MODULE-4 SLABS

One way slab:- $\left[\frac{L_y}{L_x} > 2\right]$

1. simply supported
2. continous
3. cantilever

Two way slab $\left[\frac{L_y}{L_x} \leq 2\right]$

main steel

This is the type of reinforcement which is provided to resist bending moment.

The diameters of the bar usually provided are 8mm, 10mm & 12mm.

Usually main steel is provided in the shorter span.

The clear cover for the main steel is 20mm
The spacing provided is maximum 3 times the dia of bars (or) 300mm.

Distribution Steel

This steel is provided to prevent surface cracks which is caused due to temperature Expansion + Contraction. It is also used to hold the main bar in one position.

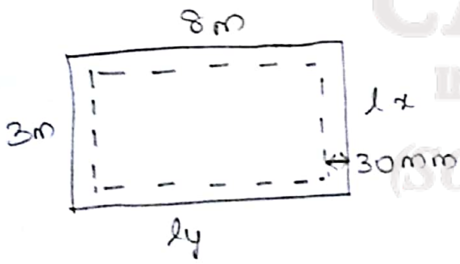
Area of distribution steel should always be 0.12% of the gross area.

Maximum spacing of distribution steel should be 5 time the dia of bars (or) 450mm.

Usually 8mm dia bars are provided for distribution steel.

7/10/17

1. Design a slab for the room dimension 8m×3m simply supported on 230mm thick wall. The live load on the slab is $2kN/m^2$ & floor finishing $0.5kN/m^2$. Use M_{20} & Fe_{415}. [only 20 grade for a slab].



Ratio of $\frac{l_y}{l_x} = \frac{8}{3} = 2.67 > 2$

∴ Its a one way slab.

Step ②: Load calculation

Take $\frac{l}{d} = 20 \times MF$ [length should always be shorter span.]

$$\frac{3000}{20 \times 1.25} = d$$

$\boxed{d = 120mm}$ = Effective depth

~~overall depth~~ Effective Cover $D' = 20mm + \left(\frac{10}{2}\right) = 25mm$. $\rightarrow$ Dia of bars.

overall depth $D = 120 + 25 = 145mm$

$\boxed{b = 1m = 1000mm}$ — Assumption.

$DL = 1 \times 0.145 \times 25$

$DL = 3.625$ kN/m

$FF = 0.5 \times 1 = 0.5$ kN/m

$LL = 2 \times 1 \rightarrow 2$ kN/m

Total load $w = 6.125$ kN/m

$w_u = 9.187$ kN/m.

Effective span $[l_e]$ = $3 + 0.23 = 3.23$

$l_e = 3 + \underset{\text{effective depth}}{0.125} = 3.125$

Taking least $l_e = 3.12$ m.

$M_u = \frac{w_u l_e^2}{8} = \frac{9.187 \times (3.12)^2}{8} = 11.17$ kN-m

$V_u = \frac{w_u l_e}{2} = 14.33$ kN

Check for depth.

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

$11.17 \times 10^6 = 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] \times 20 \times 1000 \times d^2$

$\boxed{d = 63.62mm}$ d is less than effective depth

$\therefore$ d is safe

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

$11.17 \times 10^6 = 0.87 \times 415 \times A_{st} \times 120 \left[1 - \frac{A_{st}\ 415}{20 \times 1000 \times 120}\right]$

$11.17 \times 10^6 = 43326 A_{st} - 7.49 A_{st}^2$ $\boxed{A_{st} = 270.45mm^2}$

$$\text{Spacing } \# = 10mm : \frac{\text{Area of 1 bar}}{A_{st}} \times 1000$$

$$= \frac{\frac{\pi (10)^2}{4}}{A_{st}} \times 1000$$

$$= 290.4 mm$$

$\boxed{\text{Provide } 10\phi @ 290 \text{ mm c/c.}}$

Area of distribution bars

$$Area = 0.12\% \times B D$$

$$= \frac{0.12}{100} \times 1000 \times 145$$

$\boxed{A = 174 mm^2}$

Provide $\text{spacing} = \frac{\frac{\pi (8)^2}{4}}{174} \times 1000 = 288.3mm$

Provide 8ϕ bars @ 280 mm c/c

Check for shear

$$\tau_v = \frac{V_u}{bd} = \frac{14.33 \times 10^3}{1000 \times 120} = 0.119 \, kN/mm^2$$

$$\tau_c = \frac{100 A_{st}}{bd} = \frac{100 \times 270.45}{1000 \times 120} = 0.22$$

0.15 → 0.28

0.22 → ?

0.25 → 0.36

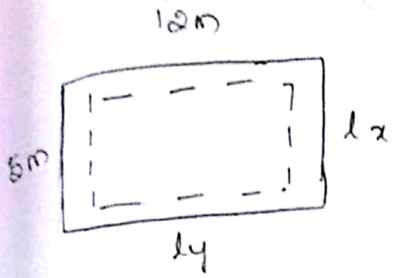
$$\tau_c = 0.336 \, N/mm^2$$

only for slabs

If $\tau_c > \tau_v$ shear design is safe

Note: If $\tau_v > \tau_c$ Increase the depth (solve from first)

(2) Design a slab for an Internal room dimension 12m x 5m by using M_{20} & Fe_{415} which carries a live load of 2.25 kN/m². & Simply supported on 230mm thick wall.



$$\frac{l_y}{l_x} = 2.4 > 2$$

∴ Its one way slab

step (2) Load calculation

Take $\frac{l}{d} = 20 \times M.F$

$$\frac{5000}{20 \times 1.25} = d$$

$\boxed{d = 200mm}$ – Effective depth.

Effective cover $d' = 20mm + \frac{10}{2} = 25mm$

Overall depth $D = 200 + 25 = 225$ mm

$\boxed{b = 1m = 1000mm}$

DL = 1 x 0.225 x 25 = 5.625 kN/m

FF = 0.5 x 1 = 0.5 kN/m

LL = 2.25 x 1 = 2.25 kN/m

Total load w = 8.375 kN/m

w_u = 12.56 kN/m

Effective span [l_e] = 5 + 0.23 = 5.23

l_e = 5 + 0.125 = 5.125

Taking least 5.2 m

$$M_u = \frac{w_u l_e^2}{8} = \frac{12.56 \times (5.2)^2}{8} \approx 42.45 \text{ kN-m}$$

$$V_u = \frac{w_u l_e}{2} = \frac{12.56 \times 5.2}{2} = 8.164 \text{ kN}$$

Check for depth

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

$$42.45\times10^6 = 0.36 \times 0.48 \left[1 - 0.42 \times 0.48\right] 20 \times 1000 \times d^2$$

$$\boxed{d = 124.03 m}$$

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

$$42.45\times10^6 = 0.87 \times 415 \times A_{st} \times 200 \left[1 - \frac{415 A_{st}}{1000\times200\times20}\right]$$

$$42.45\times10^6 = 72210 A_{st} \left[1 - 1.0375\times10^{-4} A_{st}\right]$$

$$42.45\times10^6 = 72210 A_{st} - 7.49 A_{st}^2$$

$$\boxed{A_{st} = 628.89 mm^2}$$

Spacing # 10 ϕ @ 120 mm c/c $= \dfrac{\frac{\pi (10)^2}{4}}{A_{st}} \times 1000$

$= 124.88$ mm

Provide 10ϕ @ 120 mm c/c

Area of distribution bar

$A = 0.12\% \times B \times D$

$= \dfrac{0.12}{100} \times 1000 \times 225$

$\boxed{A = 270 mm^2}$

provide spacing $= \dfrac{\frac{\pi (8)^2}{4}}{270} \times 1000 = 186.16 mm$

Provide 8ϕ bars @ 180 mm

check for shear

$$\tau_v = \frac{V_u}{bd} = \frac{8.164 \times 10^3}{1000 \times 200} = 0.040 \ KN/mm^2.$$

$$\tau_c = \frac{100 Ast}{bd} = \frac{100 \times 628.89}{1000 \times 200} = 0.314$$

$\tau_c = 0.38 \ N/mm^2$

0.5 → 0.48
0.3 → ,
0.25 → 0.36
0.38

$\tau_c > \tau_v$ Shear design is safe

3. In an Elevated highway bridge the slab span b/w 2 columns is 21m & It is a 2 lane highway along with Extra widening of 2.5m. The concrete used is 25mpa with Fe_{500} steel. If there is a single truck of 4 kN/m². Design the slab.

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

$d = \frac{9400}{20 \times 1.25} = 376mm$

per lane = 3.45m

2 lane = 3.45m

$\frac{l_y}{l_x} = \frac{21}{9.4} = 2.23 > 2$

$(3.45 \times 2) + 2.5 = 9.4m$

hence 21 × 9.4m

C.C = 20mm

$D = 376 + 20 + \frac{30}{2}$

$= 411mm$

b = 1m strip = 1000mm

$l_e = 9.4 + 0.376$

$= 9.77$

DL = 1 × 0.411 × 25 = 10.275.

LL = 1 × 4 = 4 KN/m

$l_e =$

FF = 1 KN/m

w = 15.27 KN/m

$\boxed{w_u = 22.91 \ KN/m}$

$$M_u = \frac{w_u l_e^2}{8} = \frac{22.91 \times 9.77^2}{8} = 273.3 \text{ kN-m}$$

$$V_u = \frac{w_u l_e}{2} = 111.9 \text{ kN}$$

Check for depth

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

$$273.3 \times 10^6 = 0.36 \times 0.46 [1 - 0.42 \times 0.46]\, 25 \times 1000 \times d^2$$

$$\boxed{d = \cancel{\ldots \text{ mm}}\ 286.04 \text{ mm}}$$

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

$$273.3 \times 10^6 = 0.87 \times 500 \times A_{st} \times d \left[1 - \frac{500\, A_{st}}{1000 \times 376 \times 25}\right]$$

$$273.3 \times 10^6 = 163560\, A_{st} \left[1 - 5.319 \times 10^{-5} A_{st}\right]$$

$$273.3 \times 10^6 = 163560\, A_{st} - 8.7\, A_{st}^2$$

$$\boxed{A_{st} = 1853.7 \text{ mm}^2}$$

spacing #30 ϕ @ 120 mm c/c $= \dfrac{\frac{\pi (30)^2}{4}}{A_{st}} \times 1000$

$= 381.32$

provide 30 ϕ @ 380 mm c/c

Area of distribution bar

$$A = \frac{0.12}{100} \times 1000 \times 411 = 493.2 \text{ mm}^2$$

provide spacing $= \dfrac{\frac{\pi (10)^2}{4}}{493.2} \times 1000 = 159.24$ mm provide 10ϕ bars @ 150 mm

check for shear

$$\tau_v = \frac{V_u}{bd} = \frac{111.9 \times 10^3}{1000 \times 376} = 0.29 \, kN/m^2$$

$$\tau_c = \frac{100 A_{st}}{bd} = \frac{100 \times 1853.7}{1000 \times 376} = 0.49$$

0.25 → 0.36
0.49 →
0.~~25~~ → 0.49

$\tau_c = 0.48$

$\tau_c > \tau_v$ ∴ Design is safe.

$\boxed{19/10/17}$

Effective span (l_e) is given by = centre to centre distance of the beam − width of the beam

ultimate moment of resistance $\boxed{(M_u) = \frac{w_g l^2}{10} - \frac{w_q l^2}{9}}$

For continous Beam

$V_u = 0.6 \, l_e \times [w_g + w_q]$

① Design an RC slab for a room of dimension 7m × 14m beams spaced at 3.5 m interval. If width of the beam is 230mm & super imposed load is 3kN/m² floor finish 1kN/m². Use M_{20} & Fe_{415}.

step ① Depth effective depth(d)

calculation of effective length:

$l_0 = 3.5 - 0.23 = 3.27m$ → for clear span

~~l_e~~ = Effective depth $(d) = \left(\frac{span}{30}\right)$ (or spacing) [∵ Assume]

$$d = \left(\frac{3500}{30}\right) = 116.62 \, mm \simeq 120 \, mm$$

$= 0.116 \, m$

$l_e = l + \text{wall thickness} (d)$ ~~$l_e = 3.5 (or)$~~

$l_e = 3.27 + 0.116$ (l + wall thickness (d))

$\boxed{l_e = 3.38 \, m}$

$l = \text{spacing} - W_b$

$= 3.5 - 0.23$

$\boxed{l = 3.2m}$

Load calculation

main bar dia = 10
Clear cover = 20

$D = 120 + 20 + (10/2)$

$\boxed{D = 145 m}$

for slab

Assumed breadth

$DL = 0.145 \times 1 \times 25 = 3.625 \text{ kN/m}$

$FF = 1 = 1 \text{ kN/m}$

$w = 4.625 \text{ kN/m}$

$W_u = 1.5 \times 4.625 = 6.93 \text{ kN/m}$

$w_g = 6.93 \text{ kN/m}$

$w_q = 1.5 \times 3 = 4.5 \text{ kN/m}$

$$M_u = \frac{w_g l_e^2}{10} + \frac{w_q l_e^2}{9}$$

$$= \frac{6.93 \times 3.38^2}{10} + \frac{4.5 \times 3.38^2}{9}$$

$\boxed{M_u = 13.62 \text{ kN-m}}$

$V_u = 0.6\, l_e [w_g + w_q]$

$= 0.6 \times 3.38 [6.93 + 4.5]$

$\boxed{V_u = 23.18 \text{ kN}}$

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

$$13.62 \times 10^6 = 0.87 \times 415 \times A_{st} \times 120 \left[1 - \frac{415 A_{st}}{1000 \times (120) \times 20}\right]$$

$$13.62 \times 10^6 = 43326 A_{st} \left[1 - 1.429 \times 10^{-6}\right]$$

$$13.62 \times 10^6 = 43326 A_{st} - 7.492 A_{st}^2$$

$\boxed{A_{st} = 333.60 \text{ mm}^2}$

Spacing of main bar $= \dfrac{\frac{\pi (10)^2}{4}}{A_{st}} \times 1000 = 235.43\ mm$

$\boxed{\text{provide } 10\phi \text{ @ } 235\ mm\ c/c \text{ - main bar}}$

~~Spacing 8mm~~ $= \dfrac{\frac{\pi (8)^2}{4}}{\cancel{A_{st}}} \cancel{\times 1000} = \cancel{150.67}$

Distribution bar $= \dfrac{0.12}{100} \times 1000 \times 145$

$\boxed{A_{bd} = 174\ mm^2}$

Spacing $= \dfrac{\frac{\pi \times 8^2}{4}}{174} \times 1000 = 288.8\ mm$

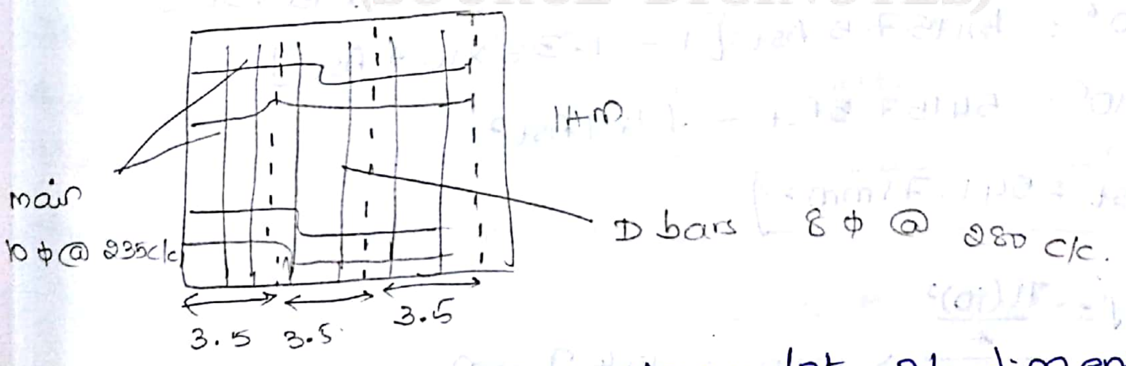
$\boxed{\text{provide } 8\phi \text{ @ } 280\ mm\ c/c \text{ - Distribution bar}}$

check for shear

$\tau_v = \dfrac{V_u}{bd} = \dfrac{23.22 \times 10^3}{1000 \times 120} = 0.1935\ N/mm^2$

$\dfrac{100 A_{st}}{bd} = \dfrac{100 \times 333.6}{1000 \times 120} = 0.278 \quad \tau_c \rightarrow 0.278$

$\boxed{\tau_c > \tau_v}$



② For a commercial parking lot of dimension 14 × 27 m as a beam spacing 4.5m centre to centre and width of the beam is 230mm placed Inside the wall thickness of 250mm Use M_{20} & Fe_{415} & Super Imposed load 3.5 kN/m²

$d = \frac{4500}{30} = 150mm$ 10/8/17

$D = 150 + 20 + (10/2)$

$= 175mm$

length $= 4.5 - 0.23$

$= 4.27m$

$l_e = 4.27 + 0.25 = 4.52$ (or) $4.27 + 0.15 = 4.42$

Considering least of both $\therefore l_e = 4.42m$

Load calculation

$DL = 0.175 \times 1 \times 25 = 4.375 \ kN/m$

$FF = 1 kN/m$, $w_g = 1.5 \times 5.375 = 8.06 \ kN/m$

$w = 5.375$

$w_q = 1.5 \times 3.5 = 3.25 \ kN/m$

$M_u = \frac{w_g l_e^2}{10} + \frac{w_q l_e^2}{9}$

$= 27.14 \ kN\text{-}m$

$V_u = 0.6 \, l_e (w_g + w_q)$

$= 35.29 \ kN$

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

$27.14 \times 10^6 = 0.87 \times 415 \times A_{st} \times 150 \left[1 - \frac{415 A_{st}}{1000 \times 150 \times 20}\right]$

$27.14 \times 10^6 = 54157.5 A_{st} [1 - 1.38 \times 10^{-4} A_{st}]$

$27.14 \times 10^6 = 54157.5 A_{st} - 7.49 A_{st}^2$

$\boxed{A_{st} = 541.71 mm^2}$

$Spacing = \frac{\frac{\pi (10)^2}{4}}{A_{st}} \times 1000 = 144.9 \ mm$

Provide 10ϕ @ 140mm c/c main bar

Distribution bar

$$\frac{0.12}{100} \times 1000 \times 175 = 210mm$$

Spacing 8mm ϕ $= \dfrac{\frac{\pi(8)^2}{4}}{210} \times 1000 = 239.35mm$

provide 8ϕ @ 235 mm c/c

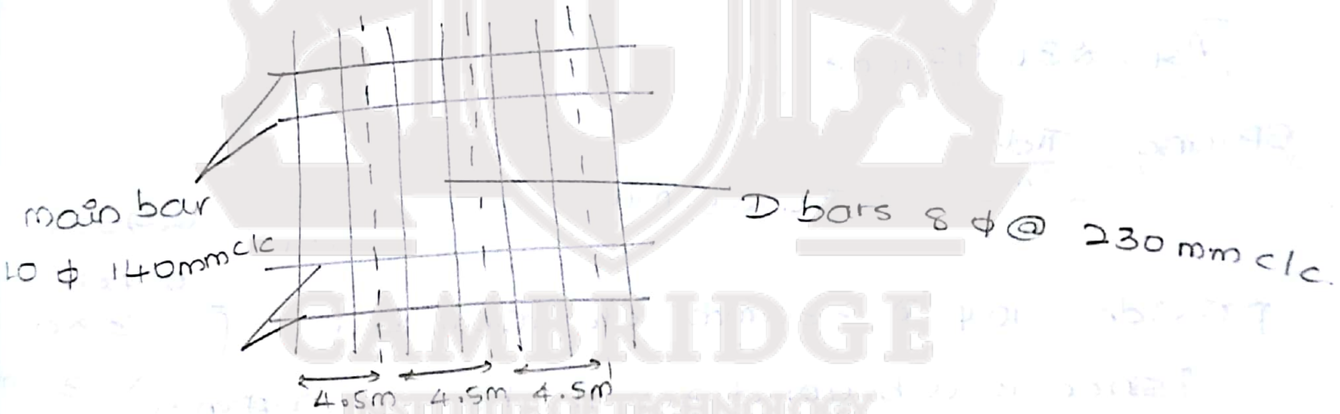
$$\tau_v = \frac{V_u}{bd} = \frac{35.29 \times 10^3}{1000 \times 150} = 0.23$$

$$\frac{100 A_{st}}{bd} = \frac{100 \times 541.7}{1000 \times 150} = 0.36$$

0.25 → 0.36

0.36 → ? $\tau_c = 0.41$

0.5 → 0.48 $\tau_c > \tau_v$ ∴ design is safe.



③ For a residential building internal room dia is 8×16m as the room spacing 3m centre to centre where width of the beam is 200mm lying on the wall of thickness 230mm. Use M_{20} & Fe_{415} & take super imposed load as 2.5 KN/m² & check for the deflection control.

$d = \dfrac{3000}{30} = 100$ mm

$D = 100 + 20 + \left(\dfrac{10}{2}\right)$

$D = 125$ mm

length = 3m − 0.23

= 2.8 m

$l_e = 2.8 + \underset{\text{(wall thickness)}}{0.23} = 3.03$

$l_e = 2.8 + \underset{(d)}{0.1} = 2.9$

considering least value.

$\boxed{l_e = 2.9}$

Load calculation

$DL = 0.125 \times 25 = 3.125\ kN/m$

$FF = 0.5\ kN/m$ [∵ its a residential building

$w_g = 1.5 \times 3.625 = 5.437\ kN/m$

$w_q = 1.5 \times 2.5 = 3.75\ kN/m$

$$M_u = \frac{w_g l_e^2}{10} + \frac{w_q l_e^2}{9} \qquad V_u = 0.6\, l_e (w_g + w_q)$$

$$M_u = 8.07\ kN\text{-}m \qquad V_u = 15.98\ kN$$

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

$$8.07 \times 10^6 = 0.87 \times 415 \times A_{st} \times 100 \left[1 - \frac{415 A_{st}}{1000 \times 100 \times 20}\right]$$

$$8.07 \times 10^6 = 36105 A_{st} \left[1 - 2.075 \times 10^{-4}\right]$$

$$8.07 \times 10^6 = 36105 A_{st} - 7.49 A_{st}^2$$

$\boxed{A_{st} = 234.97\ mm^2}$

$$\text{Spacing} = \frac{\frac{\pi d^2}{4}}{A_{st}} = 334.25\ mm \qquad \text{(or)} \quad \cancel{0.25 \times D} \quad \cancel{0.75 \times} \quad 3 \times d = 300\ mm$$

provide 10 ϕ @ 330 mm c/c main bar

[since it is beyond 300 it should'nt happen so)

$\boxed{\text{Provide } 10\ \phi\ @\ 300\ mm\ c/c \text{ main bar}}$

Distribution bar $\frac{0.12}{100} \times 1000 \times D\ (125) = 150\ mm = A_{st}$

$$\text{Spacing } 8mm\phi \quad \frac{\frac{\pi (8)^2}{4}}{150} \times 1000 = 335.1\ mm$$

provide 8 ϕ @ 335 mm c/c

$$\cancel{\tau_c = 0.45} \quad \tau_v = \frac{V_u}{bd} = \frac{15.98 \times 10^3}{1000 \times 100} = 0.159$$

$$\frac{100 A_{st}}{bd} = \frac{100 \times 234.97}{1000 \times 100} = 0.23$$

0.25 → 0.36

0.23 → ? $\tau_c > \tau_v$

0.5 → 0.48

∴ Design is safe.

$\boxed{\tau_c = 0.35}$

check for deflection

$\frac{l}{d} = 26\,MF$

$\frac{3000}{100} = 30$ from page 38 graph Fig (4)

modification factor $F_1 = \frac{100\,Ast}{bd} = 0.23$

$f_{sc} = 0.58\,f_y \left(\frac{Ast}{Act\,Ast}\right)$

$Act\,Ast = \frac{\frac{\pi (10)^2}{4}}{300} \times 1000$

$Act\,Ast = 261.7\,mm^2$.

$f_{sc} = 0.58 \times 415 \left[\frac{234.97}{261.7}\right]$

$\boxed{f_{sc} = 216.11\,N/mm^2}$

0.23 on MF & $f_{sc} = 216.11$ so $F_1 = 1.9$

$MF = 1.9 \times 26 = 49.5$
formula

$\frac{l}{d} < MF$ ∴ Hence def is under continous

(7) Design a cantilever slab of span 1.2 m from beam bearing a live load of 1.25 kN/m². Use M_{20} & Fe_{415}.

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

$d = \frac{1200}{7} = 171.4 \simeq 175 mm$

$D = 175 + 20 + \left(\frac{10}{2}\right)$

$\boxed{D = 200 mm}$

$L_e = 1.2 + 0.23$ (or) $1.2 + 0.175$

$= 1.43$ (or) 1.375

Taking the least $l_e = 1.37$

$M_u = \frac{w_u l_e^2}{2}$ $V_u = w_u l.$

$w_u = DL + LL$

$DL = 0.2 \times 25 = 5$

$LL = 1.25 = 1.25$

$FF = \quad = 0.5$

$w = 6.75 \ kN/m$

$w_u = 1.5 \times w = 10.125 \ kN/m$

$M_u = \frac{w_u l_e^2}{2} = \frac{10.125 \times 1.37^2}{2} = 9.5 \ kN\text{-}m$

$V_u = w_u l_e = 13.87 \ kN$

Check for depth

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

$9.5 \times 10^6 = 0.36 \times 0.48 [1 - 0.42 \times 0.48] \times 1000 \times d^2 \times 20$

$\boxed{d = 58.67 mm}$ $< 175 mm$, so 'd' is safe

Ast for main steel.

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

$9.5 \times 10^6 = 0.87 \times 415 A_{st}\left[1 - \frac{415 A_{st}}{1000 \times 175 \times 20}\right]$

$$9.5 \times 10^6 = 63183.75\,A_{st} - 7.49\,A_{st}^2$$

$$\boxed{A_{st} = 153.13\,mm^2}$$

spacing for 10mm dia $\dfrac{\frac{\pi(10)^2}{4}}{A_{st}} \times 1000$

$= 512.89$

Its more than 300 so take 300 from c/c

$\boxed{\text{Provide } 10\phi \text{ @ } 300mm \text{ c/c main bar}}$

Distribution steel

$A_{st} = \dfrac{0.12}{100} \times 1000 \times 200 = 240\,mm^2$

provide 8ϕ at 240mm

spacing $= \dfrac{\frac{\pi(8)^2}{4}}{240} \times 1000 = 209.43$ c/c.

So take it as 205

$\boxed{\text{provide } 8\phi \text{ @ } 205mm \text{ c/c}}$

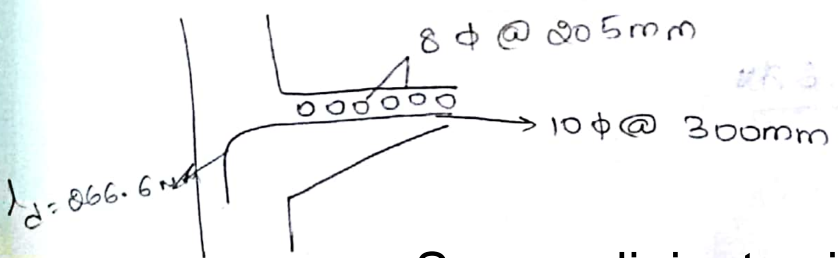
Page 48 Development Length of Bars.

$L_d = \dfrac{\phi\,\sigma_s}{4\,\tau_{bd}}$ $\quad \sigma_s = \dfrac{W_u}{A} = \dfrac{10.125}{\frac{\pi(10)^2}{4}}$

$= \dfrac{10 \times 0.128}{4 \times 1.2}$ $\quad \sigma_s = 0.128$

$L_d = 0.26\,m$

$\boxed{L_d = 266.6mm}$



$$\tau_v = \frac{V_u}{bd} = \frac{13.87 \times 10^3}{1000 \times 175} = 0.079 \text{ kN/m}$$

$$\tau_c \quad \frac{100A_{st}}{bd} = \frac{100 \times 153.13}{1000 \times 175} = 0.087$$

$\tau_c = 0.28$

$\tau_c > \tau_v$

12/10/17

TWO WAY SLAB

If the ratio of longer span by shorter span is less than (or) equal to 2 then it will be designed as two way slab i.e $\frac{l_y}{l_x} \le 2$.

Simply supported slab:-

1. For a room of Internal dimension 4m x 5m carries a live load of 2 kN/m² Use M_{20} & Fe_{415}.

$\frac{l_y}{l_x} = \frac{5}{4} = 1.25m < 2$ Hence it is 2 way slab.

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

$\frac{4000}{20} = d$

$\boxed{d = 200mm}$

$D = 200 + 20 + \frac{10}{2}$

$\boxed{D = 225mm}$

$l_e = 4 + 0.23 = 4.23$ (OR) $4 + 0.2 = 4.2$

Taking least value $\boxed{l_e = 4.2}$

$$\frac{(l_e)_y}{(l_e)_x} = \frac{5.2}{4.2} = 1.238$$

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For simply supported all the four sides of beam is free

By page 91:- 9th condition :- For simply supported slab all 4 edges are discontinous.

$1.2 \rightarrow 0.072$ $\quad \alpha_x = 0.074$

$1.24 \rightarrow x$ $\quad \alpha_y = 0.056$.

$1.3 \rightarrow 0.079$

$m_x = \alpha_x w l_x^2$

$m_y = \alpha_y w l_x^2$

Load calculation:-

$1 \times D$

D.L $\rightarrow 1 \times 0.225 \times 1 \times 25 = 5.625$ kN/m

FF $\rightarrow$ $= 0.5$ kN/m

LL $\rightarrow$ $= 2$ kN/m^2

$w = 8.125$ kN/m.

$w_u = 1.5 \times w = 12.18$ kN/m

$m_x = \alpha_x w_u l_x^2$

$= 0.074 \times 12.185 \times (4.2)^2$

$\boxed{m_x = 15.89 \text{ kN-m}}$

$m_y = \alpha_y w l_x^2$

$= 0.056 \times 12.18 \times (4.2)^2$

$\boxed{m_y = 12.03 \text{ kN-m}}$

Area of steel in x-direction

Check for depth

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

$m_x = 0.36(0.48)[1-(0.48)(0.42)] \times 1000 \times d^2 \times 20$

$\boxed{d = 75.88 \text{ mm}}$ $\therefore$ 'd' is safe.

For simply supported all the four sides of beam is free

By page 91 :- 9th condition :- For simply supported slab all 4 edges are discontinous.

$1.2 \rightarrow 0.072$

$1.24 \rightarrow x$

$1.3 \rightarrow 0.079$

$\alpha_x = 0.074$

$\alpha_y = 0.056.$

$m_x = \alpha_x w l_x^2$

$m_y = \alpha_y w l_x^2$

Load calculation :-

D.L $\rightarrow$ $1 \times 0.225 \times 1 \times 25$ ($1 \times D$) $= 5.625$ kN/m

FF $\rightarrow$ $= 0.5$ kN/m

LL $\rightarrow$ $= 2$ kN/m^2

$w = 8.125$ kN/m.

$w_u = 1.5 \times w = 12.18$ kN/m

$M_x = \alpha_x w_u l_x^2$

$= 0.074 \times 12.185 \times (4.2)^2$

$\boxed{M_x = 15.89 \text{ kN-m}}$

$m_y = \alpha_y w l_x^2$

$= 0.056 \times 12.18 \times (4.2)^2$

$\boxed{m_y = 12.03 \text{ kN-m}}$

Area of steel in x-direction

Check for depth

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

$M_x = 0.36 (0.48) [1 - (0.48)(0.42) \times 1000 \times d^2 \times 20$

$\boxed{d = 75.88 \text{ mm}}$ $\therefore$ 'd' is safe.

Ast for shorter span.

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

$$15.89 \times 10^6 = 0.87 \times 415 \times A_{st} \times 200 \left[1 - \frac{415\, A_{st}}{1000 \times 200 \times 20}\right]$$

$$15.89 \times 10^6 = \cancel{3361.05}\ 72210\, A_{st}\left[1 - \cancel{7.488}\ 1.037 \times 10^{-4} A_{st}\right]$$

$$15.89 \times 10^6 = \cancel{3361.05}\ 72210\, A_{st} - 7.488\, A_{st}^2$$

$$\boxed{A_{st} = 225.3\,mm^2}$$

~~Prov.~~ Spacing $\frac{\frac{\pi d^2}{4}}{A_{st}} \times 1000 = 348.6$

$\boxed{\text{Provide } 10\phi \text{ @ } 300\,mm \text{ c/c in } x\text{-direction}}$

$A_{st})_{long}$

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

$$\cancel{12.03 \times 10^6 = 0.36 \times 0.48\left[1 - 0.48 \times 0.42\right] 1000 \times 200}$$

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

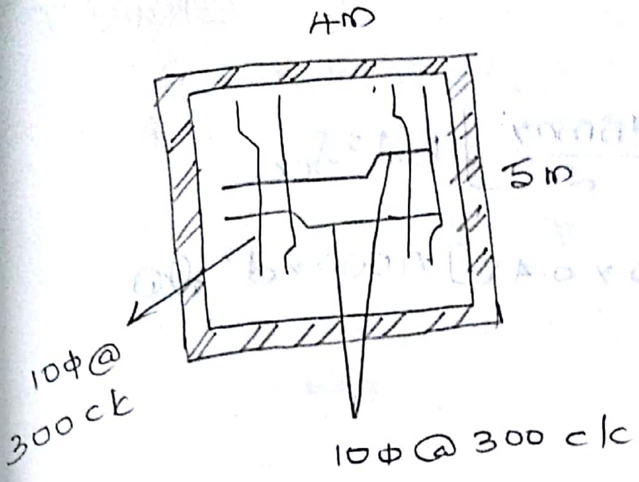
$$12.03 \times 10^6 = 0.87 \times 415 \times A_{st} \times 200\left[1 - \frac{415\, A_{st}}{1000 \times 200 \times 20}\right]$$

$$\boxed{A_{st} = 169.57\,mm^2}$$

Spacing $\frac{\frac{\pi d^2}{4}}{A_{st}} \times 1000 = 463.17\,mm$

Since it is more than 300 take only 300

Source diginotes.in



② Design a slab for a room dimension of 8m×10m carrying a live load of 2.5 kN/m² & check for the deflection using M_{20} & Fe_{415}.

$\frac{l_y}{l_x} = \frac{10}{8} = 1.25 \text{ m} < 2$ Hence 2 way slab.

$\frac{l}{d} = 20 \qquad \frac{8000}{20} = d \qquad \boxed{d = 400 \text{ mm}}$

$D = 400 + 20 + \frac{10}{2}$

$\boxed{D = 425 \text{ mm}}$

$l_e = 8 + 0.23 = 8.23$ (OR) $8 + (d) = 8 + 0.4 = 8.4$

so least is 8.23 $\boxed{l_e = 8.23}$

$\alpha_x = 0.074$
$\alpha_y = 0.056$

$\frac{(l_e)_y}{(l_e)_x} = \frac{10.23}{8.23} = \underline{1.24}$

$DL = 0.425 \times 1 \times 25 = 10.625 \text{ kN/m}$

$FF = \qquad\qquad = 0.5 \text{ kN/m}$

$LL = \qquad\qquad = \underline{2.5 \text{ kN/m}}$

$w = 13.625 \qquad w_u = 20.43 \text{ kN/m}$

$M_x = \alpha_x w_u l_x^2$

$= (0.074) \times (20.43)\,(\cancel{0.074})^2$ 8.23

$\boxed{M_x = 102.39 \text{ kN-m}}$

$M_y = \alpha_y w_u l_x^2$

$\boxed{M_y = 77.49 \text{ kN-m}}$

Check for depth

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

$$102.39 \times 10^6 = 0.36 \times 0.48\,[1 - 0.42 \times 0.48] \times 1000 \times d^2 \times 20$$

$$\boxed{d = 192.63\,mm}$$

Spacing $\frac{\pi d^2}{4}$ Ast for shorter span

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

$$102.39 \times 10^6 = 0.87 \times 415 \times Ast \times 400\left[1 - \frac{415\,Ast}{1000 \times 400 \times 20}\right]$$

$$102.39 \times 10^6 = 144420\,Ast - 7.49\,Ast^2$$

$\boxed{\cancel{Ast = 2550.36\,mm^2}}$ $\boxed{Ast = 737.155\,mm^2}$

$$\frac{\frac{\pi d^2}{4}}{Ast} \times 1000 = \cancel{142.18}\ 106.54$$

$\boxed{\text{provide } 10\phi \text{ @ } 105\,mm \text{ c/c in x-direction}}$

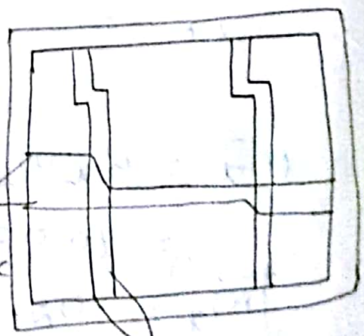
$$M_u = 0.87\,f_y\,Ast\,d\left[1 - \frac{f_y\,Ast}{bd\,f_{ck}}\right]$$

$$77.49 \times 10^6 = 0.87 \times 415 \times Ast \times 400\left[1 - \frac{415\,Ast}{1000 \times 400 \times 20}\right]$$

$$77.49 \times 10^6 = 144420\,Ast - 7.49\,Ast^2$$

$$\boxed{Ast = 552.38\,mm^2}$$

Spacing $\frac{\frac{\pi d^2}{4}}{Ast} \times 1000 = 142.18$



$\boxed{\text{Provide } 10\phi \text{ @ } 140 \text{ c/c in y-direction}}$

Deflection

$$f_{sc} = 0.58 f_y \frac{Ast}{Act\ Ast}$$ Shorter span Ast

$$= 0.58 \times 415 \times \frac{737.155}{\cancel{749.99}} = 237.2.$$

~~100~~ $$Act\ Ast = \frac{\frac{\pi (10)^2}{4}}{105} = 747.99$$

$$\frac{100 Ast}{bd} = \frac{100 \times 737.15}{1000 \times 400} = 0.18$$

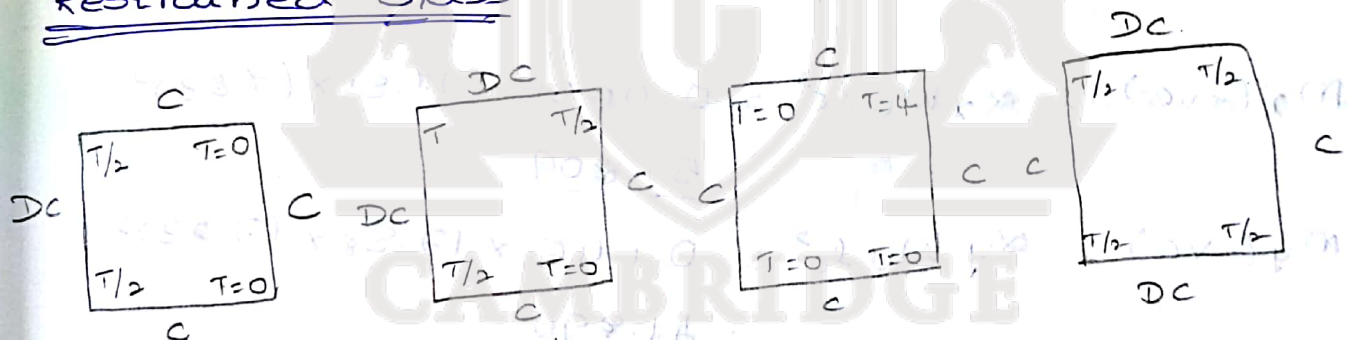
$f_1 = 2$

$$\frac{l}{d} = \frac{8000}{400} = 20$$

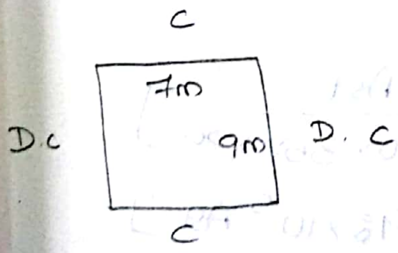
$$MF = F_1 \times \cancel{F_2} \times \cancel{F_3} \times 20$$

$$= 2 \times 20 = 40 \qquad 20 < MF$$

Restrained slabs



① Design a slab for a room internal dimension 7m x 9m where two adjacent side of shaft span are discontinous & carrying a LL of 2 KN/m². Use M_{20} & Fe_{415}



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

$$\frac{7000}{20} = 350 = d$$

$$D = 350 + 20 + \frac{10}{2}$$

$$\boxed{D = 375mm}$$

Load calculation :-

$DL = 1 \times D \times 25 = 1 \times 0.375 \times 25 = 9.375$ kN/m

$FF =$ 0.5 kN/m

$LL =$ 2 kN/m

$w = 11.8$ kN/m

$w_u = 17.81$ kN/m

$l_e = 7 + 0.23 = 7.23$ (or) $7 + 0.35 = 7.35$

least $l_e = 7.23$

$\frac{(l_e)_y}{(l_e)_x} = \frac{9.23}{7.23} = 1.27$

$\alpha_x(-ve) = 0$	$M_x(-ve)$		Ast 0
$\alpha_x(+ve) = 0.0055$	$M_x(+ve)$		
$\alpha_y(-ve) = 0.0045$	$M_y(-ve)$		
$\alpha_y(+ve) = 0.0035$	$M_y(+ve)$		

$M_u = M_x(+ve) = \alpha_x w_u l_e^2 = 0.0055 \times 17.81 \times (7.23)^2$
$= 51.209$

$M_u = M_y(-ve) = \alpha_y w_u l_e^2 = 0.045 \times 17.81 \times (7.23)^2$
$= 41.895$

$M_u = M_y(+ve) = \alpha_y w_u l_e^2 = 0.035 \times 17.81 \times (7.23)^2 = 32.58$

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

$51.20 \times 10^6 = 0.87 \times 415 A_{st} \times 350 \left[1 - \frac{415 A_{st}}{1000 \times 350 \times 20}\right]$

$51.20 \times 10^6 = 126367.5 A_{st} \left[1 - 5.92 \times 10^{-5} A_{st}\right]$

$51.20 \times 10^6 = 126367.5 A_{st} - 7.49 A_{st}^2$

$[M_x(+ve)] A_{st} = 415 mm^2$

$M_y(+ve) = 261.88$

$[M_y(-ve)] A_{st} = 338.77 mm^2$

spacing

$(M_x +ve)\ \dfrac{\frac{\pi d^2}{4}(10)^2}{Ast} \times 1000$

$(M_y (-ve)) = \dfrac{\frac{\pi d^2}{4}(10)^2}{Ast} \times 1000$

$M_x(+ve) = 189.25 \simeq 180$

$= 231.83 \simeq 230$

$M_y(+ve) = 299.9$

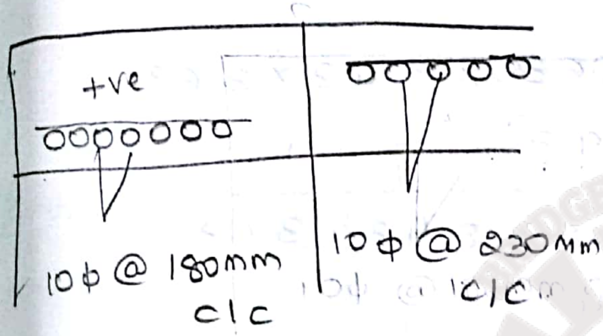
For top bars

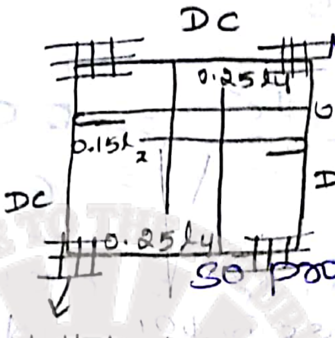
$M_x(+ve)\ Ast = \frac{3}{4} \times 415\ mm^2 = 311.25$

No of bars $= \dfrac{311.25}{\frac{\pi(10)^2}{4}}$

$= 4$ bars

So provide 4 # 10 φ 200mm c/c. The depth of slab shouldn't be > 200





4 # 10 φ @ 200 c/c.

$\boxed{16|10|17}$

② Design a slab for a room of Internal dimension 3.5 × 6 m where the two short edges are discontinous carrying a live load of 2 kN/m² Used M_{20} + Fe_{415} slab lies on the beam width of 250mm.

$\dfrac{l}{D} = 35 \times 0.8$ → for two way slab < 3.5m span should multiply with 0.8.

$\boxed{D = 125mm}$

d = 125 - 25
= 100 mm

Load calculation:

D.L = (0.125 × 1) × 25 = 3.125 kN/m

FF = = 0.5 kN/m

LL = = 2 kN/m

w = 5.625 kN/m

$w_u = 1.5 \times w = 8.43$ kN/m

If this is given it is 0.25 (or) else 0.23

$l_e = 3.5 + 0.25 = ~~3550~~\ 3.75$ ~~m~~

(or) small d value ÷ 1000

$l_e = 3.5 + 0.1 \rightarrow 3.6$ m

$$\frac{l_e(y)}{l_e(x)} = \frac{6.1}{3.6} = 1.69$$

α	y
1.5	0.06
1.75	0.065

(5)

$\alpha_x(-ve) = 0.0638$

$\alpha_x(+ve) = 0.048$

$\alpha_y(-ve) = 0$

$\alpha_y(+ve) = 0.035$

$M_u = M_x(+ve) = \alpha_x w_u l_e^2 = 0.0638 \times 8.43 \times 3.6^2$

$= 6.97$

$M_u = M_x(+ve) = \alpha_x w_u l_e^2 = 0.048 \times 8.43 \times 3.6^2$

$= 5.24$

$M_y(-ve) = \alpha_y w_u l_e^2 = 0$

$M_y(+ve) = 0.035 \times 8.43 \times 3.6^2 = 3.82$

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

$M_x(-ve)$ $\quad 6.97 \times 10^6 = 0.87 \times 415 A_{st} \times 100 \left[1 - \frac{415 A_{st}}{100 \times 1000 \times 20}\right]$

$6.97 \times 10^6 = 36105 A_{st} \left[1 - 2.075 \times 10^{-4} A_{st}\right]$

$6.97 \times 10^6 = 36105 A_{st} - 7.49 A_{st}^2$

$M_x(-ve) = A_{st} = 201.46 \text{ mm}^2$

$M_x(+ve) = 149.78 = A_{st}$

$M_y(+ve) = 0$

$M_y(-ve) = 108.23 = A_{st}$

<u>Spacing</u>

Spacing for +ve steel $= \dfrac{\frac{\pi \times 10^2}{4}}{149.78} \times 1000$

$= 524.36$ mm

Provide 10ϕ @ 300 mm c/c

spacing for -ve steel

$$= \frac{\frac{\pi \times 10^2}{4}}{198.75} \times 1000$$

$$= 395.16 \text{ mm}$$

Provide 10φ @ 300mm c/c.

For top bar

$A_{st} = (M_x +ve) = 149.78$

$$\text{No of bars} = \frac{\cancel{149.38}}{\frac{\pi(10)^2}{4}} = 1.4 \simeq 2 \text{bars}$$

Provide 2#10φ @ 125mm c/c.

③ Design a slab for a room dimension 3m x 5m whose one long edge is continous carrying a live load of 1.5 KN/m²

$\frac{l}{D} = 35 \times 0.8$

$l_e =$

$D = 107.14 \text{mm} \simeq 110 \text{mm}$

$d = 110 - 25 = 85 \text{ mm}$

~~$l_e(x)$~~ =

Load calculation

$DL = (0.11 \times 1) \times 25 = 2.75 \text{ KN/m}$

$FF = 0.5 \text{ KN/m}$

$LL = 1.5 \text{ KN/m}$

$w = 4.75$

$w_u = 7.125 \text{ KN/m}$

$l_e = 3 * 0.85 = \frac{3.23}{\cancel{0.69}}$ (or) ~~3 * 0.1 = 2.31m~~

$3 + 0.085 = 3.085$

$$\frac{l_e(y)}{l_e(x)} = \frac{5.085}{3.085} = 1.64$$

Condition ④:

$\alpha_x(-ve) = 0.087$

$\alpha_x(+ve) = 0.068$

$\alpha_y(-ve) = 0$

$\alpha_y(+ve) = 0.043$

$M_u = (M_x)_{+ve} = \alpha_x W_u l_e^2 = 0.088 \times 7.125 \times 3.085^2$

$M_x(-ve) = 5.899$

$M_x(+ve) = 4.643$

$M_y(-ve) = 0$

$M_y(+ve) = 2.915$

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

$$5.89 \times 10^6 = 0.87 \times 415 \times A_{st} \times 85 \left[1 - \frac{415 A_{st}}{1000 \times 85 \times 20}\right]$$

$$5.89 \times 10^6 = 30689.25 A_{st} \left[1 - 2.44 \times 10^{-4} A_{st}\right]$$

$$5.89 \times 10^6 = 30689.25 A_{st} - 7.49 A_{st}^2$$

$A_{st_1} = 201.86\ mm^2$

$A_{st_2} = 153.7\ mm^2$

$A_{st_3} = 97$

$A_{st_4} = 97.29\ mm^2$

Check for depth

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

$$5.89 \times 10^6 = 0.36 \times 0.48 [1 - 0.42 \times 0.48] \times 20 \times 1000 \times d^2$$

$d = 46.2\ mm$ its < than taken 'd' so ok.

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

$$5.89 \times 10^6 = 0.87 \times 415 \times A_{st} \times 85 \left[1 - \frac{415 A_{st}}{1000 \times 85 \times 20}\right]$$

$$5.89 \times 10^6 = 30689.25 A_{st} \left[1 - 2.44 \times 10^{-4}\right]$$

$$5.89 \times 10^6 = 30689.25 A_{st} - 7.48 A_{st}^2$$

$$\boxed{A_{st} = 201.85\ mm^2}$$

$A_{st} = 153.7$

$A_{st} = 204.4\ mm^2$

$A_{st} = 97.12\ mm^2$

Min Ast $\frac{A_s}{bd} = \frac{0.85}{f_y}$

$$A_s = \frac{0.85 \times 85 \times 1000}{415}$$

$A_s = 174.09\ mm^2$

For (+ve) take Asc as this value

spacing for 10mm ϕ $\frac{\frac{\pi (10)^2}{4}}{174.09} = 451.14 mm$

$\frac{\frac{\pi (10)^2}{4}}{204.4} = 384.2 mm$

provide 300m c/c

Theoritically $\frac{0.12}{100} \times b \times D$

$\frac{0.12}{100} \times 1000 \times 110 = 132 mm$

(4) Design a slab of rooms interior dimension 5x8m whose any two adjacent sides are discontinous carrying a live load of 2.25 kN/m² use M_{20} & Fe_{415}.

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

$\frac{5000}{d} = 20$

$d = 250 mm$

$D = 250 + 25$

$D = 275 mm$

Load Calculation

DL = 0.275 × 25 = 6.875

LL = 2.25

FF = 0.5

w = 9.625 kN/m²

w_u = 14.43 kN/m

$l_e = 5 + \overset{'d'}{(0.25)} = 5.25$

$5 + (0.23) = 5.23$.

$$\frac{l_e(y)}{l_e(x)} = \frac{8.23}{5.23} = 1.57$$

$\alpha_x(-ve) = 0.077$ $\quad M_u = \alpha_x w_u l_e^2 = 30.39$

$\alpha_x(+ve) = 0.057$ $\quad M_u = 22.49$

$\alpha_y(-ve) = 0.047$ $\quad M_u = 18.55$

$\alpha_y(+ve) = 0.035$ $\quad M_u = 13.81$

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

$$30.39 \times 10^6 = 0.87 \times 415 A_{st} \times 250 \left[1 - \frac{415 A_{st}}{1000 \times 250 \times 20}\right]$$

$$30.39 \times 10^6 = 90262.5 A_{st}\left[1 - 8.3 \times 10^{-5} A_{st}\right]$$

$$30.39 \times 10^6 = 90262.5 A_{st} - 7.49 A_{st}^2$$

$A_{st} = 346.30 \longrightarrow -ve$

$A_{st} = 254.53 \longrightarrow +ve$

$A_{st} = 209.14 \longrightarrow -ve$

$A_{st} = 154.99 \longrightarrow +ve.$

<u>check for depth</u>

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

$$30.39 \times 10^6 = 0.36 \times 0.48\left[1 - 0.42 \times 0.48\right] \times 1000 \times d^2 \times 20$$

$\boxed{d = 104.94\,mm}$ $\quad \therefore$ d is safe.

F_1 =	M_u	Ast	Min Ast
x (-ve)	30.39	346.65	330
(+ve)	22.49	257.53	330
y (-ve)	18.55	209.14	330
(+ve)	13.81	154.9	330.

min Ast $= 0.12 \times b \times d$

$= \frac{0.12}{100} \times 1000 \times \cancel{330}\ 275$

$=$

(+ve) Spacing.

spacing $\cancel{\frac{\pi(10)^2}{4}}$

$\frac{0.12}{100} \times b \times d$

$\frac{0.12}{100} \times 1000 \times 275$

$= 330$

$$\frac{\frac{\pi d^2}{4}}{Ast} \times 1000 = \frac{\frac{\pi (10)^2}{4}}{330} \times 1000 = 237.99$$

$= 230$ mm c/c.

For (-ve spacing) which is bigger

$$\cancel{\frac{0.12}{100}} \times \frac{\frac{\pi d^2}{4}}{Ast} \times 1000 = \frac{\frac{\pi (10)^2}{4}}{346.3} \times 1000$$

$= 226.7 \simeq 220$ mm c/c

check for deflection

$$\text{Act Ast} = \frac{\frac{\pi d^2}{4}}{Ast} \times 1000$$

Ast → +ve steel value.

$$= \frac{\frac{\pi (10)^2}{4}}{230} \times 1000$$

$\boxed{\text{Act Ast} = 341.47 \text{ mm}^2}$

$\frac{l}{d} = \frac{5000}{250} = 20 < 40$ ∴ Deflection under control

$$f_{sc} = 0.\cancel{88}\, f_y \frac{A_{st}}{Act\ A_{st}}$$

$$= \cancel{0.87}\ 0.58 \times 415 \times \frac{330}{341.37}$$

$$\boxed{f_{sc} = 232.66\ N/mm^2}$$

$$\frac{100 A_{st}}{bd} = \frac{100 \times 330}{250 \times 1000} = 0.13$$

$f_1 = 2$

$F_2 = 1$

$F_3 = 1$

$$\frac{l}{d} = 20 \times 2 \times 1 \times 1$$

$$\frac{5000}{250} = 40$$

$20 < 40$

Hence deflection is under control

$\boxed{26/10/17}$

$$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 346.65}{1000 \times 250} = 0.13$$

$$f_y = 0.58 f_y \frac{A_{st}}{Act\ A_{st}} = 0.58 \times 415 \times \frac{330}{341.49} = 232.6\ N/mm^2$$

$$Act\ A_{st} = \frac{\frac{\pi \times 10^2}{4}}{S_v} \times 1000 = \frac{\frac{\pi \times 10^2}{4}}{230} \times 1000 = 341.44\,mm^2$$

COLUMNS

There are three types of column:

1. Square column
2. Rectangular column
3. Circular column

column can be differentiated into two types based on length by breadth ratio

If $\frac{l}{b} \leq 12$ short column

" > 12 long column