

**A-solid slab design:****a)**

$$h_{min} = \frac{l}{24} = \frac{3600}{24} = 150 \text{ mm}$$

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

**b)**

*DL = own weight + superimposed*

$$DL = (0.175 * 24) + 4 = 8.2 \text{ kn/m}^2$$

$$LL = 4 \text{ kn/m}^2$$

$$Wu = 1.4(8.2) + 1.7(4) = 18.28 \text{ Kn/m}^2$$

**c)**

$$M_u = 22 \text{ kn.m} \quad , \text{ Assume } d_b = 12$$

$$d = 175 - 20 - \frac{12}{2} = 149 \text{ mm} \quad , \quad R_n = \frac{22/0.9}{1000 * 149^2} * 10^6 = 1.101 \text{ Mpa}$$

$$m = \frac{420}{0.85 * 25} = 19.765 \quad , \quad \rho = \frac{1}{19.765} \left( 1 - \sqrt{1 - \frac{2 * 1.101 * 19.765}{420}} \right) = 0.00269$$

$$A_s = 0.00269 * 1000 * 149 = 401.3 \text{ mm}^2 \quad , \quad A_{s \text{ min}} = 0.0018 * 1000 * 175 = 315 \text{ mm}^2$$

$$S_{max} = \min \left( \frac{113.04}{401.3} * 1000 = 281.7 \text{ mm} , 300 \text{ mm} , 2 * 175 = 350 \right) = 281.7 \text{ mm}$$

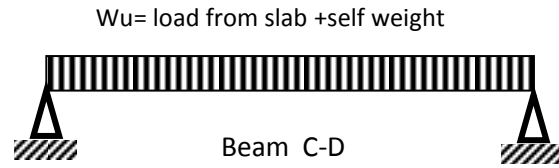
*for flexural → use Ø12@280 mm*

$$A_{s \text{ shrinkage}} = 0.0018 * 1000 * 175 = 315 \text{ mm}^2$$

$$S_{max} = \min \left( \frac{113.04}{315} * 1000 = 358.86 \text{ mm} , 300 \text{ mm} , 4 * 175 = 700 \right) = 300 \text{ mm}$$

*for shrinkage → use Ø12@300 mm*

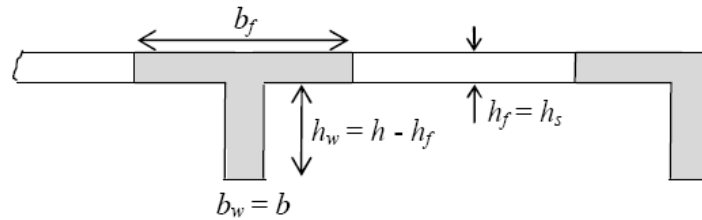
**d)**



$$Wu \text{ slab} = 18.28 \text{ kn/m}^2$$

$$Wu \text{ beam}(C - D) = 18.28 * \left( \frac{3.6}{2} + \frac{3.6}{2} \right) + 1.4 * (0.425 * 0.3 * 24) = 70.092 \text{ kn/m}$$

**e)**



The effective flange width  $b_f$  is determined as follows: –

$$b_f = \text{Min} \left\{ \begin{array}{l} \frac{L_n}{4} (\text{shortest span}) = \frac{7300}{4} = 1825 \text{ mm} \\ b_w + 16h_f = 300 + 16 * 175 = 3100 \text{ mm} \\ \text{beam tributary width} = 3600 \text{ mm} \end{array} \right\} = 1825 \text{ mm}$$

**B-joist slab design:****a)***DL = own weight + superimposed*

$$DL = (0.08 * 24) + 4 = 5.92 \text{ kn/m}^2$$

$$LL = 4 \text{ kn/m}^2$$

$$Wu = 1.4DL + 1.7LL$$

$$Wu = 1.4(5.92) + 1.7(4) = 15.088 \text{ kn/m}^2$$

**Load on typical rip:**

$$Wu_{/rip} = 15.088 * (0.65) + 1.4 * [(0.32 * 0.15 * 24) + (14 * 0.5 * 0.32)] = 14.556 \text{ kn/m}$$

**b)**

$$M_u+ = \frac{1}{14} * 14.556 * 3.3^2 = 11.32 \text{ kn.m}$$

$$M_u- = \frac{1}{9} * 14.556 * 3.3^2 = 17.613 \text{ kn.m}$$

**c)**

$$DL = (0.08 * 24) + 4 = 5.92 \text{ kn/m}^2$$

$$LL = 4 \text{ kn/m}^2$$

$$Wu = 1.4(5.92) + 1.7(4) = 15.088 \text{ kn/m}^2$$

$$S = 0.5 \text{ m}$$

$$M_u = \frac{W_u * S^2}{12} = \frac{15.088 * 0.5^2}{12} = 0.3143 \text{ KN.m}$$

$$\sigma_t = 0.7\sqrt{f_c} = 0.7\sqrt{25} = 3.5 \text{ Mpa}$$

$$M_n = \sigma_t * \frac{b * h_f^2}{6} = 3.5 * \frac{1000 * 80^2}{6} * 10^{-6} = 3.733 \text{ Kn.m}$$

$$\phi M_n = 0.65 * 3.733 = 2.427 \text{ Kn.m} > M_u \rightarrow \text{the flange is thus ok}$$

**d)**

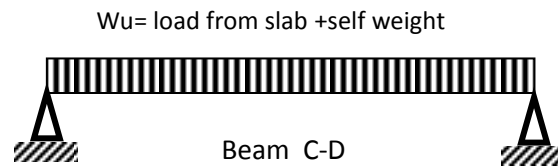
$$C_v = 1.15, \quad V_u = \frac{1.15 * 11.42 * 3.3}{2} = 21.669 \text{ kn}$$

$$d = 400 - 20 - 8 - \frac{12}{2} = 366 \text{ mm}$$

$$\phi V_c = (1.1)0.75 * \frac{\sqrt{25}}{6} * 150 * 366 * 10^{-3} = 37.744 \text{ kn}$$

$\phi V_c > V_u \rightarrow$  no shear reinforcement required

**e)**



$$W_u \text{ beam}(C - D) = \frac{14.556}{0.65} * \left( \frac{3.6}{2} + \frac{3.6}{2} - 0.3 \right) + 1.4 * [(0.6 * 0.3 * 24) + (0.3 * 4)] + 1.7 * (0.3 * 4)$$

$$W_u \text{ beam}(C - D) = 83.67 \text{ kn/m}$$

**Q2)**

$$A_{s1} = 1962.5 \text{ mm}^2, \quad A_{s2} = 1962.5 \text{ mm}^2$$

$$A_g = 160 * 10^3 \text{ mm}^2, \quad A_{st} = 3925 \text{ mm}^2$$

**a- Pure compression point:-**

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

$$P_o = [0.85 * 25 * (160 * 10^3 - 3925) + 420 * 3925] * 10^{-3}$$

$$P_o = 4965.094 \text{ Kn}$$

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

$$\phi P_{n,max} = 0.80 * 0.65 * [0.85 * 25 * (250 * 10^3 - 3925) + 420 * 3925] * 10^{-3}$$

$$\phi P_{n,max} = 2743.214 \text{ Kn}$$

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

$$d_1 = 62.5 \text{ mm}, \quad d_3 = 337.5 \text{ mm}$$

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

$$C = \frac{0.003}{0.003 + 0.0021} * 337.5 = 198.53 \text{ mm}$$

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

$$\epsilon_1 = \frac{62.5 - 198.53}{198.53} * 0.003 = -0.00206$$

$$\epsilon_2 = \frac{337.5 - 198.53}{198.53} * 0.003 = 0.0021$$

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

$$f_{s1} = -0.00206 * 200,000 = -412$$

$$f_{s2} = 0.0021 * 200,000 = 420 \text{ Mpa}$$

$$a_b = \beta * C$$

$$a_b = 0.85 * 198.53 = 168.751 \text{ mm}$$

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

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

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

$$F_{s1} = (-412 + 0.85 * 25) * 1962.5 * 10^{-3} = -766.85 \text{ Kn}$$

$$F_{s2} = 420 * 1962.5 * 10^{-3} = 824.25 \text{ Kn}$$

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

$$C_c = 0.85 * 25 * 400 * 0.85 * 198.53 * 10^{-3} = 1434.38 \text{ Kn}$$

$$P_n = C_c - \Sigma F_s$$

$$P_n = 1434.38 - (-766.85 + 824.25) = 1376.98 \text{ Kn}$$

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

$$M_n = 1434.38 \left[ \frac{400}{2} - \frac{168.751}{2} \right] - 766.85 \left[ 62.5 - \frac{400}{2} \right] + 824.25 \left[ 337.5 - \frac{400}{2} \right] * 10^{-3}$$

$$= 384.63 \text{ Kn.m}$$

$$\phi P_n = 0.65 * 1376.98 = 895.037 \text{ Kn}$$

$$\phi M_n = 0.65 * 384.63 = 250 \text{ Kn.m}$$

**C – at point C = 100 mm**

$$d_1 = 62.5 \text{ mm} , , d_3 = 337.5 \text{ mm}$$

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

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

$$\varepsilon_1 = \frac{62.5 - 100}{100} * 0.003 = -0.001125$$

$$\varepsilon_2 = \frac{337.5 - 100}{100} * 0.003 = 0.007125$$

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

$$f_{s1} = -0.001125 * 200,000 = -225$$

$$f_{s2} = 0.007125 * 200,000 = 1425 > 420 \rightarrow \text{use } 420 \text{ Mpa}$$

$$a_b = \beta * C$$

$$a_b = 0.85 * 100 = 85 \text{ mm}$$

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

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

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

$$F_{s1} = (-225 + 0.85 * 25) * 1962.5 * 10^{-3} = -399.86 \text{ Kn}$$

$$F_{s2} = 420 * 1962.5 * 10^{-3} = 824.25 \text{ Kn}$$

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

$$C_c = 0.85 * 25 * 400 * 0.85 * 100 * 10^{-3} = 722.5 \text{ Kn}$$

$$P_n = C_c - \Sigma F_s$$

$$P_n = 722.5 - (-399.86 + 824.25) = 298.11 \text{ Kn}$$

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

$$M_n = 722.5 \left[ \frac{400}{2} - \frac{85}{2} \right] - 399.86 \left[ 62.5 - \frac{400}{2} \right] + 824.25 \left[ 337.5 - \frac{400}{2} \right] * 10^{-3} = 282.185 \text{ Kn.m}$$

$$\phi P_n = 0.9 * 298.11 = 268.3 \text{ Kn}$$

$$\phi M_n = 0.9 * 282.185 = 253 \text{ Kn.m}$$