Design of combined foundation

Design a RC combined rectangular footings of two columns A and B carrie 600 KN and 800 KN respectively. The dimension of column A is 400 mm * 400 mm and column B 500 mm*500 mm. The center to center spacing between columns is 3.8m. The safe bearing capacity of a soil is 150 KN/m2. $f_c = 30Mpa$, $and\ f_y = 430\ Mpa$

Solution:

Assume Weight of footing = (0.1)Q = 0.1*1400 KN = 140 KN

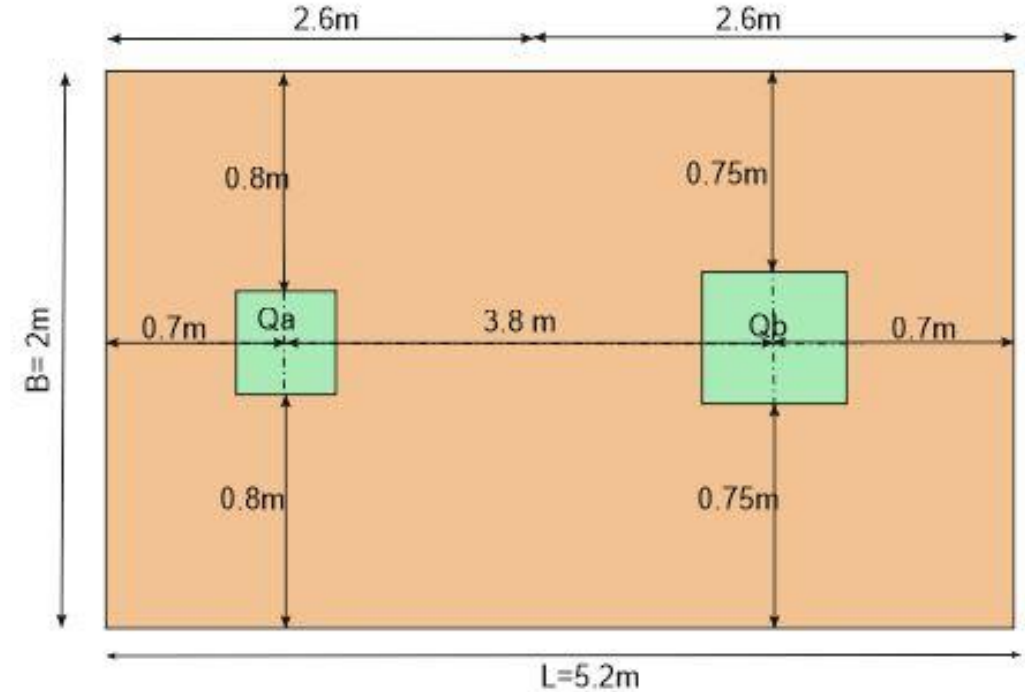
Total Q = 1400 +140 = 1540KN

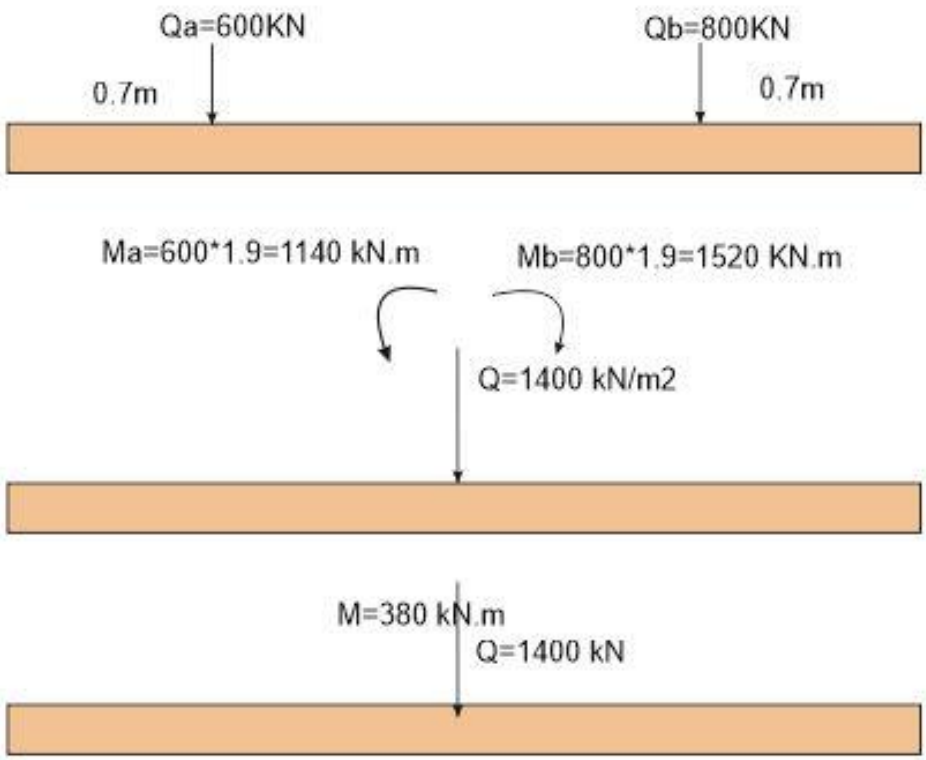
Area of footing =$\frac{1540\ KN}{150KN/m2}$ =10.27 m^2

$A = BL$, if we assume B = 2 m, then $L = \frac{10.27}{2} = 5.135\ m \cong 5.2\ m$

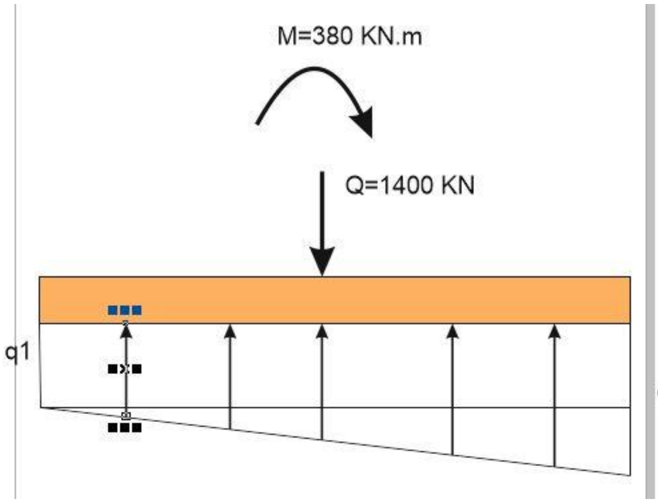
Then new A = 5.2*2=10.4 m^2

Address the eccentricity


2.6m
2.6m
0.8m
0.75m
B= 2m
0.7m
Qa
3.8 m
Qb
0.7m
0.8m
0.75m
L=5.2m


Qa=600KN
Qb=800KN
0.7m
0.7m
Ma=600*1.9=1140 kN.m
Mb=800*1.9=1520 KN.m
Q=1400 kN/m2
M=380 kN.m
Q=1400 kN

Soil reaction



$$I_L = \frac{BL^3}{12} = \frac{2(5.2)^3}{12} = 23.43m4$$

$$q = \frac{Q}{BL} + \frac{MX}{I_L}$$

$$q_2 = \frac{1400}{2*5.2} + \frac{380*2.6}{23.43} = 134.6 + 42.168 = 176.7KN/m2$$

$$q_1 = \frac{1400}{5.2*2} - \frac{380*2.6}{11.71} = 134.6 - 42.168 = 91.8KN/m2$$

$$q_2 > 150\ Not\ ok$$

Let B=2.5m

$$I_L = \frac{BL^3}{12} = \frac{2.5(5.2)^3}{12} = 29.29m4$$

$$q = \frac{Q}{BL} + \frac{MX}{I_B}$$

$$q_2 = \frac{1400}{2.5*5.2} + \frac{380*2.6}{29.29} = 107.692 + 33.731 = 141.423KN/m2$$

$$q_1 = \frac{1400}{5.2*2} - \frac{380*2.6}{11.71} = 107.692 - 33.731 = 73.961KN/m2$$

$$q_2 < 150\ \ ok$$

This is based on the total settlement is within the allowable limits.

Shear force and bending moment diagram

Shear 0 - a

$$V = q_1 x + \frac{(q_{2-q1})X}{L} * \frac{X}{2} = q_1 x + \frac{(q_{2-q1})x^2}{2L}$$

Shear a – b

$$V = q_1 x + \frac{(q_{2-q1})x^2}{2B} - 600$$

Point of zero shear

$$0 = q_1 x + \frac{(q_{2-q1})x^2}{2L} - 600$$

$$600 = 184.9x + \frac{(353.557-184.9)}{2*5.2} x^2 \text{ , } 600 = 184.9x + 16.217x^2$$

$$x = 2.64m$$

Bending moment

Moment 0 - a

$$M = q1 \frac{x^2}{2} + \frac{(q2-q1)x}{B} * \frac{x}{2} * \frac{x}{3} = q1 \frac{x^2}{2} + \frac{(q2-q1)x^3}{6B}$$

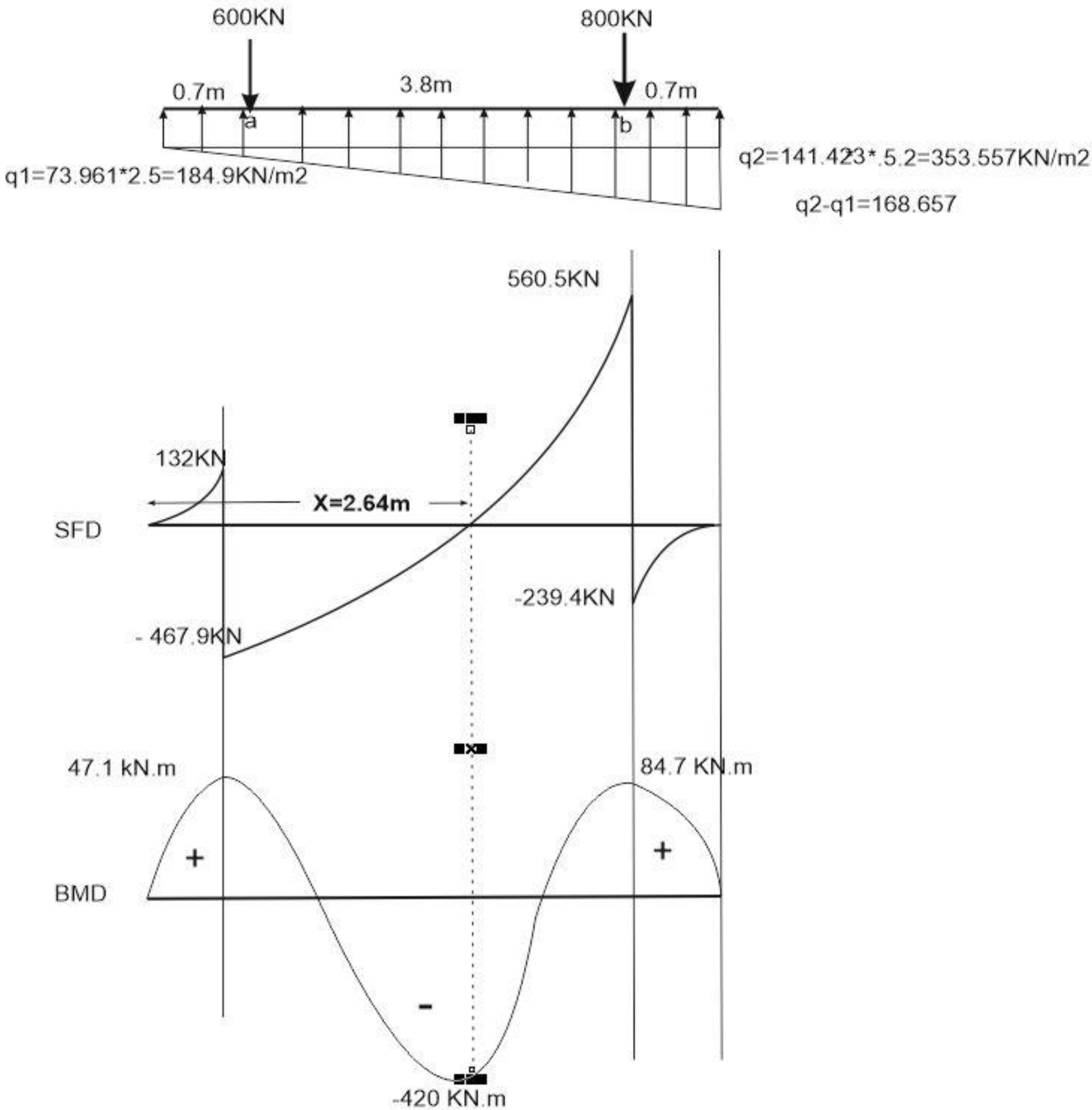
$$M_a = 185 * \frac{0.7^2}{2} + \frac{(353.557-184.9)0.7^3}{6*5.2} = 47.1KN.m$$

Moment a – b

$$M = q1 \frac{x^2}{2} + \frac{(q2-q1)x^3}{6B} - 600 * (x - 0.7)$$

$$M_{max} = 184.9 * \frac{(2.64)^2}{2} + \frac{(353.557-184.9)(2.64)^3}{6*5.2} - 600 * (2.64 - 0.7) = -420\ kN.m$$

$$M_b = 184.9 * \frac{(4.5)^2}{2} + \frac{(353.557-184.9)(4.5)^3}{6*5.2} - 600*(4.5-0.7) = 84.7\ kN.m$$



Footing Thickness (d)

$U = b_\circ d\emptyset(0.34)\sqrt{f'c}$

Column1

$$800 = 4(d + 0.5)d * 0.85(0.34) * 1000 * \sqrt{30}$$

$$0.1263 = (d + 0.5)d\,,\ d = 0.18m$$

Punching check

$$V_{max\ punching} = 0.33\sqrt{fc} = 0.33\sqrt{30} = 1.8\ Mpa$$

$$V_{punching} = \frac{U}{b_\circ d} = \frac{800/1000}{4(0.5+0.18)0.18} = 1.633\ Mpa$$ ok

Column2

$$V_{punching} = \frac{U}{b_\circ d} = \frac{600/1000}{4(0.4+0.18)0.18} = 1.436\ Mpa$$

O.K

Shear check

$$V_{cmax} = 0.17\sqrt{30} = 0.93\ Mpa$$

$$V_C = \frac{V}{Bd} = \frac{560.5/1000}{2.5*0.18} = 1.24555\ Mpa$$

Not good

Take $d = 0.25m$

$$V_C = \frac{V}{Ld} = \frac{560.5/1000}{2.5*0.25} = 0.8964\ Mpa < V_{Cmax}$$ ok

$H = 0.25 + 0.075 = 0.325m,$ take H=35 cm

$$dnet = 0.35 - 0.075 = 0.275m$$

Reinforcement design of negative moment

$$\rho = \frac{A_S}{bd}$$

$$M_U = \emptyset\rho bd^2 f_y(1 - \frac{\rho f_y}{1.7f_C})$$

$$1.7 * 420 = 0.85 * \rho * 2.5 * 0.275^2 * 1000 * 430\left(1 - \frac{\rho * 430}{1.7 * 30}\right)$$

$$0.0103 = \rho(1 - 8.4\rho)$$

$$\rho = 0.0115$$

$$A_S = 0.0115 * 2.5 * 0.275 * 10^6 = 7906\ mm2$$

$A_S Min = 0.0018Ld = 0.0018 * 2.5 * 0.275 * 10^6 = 1125\ mm2$ **<7906mm2 ok**

$$A_s\emptyset 16 = 201mm2$$

$$No\ of\ Bars = \frac{7906}{201} = 39.33, \qquad use\ 40\emptyset 16mm/2.5m$$

Design of reinforcement at b

$$\rho = \frac{A_S}{bd}$$

$$M_U = \emptyset\rho bd^2 f_y(1 - \frac{\rho f_y}{1.7f_C})$$

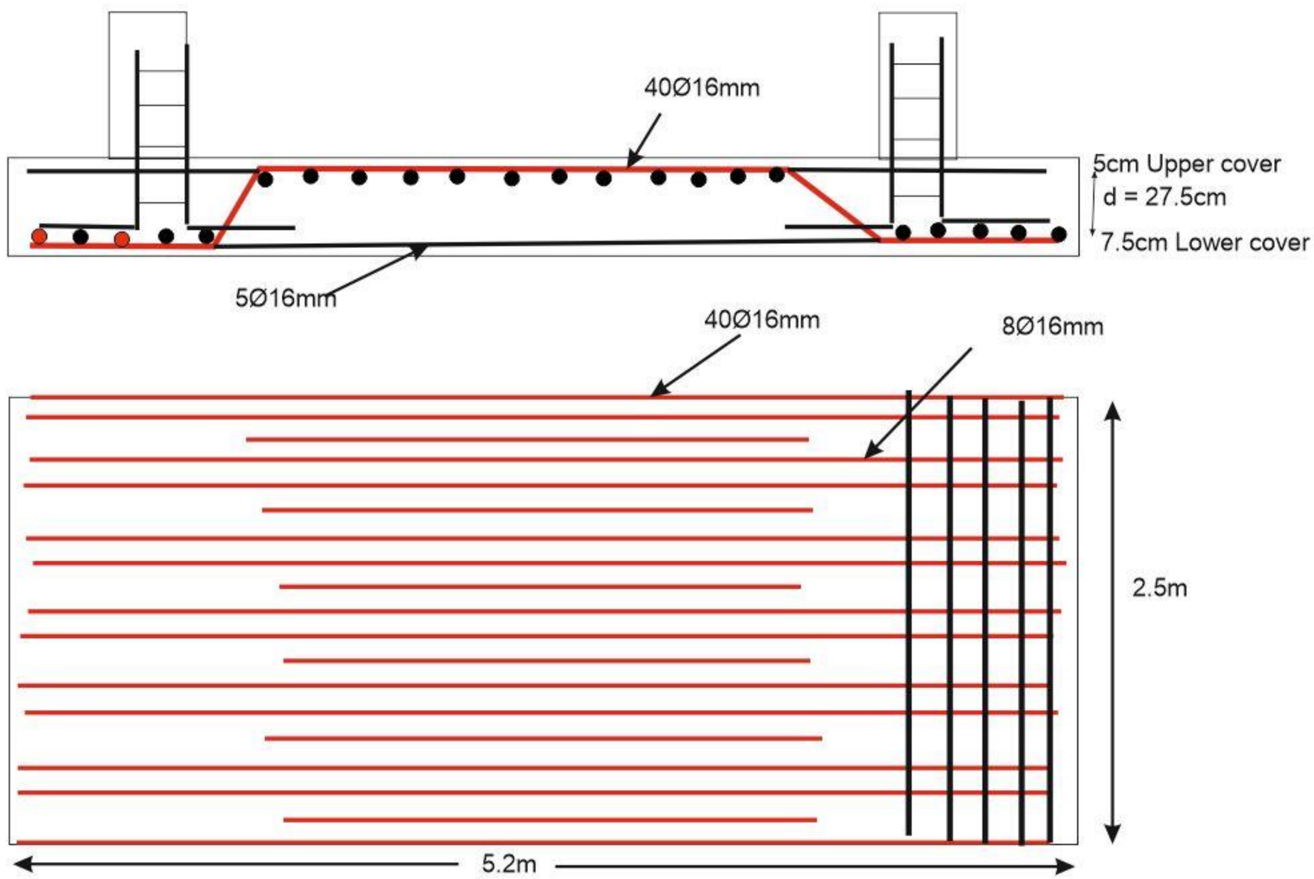
$$1.7 * 84.7 = 0.85 * \rho * 2.5 * 0.275^2 * 1000 * 430\left(1 - \frac{\rho * 430}{1.7 * 30}\right)$$

$$0.00208 = \rho(1 - 8.4\rho)$$

$$\rho = 0.0021$$

$$A_S = 0.0021 * 2.5 * 0.275 * 10^6 = 1443\ mm2$$

No of bars = 7.1, use $8\emptyset16mm$



Now the solution should be repeated in the other direction