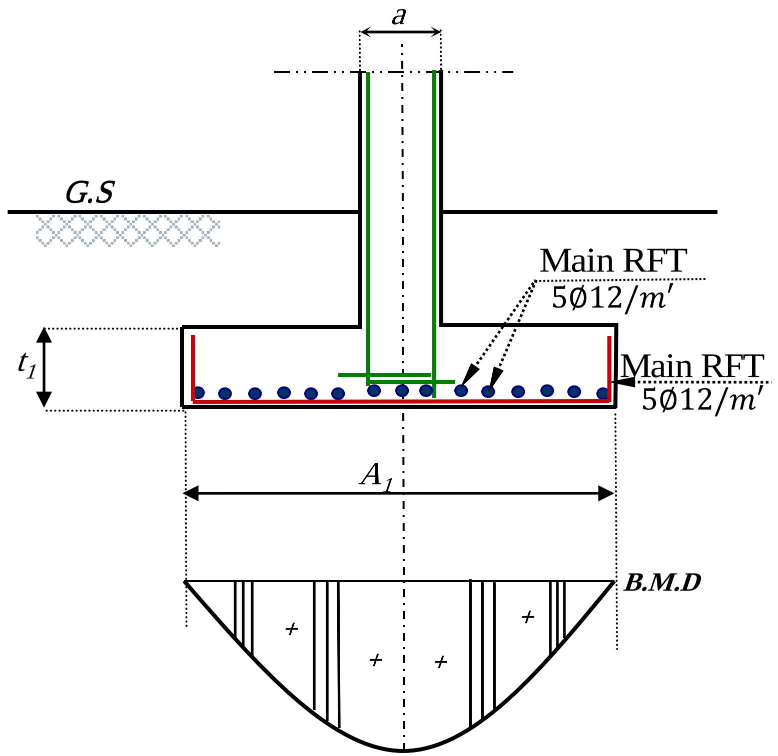
- Footing Reinforcement:

Which is required?

Top or bottom RFT

why?

$$A_s = \frac{M_I}{f_y * d * j}$$



Notes:

- Minimum number of bars per meter is five.
- Minimum diameter for main RFT is 12mm.
- Number of bars may be taken 5 to 8.
- Diameter of bars may be selected from 12 to 18mm.

Design of Spread Footing

- Example(1):

Make a complete design for a footing supporting a 30cm X 60cm column load of 230t at ground surface (G.S.). The foundation level is 1.5 m below G.S. and the net allowable bearing capacity is 1.75kg/cm2. Make the design considering the following two cases:

1- with plain concrete base

2- without Plain concrete base

$a = 0.60m.$ $B = 0.30m$

$p_{G.S} = 230t/m'$

$q_a = 1.75kg/cm^2 = 17.5t/m^2.$

$f_{cu} = 250kg/cm^2.$

$f_y = 3600kg/cm^2$

Design of Spread Footing

- Plain concrete footing (P.C.)

$$Area = A * B = \frac{P_{F.L}}{q_a} = \frac{230*1.15}{17.5} = 15.11 m^2$$

Dim. of P.C. = 4.05 * 3.75 * 0.30

$$A * B = 15.11 m^2 \longrightarrow \text{Eq.(1)}$$

$$(A - a) = (B - b)$$

$$(A - B) = 0.30 \longrightarrow A = B + 0.30 \longrightarrow \text{Eq.(2)}$$

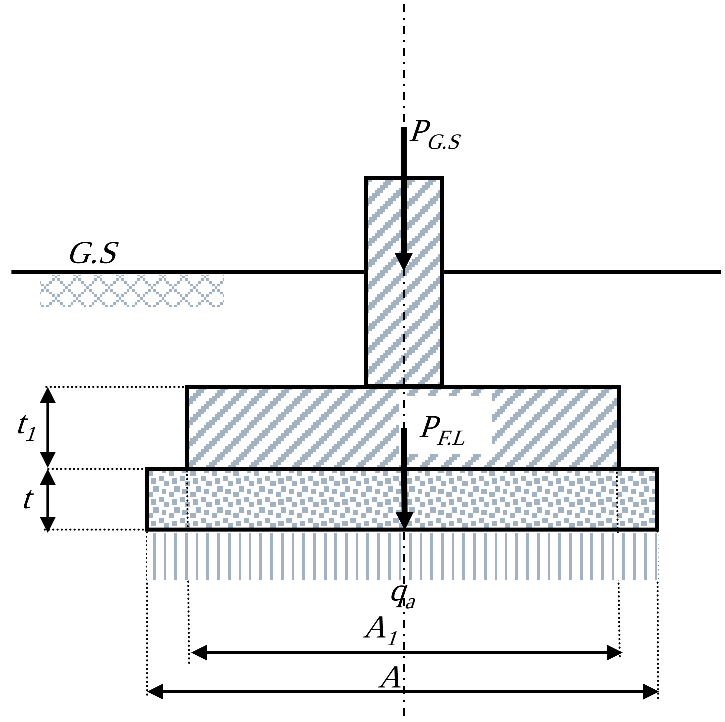
Solve Eqs (1)&(2) to get A and B

$$(B + 0.30) * B = 15.11 m^2$$

$$B^2 + 0.30 * B - 15.11 = 0.0$$

$$B = \frac{-0.30 + \sqrt{0.30^2 + 4*1*15.11}}{2*1} = 3.75 m$$

$$A = 3.75 + 0.30 = 4.05 m$$



Assume thickness of P.C.: t = 0.30m

Design of Spread Footing

- Reinforced concrete footing (R.C.)

$$X = 0.30m$$

$$A_1 = 4.05 - 2*0.30 = 3.45m$$

$$B_1 = 3.75 - 0.60 = 3.15m$$

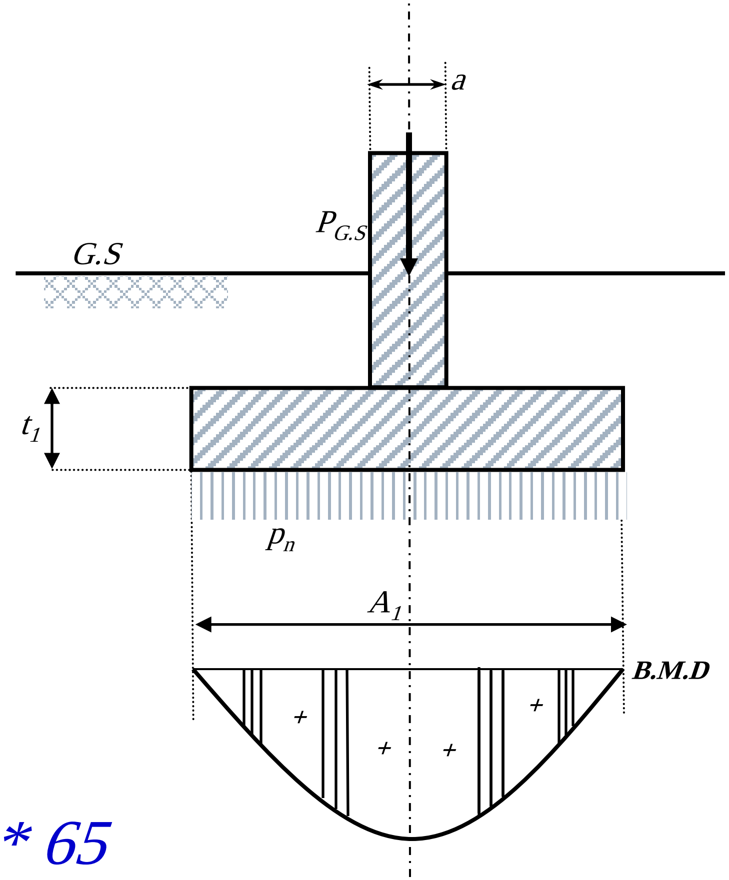
$$p_n = \frac{P_{G.s}}{A_1 * B_1} = \frac{230*1.50}{3.45*3.15} = 31.75 t/m^2$$

$$M_I = p_n \frac{[(A_1 - a)/2]^2}{2}$$

$$M_I == 31.75 \frac{[(3.45 - 0.60)/2]^2}{2} = 32.23 m.t/m'$$

$$d = C\sqrt{\frac{M}{b * F_{cu}}} = 5\sqrt{\frac{32.23*10^5}{100*250}} = 56.77 = 60cm$$

$$t_1 = 60 + 5 = 65cm$$



Dim. of R.C. = *3.45 * 3.15* 65*

Design of Spread Footing

- Shear Stress:

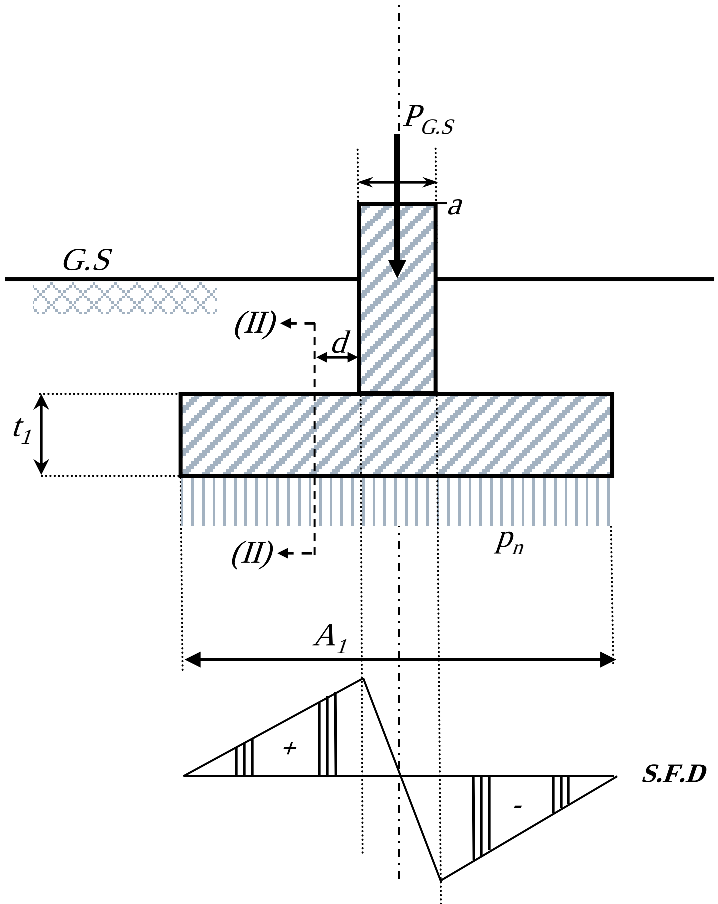
$$Q_s = p_n * \left(\frac{A_1 - a}{2} - d \right)$$

$$Q_s = 31.75\left(\frac{3.45 - 0.60}{2} - 0.60\right) = 26.19 t / m'$$

$$q_s = \frac{Q_s}{b * d} = \frac{26.19 * 10^3}{100 * 60} = 4.37 t / m^2$$

$$q_{su} = 0.75 \sqrt{\frac{f_{cu}}{\gamma_c}} = 0.75 \sqrt{\frac{250}{1.50}} = 9.68 t / m$$

$$q_s \prec q_{su} \rightarrow safe\ shear$$



<u>Notes:</u>

•No shear RFT in Footing.

Q_s: shear force at critical sec. (II).

q_s: shear stress.

q_{su}: ultimate shear strength.

Design of Spread Footing

- Punching Stress:

$$Q_p = P_{G.s} - p_n * \left[(a+d)*(b+d)\right]$$

$$Q_p = 230*1.50 - 31.75*\left[(0.60+0.50)*(0.30+0.50)\right] = 317.1t$$

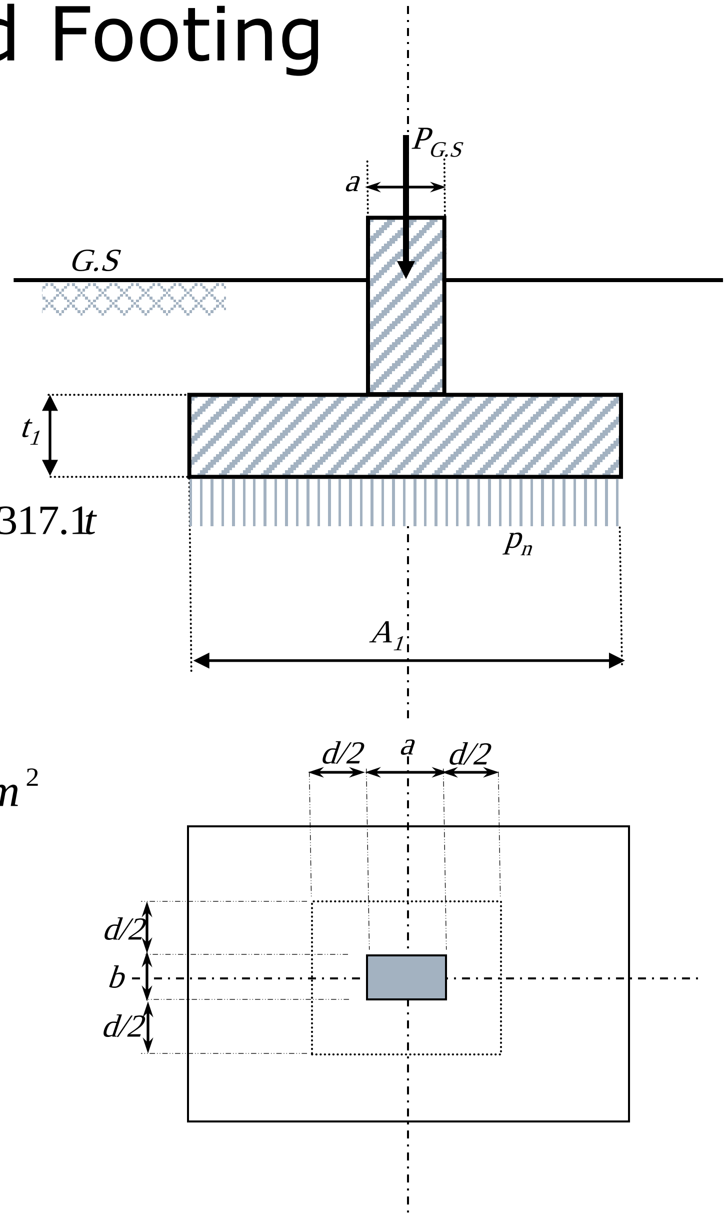
$$A_p = d*2*\left[(a+d)+(b+d)\right]$$

$$A_p = 0.60*2*\left[(0.60+0.60)+(0.30+0.60)\right] = 2.52m^2$$

$$q_p = \frac{Q_p}{A_p} = \frac{317.10*10^3}{2.52*10^4} = 12.58kg/cm^2$$

$$q_{cup} = \left[0.5+(b/a)\right]\sqrt{f_{cu}/\gamma_c} = \sqrt{250/1.50} = 12.91$$

$$q_p \prec q_{cup} \rightarrow safe\ punching$$



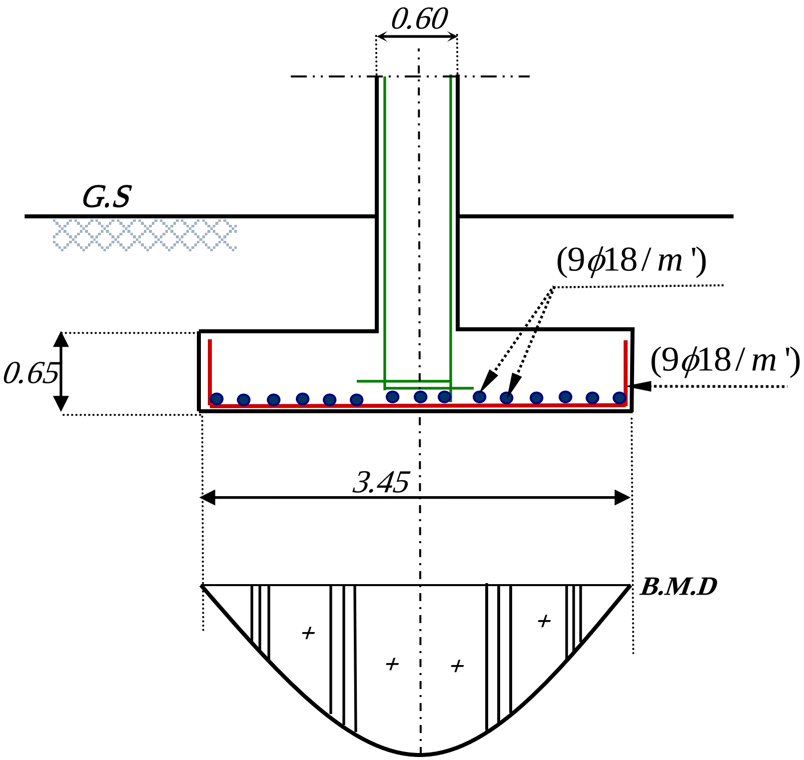
Design of Spread Footing

- Footing Reinforcement:

$$A_s = \frac{M_I}{f_y * d * j} = \frac{32.23*10^5}{3600*60*0.695} = 21.50 cm^2$$

A_s (short dir.)= *9φ18mm/m'*

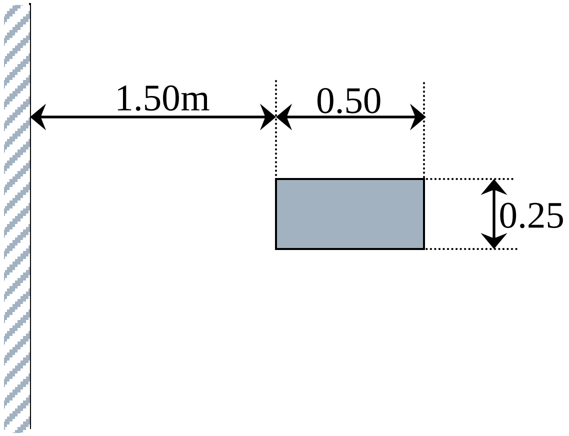
A_s (long dir.)= *9φ18mm/m'*



Design of Spread Footing

- Problem(1):

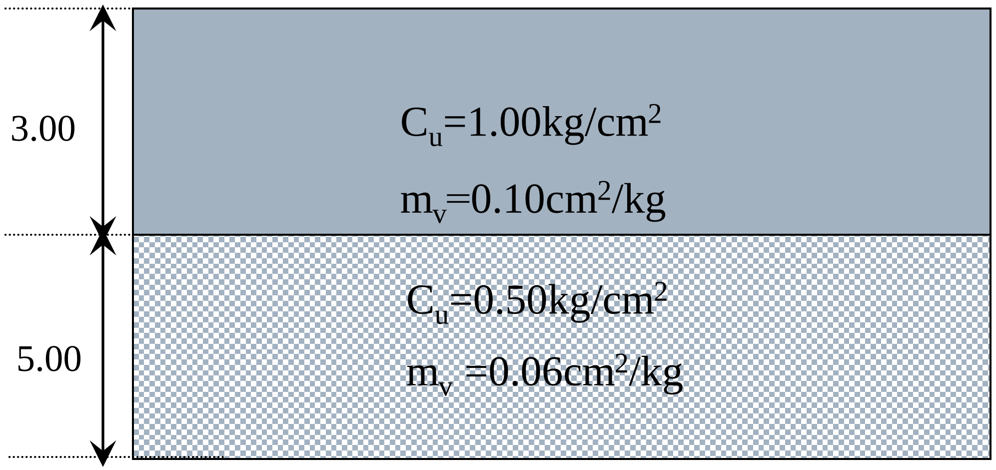
Make a complete design for a footing supporting a 25cm X 50cm column load of 150 t at ground surface (G.S.). The foundation level is 1.5 m below G.S. and the net allowable bearing capacity is 1.50kg/cm^2. The column location with respect to neighbors is shown in Figure.



Design of Spread Footing

- Problem(2):

Make a complete design for a footing supporting a 25cm X 50cm column load of 120 t at ground surface (G.S.). The foundation level is 1.5 m below G.S. Soil Profile under footing is shown in the Figure. Allowable settlement is 2.0cm.



Design of Spread Footing

- Problem(3):

Prove that the unconfined compressive strength of saturated clay can be considered as the allowable net bearing capacity of this clay.

$$q_{ult} = CN_c \lambda_c i_c + \gamma_1 D_f N_q \lambda_q i_q + \gamma_2 B N_\gamma \lambda_\gamma i_\gamma \cdots\cdots\cdots\cdots \text{(ECP:202/3) Eq. (3-8)}$$

$$q_{ult} = C_u N_c \lambda_c i_c = C_u * 5.14 * 1.30 * 1.0 = 6.68 C_u$$

F.S. from Table (3-3) ECP:202/3

$$q_a = \frac{q_{ult}}{F.S.} = \frac{6.68 C_u}{2.50} = 2.60 C_u \approx 2C_u = q_u$$

Design of Spread Footing

- Problem(4):

A large footing settles more than a small one resting on the same ground profile and subjected to the same stresses. Give reasons using neat sketches.