3.3 Design of footings:

Design Procedure for rectangular footing:

Step1) To find column load

$$Q=Q_1+Q_2$$

Q_1=load in exterior column

Q_2= load in interior column

Step2) Find the area of footing

$$A = \frac{Q}{q_{na}} = \frac{Q}{q_s}$$

$$q_{na} = Allowable\ bearing\ pressure$$

Step3) Locate the line of action of the column loads measured from the centre of the exterior column

$$\bar{x}_1 = \frac{Q_2 x_2}{Q_1 + Q_2}$$

X_2=centre to centre distance between the column

Step4) Define the total length of the footing

$$L = 2(\bar{x} + e_1)$$

$$e_1 = projection\ of\ footing$$

Step 5) Find the width of the footing

$$B = \frac{A}{L}$$

Step6) Find the actual area provided (A_o)

Step 7) Find the actual pressure

$$q_o = \frac{Q}{A_o}$$

$$q_{max} = \frac{Q}{A_o}(1 + \frac{6e}{L})$$

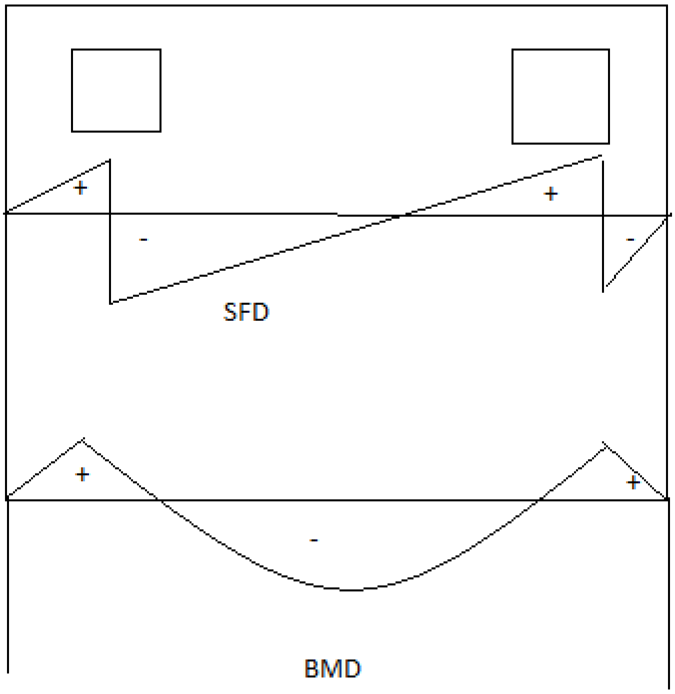
$$q_{min} = \frac{Q}{A_o}(1 - \frac{6e}{L})$$

Step 8) Draw the shear force and BM diagram

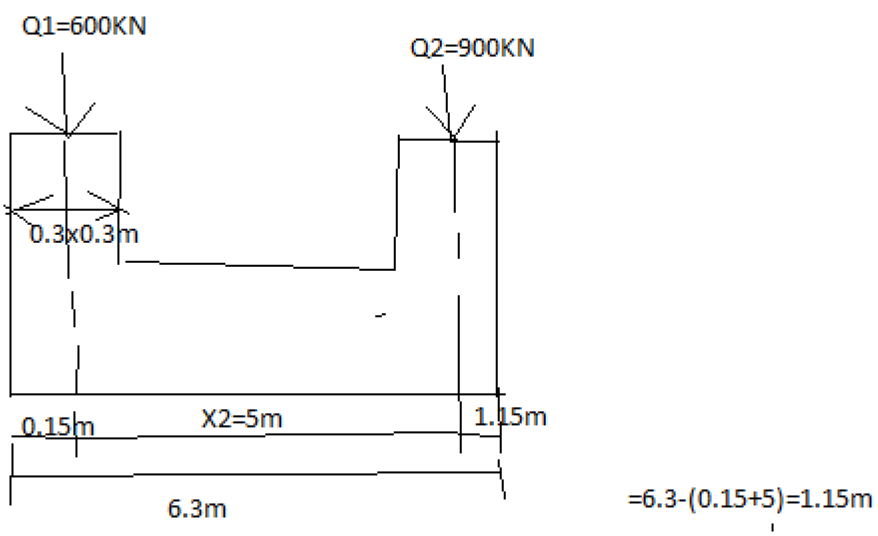
Step9)Determine the BM at the face of the column of maximum BM at the point of zero stress.

Step 10)Find the thickness of footing

Step11)Determine the required reinforcement for the maximum bending moment



1. Design a rectangular combined footing two column shown in figure. Take allowable soil pressure as 100KN/m^2.



Step1) To find column load

$Q=Q_1+Q_2=600+900=1500KN$

Step2) Find the area of footing

$$A = \frac{Q}{q_{na}} = \frac{Q}{q_s} = \frac{1500}{100} = 15m^2$$

$$q_{na} = Allowable\ bearing\ pressure$$

Step3) Locate the line of action of the column loads measured fronm the centre of the exterior column

$$\bar{x}_1 = \frac{Q_2 x_2}{Q_1 + Q_2} = \frac{900x5}{600 + 900} = 3m$$

X_2=centre to centre distance between the column

Step4) Define the total length of the footing

$$L = 2(\bar{x}_1 + e_1)$$

$$e_1 = \frac{B}{2} = \frac{0.3}{2} = 0.15m$$

$$L = 2(3 + 0.15) = 6.3m$$

$$e_1 = projection\ of\ footing$$

Step 5) Find the width of the footing

$$B = \frac{A}{L} = \frac{15}{6.3} = 2.38m = 2.4m$$

Step6) Find the actual area provided (A_o)

$$A_o = BxL = 2.4x6.3 = 15.12m^2$$

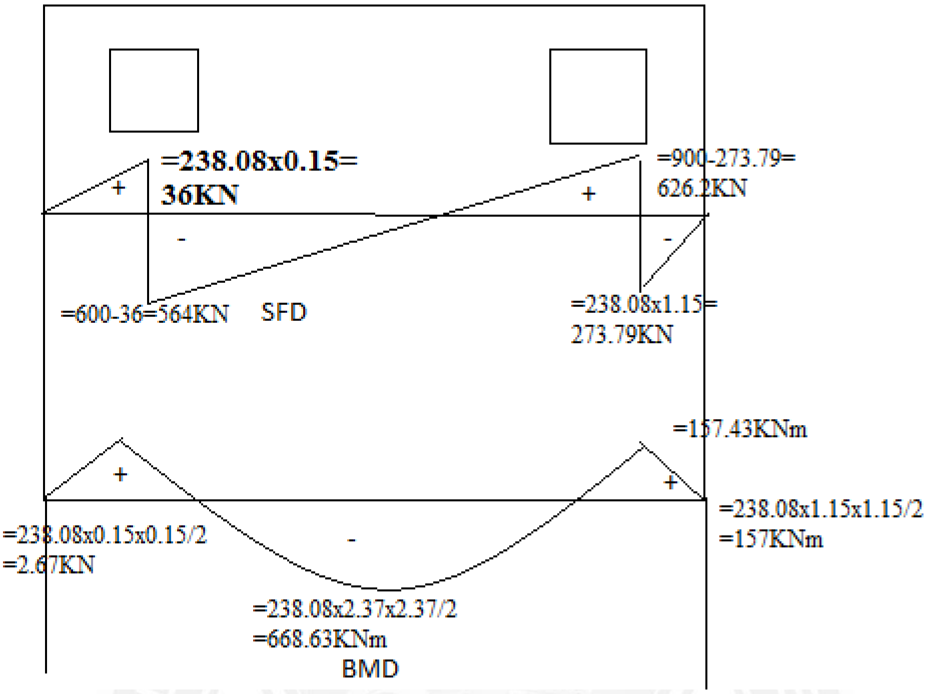
Step 7) Find the actual pressure

$$q_o = \frac{Q}{A_0}$$

$$q_o = \frac{1500}{15.12} = 99.2KN/m^2$$

Step8) Actual pressure per meter

$$q_o = 99.2x2.4 = 238.08KN/m$$



Design Procedure for trapezoidal footing:

Step1) To find column load

$$Q=Q_1+Q_2$$

Q_1=load in exterior column

Q_2= load in interior column

Step2)Find the area of footing

$$A=\frac{Q}{q_{na}}=\frac{Q}{q_s}$$

$$q_{na}= Allowable\ bearing\ pressure$$

Step3)Locate the line of action of the column loads measured fronm the centre of the exterior column

$$\bar{x}_1=\frac{Q_2 x_2}{Q_1+Q_2}$$

X_2=centre to centre distance between the column

Step4) Find x'

$$x'=\bar{x}+\frac{b_1}{2}$$

Step 5) Find$\frac{L}{} + \frac{L}{}$

2 3

$$\frac{L}{3} < x' < \frac{L}{2}$$

Step 6) Find the width of the footing

$$B_2 = \frac{2A}{L}\left(\frac{3x'}{L} - 1\right)$$

$$B_1 = \frac{2A}{L} - B_2$$

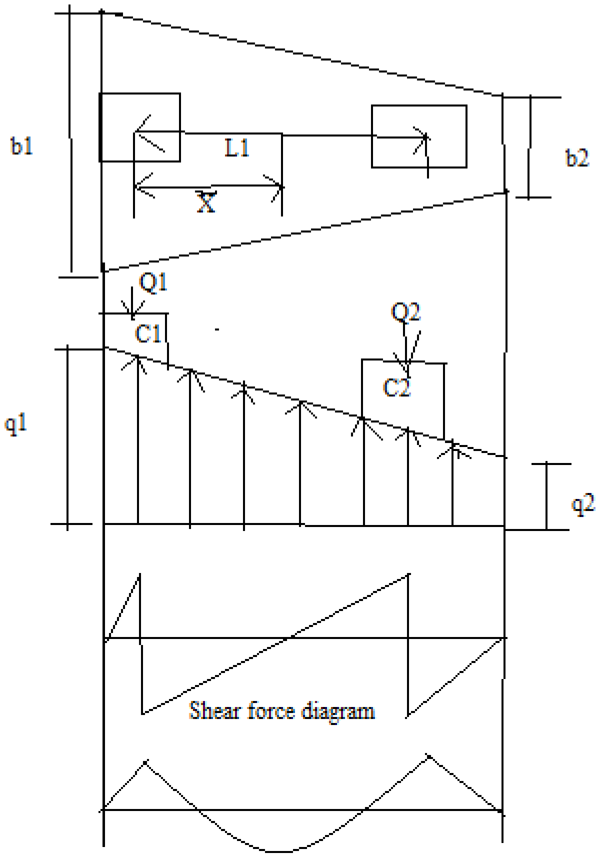
Step 7)Find the actual pressure

$$q_o = \frac{Q}{A_o}$$

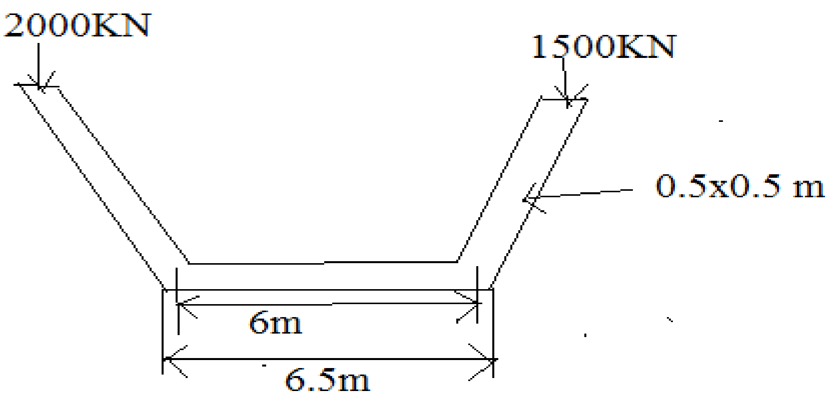
$$q_{max} = \frac{Q}{A_o}\left(1 + \frac{6e}{L}\right)$$

$$q_{min} = \frac{Q}{A_o}\left(1 - \frac{6e}{L}\right)$$

Step 8) Draw shear force and bending moment Diagram



3.Design a trapezoidal footing for the two column shown in figure .Take allowable soil pressure is 200KN/m^2.



Step1) To find column load

$$Q = Q_1 + Q_2 = 2000 + 1500 = 35000KN$$

Q_1=load in exterior column

Q_2= load in interior column

Step2)Find the area of footing

$$A = \frac{Q}{q_{na}} = \frac{Q}{q_s} = 17.5m^2$$

$$q_{na} = Allowable\ bearing\ pressure$$

Step3)Locate the line of action of the column loads measured fronm the centre of the exterior column

$$\bar{x}_1 = \frac{Q_2 x_2}{Q_1 + Q_2}$$

$$\bar{x}_1 = \frac{3000x6}{3500} = 2.57m$$

X_2=centre to centre distance between the column

Step4) Find x'

$$x' = \bar{x} + \frac{b_1}{2}$$

$$x' = 2.57 + \frac{0.5}{2} = 2.82m$$

Step 5) Find $\frac{L}{2}, \frac{L}{3}$

$$\frac{L}{} < x' < \frac{L}{}$$

3 2

$2.167<2.82<3.25$

Step 6) Find the width of the footing

$$B_2 = \frac{2A}{L}(\frac{3x'}{L} - 1)$$

$$B_2 = \frac{2x17.5}{6.5}(\frac{3x2.82}{6.5} - 1) = 1.62m$$

$$B_1 = \frac{2A}{L} - B_2$$

$$B_1 = \frac{2x17.5}{6.5} - 1.62 = 3.76$$

Step 7)Find the actual pressure

$$q_o = \frac{Q}{A_o}$$

$$q_o = \frac{3500}{17.42} = 200.17KN/m^2$$

Step 7)Find the actual pressure per meter

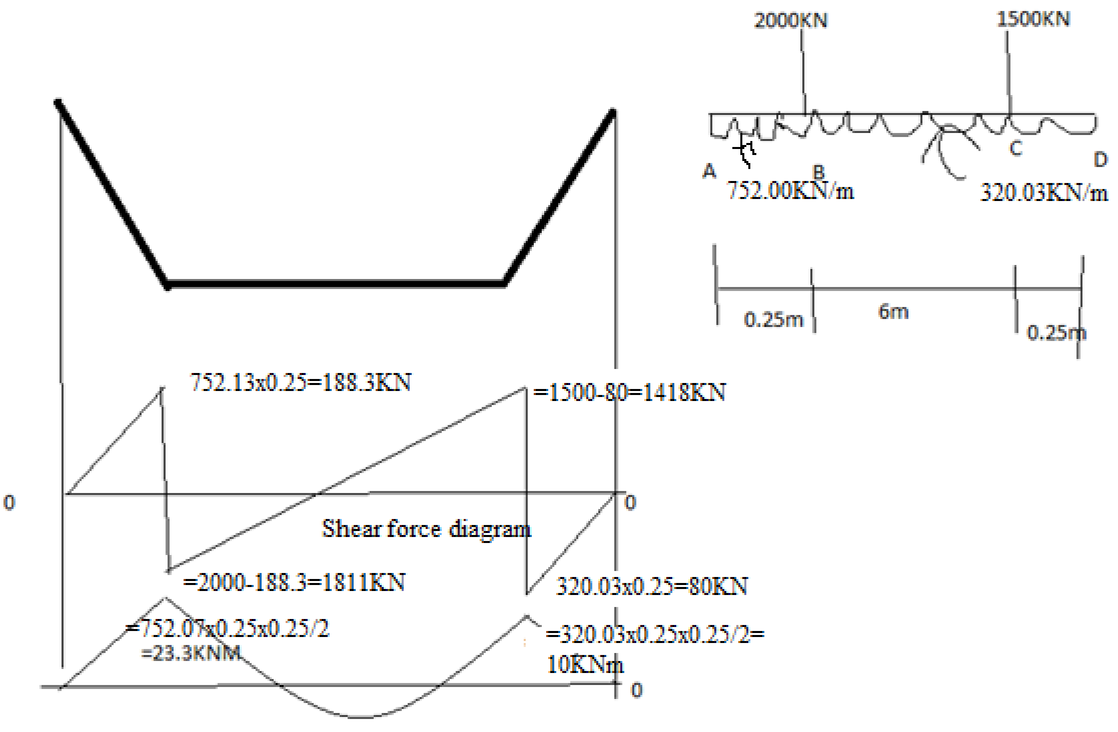
$$q_o = 200.17xB_1$$
$$q_o = 200.17x3.76$$

=752.63KN/m

$$q_o = 200.17xB_2$$

$$q_o = 200.17x1.62$$

=320.03KN/m



Bending moment diagram

Strap footing:

Design Procedure for strap footing:

Step 1: calculate length

$$L_1 = 2(e + 0.5b_1)$$

Step 2) calculate R_1

$$R_1 = \frac{Q_1 x_2}{S}$$

Step 3) calculate R_2

$$R_2 = (Q_1 + Q_2) - R_1$$

Step 4) calculate A_1

$$A_1 = \frac{R_1}{q_{na}}$$

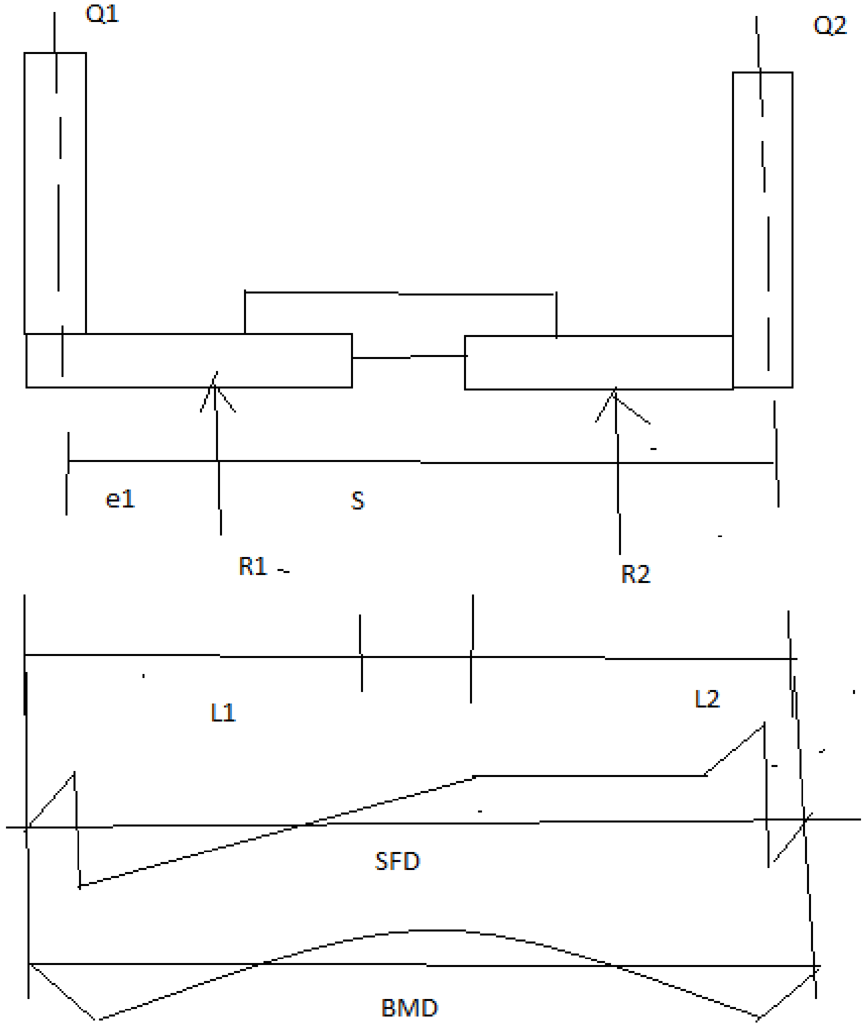
$$A_2 = \frac{R_2}{q_{na}}$$

Step 5)calculate Pressure intensity

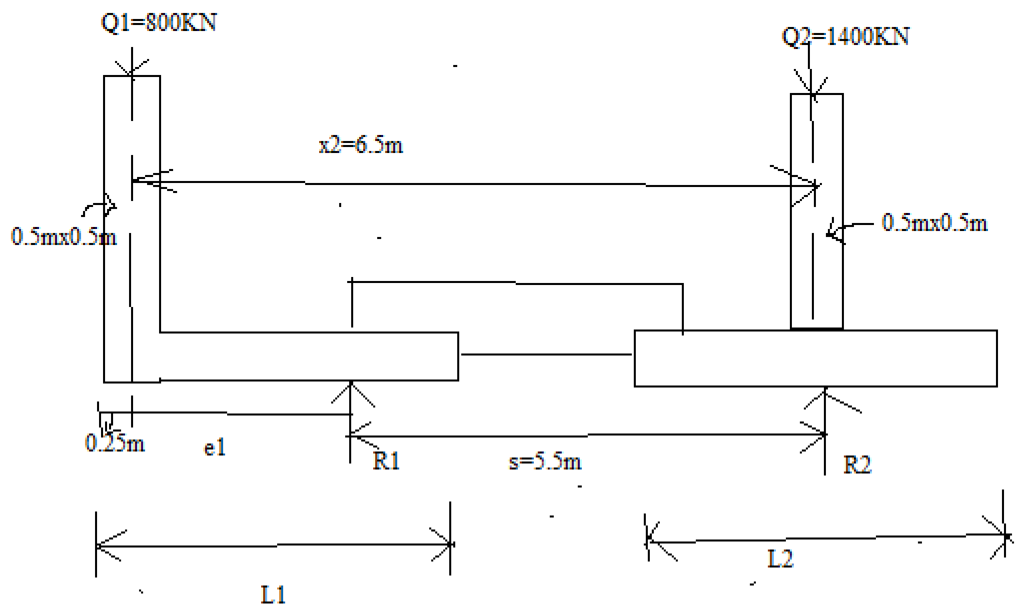
$$B_1 = \frac{A_1}{L_1}$$

$$q_1 = \frac{R_1}{L_1 x B_1} = \frac{R_1}{A_1}$$

$$q_2 = \frac{R_2}{L_2 x B_2} = \frac{R_2}{A_2}$$



3. Design a strap footing for two columns with Centre to center distance6.5m and distance between the reactions is 5.5 m. The allowable soil pressure is 120KN/m^2.take eccentricity of footing of column is 1.The size of the column is 0.5mx0.5m



Step 1:calculate length

$$L_1 = 2(e + 0.5b_1)$$

$$L_1 = 2(1 + 0.5x0.5) = 2.5m$$

Step 2) calculate R_1

$$R_1 = \frac{Q_1 x_2}{S}$$

$$R_1 = \frac{800x0.5}{5.5} = 945.45KN$$

Step 3) calculate R_2

$$R_2 = (Q_1 + Q_2) - R_1$$

$$R_2 = (800 + 1400) - 945.45 = 1254.55KN$$

Step 4) calculate A_1

$$A_1 = \frac{R_1}{q_{na}} = \frac{945.45}{120} = 7.878m^2$$

$$A_2 = \frac{R_2}{q_{na}} = \frac{1254.5}{120} = 10.45m^2$$

Step 5)calculate Pressure intensity

$$B_1 = \frac{A_1}{L_1} = \frac{7.878}{2.5} = 315m$$

$$q_1 = \frac{R_1}{L_1 x B_1} = \frac{R_1}{A_1} = \frac{945.45}{7.878} = 120KN/m^2$$

$$q_2 = \frac{R_2}{L_2 x B_2} = \frac{R_2}{A_2} = \frac{1254.55}{10.45} = 120KN/m^2$$

$$B_2 = \sqrt{A_2} = \sqrt{10.45} = 3.23$$

$$B_2 = \frac{A_2}{L_2}$$

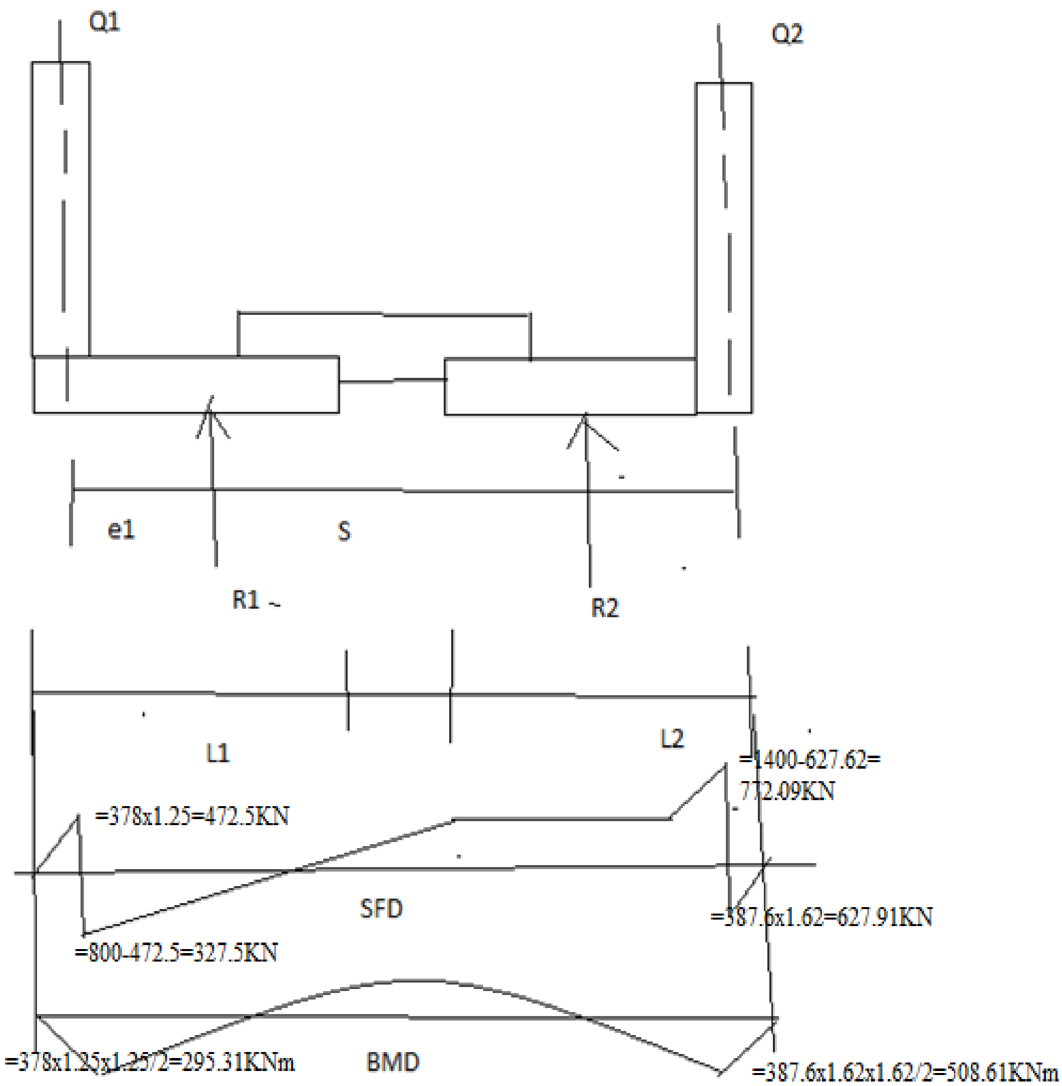
$$3.23 = \frac{10.45}{L_2}$$

$$L_2 = 3.23m$$

Pressure intensity per meter,

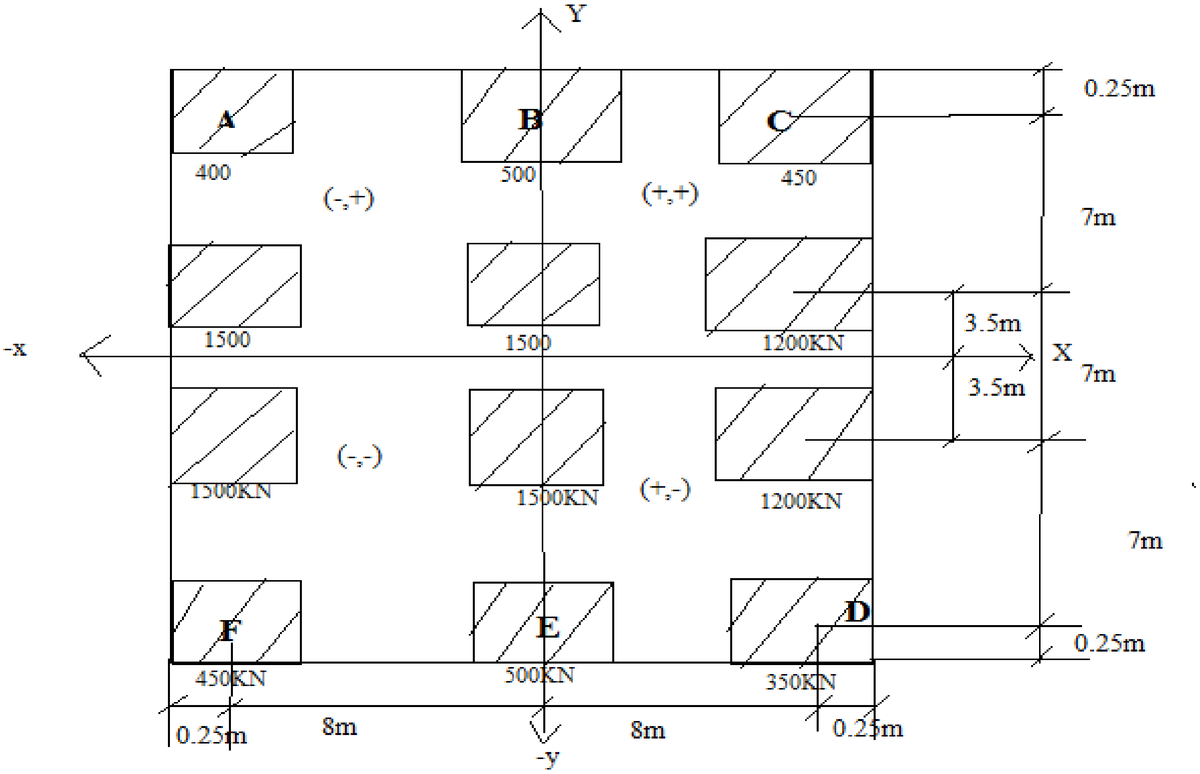
$$q_1 = 120x3.15 = 378KN/m$$

$$q_2 = 120x3.2 = 387.6KN/m$$



Mat Foundation:

4. A plan of raft foundation with column load as shown in figure .Calculate the soil pressure at point A,C,D,F The size of mat is16.5x21.5m all column are 0.5x0.5m in the section .The allowable soil pressure is 60KN/m^2.Determine the soil pressure at the point.



Solution:

Step1) Area of mat

$A = bxd$=16.5x21.5=354.75m^2

Step2)Calculate the moment of inertia

$$I_{xx} = \frac{bd^3}{12} = \frac{16.5x21.5^3}{12} = 13665.26m^4$$

$$I_{yy} = \frac{db^3}{12} = \frac{21.5x16.5^3}{12} = 8048.3m^4$$

Step 3) Calculate Moment:

$$M_y = Qxe_x$$

$$e_x = x' - \frac{B}{2}$$

$$x' = \frac{Q_1x_1 + Q_2x_2 + \cdots. + Q_nx_n}{Q}$$

$$= \frac{1}{11000}[(400 + 1500 + 1500 + 400)x0.25]$$
$$+ [(500 + 1500 + 1500 + 500)x8.25]$$
$$+ [(450 + 1200 + 1200 + 30)x16.25]$$

$$x' = 7.81m$$

$$e_x = 7.81 - \frac{16.5}{2} = -0.44m$$

$$M_y = 11000x(-0.44) = -4840KNm$$

$$M_x = Qxe_y$$

$$e_y = y' - \frac{d}{2}$$

$$y' = \frac{Q_1y_1 + Q_2y_2 + \cdots. + Q_ny_n}{Q}$$

$$= \frac{1}{11000}[(400 + 500 + 450)x0.25] + [(1500 + 1500 + 1200)x7.25]$$
$$+ [(1500 + 1500 + 1200)x14.25] + [(400 + 500 + 350)x21.25$$

$$y' = 10.65m$$

$$e_y = 10.65 - \frac{21.5}{2} = 0.1m$$

$$M_x = 11000x0.1 = 1100KNm$$

Step 4) Calculate soil Pressure:

$$q = \frac{Q}{A} \pm \frac{M_yx}{I_y} \pm \frac{M_xy}{I_x}$$

$$q = \frac{11000}{354.75} \pm \frac{4840x}{8048.39} \pm \frac{1100y}{13665.27}$$

$$q = 31 \pm 0.6x \pm 0.08y$$

Soil pressure at A=$31 - 0.6x8.25 + 0.08x10.75 = 26.91KN/m^2$

Soil pressure at C=$31 + 0.6x8.25 + 0.08x10.75 = 31.81KN/m^2$

Soil pressure at D=$31 + 0.6x8.25 - 0.08x10.75 = 35.09KN/m^2$

Soil pressure at E=$31 - 0.6x8.25 - 0.08x10.75 = 25.19KN/m^2$