MODULE 3

TWO WAY SLAB - depth can be reduced

Q Design a RC slab for a room measuring 4m x 5m from inside. the slab carries a live load of 2000 N/m² & if it is finished with 20mm thick topping of self wt 24 kN/m3 Use M_{20} Concrete & Fe 415 steel. The slab is simply supported @ all edges with corners free to lift.

Given:

$L = 5m$

$l = 4m$

F.L = 200mm thick with 24 kN/m³

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

$f_y = 415 N/mm^2$

L.L = 2000 N/m² kN/m

multiply with breadth IIIly in beam

LL = 2000 x 1 x N/m

= 2 kN/m

Step 1: Check for 2 way slab

$\frac{L}{l} = \frac{5}{4} = 1.25 < 2$

∴ It is 2 way slab

Step 2: Computation of Slab dimension

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

Assume percentage tension reinforcement = 0.35

Modification factor = 1.4 from fig 4

$\frac{l}{d} = 20 \times 1.4$

$\frac{4000}{d} = 20 \times 1.4$

$d = 142.85$

Assume a clear cover of 20 mm / Better or take 30mm

ϕ of bars = 10mm

$D = d + c + \phi/2$

$= 142.85 + 20 + 5$

$= 167.85$

≈ 170 mm

$d = 170 - 20 - 5$

$d = 145$ mm

Assume width of slab b = 1m

Effective span

c/c → Support
...

Effective span in ... direction = 4+...

= 4.1...

Effective span in ...

= 5 + 0.1...

= 5.14...

Step 3: Computa... bending momen...

L.L = 2 kN/...

D.L = c/s Area...

= D x b x w...

= 0.17 x 2...

= 4.25

F.L = 0.02...

= 0.48

T.L = 6.73 k...

Moment = ?

Pg: 90 Anne...

cl. D-1.1

$l_x = 4.145$

$l_y = 5.145$

$M_x = \alpha_x w...$

$M_y = \alpha_y w...$

Effective Span

c/c → support length not given

So take only $l + d$.

effective span in one direction $= 4 + 0.145$

$= 4.145\,m$

effective span in other d^{rn}

$= 5 + 0.145$

$= 5.145\,m$

Step 3 : Computation of bending moment & Load.

L.L = 2 KN/m

D.L = c/s Area × unit wt

= D× b× unit wt

= 0.17 × 25

= 4.25 KN/m

F.L = 0.02 × 1 × 24

= 0.48

T.L = 6.73 KN/m

Moment = ?

Pg: 90 Annex D

cl. D-1.1

$l_x = 4.145\,m$ (smallest)

$l_y = 5.145\,m$

$M_x = \alpha_x w l_x^2$

$M_y = \alpha_y w l_x^2$

for α_x & α_y.

Table 27

$$\frac{l_y}{l_x} = \frac{5.145}{4.145} = 1.24 \approx 1.25$$

interpolate

$$\alpha_x = \frac{0.084 + 0.093}{2}$$

$= 0.0885$

$$\alpha_y = \frac{0.059 + 0.055}{2}$$

$= 0.057$

$M_x = \alpha_x\, w\, l_x^2$

$= 0.0885 \times 6.73 \times 4.145^2$

$= 10.233$ KNm

$M_{ux} = 15.345$ KNm

$M_y = \alpha_y\, w\, l_x^2$

$= 0.057 \times 6.73 \times 4.145^2$

$= 6.59$ KNm

$M_{uy} = 9.885$ KNm

Step 4 : Effective depth required =

should be less than 170.

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

$15.349 \times 10^6 = 0.36 \times 0.48 (1 - 0.42 \times 0.48) \times 1000 \times d^2 \times 20$

$d = 74.5\,mm$

$d_{provided} > d_{required}$

$145 > 74.5$

Hence Safe

Step 5: Computation of steel

(i) Shorter Direction (main bar)

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

$$15.349 \times 10^6 = 0.87 \times 415 \times A_{st} \times 145 \left[1 - \frac{A_{st}\, 415}{1000 \times 145 \times 20}\right]$$

$$A_{st} = \cancel{293.48}\ 306.63\,mm^2$$

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

$$= \frac{1000 \times \pi/4 \times 10^2}{306.63}$$

$$= 256.13\,mm \approx$$

$$250\,mm$$

Provide 10mm ϕ bar @ 250mm Shorter direction.

$$A_{st\,min} = 0.12\%\ bD$$

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

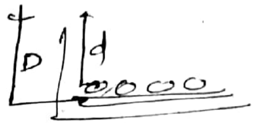
$$= 204\,mm^2.$$

(ii) Longer direction (main bar)

Both direction → Main bar.

$$d = 145 - \frac{10}{2} - \frac{10}{2}$$

$$= 135\,mm$$



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

$$9.885 \times 10^6 = 0.87 \times 415 \times A_{st} \times 135 \left(1 - \frac{A_{st} \times 415}{1000 \times 135 \times 20}\right)$$

$$A_{st} = 209.5\,mm^2$$

$$\text{Spacing} = 1000 \times \pi/4 \times 10^2 / 209.5$$

$$= \cancel{374}\ \approx 300\,mm$$

Provide 10mm ϕ bar 300 c/c longer

Check of spa

Step 6: Check for Shear

Cl. 40.1

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

$$V_u = \frac{w l_x}{2} \times 1.5$$

$$= \frac{6.73 \times 4.145}{2}$$

$$= 13.947 \times 1.5$$

$$= 20.9205$$

$$\tau_v = \frac{20.92 \times 10^3}{1000 \times 145}$$

$$= 0.144\,N/mm^2$$

145 − $\frac{10}{2}$ − $\frac{10}{2}$

= 135 mm

d

1000

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

$0.87 \times 415 \times A_{st} \times 135$

$1 - \frac{A_{st} \times 415}{1000 \times 135 \times 20}$

= 209.5 mm²

$\frac{1000 \times \pi/4 \times 10^2}{209.5}$

= 3~~74~~ ≈ 300 mm

Check of spa

mm ϕ bar 300 c/c longer

Check for Shear

Cl. 40.1

$= \frac{V_u}{bd}$

$\frac{w l_x}{2} \times 1.5$

$\frac{6.73 \times 4.145}{2}$

= 13.947 × 1.5

= 20.9205

$\frac{.92 \times 10^3}{00 \times 145}$

0.144 N/mm²

$\tau_c = \frac{100 A_s}{bd}$

$A_s = \frac{1000 \times \text{Area of 1 bar}}{\text{Spacing}}$

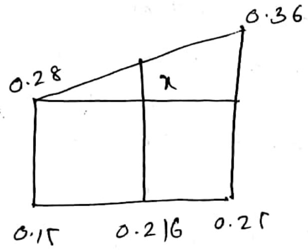
Shorter direcⁿ

$= \frac{1000 \times \pi/4 \times 10^2}{250}$

= 314.159 mm²

$\frac{100 A_s}{bd} = \frac{100 \times 314.159}{1000 \times 145}$

= 0.216



$\frac{0.25 - 0.15}{0.216 - 0.15} = \frac{0.36 - 0.28}{x}$

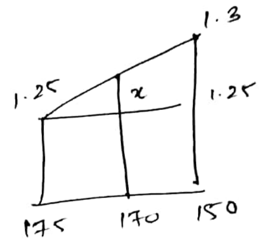
x = 0.0528

τ_c = 0.28 + 0.0528

τ_c = 0.3328

From Cl. 40.2.1.1 of

D = 170



$\frac{175 - 150}{175 - 170} = \frac{1.3 - 1.25}{x}$

x = 0.01

k = 1.26

$k\tau_c$ = 0.4193

$\tau_v < k\tau_c$

Slab is safe in shear.

Step 7 : Check for development length.

[Cl. 26.2]

$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}}$

$= \frac{10 \times 0.87 \times 415}{4 \times 1.2}$

= 752.187 mm

Q: Design a RCC roofing slab over a room 4m×5m the slab is simply supported on all 4 edges with corners held down. The superimposed load is 2kN/m² and floor finish is

Scanned by CamScanner

0.5 kN/m². Use M 15 concrete
Fe 415 steel

Given :-

$L = 5m$

$l = 4m$

$f_{ck} = 15 N/mm^2$

$f_y = 415 N/mm^2$

L.L = 2 kN/m² ↳ for an area ? doubt

= 2×1 kN/m [× breadth if unit is kN/m²]

STEP 1: CHECK FOR ONE WAY OR TWO WAY SLAB.

$\frac{L}{l} = \frac{5}{4} = 1.25 < 2$

∴ It is a 2 way slab.

STEP 2: COMPUTATION OF SLAB DIMENSION

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

Assume % tensile reinforcement = 0.35%.

~~MF = 1.4~~

∴ from fig 4. of IS 456:2000

MF = 1.4

$\frac{l}{d} = 20 \times 1.4$

$\frac{4000}{d} = 20 \times 1.4$

$d = 142.857$

Assume a clear cover of 20mm and diameter of 10 mm

$D = d + c + \phi/2$

$= 142.85 + 20 + 10/2$

$= 167.85 \approx 170$

$d = D - c - \phi/2$

$= 170 - 20 - 10/2$

$= 145$

Assume width b = 1m

Effective span ~~in~~ one direction

~~L+d~~

$l + d = 4000 + 145$

$= 4145 mm$

Effective span in other direction

$l + d = 5000 + 145$

$= 5145 mm$

STEP 3: COMPUTATIONS OF LOADS AND BENDING MOMENT

L.L = 2 kN/m

D.L = 0.17 × 1 × 25

= 4.25 kN/m

F.L = 0.5 × 1 kN/m²

= 0.5 kN/m

Total ~~tot~~ load

= 6.75 kN/m

$\frac{l_y}{l_x} = \frac{5.145}{4.145} = 1.24 \approx 1.25$

From table 27

$\alpha_x = \frac{0.072 + 0.079}{2}$

$= 0.0755$

(For all edges discontinuous) From table

$\alpha_y = 0.056$

~~Mx~~ =

Anne

D-1.1

Mx =

=

=

Mux =

My =

=

=

Muy =

Effec

Mu = 0.

↓

Highest

13.134

c

dreq

Her

STEP 4:

REI

Shorter

Mu = 0

13.134 = 0.

7.508×10

As

~~$M_x =$~~
Annex D

D-1.1.

$M_x = \alpha_x w l_x^2$

$= 0.0755 \times 6.75 \times 4.145^2$

$= 8.755$ kNm

$M_{ux} = 8.755 \times 1.5 = 13.1325$ kNm

$M_y = \alpha_y w l_{yx}^2$

$= 0.056 \times 6.75 \times 4.145^2$

$= 6.494$ kNm

$M_{uy} = 9.741$ kNm

Effective depth required =

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

↓
Highest

$13.134 \times 10^6 = 0.36 \times 0.48 [1 - 0.42 \times 0.48] \times 1000 \times d^2 \times 15$

$d_{required} = 79.66$ mm

$d_{required} < d_{provided}$

Hence safe

STEP 4: COMPUTATION OF REINFORCEMENT

Shorter direction

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

$13.134 = 0.87 \times 415 \times A_{st} \times 145 \left(1 - \frac{A_{st} \times 415}{1000 \times 145 \times 15}\right)$

$2.508 \times 10^{-4} = A_{st} - A_{st}^2 \, 1.908 \times 10^{-4}$

$A_{st} = 264.124$

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

$= \frac{1000 \times \frac{\pi}{4} \times 10^2}{264.124}$

$= 297.35 \approx 290$ mm

Longer direction: $d_{eff} = 145 - 10 = 135$

$9.741 \times 10^6 = 0.87 \times 415 \times A_{st} \times 135 \left[1 - A_{st} \times \frac{415}{1000 \times 135 \times 15}\right]$

~~$= A_{st} - A_{st}^2 \, 1.908 \times 10^{-4}$~~

$\frac{199.8}{\cancel{1.998 \times 10^{-4}}} = A_{st} - A_{st}^2 \, 2.049 \times 10^{-4}$

$\cancel{1.49 \times 10^{-4}}$ 208.7
$\cancel{4880}$ 4671.7

$A_{st} = 208.7$

Spacing $= 1000 \frac{\text{Area of 1 bar}}{A_{st}}$

$= \frac{1000 \, \pi/4 \times 10^2}{208.7}$

$= 376.3 \approx 300$
max

STEP 5: TORTIONAL REINFORCEMENT

As the corners are held on all the 4 corners are provided with torsion reinforcement

Size of torsion mesh

Size $= \frac{l_x}{5} \times \frac{l_{yx}}{5}$

$\frac{4.145}{5} = 0.83$

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$Size = 0.829m \times 0.829m$

At each corner & meshes one @ the top and one @ the bottom are provided.

Area of torsion steel =

$= \frac{3}{4} A_{st x}$

$= \frac{3}{4} \times 264.124$

$= 198.09 \, mm^2$

provide 10mm ϕ bars at spacing

$$= \frac{1000 \times \text{Area of 1 bar}}{A_{st}}$$

$$= \frac{1000 \times \frac{\pi}{4} \times 10^2}{198.09}$$

$= 396 \approx 300$

STEP 6: CHECK FOR SHEAR

MODULE - 2

FLANGED BEAM SECTION

Q: Determine the moment of resistance of an T-beam with following data

$b_f = 740mm$

$d = 400\,mm$

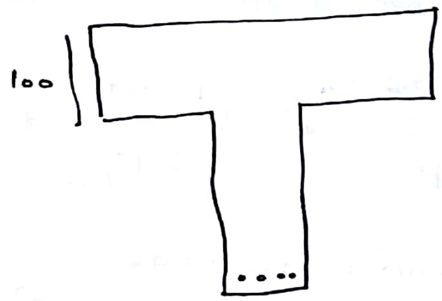
$b_w = 240\,mm$

$A_{st} = 5, 20mm\phi$

Fe 250

$D_f = 100\,mm$

M_{15} concrete



$\frac{x_u}{d} =$