A-solid slab design:

a)

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

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

b)

$$DL = own\ weight + superimposed$$

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

$$LL = 3\ \ kn/m^2$$

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

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

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

c)

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

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

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

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

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

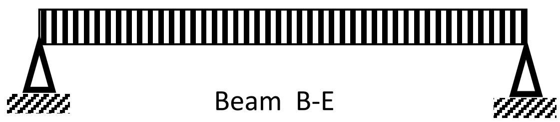
$$for\ flexural\ \ \rightarrow use\ \emptyset 12@300\ mm$$

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

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

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

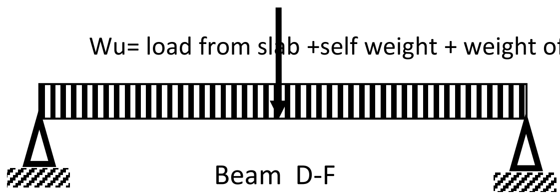
d)



$$Wu \quad slab = 14.2 \ kn/m^2$$

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

e)



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

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

B-joist slab design:

a)

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

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

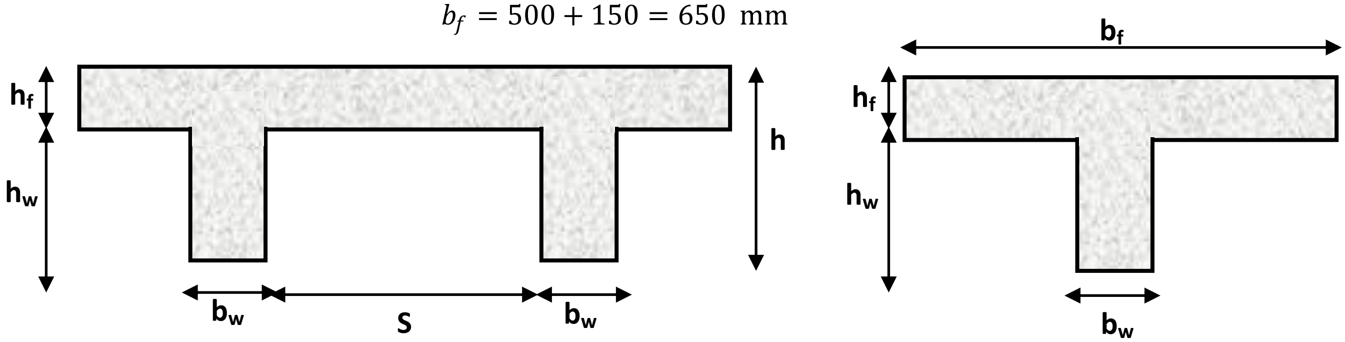
$$h_f \geq \left(50mm\ , \frac{500}{12} = 41{,}67\, mm\right) = 50\, mm \qquad h_f = 80\, mm \quad ok$$

$$h_w \ngtr (3.5 * 150 = 525mm) \qquad h_w = 300 \quad mm \quad ok$$

$$b_w \geq 100\, mm \qquad b_w = 150\, mm \quad ok$$

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

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



b)

The appropriate direction of joists slab is with short direction

C)

$$DL = own\ weight + superimposed$$

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

$$LL = 3\ kn/m^2$$

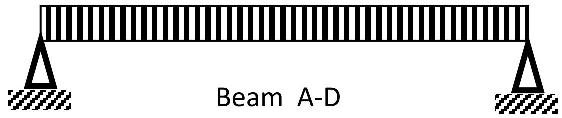
$$Wu = 1.4DL + 1.7LL$$

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

Load on typical rip:

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

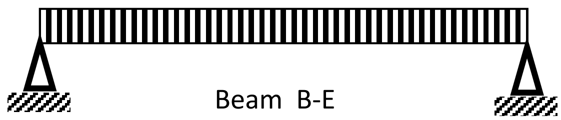
d)



$$Wu\ beam(A-D) =$$

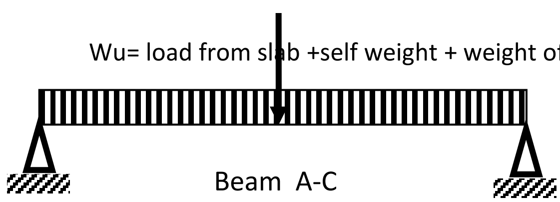
$$\frac{8.53}{0.65} * \left(\frac{3}{2} - 0.15\right) + 1.4 * [(0.6 * 0.3 * 25) + (0.3 * 2) + (2.8 * 3)] + 1.7 * (0.3 * 3) = 38.146\ kn/m$$

e)



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

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



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

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

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

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

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

$$\textbf{Total axial load on column A} =$$

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

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

<u>Q2)</u>

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

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

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

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

$$P_o = 5831.775\ Kn$$

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

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

$$\emptyset P_{n,max} = 3032.523\ Kn$$

$$d_1 = 62.5\ mm\ \ , \qquad d_2 = 250\ mm\ \ ,\ \ d_3 = 437.5\ mm$$

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

<u>**Balanced point $\boldsymbol{\varepsilon_t = 0.0021}$**</u>

$$C = \frac{0.003}{0.003 + 0,0021} * 437.5 = 257.35\ mm$$

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

$$\varepsilon_1 = \frac{62.5 - 257.35}{257.35} * 0.003 = -0.0023$$

$$\varepsilon_2 = \frac{250 - 257.35}{257.35} * 0.003 = -8.5681 * 10^{-5}$$

$$\varepsilon_3 = \frac{437.5 - 257.35}{257.35} * 0.003 = 0.0021$$

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

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

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

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

$$a_b = \beta * C$$

$$a_b = 0.85 * 257.35 = 218.75\ mm$$

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

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

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

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

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

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

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

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

$$P_n = C_c - \Sigma F_s$$

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

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

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

$$\emptyset P_n = 0.65 * 1851.14 = 1203.24\ Kn$$

$$\emptyset M_n = 0.65 * 487.44 = 316.84 Kn.m$$

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