A-solid slab design:

a)

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

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

b)

$$DL = own\ weight + superimposed$$

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

$$LL = 4\ \ kn/m^2$$

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

c)

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

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

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

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

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

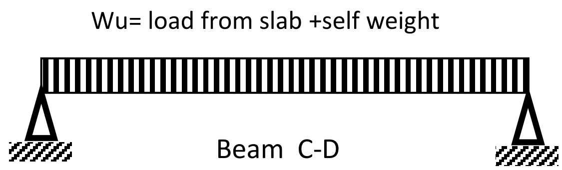
$$for\ flexural\ \rightarrow use\ \emptyset 12@280\ mm$$

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

$$S_{max} = \min\left(\frac{113.04}{315} * 1000 = 358.86mm, 300mm, 4 * 175 = 7200\right) = 300mm$$

$$for\ shrinkage\ \rightarrow use\ \emptyset 12@300\ mm$$

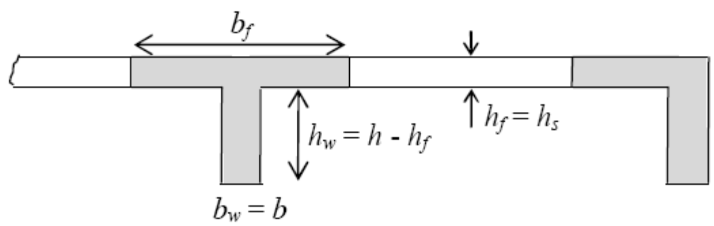
d)



$$Wu \;\; slab = 18.28 \;\; kn/m^2$$

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

e)



The effective flange width b_f is determined as follows: −

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

B-joist slab design:

a)

$$DL = own\ weight + superimposed$$

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

$$LL = 4\ \ kn/m^2$$

$$Wu = 1.4DL + 1.7LL$$

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

Load on typical rip:

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

b)

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

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

c)

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

$$LL = 4\ \ kn/m^2$$

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

$$S = 0.5\ m$$

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

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

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

$$\emptyset M_n\ = 0.65 * 3.733 = 2.427\ Kn.m > M_u \rightarrow the\ flange\ is\ thus\ ok$$

d)

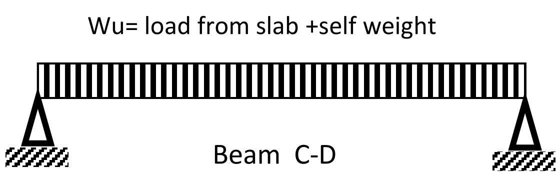
$$C_v = 1.15\ , \qquad V_u = \frac{1.15 * 11.42\ * 3.3}{2} = 21.669\ \ kn$$

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

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

$$\emptyset V_c > V_u \rightarrow \ \ no\ shear\ reinforcment\ requird$$

e)



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

$$Wu\ beam(C - D) = 83.67\ \ kn/m$$

Q2)

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

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

a- Pure compression point:-

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

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

$$P_o = 4965.094\ Kn$$

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

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

$$\emptyset P_{n,max} = 2743.214\ Kn$$

b − Balanced point $\boldsymbol{\varepsilon_t = 0.0021}$

$$d_1 = 62.5\ mm \quad , \quad , \ d_3 = 337.5\ mm$$

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

$$C = \frac{0.003}{0.003 + 0,0021} * 337.5 = 198.53\ mm$$

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

$$\varepsilon_1 = \frac{62.5 - 198.53}{198.53} * 0.003 = -0.00206$$

$$\varepsilon_2 = \frac{337.5 - 198.53}{198.53} * 0.003 = 0.0021$$

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

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

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

$$a_b = \beta * C$$

$$a_b = 0.85 * 198.53 = 168.751\ mm$$

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

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

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

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

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

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

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

$$P_n = C_c - \Sigma F_s$$

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

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

$$M_n = 1434.38\left[\frac{400}{2} - \frac{168.751}{2}\right] - 766.85\ \left[62.5 - \frac{400}{2}\right] + 824.25\left[337.5 - \frac{400}{2}\right] * 10^{-3} = 384.63\ Kn.m$$

$$\emptyset P_n = 0.65 * 1376.98 = 895.037\ Kn$$

$$\emptyset M_n = 0.65 * 384.63 = 250\ Kn.m$$

<u>C − at point $C = 100\ mm$</u>

$$d_1 = 62.5\ mm\ \ ,\ \ ,\ \ d_3 = 337.5\ mm$$

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

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

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

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

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

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

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

$$a_b = \beta * C$$

$$a_b = 0.85 * 100 = 85\ mm$$

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

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

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

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

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

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

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

$$P_n = C_c - \Sigma F_s$$

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

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

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

$$\emptyset P_n = 0.9 * 298.11 = 268.3\ Kn$$

$$\emptyset M_n = 0.9 * 282.185 = 253\ Kn.m$$