

**A-solid slab design:**

**a)**

$$h_{min} = \frac{l}{24} = \frac{3000}{24} = 125 \text{ mm}$$

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

**b)**

*DL = own weight + superimposed*

$$DL = (0.18 * 25) + 2 = 6.5 \text{ kn/m}^2$$

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

$$Wu = 1.4(6.5) + 1.7(3) = 14.2 \text{ Kn/m}^2$$

$$M_{u+} = \frac{1}{14} * 14.2 * 2.7 = 7.394 \text{ kn.m}$$

$$M_{u-} = \frac{1}{12} * 14.2 * 2.7 = 8.6265 \text{ kn.m}$$

**c)**

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

$$d = 180 - 20 - \frac{12}{2} = 154 \text{ mm} \quad , \quad R_n = \frac{20/0.9}{1000 * 154^2} * 10^6 = 0.937 \text{ Mpa}$$

$$m = \frac{420}{0.85 * 25} = 19.765 \quad , \quad \rho = \frac{1}{19.765} \left( 1 - \sqrt{1 - \frac{2 * 0.937 * 19.765}{420}} \right) = 0.00228$$

$$A_s = 0.00228 * 1000 * 154 = 351.5 \text{ mm}^2 \quad , \quad A_{s \text{ min}} = 0.0018 * 1000 * 180 = 324 \text{ mm}^2$$

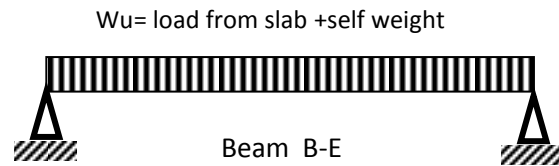
$$S_{max} = \min \left( \frac{113.04}{351.5} * 1000 = 321.6 \text{ mm} , 300 \text{ mm} , 2 * 180 = 360 \right) = 300 \text{ mm}$$

*for flexural → use Ø12@300 mm*

$$A_{s \text{ shrinkage}} = 0.0018 * 1000 * 180 = 324 \text{ mm}^2$$

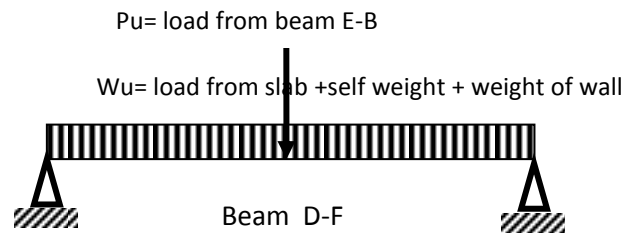
$$S_{max} = \min \left( \frac{113.04}{324} * 1000 = 348.89 \text{ mm} , 300 \text{ mm} , 4 * 180 = 720 \right) = 300 \text{ mm}$$

*for shrinkage → use Ø12@300 mm*

d)

$$W_u \text{ slab} = 14.2 \text{ kn/m}^2$$

$$W_u \text{ beam}(B - E) = 14.2 * \left(\frac{3}{2} + \frac{3}{2}\right) + 1.4 * (0.42 * 0.3 * 25) = 47.01 \text{ kn/m}$$

e)

$$W_u \text{ beam}(D - F) = 1.4 * [(0.42 * 0.3 * 25) + (3 * 2.8)] = 16.17 \text{ kn/m}$$

$$P_u \text{ beam}(D - F) = 47.01 * \frac{6.2}{2} = 145.731 \text{ Kn}$$

**B-joist slab design:**

**a)**

$$h_{min} = \frac{l}{18.5} = \frac{3000}{18.5} = 162.16 \text{ mm}$$

$$h = 380 \text{ mm} > h_{min} \rightarrow \text{ok}$$

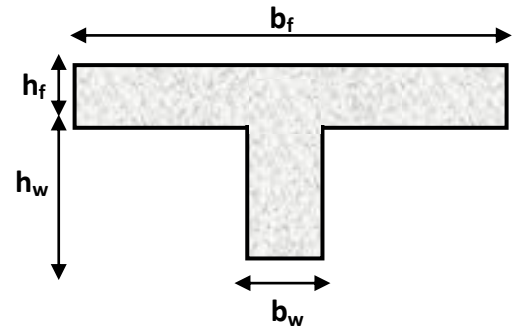
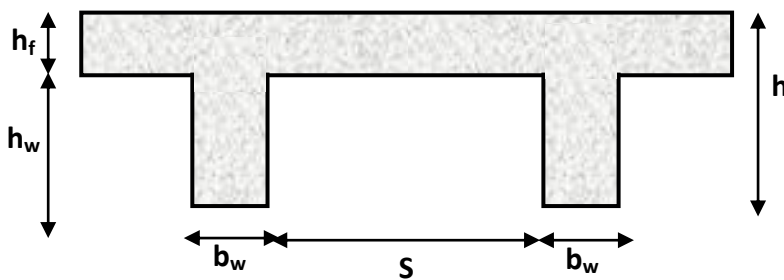
$$h_f \geq \left( 50 \text{ mm} , \frac{500}{12} = 41,67 \text{ mm} \right) = 50 \text{ mm} \quad h_f = 80 \text{ mm} \quad \text{ok}$$

$$h_w \nlessgtr (3.5 * 150 = 525 \text{ mm}) \quad h_w = 300 \text{ mm} \quad \text{ok}$$

$$b_w \geq 100 \text{ mm} \quad b_w = 150 \text{ mm} \quad \text{ok}$$

$$S \nlessgtr 800 \text{ mm} \quad S = 500 \text{ mm} \quad \text{ok}$$

$$b_f = 500 + 150 = 650 \text{ mm}$$



**b)**

The appropriate direction of joists slab is with short direction

**c)**

*DL = own weight + superimposed*

$$DL = (0.08 * 25) + 2 = 4 \text{ kn/m}^2$$

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

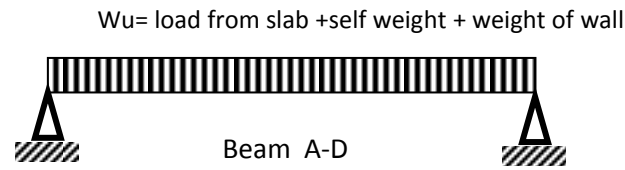
$$Wu = 1.4DL + 1.7LL$$

$$Wu = 1.4(4) + 1.7(3) = 10.7 \text{ kn/m}^2$$

**Load on typical rip:**

$$Wu_{/rip} = 10.7 * (0.65) + 1.4 * (0.3 * 0.15 * 25) = 8.53 \text{ kn/m}$$

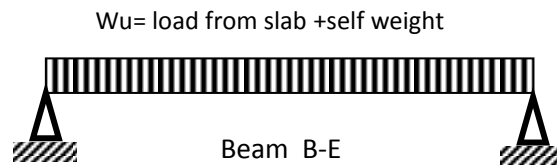
**d)**



$$Wu \text{ beam}(A - D) =$$

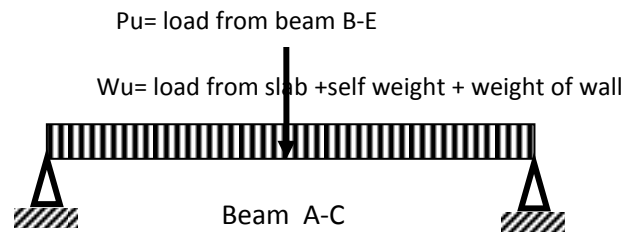
$$\frac{8.53}{0.65} * \left(\frac{3}{2} - 0.15\right) + 1.4 * [(0.6 * 0.3 * 25) + (0.3 * 2) + (2.8 * 3)] + 1.7 * (0.3 * 3) = 38.146 \text{ kn/m}$$

**e)**



$$Wu \text{ beam}(B - E) = \frac{8.53}{0.65} * \left(\frac{3}{2} + \frac{3}{2} - 0.3\right) + 1.4 * [(0.6 * 0.3 * 25) + (0.3 * 2)] + 1.7 * (0.3 * 3)$$

$$Wu \text{ beam}(B - E) = 44.10 \text{ kn/m}$$



$$Wu \text{ beam}(A - C) = 1.4 * [(0.6 * 0.3 * 25) + (2.8 * 3)] = 18.06 \text{ kn/m}$$

$$Pu \text{ beam}(A - C) = 44.10 * \frac{6.2}{2} = 136.71 \text{ Kn}$$

$$\text{Axial load on column(A) from beam (A - C)} = \left[18.06 * \frac{6}{2}\right] + \left[136.71 * \frac{1}{2}\right] = 122.535 \text{ Kn}$$

$$\text{Axial load on column(A) from beam (A - D)} = \left[38.146 * \frac{6.5}{2}\right] = 123.9745 \text{ Kn}$$

$$\text{Self weight of column A} = 1.4 * 0.3 * 0.3 * 25 * 2.8 = 8.82 \text{ Kn}$$

**Total axial load on column A =**

*No. of story \* (Axial load from beam (A – D) + Axial load from beam (A – C)  
+ self weight of column A)*

$$\text{Total axial load on column A} = 4 * (123.9745 + 122.535 + 8.82) = 1021.318 \text{ Kn}$$

**Q2)**

$$A_{s1} = 1471.875 \text{ mm}^2 , A_{s2} = 981.25 \text{ mm}^2 , A_{s1} = 1471.875 \text{ mm}^2$$

$$A_g = 250 * 10^3 \text{ mm}^2 , A_{st} = 3925 \text{ mm}^2$$

$$P_o = [0.85 f_c (A_g - A_{st}) + f_y * A_{st}] * 10^{-3}$$

$$P_o = [0.85 * 20 * (250 * 10^3 - 3925) + 420 * 3925] * 10^{-3}$$

$$P_o = 5831.775 \text{ Kn}$$

$$\phi P_{n,max} = 0.80 * 0.65 * [0.85 f_c (A_g - A_{st}) + f_y * A_{st}] * 10^{-3}$$

$$\phi P_{n,max} = 0.80 * 0.65 * [0.85 * 20 * (250 * 10^3 - 3925) + 420 * 3925] * 10^{-3}$$

$$\phi P_{n,max} = 3032.523 \text{ Kn}$$

$$d_1 = 62.5 \text{ mm} , d_2 = 250 \text{ mm} , d_3 = 437.5 \text{ mm}$$

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

**Balanced point  $\epsilon_t = 0.0021$**

$$C = \frac{0.003}{0.003 + 0.0021} * 437.5 = 257.35 \text{ mm}$$

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

$$\epsilon_1 = \frac{62.5 - 257.35}{257.35} * 0.003 = -0.0023$$

$$\epsilon_2 = \frac{250 - 257.35}{257.35} * 0.003 = -8.5681 * 10^{-5}$$

$$\epsilon_3 = \frac{437.5 - 257.35}{257.35} * 0.003 = 0.0021$$

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

$$f_{s1} = -0.0023 * 200,000 = -460 \text{ use } -420 \text{ Mpa}$$

$$f_{s2} = -8.5681 * 10^{-5} * 200,000 = -17.1362 \text{ Mpa}$$

$$f_{s3} = 0.0021 * 200,000 = 420 \text{ Mpa}$$

$$a_b = \beta * C$$

$$a_b = 0.85 * 257.35 = 218.75 \text{ mm}$$

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

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

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

$$F_{s1} = (-420 + 0.85 * 20) * 1471.875 * 10^{-3} = -593.16 \text{ Kn}$$

$$F_{s2} = -17.1362 * 981.25 * 10^{-3} = -16.815 \text{ Kn}$$

$$F_{s3} = 420 * 1471.875 * 10^{-3} = 618.1875 \text{ Kn}$$

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

$$C_c = 0.85 * 20 * 500 * 0.85 * 257.35 * 10^{-3} = 1859.35 \text{ Kn}$$

$$P_n = C_c - \Sigma F_s$$

$$P_n = 1859.35 - (-593.16 - 16.815 + 618.1875) = 1851.14 \text{ Kn}$$

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

$$M_n = 1851.14 \left[ \frac{500}{2} - \frac{218.75}{2} \right] - 593.16 \left[ 62.5 - \frac{500}{2} \right] - 16.815 \left[ 250 - \frac{500}{2} \right] + 618.1875 \left[ 437.5 + \frac{500}{2} \right] * 10^{-3} = 487.44 \text{ Kn.m}$$

$$\phi P_n = 0.65 * 1851.14 = 1203.24 \text{ Kn}$$

$$\phi M_n = 0.65 * 487.44 = 316.84 \text{ Kn.m}$$

## CE472

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point	$P_n$	$M_n$	$\phi P_n$	$\phi M_n$
Pure compression $\phi = 0.65$	4665.42	0	3032.523	0
Balanced $\phi = 0.65$	1851.14	488.6	1203.24	317.59
0.005 strain $\phi = 0.9$	780.2404	427.5199	702.2163	384.7680
Pure bending $\phi = 0.9$	0	323.6746	0	291.3071