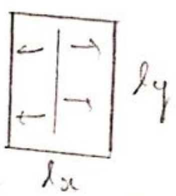
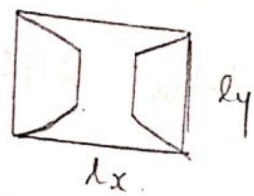
IAT - 02

1) a)

One way slab	Two way slab.
• It will bend in only one direction	• It will bend in both the directions.
• The main reinforcement is provided along the shorter span.	• The main reinforcement is provided in both the direction & perpendicular to each other.
• The l_y/l_x ratio is ≥ 2	• The l_y/l_x ratio is < 2.
• The thickness of the slab is 100-150 mm	• The thickness of the slab is 100 - 200 mm.





1) b) $L_y = 7500$ mm

$L_x = 3000$ mm.

$LL = 4 \, kN/m^2$

$FL = 1 \, kN/m^2$

$f_{ck} = 20 \, N/mm^2$

$f_y = 415 \, N/mm^2$

Step-1: $\frac{L_y}{L_x} = \frac{7500}{3000} = 2.5 > 2$

It is one way slab.

Step-1: Fixing the dimension

$\frac{l}{d} = 20$ (Pg 37. 23.2.1 IS456 -2000)

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

$d_{prov.} = 150mm$

Assume clear cover as 15mm & bar ϕ as 10mm.

$D = d + cc + \frac{1}{2}\phi\ bar = 150 + 15 + \frac{10}{2}$

$D = 170mm$

Step-2: Effective length

$L_{eff} = 3000 + d = 3000 + 150 = 3150mm = 3.15m.$

or } least

$L_{eff} = 3000 + 230 = 3230mm = 3.23m$

(Assuming thickness of wall as 230mm)

$\therefore L_{eff} = 3.15m$

Step-3 :- Load calculation

DL = 25 × 0.17 × 3.15 = 13.3875 KN/m

LL = 4 × 1 = 4 KN/m

FL = 1 × 1 = 1 KN/m

TL = 18.3875 KN/m.

Factored load = 1.5 × TL = 1.5 × 18.3875

= 27.581 KN/m.

Step-4 :- BM & SF Calculation.

$M_f = \frac{W L_{eff}^2}{8} = \frac{27.581 \times 3.15^2}{8} = 34.209$ KNm

$V_f = \frac{W L_{eff}}{2} = \frac{27.581 \times 3.15}{2} = 43.44$ KNm.

Step-5 :- Check for depth. (Pg 96. G.1.1.(c))

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

Takes M_{ulim} as M_f , b = 1000 mm

$\frac{x_{umax}}{d} = 0.48$ for Fe415 (Pg 70)

$34.209 \times 10^6 = 0.36 \times 0.48 (1 - 0.42 \times 0.48) \times 1000 \times d^2 \times 20$

$34.209 \times 10^6 = 2759.2704 d^2$

$d^2 = 12397.84256$ mm

$d_{req} = 111.34$ mm

$d_{req} < d_{prov}$ hence it is safe.

$111.34 < 150$.

Step-6 :- A_{st} Calculation (Pg 96) 9.1.1.(b).

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

$$34.209 \times 10^6 = 0.87 \times 415 \times A_{st} \times 150 \left(1 - \frac{A_{st} \times 415}{1000 \times 150 \times 20}\right)$$

$$A_{st_{req.}} = 699.306 \text{ mm}^2$$

use 10mm ϕ bar.

$$\text{spacing} = \frac{\text{area of one bar}}{A_{st}} \times 1000$$

$$= \frac{\pi/4 \times 10^2}{699.306} \times 1000$$

spacing = 112.31 mm ≈ 110 mm

Check for spacing (Pg 46). 23.3.3 b.

a) 3×d = 3×150 = 450 mm.
b) 300 mm
c) 110 mm

} least

Provide 10 mm ϕ bars @ 110 mm c/c as a main reinforcement along shorter span.

Step-7 :- Distribution Reinforcement (Pg 48, 26.5.2.

Minimum reinforcement = $\frac{0.12}{100} \times D \times b$.

$= \frac{0.12}{100} \times 170 \times 1000$

use 8mm ϕ bars $\quad A_{st} = 204\ mm^2$

Spacing = $\frac{\text{Area of one bar}}{A_{st}} \times 1000$

$= \frac{\pi/4 \times 8^2}{204} \times 1000$

$= 246.39mm \approx 240mm.$

Check for spacing (Pg 46)

a) 5d = 5×150 = 750mm
b) 450mm
c) 240mm

} least

Provide 8mm ϕ bars @ 240mm c/c as distribution reinforcement along longer span.

Step-8 :- Check for shear (Pg 72 & 73)

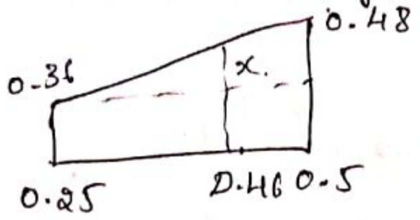
$\tau_v = \frac{V_F}{bd} = \frac{43.44 \times 10^3}{1000 \times 150}$

$\tau_v = 0.289\ N/mm^2$

$$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 699.306}{1000 \times 150}.$$

$$P_t = 0.46$$

From Table 19, Pg 73.



$$\frac{x}{0.12} = \frac{0.21}{0.25}$$

$$x = 0.1008$$

$$\tau_c = 0.36 + x = 0.460 \ N/mm^2.$$

~~$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times \pi/4 \times 10^2}{1000 \times 150}.$~~

$\tau_c > \tau_v$, So if fails in shear.

Step-9 : Check for deflection

$$(l/d)_{max} = (l/d)_{basic} \times K_t$$

$$K_t \begin{cases} P_t = 0.46 \\ f_{sc} \end{cases}$$

$$f_{sc} = 0.58 f_y \times \frac{A_{st\ req}}{A_{st\ prov}}. \quad (Pg\ 38)$$

$$A_{st\ prov} = \frac{\text{area of one bar}}{\text{Spacing}} \times 1000 = \frac{\pi/4 \times 10^2}{110} \times 1000$$

$$A_{st\ prov} = 713.998 \ mm^2$$

$$f_{sc} = 0.58 \times 415 \times \frac{699.306}{713.998}$$

$f_{sc} = 235.74\ N/mm^2$ or $240\ N/mm^2$.

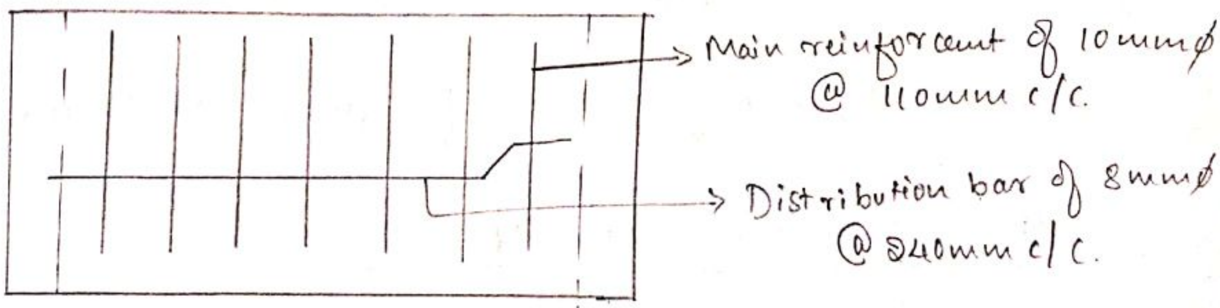
$K_t = 1.3$ (approx).

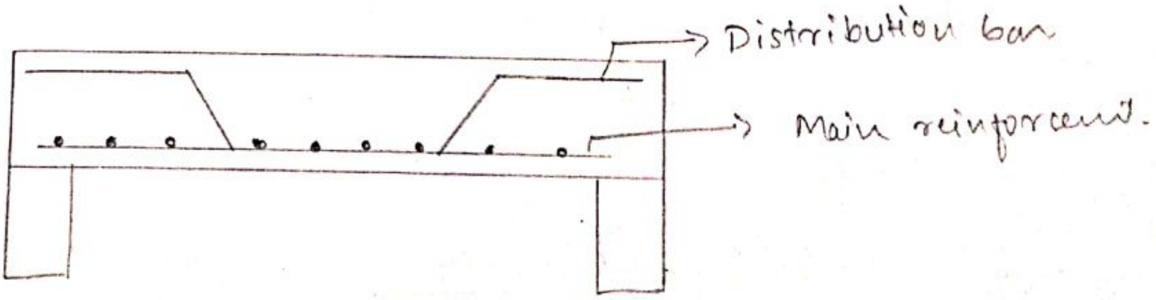
$$(l/d)_{max} = (l/d)_{basic} \times K_t$$

$$= 20 \times 1.3 = 26.$$

$$(l/d)_{actual} = \frac{3150}{150} = 21$$

$(l/d)_{actual} < (l/d)_{max}$, Hence it is safe.





a) $L_{eff} = 5m$

$b = 250 mm$

$D = 500 mm.$

service load $= 40 kN/m.$

Effective cover $= 50 mm. = d''$

$f_{ck} = 20 N/mm^2$

$f_y = 415 N/mm^2.$

Step-1: Factored moment ~~(Pg~~

Factored load $= 1.5 \times$ service load $= 1.5 \times 40 = 60 kN/m.$

$$M_F = \frac{W L_{eff}^2}{8} = \frac{60 \times 5^2}{8} = 187.5 \text{ kNm.}$$

$$V_F = \frac{W L_{eff}}{2} = \frac{60 \times 5}{2} = 150 \text{ kN.}$$

Step-2: Find M_{ulim}. (Pg 96 G.1.1.(c))

$d = D -$ eff cover $= 500 - 50$

$d = 450 mm.$

$\frac{x_{umax}}{d} = 0.48$ for Fe415 (Pg. 70)

$$M_{ulim} = 0.36 \frac{x_{umax}}{d} \left(1 - 0.42 \frac{x_{umax}}{d}\right) \times 250 \times 450^2 \times 20$$

$$= 0.36 \times 0.48 \times (1 - 0.42 \times 0.48) \times 250 \times 450^2 \times 20$$

$M_{ulim} = 139688064$ Nmm

$M_{ulim} = 139.688$ kNm

CMR

Step-3 :- Compare M_{ulim} & M_F.

$M_{ulim} < M_F$. Hence it is over reinforced.

Design doubly reinforced beam.

Step-4 :- Find A_{sc} (Pg. 96, G. 1.2)

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

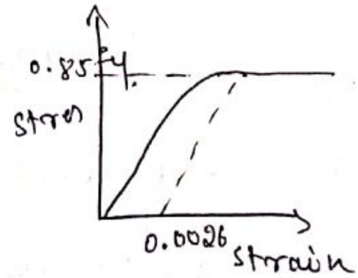
$$\text{Strain} = 0.0035 \left(\frac{x_{umax} - d''}{x_{umax}} \right)$$

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

$$x_{umax} = 0.48 \times 450 = 216 \text{ mm}$$

From ~~fig 23 Pg 70~~.

$$\text{Strain} = 0.0035 \frac{(216 - 50)}{216}$$



$= 0.0026$

From Fig 23 Pg 70.

$$f_s = 0.85 f_y$$

$$= 0.85 \times 415$$

$$f_s = 352.75 \text{ N/mm}^2$$

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

$187.5 \times 10^6 - 139.688 \times 10^6 = 352.75 \times A_{sc} (450 - 50)$

$47.812 \times 10^6 = 141100 A_s$

$A_{sc} = 338.85 \, mm^2$

use 16 mm ϕ bar.

No. of bars = $\frac{A_{sc}}{\text{area of one bar}} = \frac{338.85}{\pi/4 \times 16^2} = 1.68$

$\simeq 2$ bars

Step-5 :- Calculation of A_{st} (Pg 96)

$A_{st} = A_{st_1} + A_{st_2}$.

A_{st_1} = equation tensile force & compression force.

$0.87 f_y A_{st_1} = 0.36 f_{ck} b x_{umax}$

$0.87 \times 415 \times A_{st_1} = 0.36 \times 20 \times 250 \times 216$

$A_{st_1} = 1076.85 \, mm^2$.

$A_{st_2} = \frac{A_{sc} f_{sc}}{0.87 f_y}$ (Pg 96)

$= \frac{338.85 \times 352.75}{0.87 \times 415}$

$A_{st_2} = 331.06 \, mm^2$

$A_{st_{req}} = 1076.85 + 331.06 = 1407.91 \, mm^2$

use 20mm ϕ bars

no. of bars = $\frac{A_{st}}{\text{area of one bar}} = \frac{1407.91}{\pi/4 \times 20^2} = 4.48$

$\simeq$ 5 bars

Step-6 :- Check for shear. (Pg 72 & 73)

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

$= \frac{150 \times 10^3}{250 \times 450}$

$\tau_v = 1.33 \ N/mm^2$

$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 1407.91}{250 \times 450}$

$P_t = 1.25$

From Table 19. Pg 73.

for $P_t = 1.25$

$\tau_c = 0.67 \ N/mm^2$

$\tau_c < \tau_v$, hence is safe to shear.

Provide vertical stirrups of 8mm ϕ (two legged)

Shear reinforcement

$V_{us} = V_F - \tau_c bd$. (Pg 73)

$V_{us} = 150 \times 10^3 - 0.67 \times 250 \times 450$

$V_{us} = 74625 \ N = 74.625 \ KN$

$$V_{us} = \frac{0.87 f_y A_{sv} d}{S_v} \quad \text{(Pg 73)}$$

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

$$74.625 \times 10^3 = \frac{0.87 \times 415 \times 100.53 \times 450}{S_v}$$

$$S_v = 218.87 \, mm$$

~~Clear~~ check for spacing.

$S_v < 0.75d$ (Pg 47, 26.5.1.5)

$S_v < 0.75 \times 450$

$218.87 < 337.5$

and it should not exceed 300 mm in any case.

$\therefore \; S_v = 218.87 \, mm$

Step-7 :- Check for deflection

$$(l/d)_{max} = (l/d)_{basic} \times K_t \times K_c.$$

$(l/d)_{basic} = 20$ For simply supported (Pg 37)

K_t → $P_t = 1.25$
→ f_{sc}

$$f_{sc} = 0.58 f_y \times \frac{A_{st\,req}}{A_{st\,prov.}}$$

$$A_{st\,prov.} = 5 \times \frac{\pi}{4} \times 20^2 = ~~1570~~ \; 1570.796 \, mm^2.$$

CMR

$f_{sc} = 0.58 \times 415 \times \frac{1407.91}{1570.796}$

$f_{sc} = 215.74 \ N/mm^2 \simeq 240 \ N/mm^2$

From Fig 4. Pg 38.

$K_t = 0.95$ (approx)

For K_c

$P_c = \frac{100 A_{sc}}{bd} = \frac{100 \times 338.85}{250 \times 450} = 0.30$

from Fig 5 Pg 39.

$K_c = 1.1$ (approx)

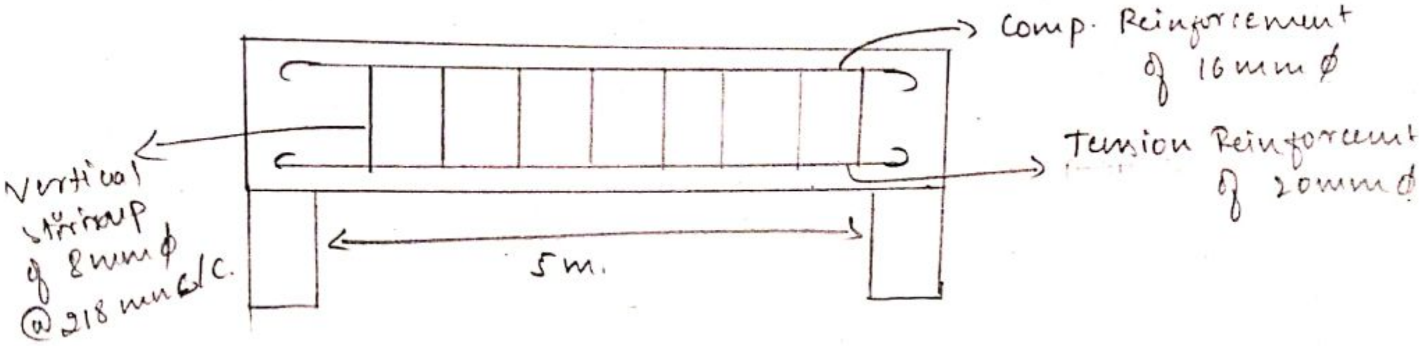
$(l/d)_{max} = (l/d)_{basic} \times K_t \times K_c$

$= 20 \times 0.95 \times 1.1$

$= 20.9$

$(l/d)_{actual} = \frac{5000}{450} = 11.11$

$(l/d)_{actual} < (l/d)_{max}$. Hence it is safe.


Comp. Reinforcement
of 16mm ϕ
Tension Reinforcement
of 20mm ϕ
Vertical stirrup
of 8mm ϕ
@ 218 mm c/c.
5m.