$\tau_c = 0.67 + x$

$= 0.68\ N/mm^2$

$\tau_{c max} = 2.8\ N/mm^2$

$\tau_v > \tau_c > \tau_{cmax}$

Provide design shear reinforcement in the form of vertical stirrups

$$V_{us} = \frac{0.87\ f_y\ A_{sv} d}{S_v}$$

$V_{us} = V_u - \tau_c bd$

$= 150 \times 10^3 - 0.68 \times 250 \times 450$

$= 73500\ N$

2 legged - ϕ 8mm

$$73500 = \frac{0.87 \times 415 \times 2 \times \frac{\pi}{4} 8^2 \times 450}{S_v}$$

$S_v = 222.22\ mm = 220$

Check for spacing of shear reinforcement

Cl 26.5.1.5 of IS 456:2000

(i) 222.22 = 220

(ii) $0.75d = 0.75 \times 450 = 337.5$

(iii) 300

So provide 2 legged stirrup of 8mm ϕ @ 220 c/c

STEP 7 CHECK FOR DEFLECTION

$$\frac{l}{d} = \frac{5000}{450} = 11.11 < 20$$

$\therefore$ safe

STEP 8 CHECK FOR DEVELOPMENT LENGTH

cl. 26.2.1

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

$$= \frac{25 \times 0.87 \times 415}{4 \times 1.2}$$

$= 1880.46\ mm$

23.10.19 wednesday

SLAB MODULE 3

ONE WAY SLAB

- $\frac{L}{l}$ (larger span by shorter span) always greater than 2
- Slab is supported only on 2 opposite sides
- Since the ratio of longer span to shorter span is greater than 2 the load distribution takes place in the shorter direction
- The main reinforcement is provided only in one direction.

TWO WAY SLAB

The ratio of long[er] to shorter span is [less] than 2 and the [load] distribution takes pl[ace] [in b]oth direction

The main reinforc[ement] is provided in [both] direction

Slab is supporte[d on] the 4 sides

Q: Design a reinf[orced] concrete slab for [a room] having inside [dimensions] 3x7 m thicknes[s of] supporting wal[l] slab carries 75[mm] lime mortar at[...] The unit weight [...] by 20kN/m³ [...] on the slab [...] Assume the sl[ab] simply support[ed at] ends. Use M20 [and] Fe 415 steel.

L = 7m

l = 3m

thickness of s[...]

= 300[mm]

~~Finishing load~~ ~~= 20k~~

L.L = 2 kN/[...]

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FOR

l

= 11.11 < 20

FOR

ENT LENGTH

87 × 415

1.2

.46 mm

MODULE 3

AB

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always

2

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c sides

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reinforcement

only in

on.

TWO WAY SLAB

- The ratio of longer span to shorter span is less than 2 and the load distribution takes place in both direction
- The main reinforcement is provided in both direction
- Slab is supported on all the 4 sides

Q: Design a reinforced concrete slab for a room having inside dimension 3×7 m thickness of the supporting wall is 300mm slab carries 75mm thick lime mortar at its top The unit rate is given by 20 kN/m³ live load on the slab is 2 kN/m Assume the slab to be simply supported at the ends. Use M20 concrete & fe 415 steel.

$L = 7m$

$l = 3m$

modification factor

thickness of support = 300 mm

~~Finishing load = 20 kN/m³~~

L.L = 2 kN/m

Finishing load =

[75mm thick lime mortar unit wt = 20 kN/m³]

$= \cancel{1} \times 75 \times 20$

$= 1500$

length is always 1m

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

$f_y = 415 N/mm^2$

STEP 1: CHECK FOR ONE WAY SLAB

$\frac{L}{l} = \frac{7}{3} = 2.33$

> 2

∴ It is one way slab

STEP 2: SLAB DIMENSIONS

Pg: 38

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

{Assume Percentage tension reinforcement = 0.35

∴ Modification factor = 1.4 }

⇓

from Fig 4 of IS 456:2000

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

$\frac{3000}{d} = 20 \times 1.4$

$d = \frac{3000}{20 \times 1.4} = 107.14 mm$

Assume clear cover = 30

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

$c = 30$

$\phi = 12$ → max upto 16

$= 107.14 + 30 + 12/2$

$= 143.14$

$\approx 150 mm$

$d = 150 - 30 - 6 = 114 mm$, $b = 1m$

Effective span [cl 21.2.1

(i) c/c = 3300 (3000+300)

(ii) $l+d$ = 3000 + 114 = 3114

∴ effective span = 3114 mm

STEP 3 : COMPUTATION OF BENDING MOMENT & LOAD

L.L = 2 kN/m

D.L = c/s Area × unit wt

= 0.15 × 1 × 25

= 3.75 kN/m

FL = 0.075 × 1 × 20

= 1.5 kN/m

Total DL = 3.75 + 1.5

= 5.25 kN/m

Total Load = L.L + D.L

= 2 + 5.25

= 7.25 kN/m

$M = \frac{wl^2}{8} = \frac{7.25 \times 3.114^2}{8}$

$M_u = \frac{7.25 \times 3.114^2}{8} \times 1.5$

= 13.18 kNm

STEP 4 :

DEPTH OF NEUTRAL AXIS

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

$13.18 \times 10^6 = 0.36 \frac{x_u}{d}\left[1 - 0.42\frac{x_u}{d}\right]$

$1000 \times 114^2 \times 20$

$\frac{x_u}{d} = 0.15$ 0.0149 2.237

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

[cl. 38.1 of IS 456:2000

$\frac{x_u}{d} < \frac{x_{umax}}{d}$

∴ under reinforced

STEP 5: COMPUTATION OF Ast

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

$13.18 \times 10^6 = 0.87 \times 415 \times A_{st} \times 114 \left[1 - \frac{A_{st}\, 415}{1000 \times 114 \times 20}\right]$

$320.21 = A_{st} - A_{st}^2\, 1.82 \times 10^{-4}$

$x = 341.3,\ 5153.20$

$A_{st} = 341.3\ mm^2 \rightarrow$ main bar

frm Cl. 26.5.2.1

$A_{st\,min} = 0.12\%$ c/s area

$= \frac{0.12\, bD}{100}$ HYSD

$= \frac{0.12 \times 1000 \times 150}{100}$

$= 180\ mm^2 \rightarrow$ for distribution bar.

SPACING OF MAIN BAR

$= \frac{100\ \text{breadth} \times \text{Area of 1 bar}}{A_{st}}$

$= 1000 \times \frac{\pi}{4} \times 12^2$

$\overline{341.431}$

= 331.24 mm

check for spa

cl. 26.3.3 b of

(i) 331.24

(ii) 3×d = 3×

(iii) 300

So provide

@ 300 mm c/

main rein

DISTRIBUTION

Spacing = 1000×

Assume φ

8 mm =

1000 ×

= 279

Check for sp

distribution

(i) 279 ≈ 2

(ii) 5d = 5

(iii) 450

provide 8

@ 270 mm

distribution

of IS 456:2000]

ar

nforced

ATION of

st

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

$\times A_{st} \times 114$

$\frac{A_{st}\ 415}{1000 \times 114 \times 20}\Big]$

1.82×10^{-4}

53.20

main bar

c/s area

150

c150

for distribution bar.

IN BAR

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

$= \frac{1000 \times \frac{\pi}{4} \times 12^2}{341.431}$

$= 331.24\ mm^2$

check for spacing

cl. 26.3.3b of IS 456:2000 pg. 46

(i) 331.24

(ii) $3\times d = 3 \times 114 = 342$

(iii) 300

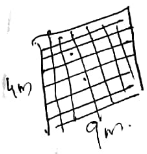
So provide 12mm ϕ bar @ 300mm c/c as main reinforcement

DISTRIBUTION REINFORCM^t

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

Assume ϕ of bars as 8mm =

$\frac{1000 \times \frac{\pi}{4} \times 8^2}{180}$



$= 279\ mm^2$

Check for spacing of distribution bars

(i) 279 ≈ 270mm

(ii) $5d = 5 \times 114 \times 570$

(iii) 450

Provide 8mm ϕ bars @ 270mm c/c as distribution bars

STEP 6 : CHECK FOR SHEAR

cl. 40.1

$\tau_v < k \tau_c$

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

$V_u = \frac{wl}{2} \times 1.5$

$= \frac{7.25 \times 3.114}{2} \times 1.5$

$= 16.93 kN$

$\tau_v = \frac{16.93 \times 10^3}{1000 \times 114}$

$= 0.148\ N/mm^2$

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

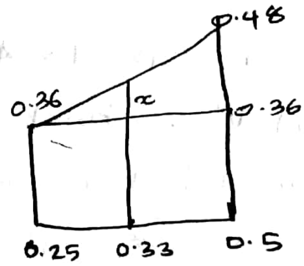
$A_s = \frac{1000 \times \text{Area of 1 bar}}{\text{Spacing}}$

$= \frac{1000 \times \pi/4 \times 12^2}{300}$

$= 376.99\ mm^2$

$\frac{100 A_s}{bd} = \frac{100 \times 376.99}{1000 \times 114}$

$= 0.33$



$$\frac{0.5-0.25}{0.33-0.25} = \frac{0.48-0.36}{x}$$

$x = 0.0384$

$\tau_c = 0.36 + 0.0384$

$= 0.3984$

From cl. 40.2.1.1 of IS 456: 2000

$k = 1.30$

$k\tau_c = 1.3 \times 0.3984$

$= 0.507$

$\therefore$ $0.148 < 0.507$

$\tau_v < k\tau_c$

$\therefore$ The slab is safe in shear

STEP 7 : CHECK FOR DEVELOPMENT LENGTH [Cl. 26.2]

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

$$= \frac{12 \times 0.87 \times 415}{4 \times 1.2}$$

$= 902.62$ mm

Q: Design a slab 9 x 4 m supported on brick wall 300 mm which is independent to be a floor of a library and is supposed to have a live load 5 kN/m. Use M20 concrete Fe 415 HYSD

$L = 9$ m

$l = 4$ m

Support 300 mm

L.L = 5 kN/m

FL = 1 kN/m

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

$f_y = 415 \text{ N/mm}^2$

STEP 1 : CHECK FOR ONE WAY SLAB

$$\frac{L}{l} = \frac{9}{4} = 2.25 > 2$$

It is one way slab

STEP 2 : SLAB DIMENSIONS

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

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

$d = 142.85$

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

$= 142.85 + 30 + 12/2$

$= 178.85$

≈ 200 mm

$d = 200 - 30 - 6$

$= 164$ mm

$b = 1$ m

Effective span

$c/c = 4000 +$

$l + d = 4000$

Effective sp

STEP 3 : COM

BENDING

LOAD

L.L = 5

D.L = 0.2

= 5

F.L = 1

TL = L.L +

= 11

$m = \frac{w l^2}{8}$

= 2

$M_u =$

=

STEP 4 : D

NE

$M_u = 0.36 \frac{x_u}{d}$

$35.161 \times 10^6 =$

$\frac{x_u}{d} -$

$\frac{x_u}{d} =$

$\frac{x_u}{d}$

N/m Use
Fe 415 HYSD steel

m

/m

$/mm^2$

N/mm^2

FOR
LAB

> 2

slab

DIMENSIONS

$+12/2$

6

(i) $c/c = 4000 + 300 = 4300$

$l + d = 4000 + 164 = 4164$

effective span = 4164 mm

STEP 3: COMPUTATION OF BENDING MOMENT & LOAD.

$L.L = 5 kN/m$

$D.L = 0.2 \times 1 \times 25$

$= 5$

$F.L = 1 kN/m$

$TL = L.L + D.L + FL$

$= 11 kN/m$

$$m = \frac{w l^2}{8} = \frac{11 \times 4.164^2}{8}$$

$= 23.84$.

20

$M_u = m \times 1.5$

$= 35.761 kNm$

STEP 4: DEPTH OF NEUTRAL AXIS

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

$$35.761 \times 10^6 = 0.36 \frac{x_u}{d}\left[1 - 0.42 \frac{x_u}{d}\right] 1000 \times 164^2 \times 20$$

$$\frac{x_u}{d} - 0.42 \frac{x_u^2}{d} = 0.1846$$

$x = 0.201, 2.179$

$$\frac{x_u}{d} = 0.201$$

$\frac{x_u}{d} < \frac{x_{umax}}{d}$ under reinforced

STEP 5: COMPUTATION OF A_{st}

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

$$35.761 \times 10^6 = 0.87 \times 415 \times A_{st} \times 164 \left[1 - \frac{A_{st} \times 415}{1000 \times 164 \times 20}\right]$$

$603.94 = A_{st} - A_{st}^2 \ 1.2 \times 10^{-4}$

$A_{st} = 655.5$ 7697

From Cl. 26.5.2.1

$A_{st\,min} = 0.12\%$ c/s area

$$= \frac{0.12 \ bD}{100}$$

12
8

$$= \frac{0.12 \times 1000 \times 200}{100}$$

$= 240 mm^2$

SPACING OF MAIN BAR

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

$$= \frac{1000 \times \pi/4 \times 12^2}{655.5}$$

$= 172.53 mm^2$

check for spacing
Cl. 26.3.3.b of IS 456:2000

(i) $172.53 \approx 170$
(ii) $3d = 3 \times 164 = 492$
(iii) 300

So provide 12mm ϕ bar @ ~~172.53~~ 170 mm c/c as main reinforcement

DISTRIBUTION REINFORCEMENT

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

Assume $\phi = 8mm$

$$\frac{1000 \times \pi/4 \times 8^2}{240}$$

$= 209.43\ mm^2$

Check for spacing

(i) $209.43 \approx 200$

(ii) $5d = 5 \times 164 = 820$

(iii) 450

provide 8mm ϕ bar at 200 mm c/c as distribution bars.

STEP 6: CHECK FOR SHEAR

Cl-40.1

$\tau_v < k\tau_c$

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

$$V_u = \frac{wl}{2} \times 1.5$$

$$= \frac{11 \times 4.164 \times 1.5}{2}$$

$= 34.353$

$$\tau_v = \frac{34.353 \times 10^3}{1000 \times 164}$$

$= 0.209$

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

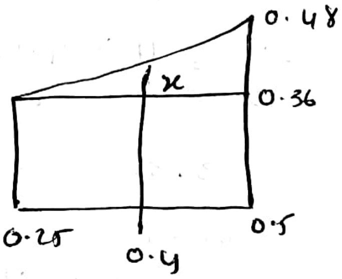
$$A_s = \frac{1000 \text{ Area of 1 bar}}{\text{Spacing}}$$

$$= \frac{1000 \times \pi/4 \times 12^2}{170}$$

$= 665.278$

$$100A_s/bd = \frac{100 \times 665.278}{1000 \times 164}$$

$= 0.405$



$$\frac{0.5 - 0.25}{0.5 - 0.4} = \frac{0.5 - 0.36}{x}$$

$x = 0.056$

$\tau_c = x + 0.36$

$= 0.416$

From cl-40.2.1.1

$k = 1.3$

$k\tau_c = 1.3 \times 0.416$

$= 0.499$

$\tau_v < k\tau_c$

slab is s...
Shear...

STEP 7: CH...
DEVELOP...
cl.26...

$Ld = \frac{\phi ...}{4 ...}$

$= 12 ...$

$= ...$

MODUL...

DESIGN OF...

A member ca... axial load ... column, the ... of which e... of its latera...

If the compre... carrying the ... ned or ho... termed as ...

- The column... various shap... circular, rect... etc.
- The longit... ment bars ... columns a... laterally t... columns a... laterally t... intervals, so... doesnot bu...

slab is safe in shear.

STEP 7: CHECK FOR DEVELOPMENT LENGTH
cl. 26.2.1

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

$$= \frac{12 \times 0.87 \times 415}{4 \times 1.2}$$

$$= 902.62 \, mm$$

MODULE 4

DESIGN OF COLUMNS

A member carrying direct axial load is called as column, the effective length of which exceeds 3 times of its lateral dimensions.

- If the compression member carrying the load is inclined or horizontal it is termed as strut
- The columns may be various shapes such as circular, rectangular, square etc.
- The longitudinal reinforcement bars in the columns are tied by laterally ties of suitable columns are tied by laterally ties or stirrups of suitable intervals, so that the bars doesnot buckle.

FUNCTIONS OF LONGITUDINAL REINFORCEMENT

- To share the vertical compressive load
- To provide ductility to the column.
- To resist the tensile stresses due to eccentric load, moment or transverse load.
- To reduce the effect of creep and shrinkage.
- To prevent brittle failure.

FUNCTIONS OF TRANSVERSE REINFORCEMENT

- To prevent brittle failure
- To provide ductility to column
- To confine the concrete thereby preventing longitudinal splitting.
- To resist diagonal tension caused due to transverse shear.
- To prevent longitudinal buckling of the longitudinal reinforcement.

SHORT COLUMNS AND LONG COLUMNS

A compression member is considered as short when the slenderness ratio (l/d) is less than 12 and if the slenderness ratio (l/d)

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