MOD-3

DESIGN OF SINGLY REINFORCED BEAM 11/9/17

A rectangular singly reinforced RC beam of clear span 5m supported on 230 mm wall. It is subjected to live load of 20kN/m. Design the beam for flexure & shear. Use M_{20} & Fe_{415}.

Step ①: Design for flexure.

Step ①: ⓐ Assumption of dimension

ⓑ Assume b = 250, 300, 350

over all depth ← D = 2×b = 500 mm

500 − Eff cover ← d = 450 (or) 550 in this case 450mm

Assume effective cover = 50 mm

$\frac{l}{d} = 20 \times 1.25 = 25$

↳ fixed value (modification factor)

$\frac{l}{d} = 20 \times 1.25$

$\frac{5000}{d} = 25$

$\boxed{d = 200 mm}$

$\boxed{b \times d = 250 \times 450 \text{ mm}}$

step ②: Load calculation.

(w_q) Live load = 20 kN/m

(w_q) Dead load = Area

$= b \times D$

$= 0.25 \times 0.5 \times 25$

$= 3.125$ kN/m

$w = 23.125$ kN/m

$w_u = w \times 1.5 = 34.68$ kN/m

$l_e = 5 + 0.23$

$= 5.23$ mm

Bending moment

BM $M_u = \frac{w_u l_e^2}{8} = \frac{34.68(5.23)^2}{8} = 118.6$ kN-m

SF $V_u = \frac{w_u l_e}{2} = 90.68$ kN

for over reinforced beam

$$M_u = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$118.57\times10^6 = 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] 250 \times d^2 \times 20$$

$$\boxed{d = 414.59\,m} < 450$$

Hence assumption is safe.

Step ③ Calculation for area of steel.

$$M_u = 0.87 \times f_y \times A_{st} \times d \left[1 - \frac{A_{st} \times f_y}{b \times d \times f_{ck}}\right]$$

$$118.57\times10^6 = 0.87 \times 415 \times A_{st} \times 450 \left[1 - \frac{A_{st} \times 415}{250 \times 450 \times 20}\right]$$

$$118.57\times10^6 = 162472.5\, A_{st}\left[1 - 0.00018 A_{st}\right]$$

$$118.57\times10^6 = 162472.5\, A_{st} - 29.96\, A_{st}^2$$

$$\boxed{A_{st} = 869.05\,mm^2}$$

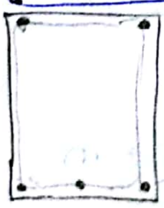
The bars will be in the dia of 18, 20, 22 mm.

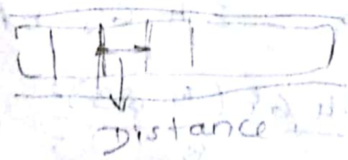
$$\text{No of bars} = \frac{A_{st}}{\frac{\pi d^2}{4}}$$

$$\text{No of bars} = \frac{869.05}{\frac{\pi}{4}(20)^2} = \boxed{2.76 \text{ bars} \simeq 3 = \text{No of bars}}$$

provide 3 No of 20mm dia bars.

$$\boxed{\text{Actual } A_{st} = \frac{3}{4}\times\pi d^2 = \frac{3\times\pi(20)^2}{4} = 942.47\,mm^2}$$





centre to centre of stirrups should be < 300

(2) Design for shear

$$\tau_v = \frac{V_u}{bd}$$

τ_v = normal shear stress N/mm^2.

$$\tau_v = \frac{90.68 \times 10^3}{250 \times 450}$$

$$\boxed{\tau_v = 0.806\ N/mm^2}$$

Concrete

In beam M_{20} (or) M_{25}

Slab M_{15}, M_{20}, M_{25}

Column least case M_{30} (or) M_{35}

$$\tau_c = \frac{100 A_{st}}{bd}$$

$$= \frac{100 \times 942.47}{250 \times 450}$$

$$\boxed{\tau_c = 0.837\ N/mm^2}$$

0.75 → 0.56

0.83 → ?

1.0 → 0.62.

$$\frac{0.56 \times 0.62}{0.56 \times x} = \frac{0.75 \times 1.0}{0.75 \times 0.83}$$

$$x \times 0.56 \times 0.75 \times 1 =$$

$$x = 0.514 = \tau_c ..$$

For stirrups provide 2-legged 8mm dia bars. Either 8 (or) 10mm bars.

$$A_{sv} = 2 \times \pi \frac{d^2}{4} = 2 \times \pi \frac{8^2}{4} = 100.53\ mm^2$$

$$V_{us} = (V_u - \tau_c\, b \times d) = \frac{0.87 \times f_y \times A_{sv} \cdot d}{S_v}$$

~~90.68 − 0.83 × 450 × 250 = 0.87 ×~~

$$S_v = \left[\frac{0.87 \times f_y \times A_{sv} \cdot d}{V_u - \tau_c \times b \times d}\right]$$

$$S_v = \frac{0.87 \times 415 \times 100.53 \times 450}{90680 - 0.57 \times 250 \times 450} = 615.07\ mm$$

$S_v = 0.75 \times d$

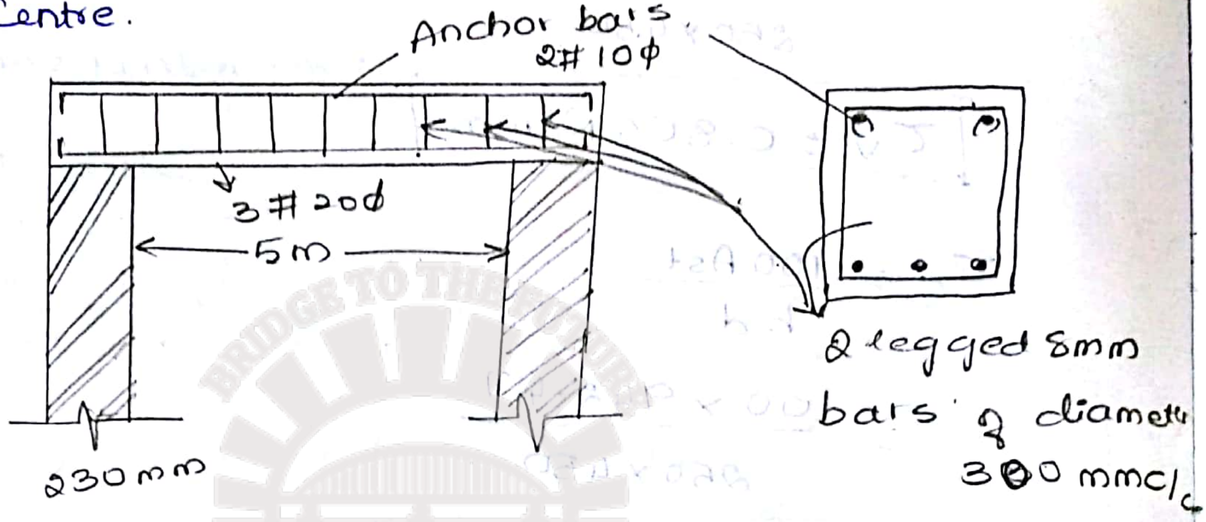
$= 0.75 \times 450$

$S_v = \underline{337.5\ mm}$

1m = 3.28 feet

9.3 feet = 3.87 feet

Hence provide 2 legged 8mm dia bars at 300mm Centre to Centre.



12/9/17

② Design a singly reinforced beam of span 3m. Live load 16 kN/m. Use M_{20} & Fe_{415}.

Step ①:- Design for flexure

ⓐ Assumption of dimensions

ⓑ Assume $b = 250, 300, 350$

$D = 2 \times b = 2 \times 250 = 500$

$d = 450$

$\boxed{b \times d = 250 \times 450}$

wall thickness

$l_e = 3 + 0.23$

$= 3.23$

Step ②: Load calculation

$w_g (LL) = \overset{b \times D}{0.25 \times 0.5} \times 25$

$= 3.125\ kN/m$

$w_q = 16\ kN/m$

$\boxed{w = 19.125\ kN/m}$

$w_u = w \times 1.5 = 19.125 \times 1.5$

$w_u = 28.68$ kN/m

$$M_u = \frac{w_u l_e^2}{8} = \frac{28.68 \times (3.23)^2}{8} = 37.4 \text{ kN-m}$$

$$V_u = \frac{w_u l_e}{2} = 46.318 \text{ kN}$$

For over reinforced beam

$$M_u = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$37.4 \times 10^6 = 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] 250 \times d^2 \times 20$$

$$\boxed{d = 232.84m}$$

Assumed d ie 450 is greater than obtained d i.e 232.8. Therefore d is safe.

step ③ Calculation for area of steel

$$M_u = 0.87 \times f_y \times A_{st} \times d\left[1 - \frac{A_{st} \times f_y}{b \times d \times f_{ck}}\right]$$

$$37.4 \times 10^6 = 0.87 \times 415 \times A_{st} \times 450\left[1 - \frac{A_{st} \times 415}{250 \times 450 \times 20}\right]$$

$$37.4 \times 10^6 = 162472.5 A_{st}\left[1 - 0.00018 A_{st}\right]$$

$$37.4 \times 10^6 = 162472.5 A_{st} - 29.9 A_{st}^2$$

$$\boxed{A_{st} = 240.869 \text{ mm}^2}$$

The bars will be in the dia of 18, 20, 22 mm²

$$\text{No of bars} = \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{240.869}{\frac{\pi}{4}(120)^2}$$

$$\boxed{\text{No of bars} = 2.129 \simeq 3 \text{ bars}}$$

$$Act\ A_{st} = \frac{3}{4} \times \pi d^2 = \cancel{942.47\ mm^2}\ 339.29\ m^2.$$

(12)²

② Design for shear

$$\tau_v = \frac{V_u}{b \times d}$$

$$= \frac{46.318 \times 10^3}{250 \times 450}$$

$$\tau_v = 411.71\ m^2$$

$$\boxed{\tau_v = 0.411\ m^2}$$

Always $\tau_v > \tau_c$

$$\tau_c = \frac{100 A_{st}}{bd}$$

$$= \frac{100 \times \cancel{942.47}\ 339.29}{250 \times 450}$$

$$\boxed{\tau_c = \cancel{0.8377}\ 0.3015\ mm^2}$$

$$\boxed{\tau_v > \tau_c}$$

0.25 → 0.36
0.30 → ?
0.5 → 0.48

$$\frac{\cancel{0.36} \times 0.48}{\cancel{0.36} \times x} = \frac{\cancel{0.25} \times 0.5}{\cancel{0.25} \times 0.3}$$

$$\cancel{2.304} = \cancel{0.2045x}$$

$$\boxed{\cancel{x = 51.2}} \qquad \boxed{x = 0.288} = \tau_c$$

for stirrups provide 2 legged 8mm dia bars

$$A_{sv} = 2 \times \frac{\pi d^2}{4} = \frac{2 \times \pi (8)^2}{4} = 100.53\ mm^2$$

$$V_{us} = (V_u - \tau_c \times b \times d) = \left(\frac{\tau_c \times f_y \times A_{sv} \cdot d}{\cancel{46318}\ S_v} \right)$$

$$S_v = \frac{\tau_c \times f_y \times A_{sv} \cdot d}{V_u - \tau_c \times b \times d}$$

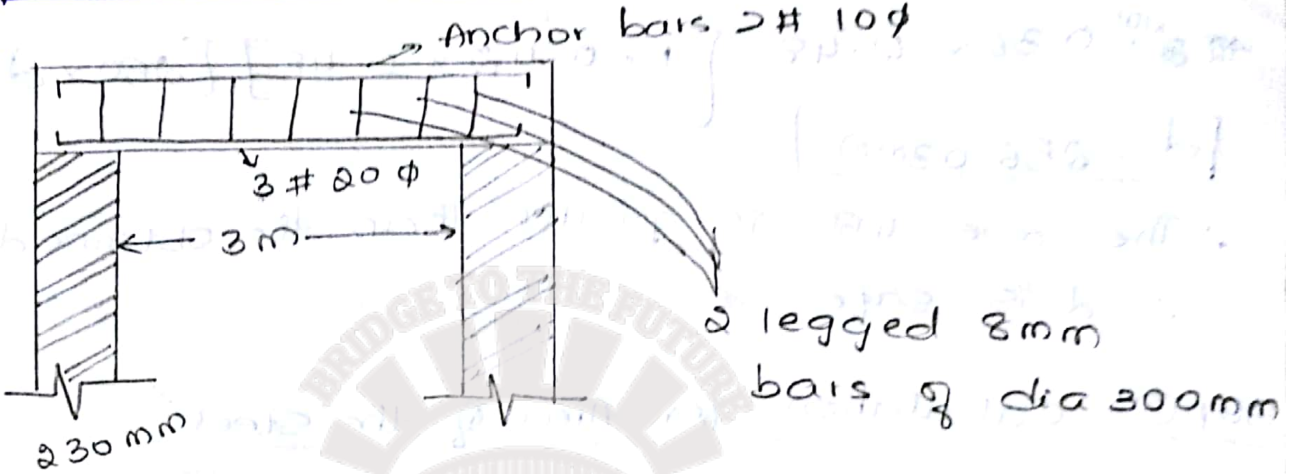
$$S_v = \frac{0.\cancel{288}^{87} \times 415 \times 100.53 \times 450}{46318 - 0.288 \times 250 \times 450}$$

$S_v = \cancel{17999\,mm}$

$\boxed{S_v = 1173.54\,mm}$

$S_v = 0.75 \times d$

$\boxed{S_v = 337.5\,mm}$



(3) Design a singly reinforced cantilever beam of 2m span length Live load 9kN/m M_{20} & Fe_{415}.

Step ①: Design for flexure

(a) Assumption of dimensions

(b) Assume $b = 250, 300, 350$

$D = 2 \times b = 2 \times 250 = 500$

$d = 450$

$\boxed{b \times d = 250 \times 450}$

$l_e = 2 + 0.23$

$= 2.23$

Step ②:- Load Calculation:-

$w_q(DL) = 0.25 \times 0.5 \times 25$

$= 3.125\,kN/m$

$w_q(LL) = 9\,kN/m$

$w = 12.125\,kN/m$

$W_u = w \times 1.5 = 18.18\,kN/m$

$$M_u = \frac{w_u l_e^2}{2} = \frac{18.18\,(2.23)^2}{2} = 45.20\,kN/m$$

$V_u = \frac{w_u l_e}{2} = \cancel{20.27} = 40.55\ KN$

for over reinforced

$$M_u = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] bd^2 f_{ck}.$$

$$\cancel{45.2} \times 10^6 = 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right]\left[250 \times d^2 \times 20\right]$$

$$\boxed{d = 256.03mm}$$

∴ The 'd' ie 450 is greater than the obtained 'd' value

∴ d is safe.

Step ③:- Calculation for Area of the Steel.

$$M_u = 0.87 \times f_y \times A_{st} \times d\left[1 - \frac{A_{st} f_y}{b \times d \times f_{ck}}\right]$$

$$= 0.87 \times \cancel{\overset{415}{418}} \times A_{st} \times 450\left[1 - \frac{A_{st}\ 415}{250 \times 450 \times 20}\right]$$

$$= 162472.5\ A_{st}\left[1 - 0.00018\ A_{st}\right]$$

$$45.2 \times 10^6 = 162472.5\ A_{st} - 29.96\ A_{st}^2$$

$$\boxed{A_{st} = 294.15\ mm^2}$$

The bars will be in the dia of $\overset{11,12}{18, 20}$ & 22 mm

No of bars $= \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{294.15}{\frac{\pi(12)^2}{4}} = 2.6 \simeq 3$ bars

Act $A_{st} = 3 \times \frac{\pi d^2}{4} = 3 \times \frac{\pi(12)^2}{4} = 339.29\ m^2$

② Design for shear.

$$\tau_v = \frac{V_u}{b \times d} = \frac{40.55 \times 10^3}{250 \times 450} = 0.36\ N/mm^2$$

$$\tau_c = \frac{100\,A_{st}}{bd} = \frac{100 \times 339.29}{250 \times 450} = 0.3015\,mm^2$$

$$\tau_v > \tau_c .$$

0.25 $\longrightarrow$ 0.36

0.3 $\longrightarrow$?

0.5 $\longrightarrow$ 0.48

$\boxed{x = 0.288 = \tau_c} = 0.384.$

For stirrups provide 2L 8# bars.

$$A_{sv} = 2 \times \frac{\pi d^2}{4} = \frac{2 \times \pi (8)^2}{4} = 100.53\,mm^2$$

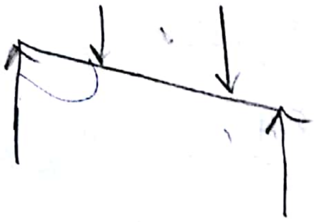
$$V_{us} = (V_u - \tau_c \times b \times d) = \frac{\overset{0.87}{\cancel{\tau_c}} \times f_y \times A_{sv} \cdot d}{S_v .}$$

$$S_v = \frac{\overset{0.87}{\cancel{\tau_c}} \times f_y \times A_{sv} \cdot d}{V_u - \tau_c \times b \times d .}$$

$$S_v = \frac{\overset{0.87}{\cancel{0.3015}} \times 415 \times 100.53 \times 450}{\underset{40.56 \times 10^3}{40.55} - 0.28\cancel{4} \times 250 \times 450}$$

$S_v =$

③ Design a beam lying below inclined water tank with a span of 3m and sudden load of 22 kN at mid of beam. Use M_{20} & Fe_{415}



Step ①: $b = 300mm$

$D = 2 \times b$ (or) $D = 600$

$\frac{l}{d} = 20$

$\frac{3000}{d} = 20 \quad d =$

$\frac{l}{d} = 20 \times 1.25$

Effective cover

$\frac{3000}{d} = 25 \quad d = 120 + 50 = 170mm$

$b \times d = 300 \times 550$

Live load = 22 kN

$DL = 0.3 \times 0.6 \times 25$

$= 4.5 \, kN/m$

$l_e = 3 + 0.23$

$= 3.23$

$M = \frac{w_d l_e^2}{8} + \frac{W_L l_e}{2}$

$= \frac{4.5 \times (3.23)^2}{8} + \frac{\cancel{22 \times 3.23}}{\cancel{4}} \frac{wab}{l_e} + \frac{22 \times 1.615 \times 1.615}{3.23}$

M $\boxed{M_u = \cancel{44.39}\ 23.63 \ kN\text{-}m}$ $\quad M_u = 23.63 \times 1.5 = 35.44 \ kN\text{-}m$

$M_u = 0.36 \frac{x_{umax}}{d} \left[1 - 0.42 \frac{x_{umax}}{d}\right] b d^2 f_{ck}$

$\cancel{44.39}\ 23.63 \times 10^6 = 0.36 \times 0.48 \left[1 - (0.42 \times 0.48)\right] 300 \times \cancel{550^2}\ d^2 \times 20$

$\boxed{d = 206.91m}$

$V = \frac{wl}{2} + \frac{W_a}{2}$

$\cancel{V = \frac{w_d l_e}{2} = \frac{4.5 \times 3.23}{2} + \frac{22}{2}}$

$\cancel{V = 18.261}$

$\boxed{V = 18.26 \, kN}$ $\quad = \frac{4.5 \times 3.23}{2} + \frac{22}{2}$

Calculation of area of steel $V_u = 18.26 \times 1.5$

$= 27.39$

$$M_u = 0.87 \times f_y \times A_{st} \times d \left[1 - \frac{A_{st} \times f_y}{b d f_{ck}}\right]$$

$$35.4 \times 10^6 = 0.87 \times 415 \times A_{st} \times 550 \left[1 - \frac{A_{st} \times 415}{300 \times 550 \times 20}\right]$$

$$\cancel{As}\ 35.4 \times 10^6 = 198577.5\, A_{st} \left[1 - 0.000125 A_{st}\right]$$

$$35.4 \times 10^6 = 198577.5\, A_{st} - 24.82\, A_{st}^2$$

$$\boxed{A_{st} = 182.42\, mm^2}$$

$$\text{No of bars} = \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{182.42}{\frac{\pi (12)^2}{4}} = 1.61 \simeq 2$$

$$\text{Actual } A_{st} = \frac{2}{4} \times \pi (12)^2 = 226.19$$

Design for shear

$$\tau_v = \frac{V_u}{b \times d} = \frac{27.39 \times 10^3}{300 \times 550} = 0.166$$

τ_c Inter

$$\tau_c = \frac{100 A_{st}}{b d} = \frac{100 \times \cancel{182.42}\ 226.19}{300 \times 550} = 0.137$$

$$\tau_v > \tau_c$$

$0.15 \rightarrow 0.28$

$0.13 \rightarrow$

$0.25 \rightarrow 0.36$

$$\frac{0.28 \times 0.36}{0.28 \times x} = \frac{0.15 \times 0.25}{0.15 \times 0.13}$$

$$\frac{0.36}{x} = 1.92$$

$$\therefore \tau_c = \boxed{x = 0.1872}$$

for stirrups provide 2 legged 8mm dia bars

$$A_{sv} = 2 \times \frac{\pi d^2}{4} = 2 \times \pi$$

(4) A Rectangular simply supported beam of span 8m as an UDL live load of 22 kN/m M_{20} & Fe_{415}. 11/9/17

$b = 250, 300, 350$

$d = D = 2B = D = 500$ mm

$d = 450$ mm

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$\frac{l}{d} = 20^{*} \times 1.25$

$\frac{8000}{d} = 20 \times 1.25$

$d = 320$ mm

$\boxed{b \times d = 250 \times 450 \text{ mm}}$

Dead load $= 0.25 \times 0.5 \times 25$

$= 3.125$ kN/m

$LL = 22$ kN/m

Total load $w = 25.125$ kN/m

$w_u = 25.125 \times 1.5 = 37.68$ kN/m

$M = \frac{3.125 \times 8.23^2}{8} + \frac{22 \times 8.23^2}{8}$

$le = 8.23$

$M = 212.72$

$M_u = 212.72 \times \cancel{8.23}$

$\boxed{M_u = \cancel{261.65}\ 1750.68}$

$M_u = \frac{w_u le^2}{8}$

$= 319.02$

$V_u = \frac{w_u le}{2}$

$V_u = 168.18$

Check for depth

$M = 0.36 \left(\frac{x_{umax}}{d}\right)\left(1 - 0.42\left(\frac{x_{umax}}{d}\right)\right) f_{ck} b d^2$

$319.02 \times 10^6 = 0.36 (0.48) (1 - 0.42 \times 0.48) 20 \times 250 \times d^2$

$\boxed{d = 680 \text{ m}}$

$\boxed{\therefore d \text{ is not safe}}$

Take $b \times d = 300 \times 650$

$D = \cancel{7}00mm$ $b \times D$

Dead load $= 0.3 \times 0.\cancel{65}^{7} \times 25$
$= \cancel{4.875}$ 5.25 kN/m

$LL = 22$ kN/m

$w = \cancel{27.825}$ 27.25 kN/m

$w_u = 27.25 \times 1.5$

$$\boxed{w_u = 40.87 \text{ kN/m}}$$

<u>BM for UDL</u>

$$M_u = \frac{w_u l_e^2}{8} = \frac{40.87 \times 8.23^2}{8} = 346.03 \text{ kN/m}$$

<u>SF for UDL</u>

$$V_u = \frac{w_u l_e}{2} = 168.18$$

$$M_{u\,lim} = 0.36 \left[\frac{x_{u\,max}}{d}\right]\left[1 - 0.42\left(\frac{x_{u\,max}}{d}\right)\right] f_{ck}\, b d^2$$

$$346.03 \times 10^6 = 0.36(0.48)\left[1 - 0.42(0.48)\right] 20 \times 300 \times d^2$$

$$\boxed{d = 646.54 \text{ m}}$$

∴ The 'd' is safe since it is less than 650.

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{f_{ck} b d}\right]$$

$$346.03 \times 10^6 = 0.87 \times 415 \times A_{st} \times 650 \left[1 - \frac{A_{st}\ 415}{20 \times 300 \times 650}\right]$$

$$346.03 \times 10^6 = 234682.5\, A_{st} \left[1 - 0.000106\, A_{st}\right]$$

$$346.03 \times 10^6 = 234682.5 A_{st} - 24.97 A_{st}^2$$

$$\boxed{A_{st} = 1831.7\ mm^2}$$

$$\underline{No} \text{ of bars} = \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{1831.7}{\frac{\pi (22)^2}{4}}$$

18
20 → 6 bars
22 → 5 bars
25

$$\underline{No} \text{ of bars} = 4.81 = 5 \text{ bars}$$

$$\text{Actual } A_{st} = 5 \times \frac{\pi d^2}{4} = 5 \times \frac{\pi (22)^2}{4} = 1900.66$$

<u>Design for shear</u>

$$\tau_v = \frac{V_u}{b \times d} = \frac{168.18 \times 10^3}{300 \times 650}$$

$V_u =$

$$\tau_v = 0.862\ kN/mm^2$$

$$\tau_c = \frac{100 A_{st}}{bd} = \frac{100 \times 1900.66}{300 \times 650} = 0.974$$

$0.75 \rightarrow 0.56$

$0.97 \rightarrow ?$

$1.00 \rightarrow 0.62$

$$\boxed{\tau_c = 0.61}$$

$$V = \frac{wle}{2} + \frac{wle}{2}$$

$$= \frac{22.823}{2} + \frac{5.25 \times 8.25}{2}$$

$$\boxed{V = 112.13 \text{ kN}}$$

$$V_U = 1.5 \times V$$

$$= 1.5 \times 112.13$$

$$\boxed{V_U = 168.19 \text{ kN}}$$

Provide 2L bars @ 8mm dia bars.

$$A_{sv} = \frac{2 \times \pi d^2}{4} = \frac{2 \times \pi (8)^2}{4} = 100.53 \text{ mm}^2$$

$$V_{us} = (V_U - \tau_c \times b \times d) = \left(\frac{\overset{0.87}{\cancel{\tau_c}} \times f_y \times A_{sv} \cdot d}{S_v}\right)$$

$$S_v = \left[\frac{\overset{0.87}{\cancel{\tau_c}} \times f_y \times A_{sv}\, d}{V_U - \underset{0.61}{\tau_c} \times b \times d}\right]$$

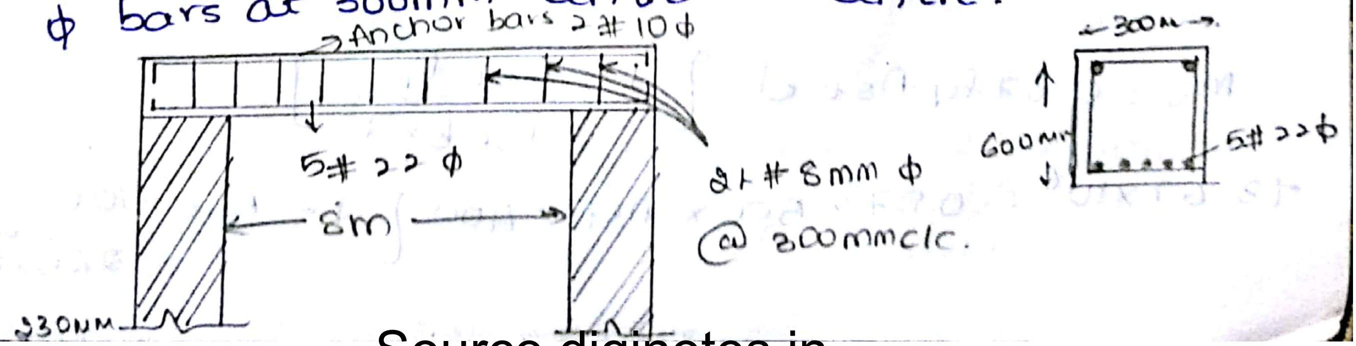
$$= \frac{0.87 \times 415 \times 100.53 \times 650}{168.19^{\times 10^3} - 0.67 \times 300 \times 650}$$

$$\boxed{S_v = 479.23}$$

Its more than 300 hence use other formula

$$S_v = 0.75 \times d = 0.75 \times 650 = 487.5$$

This value exceeds 300 hence provide 2L # 8mm ϕ bars at 300mm centre to centre.



(5) Design a cantilever of span 2.5m and wall thickness 300mm Use M_{25} & Fe500. Point load at free End is 14 KN

$b = 225$

$D = 2B = 450$

$\boxed{d = 400}$

$\frac{l}{d} = 7 \times 1.25$

$\frac{2500}{d} = 8.75$

$\boxed{d = 285.71}$

$\boxed{b \times d = 225 \times 400}$

Load calculation

$DL = 0.225 \times 0.45 \times 25$

$= 2.531 \text{ KN/m}$

$Ld = 14 \text{ KN}$

$M = \frac{\overset{(w_g)}{2.53 \times 2.8^2}}{2} + \overset{(w_q)}{14 \times 2.8}$

$l_e = 2.5 + 0.3$

$\boxed{l_e = 2.8}$

$\boxed{M = 49.117 \text{ KN-m}}$

$M_u = M \times 1.5$

$\boxed{M_u = 73.67 \text{ KN-m}}$

Check for depth

$$M = 0.36 \left(\frac{x_{u\,max}}{d}\right)\left[1 - 0.42\left(\frac{x_{u\,max}}{d}\right)\right] f_{ck}\, b d^2$$

$$73.67 \times 10^6 = 0.36\,[0.46]\,[1 - 0.42(0.46)]\; 25 \times 225 d^2$$

$\boxed{d = 313.09m}$

$\therefore$ d is safe.

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{f_{ck}\, b \times d}\right]$$

$$73.67 \times 10^6 = 0.87 \times 500 \times A_{st} \times 400 \left[1 - \frac{A_{st}\; 500}{25 \times 225 \times 400}\right]$$

$$73.67\times10^6 = 174000A_{st}[1-0.0002A_{st}]$$

$$73.67\times10^6 = 174000A_{st} - 38.66A_{st}^2$$

$$\boxed{A_{st} = 473.12\,mm^2}$$

~~Design for shear~~

$$No.\ of\ bars = \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{473.12}{\frac{\pi(18)^2}{4}} = 1.85$$

$$= \underline{2\ bars}$$

$$Actual\ A_{st} = 2\times\frac{\pi d^2}{4} = \frac{2\times\pi(18)^2}{4} = 508.9$$

Design for shear

$$V = \frac{w_g l_e}{2} + W_q$$

$$= \frac{2.53\times2.8}{2} + 14$$

1912

$$\boxed{V = 21.84\,KN}$$

$$\boxed{V_u = 1.5\times V = 31.62\ KN}$$

$$\tau_v = \frac{V_u}{b\times d} = \frac{31.62\times10^3}{225\times400} = 0.35\ KN/mm^2$$

$$\tau_c = \frac{100A_{st}}{bd} = \frac{100\times508.9}{225\times400} = 0.565\ KN/mm^2$$

$$\tau_c > \tau_v$$

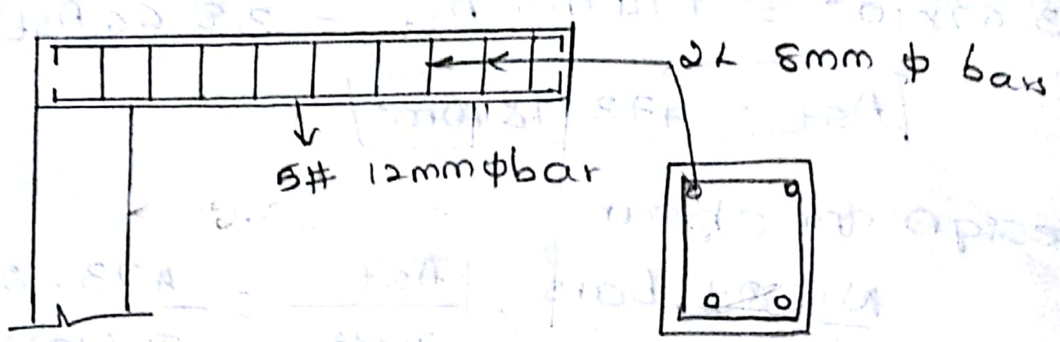
$0.5 \longrightarrow 0.49$

$0.56 \longrightarrow ?$

$0.75 \longrightarrow 0.57$

$$\underline{\tau_c = 0.509\ KN/mm^2}$$

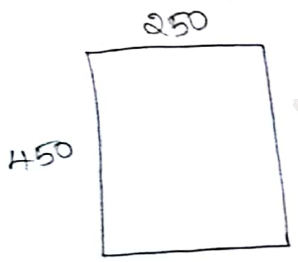
Provide 2L 8mm dia @ 300 centre to centre.



21/9/17

Design of doubly reinforced RC beam

1. Design a rectangular simply supported beam of span 5m & subjected to live load of 30 kN/m along with the self weight. The size of the beam is restricted to 250mm × 450mm Use M_{20} & Fe_{415} design both flexure & shear.



b = 250 mm

D = 450mm

Effective cover = Assumed as 50 mm

d = 400mm ⟶ D - effective cover

Design for flexure

In design (i) Load calculation

$DL = b \times d \times 25$

$= 2.81$ kN/m

$LL = 30$ kN/m

W_u = Ultimate load = $\underline{\underline{W}}$ DL + LL = 32.81 -

$W_u = 32.81 \times 1.5 = 49.215$ kN/m

$$M_u = \frac{W_u l^2}{8} = \frac{49.215 \times (5)^2}{8} = \underline{153.79 \text{ kN-m}}$$

$$M_{ulim} = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42 \frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$= 0.36 \times 0.48 [1 - 0.42 \times 0.48]\ 250 \times 400^2 \times 20$$

$$M_{ulim} = \underline{110.37 \text{ kN-m}}$$

$M_u > M_{ulim}$ ∴ Doubly reinforced.

if $M_u < M_{ulim}$ Its singly reinforced.

Area of compression steel

$$M_u - M_{ulim} = f_{sc} A_{sc} (d - d')$$

$x_{umax} = 0.48 \times d$

$= 0.48 \times 400$

$= 192$

$$\text{Strain} = 0.0035 \left[\frac{x_{umax} - d'}{x_{umax}}\right]$$

$$= 0.0035 \left[\frac{192 - 50}{x_{umax}}\right]$$

$$\boxed{\text{Strain} (~~f_{sc}~~) = 0.0025 \text{ kN/m}^2}$$

$$f_{sc} = \underline{350 \text{ kN/m}^2}$$

~~No~~ ~~$A_{sc} = \frac{\pi d^2}{4}$~~

$$M_u - M_{ulim} = f_{sc} A_{sc} (d - d')$$

$$153.79 - 110.37 = 350\ A_{sc}(400 - 50)$$

$$43.42 = 122500\ A_{sc}$$

$$\boxed{A_{sc} = 354.4 \text{mm}^2}$$

> Note:-
> Dia of compression should be always less than (4mm) tension steel.

$$\frac{354.4}{\frac{\pi (12)^2}{4}} = 3.13 \simeq 4$$

→ Assumed

$\boxed{\text{Provide } 4 \# 12\phi \text{ bars in compressed zone.}}$

$$\frac{x_{u\,max}}{d} = \frac{0.87 f_y A_{st1}}{0.36 f_{ck} b d}$$

$$0.48 = \frac{0.87 \times 415 \times A_{st1}}{0.36 \times 20 \times 250 \times 400}$$

$$\boxed{A_{st1} = 957.2 \text{ mm}^2}$$

$$A_{st2} = \frac{A_{sc} f_{sc}}{0.87 f_y}$$

$$= \frac{354.4 \times 350}{0.87 \times 415}$$

$$\boxed{A_{st2} = 343.5 \text{ mm}^2}$$

$$A_{st} = A_{st1} + A_{st2}$$

$$\boxed{A_{st} = 1300.7 \text{ mm}^2}$$

No of bars $= \frac{1300.7}{\frac{\pi \times 18^2}{4}} = 5.11 \simeq 6.$

Provide 6 # 18ϕ bars at tension zone

Act $A_{st} = 6 \times \frac{\pi d^2}{4} = \frac{6 \times \pi (18)^2}{4} = 1526.8 \text{ mm}^2$

$\cancel{\tau_v = \frac{V_u}{bd}}$ Design for shear

$$V_u = \frac{w_u l}{2} = \frac{49.215 \times 5}{2} = 123.03 \text{ kN-m}$$

$$\tau_v = \frac{V_u}{bd} = \frac{123.03 \times 10^3}{250 \times 400} = 1.23 \text{ N/mm}^2$$

$$\tau_c = \frac{100 A_{st}}{bd} = \frac{100 \times 1526.8}{250 \times 400} = 1.52$$

$1.5 \rightarrow 0.72$

$1.52 \rightarrow ?$

$1.75 \rightarrow 0.75$

$\tau_c = 0.72$

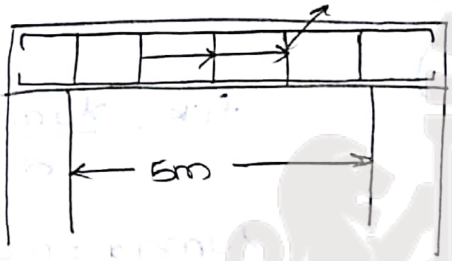
$\tau_v > \tau_c$ shear design is required

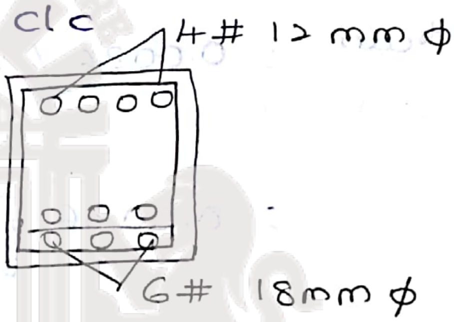
$$(V_u - \tau_c)\, bd = \frac{0.87\, A_{sv}\, f_y\, d}{S_v}$$

f_y $A_{sv} = \frac{2\pi d^2}{4}$

$$S_v = \frac{0.87 \times 415 \times 400 \times 100.53}{(123.03 - 0.72)\, 250 \times 400} = 285.67\text{mm}$$

provide 2L # 8 mm ϕ 285 mm c/c





(2.) A cantilever beam of size 250 × 500 & span 4m carries a UDL live load 28 kN/m. Design the beam for both flexure & shear M_{25} & Fe_{415}

$b \times d = 250 \times 450$

$D = 500$mm

Effective cover = 50mm

(i) flexure

$DL = 0.5 \times 0.25 \times 25$

$DL = 3.125$ kN/m

$LL = 28$ kN/m

$W = 31.125$ kN/m

$w_u = \frac{w}{\cancel{FoS}} \times 1.5$

$= 46.68$ kN/m

l_e = wall thickness × length

$l_e = 4 + 0.23$

$= 4.23$m

$$M_u = \frac{W_u l_e^2}{2} = \frac{46.68 \times 4.23^2}{2} = 417.68 \text{ kN-m}$$

$$M_u \lim = 0.36 \frac{x_u max}{d} \left[1 - 0.42 \frac{x_u max}{d}\right] f_{ck} \, b \cdot d^2$$

$$= 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] 25 \times 250 \times 450^2$$

$$M_u \lim = 174.61 \text{ kN-m}$$

$M_u > M_u \lim \rightarrow$ doubly reinforced.

$$(M_u - M_u \lim) = f_{sc} \cdot A_{sc} (d - d')$$

$$\text{Strain} = 0.0036 \left(\frac{x_u max - d'}{x_u max}\right)$$

$$f_{ck} = \frac{x_u max}{d}$$

$$= 0.0036 \left[\frac{216 - 50}{216}\right]$$

$$x_u max = 0.48 \times d$$

$$x_u max = 216$$

$$\text{Strain} = 0.0026$$

$$f_{sc} = 350 \text{ kN/m}^2.$$

$$(417.68 - 174.61) = 350 \cdot A_{sc} (450 - 50)$$

$$A_{sc} = 1.736 m^2$$

$$A_{sc} = 1735.7 \text{ mm}^2$$

$$\text{No of bars} = \frac{1735.78}{\frac{\pi (22)^2}{4}} = 4.56 \simeq 5$$

$$\boxed{\text{Provide } 5\# \; 22\phi \text{ @ Compression zone}}$$

$$A = \frac{x_u max}{d} = \frac{216}{450} \quad \frac{0.87 f_y A_{st1}}{0.36 f_{ck} bd}$$

$$0.48 = \frac{0.87 \times 415 \times A_{st1}}{0.36 \times 25 \times 450 \times 250}$$

$$\boxed{A_{st1} = 1346.07\,mm^2}$$

$$\frac{A_{st2} \times f_{sc}}{0.87 f_y} = A_{st2}$$

$$\boxed{A_{st2} = 1682.57\,mm^2}$$

$$A_{st} = 3028.6\,mm^2$$

This should be around 4 5 bars only.

$$\underline{No} \text{ of bars} = \frac{3028.6}{\frac{\pi (30)^2}{4}} = 4.28 \doteqdot 5 \text{ bars}$$

provide 5 # 30 ϕ @ Tension zone.

$$Act\,A_{st} = 5 \times \frac{\pi d^2}{4} = \frac{5 \times \pi (30)^2}{4} = 3534.29\ mm^2$$

<u>Design for shear</u>

$$V_u = \frac{w_u l_e}{\cancel{2}} = 46.68 \times 4.23$$

$$= 197.45\ KN$$

$$\tau_v = \frac{V_u}{bd} = \frac{197.45}{250 \times 450} = \underline{\underline{1.75}}$$

$$\tau_c = \frac{100\,\overset{Act}{A_{st}}}{bd} = \frac{100 \times 3028.6}{250 \times 450} = 2.69$$

$$100\left(\cancel{\frac{A_{st}}{bd}}\right)\ Act\,A_{st} = \frac{5 \times \pi (30^2)}{4}$$

$$= 3534.29\,mm^2$$

$$\tau_c = 100\left(\frac{A_{st}}{bd}\right) = 3.14$$

$$\tau_c = 0.92$$

$\boxed{\tau_v > \tau_c}$ – provide shear design

$$V_u - \tau_c bd = \frac{0.87 A_{sv} f_y \cdot d}{S_v}$$

$$A_{sv} = \frac{\pi 8^2}{4} \times 2$$

$$= \cancel{50.26}$$

$$= \cancel{25.13}$$

$$S_v = \left[\frac{0.87 A_{sv} f_y \cdot d}{V_u - \tau_c bd}\right]$$

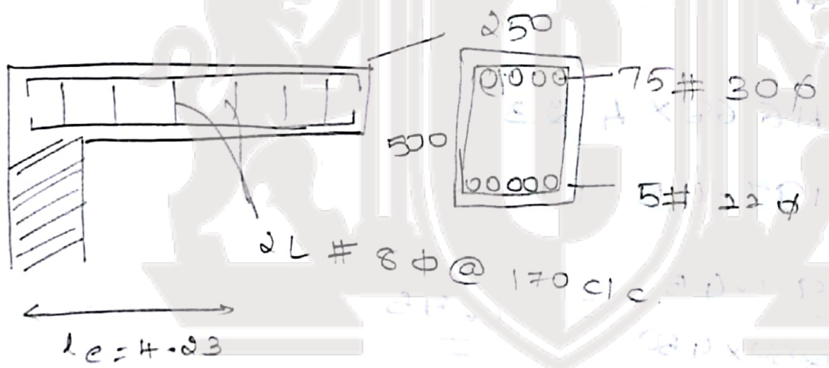
$$S_v = \left[\frac{0.87 \times \cancel{50.26}\,25.13 \times 415 \times 450}{197.45\times10^3 - 0.92 \times 450 \times 250}\right]$$

$A_{sv} = 100.5$

$$S_v = 173.77$$

Provide 2L # 8mm ϕ at 173 mm c/c.

Note:- for cantilever beam always consider Effective length (l_e)



Check for deflection for singly reinforced.

$$\frac{L}{d} = \frac{5230}{450} = 11.62 \text{ [By problem 1]}$$

$$f_{sc} = 0.58 f_y \frac{A_{st}}{Act\,A_{st}}$$

$$= 0.58 \times 415 \times \left(\frac{869.1}{942.48}\right)$$

$$\boxed{f_{sc} = 221.95}$$

By graph of pg no 38

$F_1 = 1.1$ (Ast)

$F_2 = 1$ (Asc) $\quad 1.1 \times 1 \times 1 \times 20$

$F_3 = 1$ (Flanged) $\quad = 22.$

$11.62 < 22$

Deflection is under control

from problem ③

Singly reinforced

$\frac{l}{d} = 7$

$\frac{2230}{450} = 4.95$

$\frac{100\,Ast}{bd} = 0.3$

$f_{sc} = 0.58 f_y \left(\frac{Ast}{Act\ Ast} \right) = 0.58 \times 415 \left[\frac{295.68}{339.12} \right.$

$f_{sc} = \cancel{208}\ 209.86$

$F_1 = 1.7$

$F_2 = 1 \quad F_1 \times F_2 \times F_3 \times 7$

$F_e = 1 \quad = 11.9$

$\frac{l}{d} < MF$

Doubly reinforced

$\frac{l}{d} = 20$

$\frac{100\,Ast}{bd} = 1.\cancel{5}$

$\frac{5000}{400} = 12.5$

$0.58 f_y \left(\frac{Ast}{Act\ Ast} \right) = 205.07$

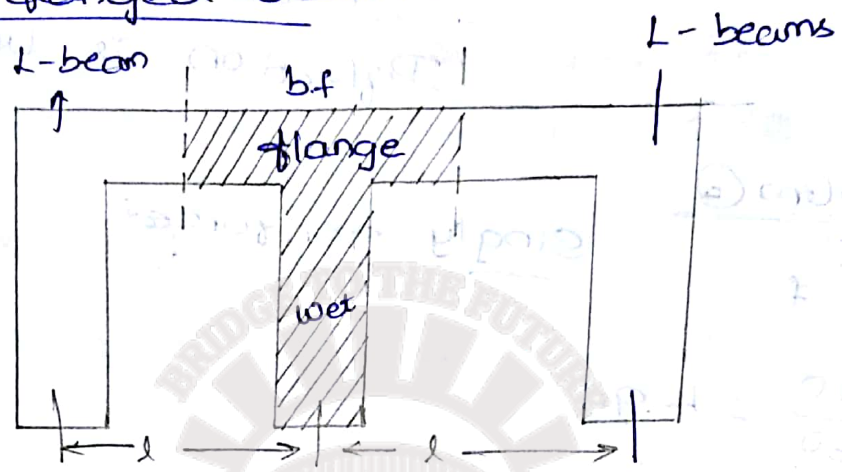
$F_1 = 1$

$$\frac{A_{sc}}{bd} \times 100 = 0.35$$

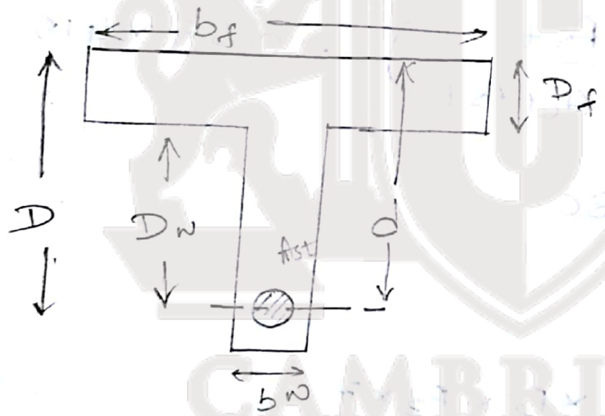
$$F_2 = 1.1$$

25/9/17

T-beams / flanged beam.



Isolated Section of T-beam



① for continous beams the breadth of the flange is given by $b_f = \frac{l_0}{6} + b_w + 6D_f$

② For Isolated T-beam

$$b_1 = \frac{l_0}{\left(\frac{l_0}{b^*}\right) + 4} + b_w$$

③ The compression equation for T-beams is given by

$$C_1 = 0.36 f_{ck} (x_u \times b_w)$$

$$(+) \quad C_2 = 0.45 f_{ck} D_f (b_f - b_w)$$

⑤ The equation for tension $T = 0.87 f_y A_{st}$

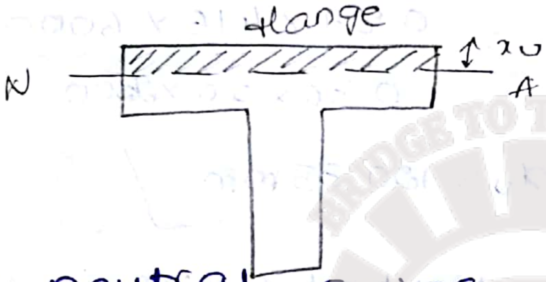
⑥ Lever arm

$$z_1 = (d - 0.42 x_u)$$

$$z_2 = (d - D_f/2)$$

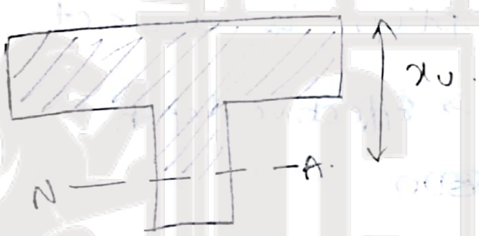
⑦ Condition for depth of neutral axis.

(i) If neutral axis lies within flange.



$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} \cdot b}.$$

(ii) If neutral axies lies within web.



The x_u is determined by the equation $C_1 + C_2 = T$

$$C_1 + C_2 = T$$

$$(0.36 f_{ck} x_u b_w) + 0.45 f_{ck} y_f (b_f - b_w) = 0.87 f_y A_{st}$$

$$\boxed{y_f = (0.15 x_u + 0.65 D_f) \ngtr D_f}$$

8. Moment of resistance if $(x_u < x_{u max})$ under reinforced.

$(x_u \geq x_{u max})$ over (or) balanced reinforced.

① Determine the working moment for a T-beam from the following data

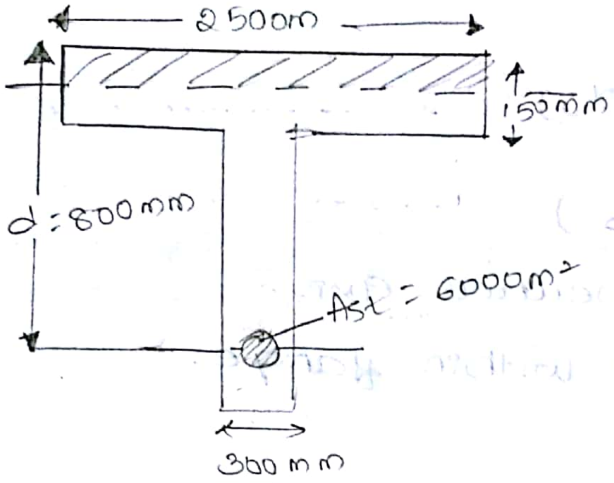
(i) Breadth of flange $(b_f) = 2500$ mm

(ii) Depth $D = 150$ mm

(iii) width of the rib $b_w = 300$ mm

(iv) Effective depth $= 800$ mm

v_t Area of Steel = $6000\,mm^2$ Use M_{20} & $Fe\,415$.



Assume:-
Neutral axis lies within the flange.

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f^{*}}$$

$$= \frac{0.87 \times 415 \times 6000}{0.36 \times 20 \times 2500}$$

$$\boxed{x_u = 120.35\,mm}$$

Depth of the flange i.e Neutral axies is within flange so assumption is correct.

$x_{u\,max} = 0.48 \times d \to$ Effective depth

$= 0.48 \times 800$

$= 384$

$x_u < x_{u\,max}$ hence the section is under Reinfo

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$$

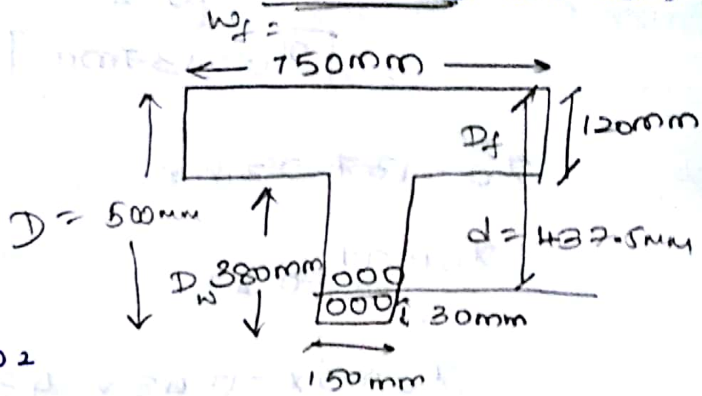
$$= 0.87 \times 415 \times 6000 \times 800 \left[1 - \frac{6000 \times 415}{2500 \times 800 \times 20}\right]$$

$$\boxed{M_u = 16.25 \times 10^{8}\ N\text{-}mm} = 1625\ KN\text{-}mm$$

$$M = \frac{M_u}{1.5} = 1083.43\ kN\text{-}m$$

② Calculate the moment of resistance for a flange beam of span 8m having following dimensions breadth of flange = 750mm, D_f = 120mm, D_w = 380mm b_w = 150mm

In tension zone there are 6 no of 20mm dia bars in 2 layers. Calculate the UDL live load It can carry. use M_{20} & Fe_{415}.



$d = 500 - 30 - 20 - \frac{25}{2}$

$d = 437.5mm$

$A_{st} = 6 \times \frac{\pi (20)^2}{4} = 1884.95mm^2$

Assume Neutral axis lies in flange

$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f} = \frac{0.87 \times 415 \times 1884.95}{0.36 \times 20 \times 750} = 126.02$

$126.02 > 120$ This assumption is wrong

~~Assume neutral axis lies with in the web~~

~~$(0.36 f_{ck} x_u b_w) + (0.45 f_{ck} y_f (b_f - b_w)] = 0.87 f_y A_{st}$~~

$(0.36 \times 20 \times x_u \times 150) + 9(0.15 x_u + 0.65 \times 120)$

Assume depth of neutral axis within web

$x_u = C_1 + C_2 = T$

$0.36 f_{ck} b_w x_u + 0.45 f_{ck} (0.15) x_u + 0.65 d_f (b_f - b_w)$

$= 0.87 f_y A_{st}$

$0.36 \times 20 \times 150 \times x_u + 0.45 \times 20 (0.15 \times \cancel{x_u} + 0.65 \times 120)$

$(750 - 150) = 0.87 \times 415 \times 1884.95$

$0.36 \times 20 \times 150 \times x_u + 9(0.15 x_u + 78)(750 - 150)$

$= 680 \times 10^3$

$1080 x_u + (1.35 x_u + 702) 600 = 680 \times 10^3$

$1080 x_u + 810 x_u + 421.2 \times 10^3 - 680 \times 10^3 = 0$

$1089 x_u - 258.8 = 0$

$$x_u = \frac{258800}{1084}$$

$$\boxed{x_u = 137mm}$$

$x_u = 137.23mm$

$$\frac{x_{umax}}{d} = 0.48$$

$x_{umax} = 0.48 \times 437.5$

$$\boxed{x_{umax} = 210mm}$$

$x_u < x_{umax}$ $\therefore$ It is under reinforced

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{bd f_{ck}}\right]$$

$$= 0.87 \times 415 \times 1884.95 \times 437.5 \left[1 - \frac{1884.95 \times 415}{150 \times 437.5 \times 20}\right]$$

$M_u = 120.28 \times 10^6$ N-mm

$$\boxed{M_u = 120.28 \text{ kN-m}}$$

load calculation

DL $w_g = [0.75 \times 0.12] + [0.15 \times 0.38] \times 25$

$$\boxed{w_g = 3.675 \text{ kN/m}}$$

$$M_u = \frac{w_g l^2}{8} + \frac{w_q l^2}{8}$$

$$120.28 = \frac{3.675 \times 8^2}{8} + \frac{w_q \times 8^2}{8}$$

$120.28 = 29.4 + 8 w_q$

$8 w_q = 120.28 - 29.4$

$$\boxed{w_q = 11.36 \text{ kN/m}}$$

Type-2

1. Determine the flexural strength for the T-beam data's are as given below. M_{20} + Fe_{415}

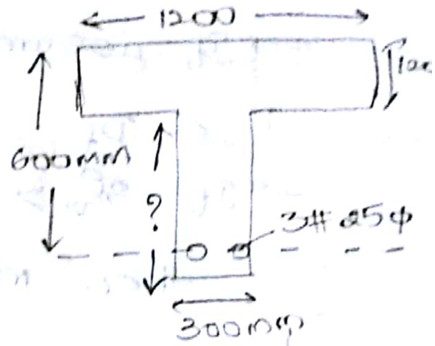
Breadth of the flange = 1200 mm

Depth of the flange = 120 mm

Width of the Rib = 300 mm

Effective depth = 600 mm

3 No of 25 mm dia bars are used



$d_w = 600 - 120 + 30 + \left(\frac{25}{2}\right)$

$d_w = 522.5 mm$

$A_{st} = 3 \frac{\pi d^2}{4}$

$= \frac{3\pi (25)^2}{4} = 1472.6$

Assume neutral axis lies within flange $x_u < d_f$

$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f}$

$= \frac{0.87 \times 415 \times 1472.6}{0.36 \times 20 \times 1200}$

$\boxed{x_u = 61.53 \text{ mm}}$

$x_u < d_f$ ∴ Assumption is true

$\frac{D_f}{d} \not> 0.2$

$\frac{120}{522.5} = 0.2$

$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$

$\boxed{M_u = 3892.4 mm}$

$M_u = 0.36 \frac{x_{umax}}{d} \left[1 - 0.42 \left(\frac{x_{umax}}{d}\right)\right] f_{ck} b_w d^2$

$+ 0.45 f_{ck} (b_f - b_w) D_f (d - D_f/2)$

$= 0.36 \times 0.48 \ (1 - 0.42 \times 0.48) \times 20 \times 300 \times 600^2$

Procedure to calculate T-beams

Step ①:- Draw the figure

Step ②:- Assume $x_u < D_f$

→ If assumption is correct, check $\frac{D_f}{d}$

→ If $\frac{D_f}{d} > 0.2$

then $M_u = 0.87 f_y A_{st} . d \left[1 - \frac{A_{st} f_y}{bd f_{ck}}\right]$

→ If $\frac{d_f}{d} \not> 0.2$

then (G.1.1) M_u by G.2.2

Step ③:-

If $x_u > D_f$

Check If $\frac{D_f}{x_u} > 0.43$

Calculate M_u by G.2.2.1

If $x_u > D_f$ doesn't Exist i.e $\frac{D_f}{x_u} \not> 0.43$

M_u = G-2.2.

② Determine ultimate moment of resistance by using the following data's

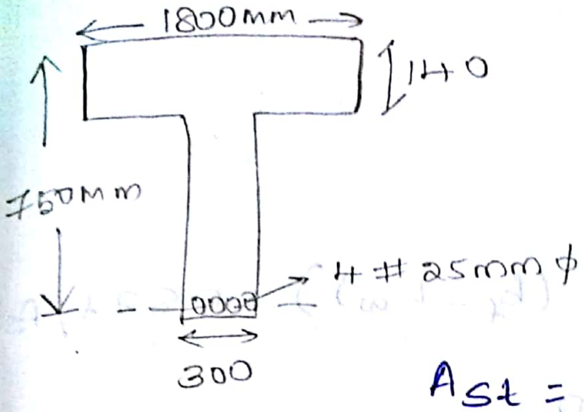
~~Depth~~ of the flange = 1800 mm

Depth of flange = 140 mm

Width of the rib = 300 mm

Effective depth = 750 mm

There are 4 no of 25 mm dia bars M 20 & Fe 500



$$d_w = 750 - 140 + 30 + \left(\frac{25}{2}\right)$$

$$\boxed{d_w = 652.5 \text{ mm}}$$

$$A_{st} = \frac{\pi d^2}{4} \times 4 = \pi (25)^2 = \underline{1963.49 \text{ mm}^2}$$

Assume neutral axis lies within the flange

$$x_u < d_f$$

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f} = \frac{0.87 \times 500 \times 1963.49}{0.36 \times 20 \times 1800}$$

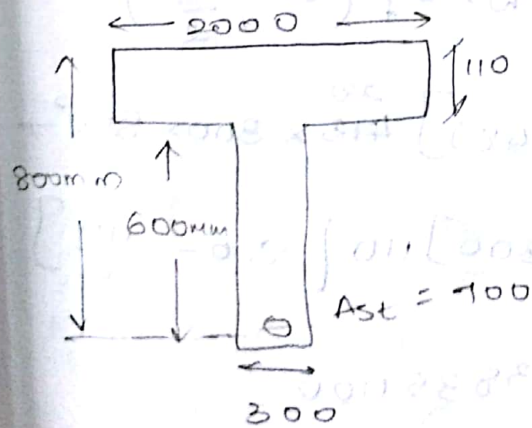
$$\boxed{x_u = 65.90 \text{ mm}}$$

$x_u < d_f$ $\therefore$ Assumption is true.

$$\frac{D_f}{d} = \frac{140}{\cancel{652.5}\ 750} = \cancel{0.21}\ 0.18$$

3/10/17

Q. Determine the UDL live load on the flange of the T-beam for the given dimensions. Breadth of the flange = 2000 mm, Depth of the flange is 110mm, Effective depth 800mm, Area of steel 7000mm², Breadth of the rib = 300mm use M_{20} & Fe_{415}. Depth of the web = 600mm



$A_{st} = 7000 \text{ mm}^2$

$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} \cdot b}$$

$$= \frac{0.87 \times 415 \times 7000}{0.36 \times 20 \times 2000}$$

$$\boxed{x_u = 175.5 \text{ mm}}$$

$\therefore$ Assumption is wrong

$x_u < d_w$

$C_1 + C_2 = T$

$y_f = 0.15 x_u + 0.65 d_f$

$(0.36 f_{ck} x_u b_w) + (0.45 f_{ck} y_f (b_f - b_w)) = 0.87 f_y A_{st}$

$y_f = 0.15 x_u + 0.65 \times 110$

$y_f = 0.15 \times x_u + 71.5$

$(0.36 \times 20 \times x_u \times 300) + [0.45 \times 20 \times (0.15 x_u + 71.5)]$

$[2000 - 300] = 0.87 \times \cancel{405} \times 7000$

$2160 x_u + 2295 x_u + 1093950 = 0.87 \times 415 \times 7000$

$4455 x_u \pm \cancel{844245}\ 1433400 = 0$

$\boxed{x_u = 321.750 mm}$

$\frac{D_f}{x_u} = \frac{110}{321.7} = 0.341 < 0.43$

$M_u = 0.36 \frac{x_{umax}}{d} \left[1 - 0.42 \frac{x_{umax}}{d}\right] f_{ck} b_w d^2 +$ E.D

$0.45 f_{ck} (b_f - b_w) D_f \left(d - \frac{D_f}{2}\right)$

$= 0.36 \times 0.48 [1 - (0.42)(0.48)] \cancel{415}\ 20 \times 300 \times 800^2 +$

$0.45 \times \cancel{415}\ 20 [2000 - 300] 110 \left[800 - \frac{110}{2}\right]$

$M_u = 529779916.8 + 1253835000$

$\boxed{M_u = 1783.6 KN\text{-}m}$

Load Calculation

$$D_L = [(2\times0.11) + (0.6\times0.3)]\times25$$

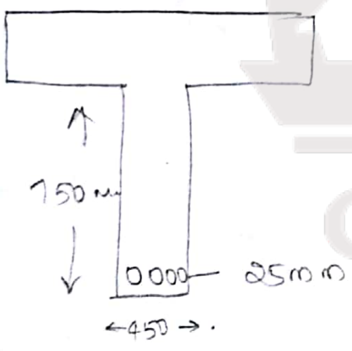
$$D_L = 10\,kN/m$$

$$M_u = \frac{w_g l^2}{8} + \frac{w_q l^2}{8}$$

$$1783.6 = \frac{10(6)^2}{8} + \frac{w_q(6)^2}{8}$$

$$\boxed{w_q = 386.35\,kN/m}$$

5. For an Isolated T-beam, determine the point load distributed on the mid of the web section [web mid] for the following dimension, $B_f = 3500mm$, $D_f = 160mm$, $D_w = 750mm$, $B_w = 450mm$. There are 4 No of 25mm dia bars in the web. Use M_{25}, Fe_{500}



$$x_u = \frac{0.87 f_y A_{st}}{0.36\times f_{ck}\cdot b}$$

$$A_{st} = 4\times\frac{\pi d^2}{4}$$

$$= \pi(25)^2$$

$$\boxed{A_{st} = 1963.4\,mm^2}$$

$$= \frac{0.87\times500\times A_{st}}{0.36\times25\times3500}$$

$$\boxed{x_u = 27.11\,mm}$$

$$D_f = 160$$

$$x_u < D_f$$

$\therefore$ Assumption is correct.

$$\frac{D_f}{d} = \frac{160}{160+750-30-\frac{25}{2}} = 0.184 \not> 0.2.$$

$$M_u = 0.36\frac{x_{umax}}{d}\left[1-0.42\frac{x_{umax}}{d}\right]f_{ck}\,b_w d^2 + 0.45 f_{ck}(b_f - b_w)D_f\left(d-\frac{D_f}{2}\right)$$

$$= (0.36 \times 0.46)(1 - 0.42 \times \overset{0.031}{0.46}) \times 25 \times 450 \times 867.5^2$$

$$+ 0.45 \times 25 \times (3500 - 450)\, 160 \left(867.5 - \frac{160}{2}\right)$$

$$\boxed{M_u = 5454.5185 \text{ KN-m}}$$

4416.6

Load calculation

$$D_L = [(3.5 \times 0.16) + (0.75 \times 0.45)] \times 25$$

$$\boxed{D_L = 22.43 \text{ KN/m}}$$

$$M_u = \frac{w_g l^2}{8} + \frac{w_q l}{2}$$

$$4416.6 = \frac{22.43 (3.5)^2}{8} + \frac{w_q (3.5)}{2}$$

$$\boxed{w_q = 2504.14 \text{ KN/m}}$$

1 Inch = 2.54 cm

room dimension > 2.5 feet should have main wall

Design procedure for T-beams

Step ①:- By calculating the loads determine M_u & V_u

Step ②:- Determine moment of resistance for flange alone $M_{uf} = 0.36 f_{ck} \cdot b_f \cdot D_f (d - 0.42 D_f)$

Step ③:- Compare M_u & M_{uf}

(i) If $M_u < M_{uf}$ then the condition is that neutral axis lies within flange.

∴ Designed T-beam as a Rectangular beam.

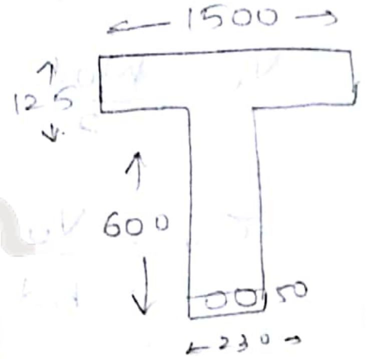
Calculate Ast & shear design:-

(ii) If $M_u > M_{uf}$ then the neutral axis lie b/w web. then design as T-beams only.

① Design a Rectangular concrete T-beam which has an effective flange width 1500mm & thickness 125mm The web is 230mm wide & 600mm deep. The beam carries a total load of 30kN/m Including self weight over the span of 8m. M_{20} & Fe_{415}. Effective cover = 50

$W_L = 30$ kN/m

$w_u = 30 \times 1.5 = 45$ kN/m



$$M_u = \frac{w_u L^2}{8} \qquad V_u = \frac{w_u L}{2}$$

$$= \frac{(45)(8)^2}{8} \qquad = \frac{45 \times 8}{2}$$

$$\boxed{M_u = 360 \text{ kN-m}} \qquad \boxed{V_u = 180 \text{ kN}}$$

$d = 125 + 600 - 50$

$\boxed{d = 675}$

$$M_{uf} = 0.36 f_{ck} b_f D_f (d - 0.42 D_f)$$

$$= 0.36 \times 20 \times 1500 \times 125 [675 - 0.42 \times 125]$$

$$\boxed{M_{uf} = 840.37 \text{ kN-m}}$$

$M_u < M_{uf}$

Neutral axies lies with in flange

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{f_y A_{st}}{f_{ck} b d}\right]$$

$$360 = 0.87 \times 415 \times A_{st} \times 675 \left[1 - \frac{415 \times A_{st}}{20 \times 1500 \times 675}\right]$$

$$360 = 243708.75 A_{st} \left[1 - \underset{2.049 \times 10^{-5}}{0.00002 A_{st}}\right]$$

$$360 = 243708.75 A_{st} - 4.99 A_{st}^2$$

360 $\boxed{A_{st} = 1524.77 \text{ mm}^2}$

provide 20 mm bars of

$$\text{No of bars} = \frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{1524.77}{\frac{\pi (20)^2}{4}} = 4.85 \simeq 5 \text{ bars.}$$

$$\text{Act } A_{st} = \text{No of bars} \times \frac{\pi d^2}{4}$$

$$\boxed{\text{Act } A_{st} = 1570.79 \text{ mm}^2}$$

Shear design:- $[b = b_w]$

$$V_u = \frac{W_u l}{2} = \frac{45 \times 8}{2} = 180 \text{ kN-m}$$

$$\tau_v = \frac{V_u}{bd} = \frac{180}{230 \times 675} = 1.159 \text{ N/mm}^2.$$

$$\tau_c = \frac{100 A_{st}}{bd} = \frac{100 \times 1570.79}{230 \times 675} = 1.0117$$

$1 \longrightarrow 0.62$

$1.011 \longrightarrow ?$ $\boxed{\tau_c = 0.622 \text{ N/mm}^2}$

$1.25 \longrightarrow 0.67$

$$\boxed{\tau_v > \tau_c}$$

$$A_{sv} = \frac{2\pi d^2}{4} = \frac{2\pi 8^2}{4}$$

$$(V_u - \tau_c)\, bd = \frac{0.87 A_{sv} f_y d}{S_v}$$

$$A_{sv} = 100.53$$

$$S_v = \frac{0.87 \times 100.53 \times 415 \times 675}{(180 \times 10^3 - 0.622)\, 230 \times 675}$$

$$\boxed{S_v = 292.5}$$

$\frac{l}{d} = \frac{8}{0.67} = 11.85$

$F_1 = \frac{100\,Ast}{bd} = P_t = \frac{100 \times 1570.79}{230 \times 675}$

$\boxed{P_t = 1.01}$

$f_s = 0.58\, f_y \frac{Ast}{Act\ Ast} = 0.58 \times 415 \times \frac{1524.8}{1570.79}$

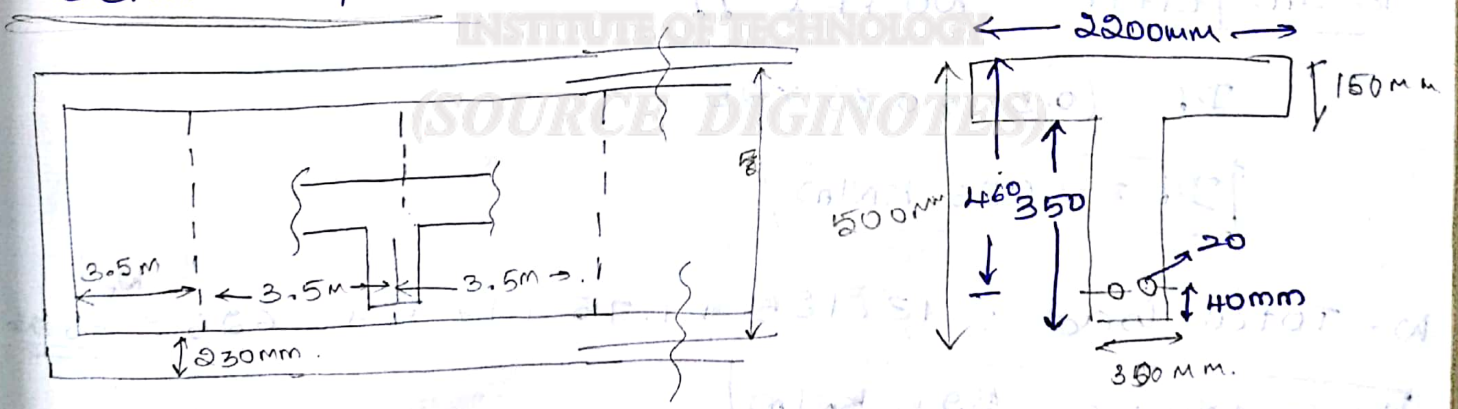
$\boxed{f_s = 233.65\ N/mm^2}$

from graph $f_1 = 1.05$

5/10/17

② T-beam slab floor consists of 15cm thick RC slabs monolithic with 30cm wide beams. The beams are spaced at 3.5m centre to centre. The effective span of beam is 6m. The super Imposed load on the slab is 5KN/m². Design an Intermediate beam using Fe_{415} steel. Also design the shear reinforcement & sketch the details of reinforcement assuming moderate Exposure.

By page 47 500-40=460



$\frac{l}{d} = 12$

$\frac{6000}{12} = D$

$\boxed{D = 500mm}$

$d = 500 - 40$

$= 460mm$

Source diginotes.in

Effective flange width [page 37]

$$b_f = \frac{l_0}{6} + b_w + 6D_f$$

$$= \frac{6000}{6} + 300 + (6 \times 150)$$

$$\boxed{b_f = 2200\,mm}$$

After slab is placed above it tiles (or) Granite are placed.

Load calculation

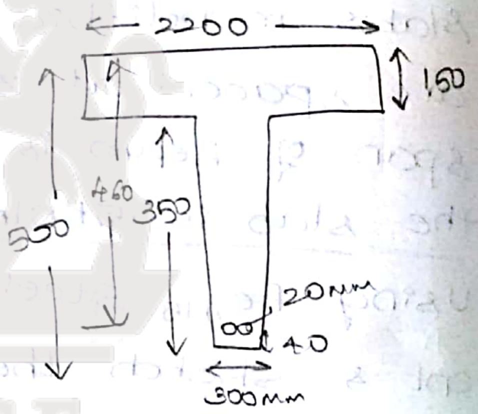
Slab $DL = (3.5 \times 0.15)\,25$

$$\boxed{DL = 13.125\,kN/m}$$

Assume the floor finishing value as $0.5\,kN/m^2$

$$FF = 0.5\,\frac{kN}{m^2} \times 3.5\,m$$

$$\boxed{FF = 1.75\,kN/m}$$



$$LL = 5\,kN/m^2 \times 3.5\,m$$

$$\boxed{LL = 17.5\,kN/m}$$

Beam portion No FF & LL

$$DL = (0.35 \times 0.3) \times 25$$

$$\boxed{DL = 2.625\,kN/m}$$

w = Total load = $13.125 + 1.75 + 17.5 + 2.625 = \underline{315\,kN/m}$

$$\boxed{w_u = w \times 1.5 = 52.5\,kN/m}$$

$$M_u = \frac{w_u l_e^2}{8} = \frac{52.5 \times (6.\cancel{23})^2}{8}$$

least of 2. $\left\{ \begin{array}{l} \cancel{l_e = 6 + 0.23 = 6.23} \\ \cancel{l_e = 6 + 0.46 = 6.46} \end{array} \right.$

$$\boxed{M_u = 236.25\,kN\text{-}m}$$

$$V_u = \frac{w_u l_e}{2}$$

$$= \frac{52.5 \times 6}{2}$$

$$\boxed{V_u = 157.5 \text{ kN/m}}$$

By page 20 $f_{ck} = M_{25}$

$$M_{uf} = 0.36 f_{ck} \, b_f \, D_f \, (d - 0.42 D_f)$$

$$= 0.36 \times 25 \times 2200 \times 150 \, (460 - 0.42 \times 150)$$

$$\boxed{M_{uf} = 1179.09 \text{ kN-m}}$$

$M_u < M_{uf} \rightarrow$ so design as singly reinforced Rectangular beam,

$$\cancel{A_{st}} M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$$

$$\cancel{1179.09}\ 236.25 \times 10^6 = 0.87 \times 415 \times A_{st} \times 460 \left[1 - \frac{A_{st} \times 415}{2200 \times 460 \times 25}\right]$$

$$\cancel{1179.09} \times 10^6 = 166083 A_{st} \left[1 - 1.640 \times 10^{-5} A_{st}\right]$$

$$1179.09 \times 10^6 = 166083 A_{st} - 2.724 A_{st}^2$$

$$\boxed{A_{st} = 1457.31 \text{ mm}^2}$$

No of bars $= \dfrac{A_{st}}{\frac{\pi d^2}{4}} = \dfrac{1457.31}{\frac{\pi (20)^2}{4}} = 4.6 \simeq 5$ bars

Act $A_{st} = \dfrac{\pi d^2}{4} \times 5 = 1570.7 \text{ mm}^2$

Design for shear

$$\tau_v = \frac{V_u}{bd} = \frac{157.5}{\cancel{2200}\ 460 \times 300} = 1.141$$

$$\frac{100 A_{st}}{bd} = \frac{100 \times 1570.7}{460 \times 300} = 1.138$$

$1.00 \rightarrow 0.64$

$1.138 \rightarrow ?$

$1.25 \rightarrow 0.7$

$\boxed{\tau_c = 0.67}$

$\boxed{\tau_v > \tau_c}$ Design for shear

$$(V_u - \tau_c)bd = \frac{0.87 A_{sv} f_y d}{S_v}$$

$$S_v = \frac{0.87 A_{sv} f_y d}{(V_u - \tau_c)bd}$$

$$A_{sv} = \frac{\pi d^2}{4}$$

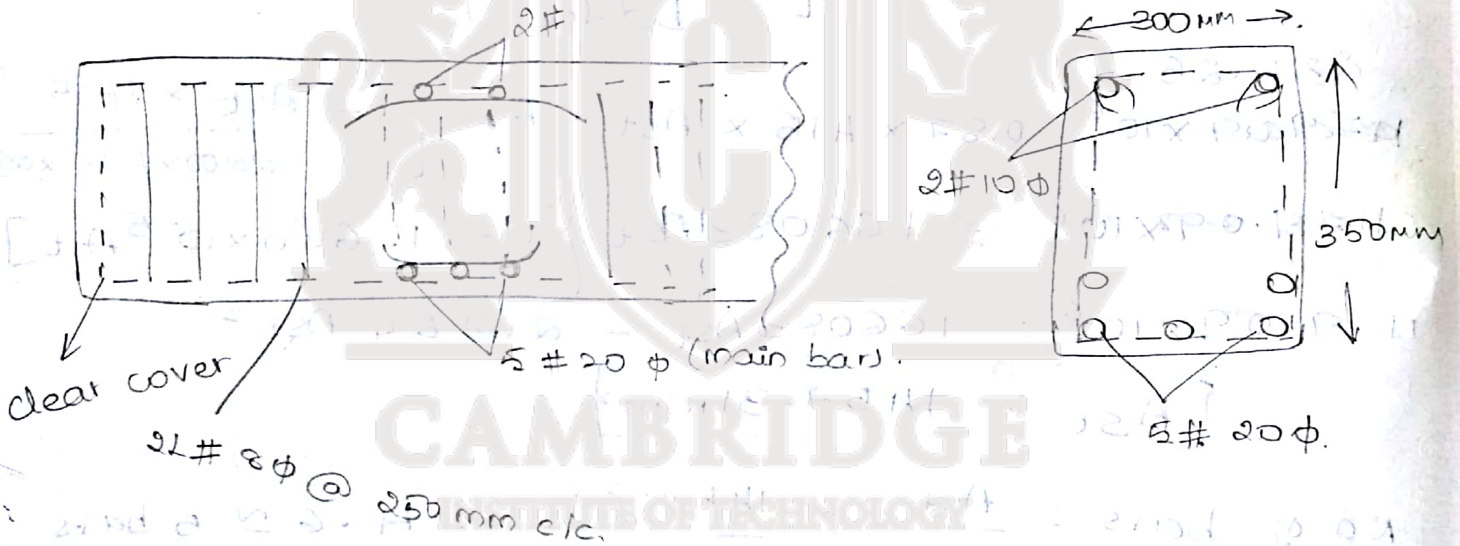
$$= 2\frac{\pi (8)^2}{4}$$

$$= \frac{0.87 \times 100.53 \times 415 \times 460}{(157.5 \times 10^3 - 0.67)(300 \times 460)}$$

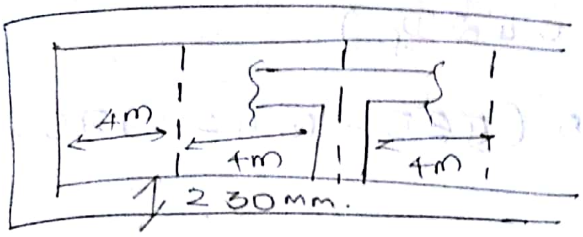
$$A_{sv} = 100.53 \text{ mm}^2$$

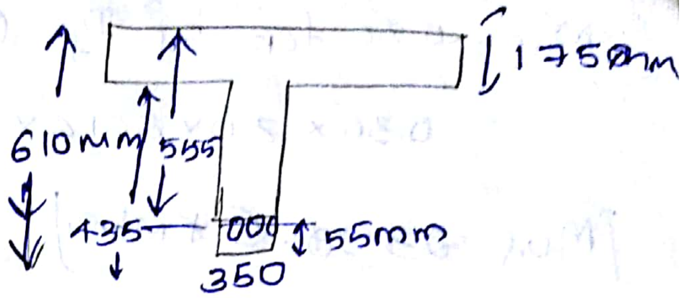
$$\boxed{S_v = 256.7 \text{ mm}}$$

Provide 2L 8mm dia bars 250 mm Centre to Centre



③ Design an Intermediate T-beam slab floor consisting of 17.5cm thick RC slab Monolithic with 35cm wide beams. The beams are spaced at 4m centre to centre The effective span of the beam is 7.3m. The super Imposed load on the slab is 5kN/m². Also design for shear reinforcement assuming severe Exposure and Fe500 Steel.





$\frac{l}{d} = 12$

$\frac{7300}{12} = D$

$\boxed{D = 608.33 \simeq 610 \text{ mm}}$

Effective flange

$b_f = \frac{l_0}{6} + b_w + 6D_f$

$= \frac{7300}{6} + 350 + (6 \times 175)$

$\boxed{b_f = 2616 \text{ mm}}$

Load calculation

Slab

spacing from centre to centre

$DL = (4.\cancel{35} \times 0.175)25$

$= \cancel{48848}$ $\boxed{DL = 17.5 \text{ mm}}$

$FF = 0.5 \times 4$

$\boxed{FF = 2 \text{ kN/m}}$

$LL = 5 \times 4$

$\boxed{LL = 20 \text{ kN/m}}$

Beam portion

$DL = (0.43 \times 0.35) \times 25$

$\boxed{DL = 3.7625 \text{ kN/m}}$

$w = 43.26 \text{ kN/m}$

$w_u = 64.89 \text{ kN/m}$

$M_u = \frac{w_u l_e^2}{8} = \frac{64.89 \times (7.3)^2}{8} = 432.24 \text{ kN-m}$

$V_u = \frac{w_u l_e}{2} = 236.84 \text{ kN/m}$

$M_{uf} = 0.36\, f_{ck}\, b_f\, D_f\, (d - 0.42 D_f)$

$= 0.36 \times 30 \times 2616 \times 175\, (555 - 0.42 \times 175)$

$\boxed{M_{uf} = 2380.6 \text{ kN m}}$

$M_u < M_{uf}$ so design as singly reinforced beam

$M_u = 0.87\, f_y\, A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$

$432.24 \times 10^6 = 0.87 \times 500 \times A_{st}\, 555 \left[1 - \frac{A_{st}\, 500}{2616 \times 555 \times 30}\right]$

$432.24 \times 10^6 = 241425 A_{st} \left[1 - 1.14 79 \times 10^{-5} A_{st}\right]$

$432.24 \times 10^6 = 241425 A_{st} - 2.77 A_{st}^2$

$\boxed{A_{st} = 1828.74 \text{ mm}^2}$

No of bars $\frac{A_{st}}{\frac{\pi d^2}{4}} = \frac{1828.74}{\frac{\pi (22)^2}{4}} = \cancel{4.8}\text{ bars} \simeq 6$ bars

Act $A_{st} = \frac{\pi d^2}{4} \times 6 = 1884.95 \text{ mm}^2$

Design for shear

$\tau_v = \frac{V_u}{bd} = \frac{236.84}{555 \times 350} = 1.219$

$\frac{100 A_{st}}{bd} = \frac{100 \times 1884.95}{555 \times 350} = 0.97$

$1.00 \longrightarrow 0.66$

$0.97 \longrightarrow ?$ $\qquad \tau_c = 0.64$

$0.75 \longrightarrow 0.57$

$\tau_v > \tau_c$

$$(V_u - \tau_c) b d = \frac{0.87 \, A_{sv} f_y d}{S_v}$$

$$S_v = \frac{0.87 \, A_{sv} f_y d}{(V_u - \tau_c) b d}$$

$$= \frac{0.87 \times 100.53 \times 500 \times 555}{(236.84 \times 10^3 - 0.64)(350 \times 555)}$$

$$\boxed{S_v = 215.699 \, mm}$$