

**Q1)**

*super imposed* = 2 Kn/m<sup>2</sup> , LL = 3 Kn/m<sup>2</sup> , h = 185 mm

**a)**

$$h_{min} = \frac{l}{24} = \frac{4000}{24} = 166.67 \text{ mm}$$

$$h > h_{min} \rightarrow \text{ok}$$

**b)**

$$DL = (0.185 * 24) + 2 = 6.44 \text{ kn/m}^2$$

$$LL = 3 \text{ kn/m}^2$$

$$Wu = 1.4(6.44) + 1.7(3) = 14.116 \text{ Kn/m}^2$$

**c)**

$$M_{u+} = \frac{1}{14} * 14.116 * 3.7^2 = 13.803 \text{ kn.m}$$

$$M_{u-} = \frac{1}{9} * 14.116 * 3.7^2 = 21.47 \text{ kn.m}$$

**d)**

$$M_u = 20 \text{ kn.m} , \text{ Assume } d_b = 12$$

$$d = 185 - 20 - \frac{12}{2} = 159 \text{ mm} , \quad R_n = \frac{20/0.9}{1000 * 159^2} * 10^6 = 0.879 \text{ Mpa}$$

$$m = \frac{420}{0.85 * 25} = 19.765 , \quad \rho = \frac{1}{19.765} \left( 1 - \sqrt{1 - \frac{2 * 0.879 * 19.765}{420}} \right) = 0.00214$$

$$A_s = 0.00214 * 1000 * 159 = 340 \text{ mm}^2 , \quad A_{s \text{ min}} = 0.0018 * 1000 * 185 = 333 \text{ mm}^2$$

$$S_{max} = \min \left( \frac{113.04}{340} * 1000 = 332.5 \text{ mm} , 300 \text{ mm} , 2 * 185 = 370 \right) = 300 \text{ mm}$$

*for flexural* → use Ø12@300 mm

$$A_s \text{ shrinkage} = 0.0018 * 1000 * 185 = 333 \text{ mm}^2$$

$$S_{max} = \min \left( \frac{113.04}{333} * 1000 = 339.45 \text{ mm}, 300 \text{ mm}, 4 * 185 = 740 \right) = 300 \text{ mm}$$

for shrinkage → use  $\phi 12 @ 300 \text{ mm}$

**d)**

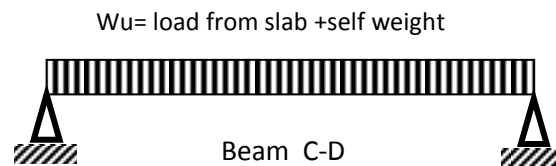
$$C_v = 1.15, \quad V_u = \frac{1.15 * 14.116 * 3.7}{2} = 30.03 \text{ kn}$$

$$d = 185 - 20 - \frac{12}{2} = 159 \text{ mm}$$

$$\phi V_c = 0.75 * \frac{\sqrt{25}}{6} * 1000 * 159 * 10^{-3} = 99.375 \text{ kn}$$

$$\phi V_c > V_u \rightarrow \text{ok}$$

**f)**



$$Wu \text{ slab} = 14.116 \text{ kn/m}^2$$

$$Wu \text{ beam}(B - E) = 14.116 * \left( \frac{4}{2} + \frac{4}{2} \right) + 1.4 * (0.415 * 0.3 * 24) = 60.65 \text{ kn/m}$$

**g)**

Force transfer from beam (B-E) to (D-F):-

$$P_{(D-F)} = 60.65 * \left( \frac{8.1 - 0.3}{2} \right) = 236.535 \text{ kn/m}$$

**Q2)**

super imposed = 2 Kn/m<sup>2</sup> , LL = 3 Kn/m<sup>2</sup> , h = 190 mm

$$Wu = 1.4(2 + 0.19 * 24) + 1.7(3) = 14.284 \text{ Kn/m}^2$$

	Span B <sub>1</sub> -B <sub>2</sub>		
L <sub>1</sub> (m)	5		
L <sub>2</sub> (m)	5		
L <sub>n</sub> (m)	4.7		
$M_o = W_s L_2 \frac{L_n^2}{8}$ (KN.m)	197.21		
L <sub>min</sub> (m)	6		
CS width (m) = 0.5 L <sub>min</sub>	3		
Moment coefficients	0.26	0.52	0.7
-ve and +ve moments	51.27	102.55	138.05
CS moment (%)	100	60	75
CS moments (kN.m)	51.27	61.53	103.54

**Q2)**

**a)**

$$A_{s1} = 628 \text{ mm}^2 , \quad A_{s2} = 628 \text{ mm}^2$$

$$A_g = 90 * 10^3 \text{ mm}^2 , \quad A_{st} = 1256 \text{ mm}^2$$

**I – At point  $\epsilon_t = 0.006$**

$$d_1 = 60 \text{ mm} , \quad , \quad d_3 = 240 \text{ mm}$$

$$C = \frac{0.003}{0.003 + \epsilon_t} * d_3$$

$$C = \frac{0.003}{0.003 + 0,006} * 240 = 80 \text{ mm}$$

$$\epsilon_i = \frac{d_i - C}{C} * 0.003$$

$$\epsilon_1 = \frac{60 - 80}{80} * 0.003 = -0.00075$$

$$\varepsilon_2 = \frac{240 - 80}{80} * 0.003 * 0.003 = 0.006$$

$$f_{si} = \varepsilon_i * E = -420 < f_{si} < 420$$

$$f_{s1} = -0.00075 * 200,000 = -150$$

$$f_{s2} = 0.006 * 200,000 = 1200 > 420 \Rightarrow \text{use } 420 \text{ Mpa}$$

$$a_b = \beta * C$$

$$a_b = 0.85 * 80 = 68 \text{ mm}$$

$a_b > d_i \rightarrow \text{compression zone}$  ,  $a_b < d_i \rightarrow \text{tension zone}$

$$F_{si} = f_{si} * A_{si} * 10^{-3} \rightarrow \text{Tension Zone}$$

$$F_{si} = (f_{si} + 0.85 * f_c') * A_{si} * 10^{-3} \rightarrow \text{Compression Zone}$$

$$F_{s1} = (-150 + 0.85 * 25) * 628 * 10^{-3} = -80.855 \text{ Kn}$$

$$F_{s2} = 420 * 628 * 10^{-3} = 263.76 \text{ Kn}$$

$$C_c = 0.85 * f_c' * b * \beta * c * 10^{-3}$$

$$C_c = 0.85 * 25 * 300 * 0.85 * 80 * 10^{-3} = 433.5 \text{ Kn}$$

$$P_n = C_c - \Sigma F_s$$

$$P_n = 433.5 - (-80.55 + 263.76) = 250.595 \text{ Kn}$$

$$M_n = C_c \left[ \frac{h}{2} - \frac{a}{2} \right] + F_{s1} \left[ d_1 - \frac{h}{2} \right] + F_{s2} \left[ d_2 - \frac{h}{2} \right] + F_{s3} \left[ d_3 - \frac{h}{2} \right] * 10^{-3}$$

$$M_n = 433.5 \left[ \frac{300}{2} - \frac{68}{2} \right] - 80.855 \left[ 60 - \frac{300}{2} \right] + 236.76 \left[ 240 - \frac{300}{2} \right] * 10^{-3} = 78.87 \text{ Kn.m}$$

$$\phi P_n = 0.9 * 250.595 = 225.536 \text{ Kn}$$

$$\phi M_n = 0.9 * 78.87 = 70.98 \text{ Kn.m}$$

## II – at point C = 150 mm

$$d_1 = 60 \text{ mm} , , d_3 = 240 \text{ mm}$$

$$\varepsilon_i = \frac{d_i - C}{C} * 0.003$$

$$\varepsilon_i = \frac{d_i - C}{C} * 0.003$$

$$\varepsilon_1 = \frac{60 - 150}{150} * 0.003 = -0.0018$$

$$\varepsilon_2 = \frac{240 - 150}{150} * 0.003 = 0.0018$$

$$f_{si} = \varepsilon_i * E = \quad -420 < f_{si} < 420$$

$$f_{s1} = -0.0018 * 200,000 = -360$$

$$f_{s2} = 0.0018 * 200,000 = 360$$

$$a_b = \beta * C$$

$$a_b = 0.85 * 150 = 127.5 \text{ mm}$$

$$a_b > d_i \rightarrow \text{compression zone} \quad , \quad a_b < d_i \rightarrow \text{tension zone}$$

$$F_{si} = f_{si} * A_{si} * 10^{-3} \rightarrow \text{Tension Zone}$$

$$F_{si} = (f_{si} + 0.85 * f_c) * A_{si} * 10^{-3} \rightarrow \text{Compression Zone}$$

$$F_{s1} = (-360 + 0.85 * 25) * 628 * 10^{-3} = -212.735 \text{ Kn}$$

$$F_{s2} = 360 * 628 * 10^{-3} = 226.08 \text{ Kn}$$

$$C_c = 0.85 * f_c * b * \beta * c * 10^{-3}$$

$$C_c = 0.85 * 25 * 300 * 0.85 * 150 * 10^{-3} = 812.813 \text{ Kn}$$

$$P_n = C_c - \Sigma F_s$$

$$P_n = 812.813 - (-212.735 + 226.08) = 799.468 \text{ Kn}$$

$$M_n = C_c \left[ \frac{h}{2} - \frac{a}{2} \right] + F_{s1} \left[ d_1 - \frac{h}{2} \right] + F_{s2} \left[ d_2 - \frac{h}{2} \right] + F_{s3} \left[ d_3 - \frac{h}{2} \right] * 10^{-3}$$

$$M_n = 812.813 \left[ \frac{300}{2} - \frac{127.5}{2} \right] - 212.74 \left[ 60 - \frac{300}{2} \right] + 226.08 \left[ 240 - \frac{300}{2} \right] * 10^{-3} = 109.6 \text{ Kn.m}$$

$$\phi P_n = 0.65 * 799.468 = 519.654 \text{ Kn}$$

$$\phi M_n = 0.65 * 109.6 = 71.24 \text{ Kn.m}$$

**b)**

$$f'_c = 25 \text{ MPa} \quad , \quad 300 \times 300 \quad , \quad L = 3000 \quad , \quad K = 1 \quad , \quad M_1 = M_2 = 100 \text{ Kn.m}$$

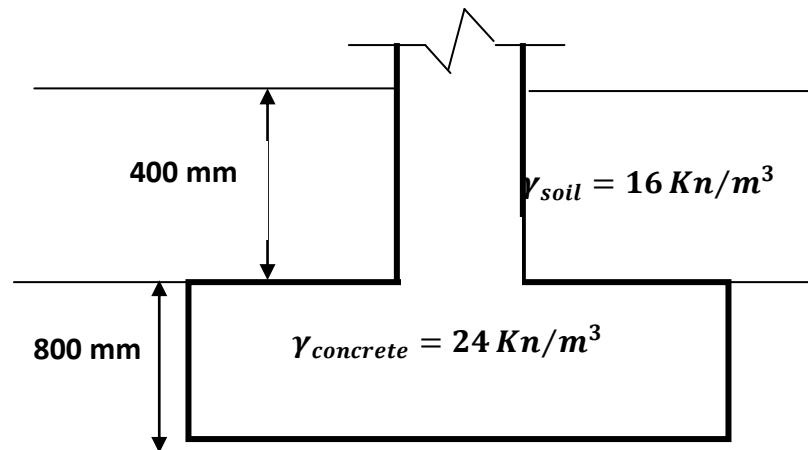
**Double curvature**

$$\frac{1 * 3000}{0.3 * 300} \leq 34 - 12 \left( \frac{100}{-100} \right) \Rightarrow 33.33 \leq 46 \Rightarrow \text{short column}$$

**Q3)**

$$q_{\text{all}} = 280 \text{ Kn/m}^2 \quad , \quad 400 \times 400$$

$$P_{\text{dead}} = 1500 \text{ Kn} \quad , \quad P_{\text{live}} = 1300 \text{ Kn}$$

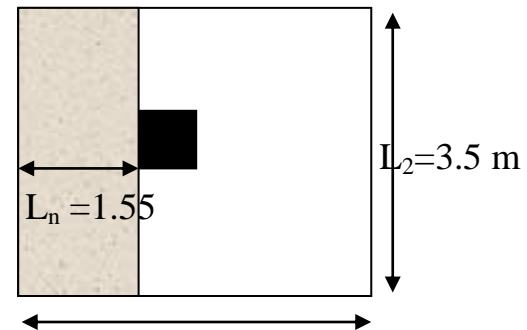


**a)**

$$q_{\text{net}} = 280 - \{0.4 * 16 + 0.8 * 24\} = 254.4 \text{ Kn/m}^2$$

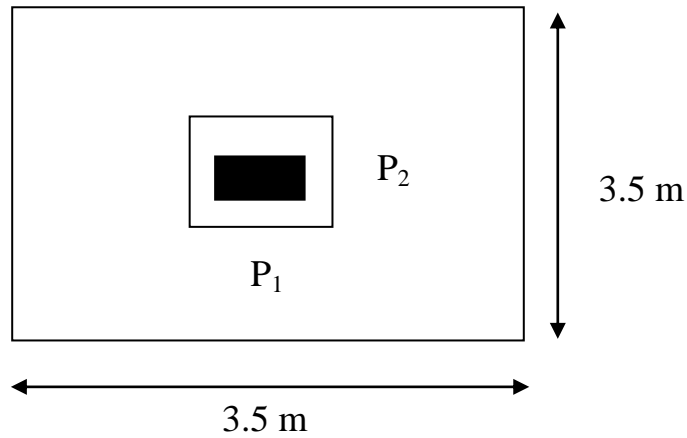
$$\text{Minimum Area of footing} = \frac{1500 + 1300}{254.4} = 11.006 \text{ m}^2$$

**b)**



$$q_{\text{ult}} = \frac{1.4 * 1500 + 1.7 * 1300}{12.25} = 351.84 \text{ Kn/m}^2 \quad , \quad L_n = \frac{3.5 - 0.4}{2} = 1.55 \text{ m}$$

$$M_u = \frac{q_{\text{ult}} * L_2 * L_n^2}{2} = \frac{351.84 * 3.5 * 1.55^2}{2} = 1479.27 \text{ Kn.m}$$



$$P_1 = C_1 + d_{ave} = 400 + 710 = 1110 \text{ mm}$$

$$P_2 = C_2 + d_{ave} = 400 + 710 = 1110 \text{ mm}$$

$$V_u = W_u(A_o - A_c) = 351.84 (3.5 * 3.5 - 1.11 * 1.11) = 3876.54 \text{ KN}$$

$$b_o = \text{length of critical perimeter} = 2 * (P_1 + P_2) = 2 * (1110 + 1110) = 4440 \text{ mm.}$$

$$\beta_c = \text{column length ratio} \left( \frac{\text{long side}}{\text{short side}} \right) = \frac{400}{400} = 1$$

$$\alpha_s = 40$$

$$V_c = \text{Min} \left\{ \begin{array}{l} \left( 1 + \frac{2}{1} \right) \frac{\sqrt{25}}{6} * 4440 * 710 * 10^{-3} = 7881 \text{ Kn} \\ \left( 2 + \frac{40 * 710}{4440} \right) \frac{\sqrt{25}}{12} * 4440 * 710 * 10^{-3} = 11028.67 \text{ KN} \\ \frac{\sqrt{25}}{3} * 4440 * 710 * 10^{-3} = 5254 \text{ Kn} \end{array} \right\} = 5254 \text{ KN}$$

$$\phi V_c = 0.75 * 5254 = 3940.5 \text{ Kn} > 3876.54 \text{ Kn} \therefore \text{ok}$$