LNCT GROUP OF COLLEGES

Name of Faculty: Dr. D. K. Jain

Designation: Professor

Department: Civil Engineering

Subject: CE-601 Structural Design and Drawing (RCC-1)

Unit: 3 – Design of Slabs

Topic: Design of Circular Slabs

# Teaching/Learning from home

26.3.2020

Name of faculty : Dr. D. K. Jain

Designation : Professor

Department : Department of Civil Engineering
LNCT, Bhopal

Subject : CE-601
Structural Design & Drawing (RCC-1)

Unit : Unit-3 "Design of Slabs"

Topic : Design of circular slab
— Numerical example.

CE-601 SDD (RCC-1)

Unit-3 : Design of Slabs

Topic: Design of circular slab

## Numerical Example:-

Design a simply supported circular slab carrying a superimposed load of 3 kN/m². The effective diameter of the slab is 4.8m. Use M20 grade concrete and Fe 415 grade steel. Assume Poisson's Ratio for RCC as zero.

## Solution:-

For circular slabs of smaller spans ratio of $\frac{\text{Effective span}}{\text{Overall depth}}$ i.e. $\frac{l}{D}$ can be taken as 40 to meet serviceability criteria of deflection.

$\frac{l}{D} = 40$ or, $\frac{4800}{D} = 40$ $\therefore D = 120$ mm.

effective depth $d = D -$ clear cover $- \frac{\text{bar diameter}}{2}$

or, $d = 120 - 15 - \frac{10}{2} = 100$ mm.

### Load Calculations:-

Dead Load of slab $= 0.12 \times 25 = 3$ kN/m²

Superimposed Load $= 3$ kN/m²

Total load $= 6$ kN/m²

Factored load $w_u = 6 \times 1.5 = 9$ kN/m²

Moment Calculations:- (Bending moments per m. width of slab)

A. At Centre of Span:-

Maximum radial B.M. $M_r = \frac{3\,w_u \cdot R^2}{16}$

$= \frac{3 \times 9 \times (2.4)^2}{16}$

$\therefore M_r = 9.72$ kN-m ——— ①

$R = \frac{D}{2}$
$= \frac{4.8}{2}$
$\therefore R = 2.4$ m.

Maximum circumpherencial B.M. $M_\theta = \frac{3\,w_u \cdot R^2}{16} = M_r$

$\therefore M_\theta = 9.72$ kN-m. ——— ②

B. At Support:-

$M_r = 0$ ——— ③

$M_\theta = \frac{2\,w_u \cdot R^2}{16} = \frac{2 \times 9 \times (2.4)^2}{16} = 6.48$ kN-m ——— ④

Check for depth & type of section:-

Max. B.M. from ①, ②, ③ & ④ $M_u = 9.72$ kN-m.

for balanced section $M_u = 0.138\, f_{ck} \cdot b \cdot d^2$
& Fe 415 grade steel

$\therefore d = \sqrt{\frac{M_u}{0.138 \cdot f_{ck} \cdot b}}$

$= \sqrt{\frac{9.72 \times 10^6}{0.138 \times 20 \times 1000}}$

$\therefore d = 59.34$ mm. $< (d)_{provided} = 100$ mm.

Hence, OK

Since $(d)_{required} < (d)_{provided}$, the section is under-reinforced.

## Area of steel calculations:-

Since section is under-reinforced

So, $M_u = 0.87 . f_y . A_{st} . d \left(1 - \frac{A_{st}}{b.d} . \frac{f_y}{\cancel{A_{st}}\, f_{ck}}\right)$ ---- Ann. G IS 456: 2000

### A. At midspan:-

$M_x = M_\theta = M_u = 9.72$ kN-m.

So, $9.72 \times 10^6 = 0.87 \times 415 \times A_{st} \times 100 \left(1 - \frac{A_{st}}{1000 \times 100} \times \frac{415}{20}\right)$

Or, $269.21 = A_{st}\left(1 - \frac{A_{st}}{4819}\right)$

solving by trial & error we get $A_{st} = 290\ mm^2$

Minimum steel $= 0.12\%$ of gross cross sectional area

$= \frac{0.12}{100} \times 1000 \times 120$

$= 144\ mm^2$ $\qquad 290 > 144$ so, OK.

Spacing of 10 mm. dia bars (area $= 78.5\ mm^2$) $= \frac{1000}{290/78.5} = 270.7$ mm.

Hence provide 10 mm. dia bars @ 270 mm. c/c in both directions (x & y) in the form of mesh.

### B. At Support:-

$M_r = 0$

$M_\theta = 6.48$ kN-m.

which is $\frac{2}{3}$ of $M_\theta$ at centre $\left[\begin{array}{l} M_\theta \text{ at centre} = \frac{3}{16} W_u R^2 \\ M_\theta \text{ at support} = \frac{2}{16} W_u R^2 \end{array}\right.$

$\therefore A_{st} = \frac{2}{3} \times 290 = 193\ mm^2 > \text{min. } 144\ mm^2$

Hence, OK

This is to be provided in the form of circumferential rings near support in a distance of $\frac{2}{3} L_{dt} = \frac{2}{3} \times 47\phi = \frac{2}{3} \times 47 \times 10 = 313$ mm.
say 320 mm.

[ $L_{dt}$ is development length in tension $= 47\phi$ for M20 concrete. & $\phi$ = dia of bar = 10 mm. (say) ]

No. of 10 mm. dia rings required $= \frac{193}{78.5} = 2.46$
say 3

So, provide 3 rings in a distance of 320 mm. near support.

All the above steel is provided as bottom steel.

__Top steel near support:-__

To account for partial fixity, if any (due to construction of parapet wall over slab etc.), −ve moment reinforcement is provided near supporting edge for a moment of approx. $\frac{1}{3}$ of moment at centre

So, $A_{st} = \frac{1}{3} \times$ midspan steel

$= \frac{1}{3} \times 290$

$= 96.7 \text{ mm}^2 < \text{min. } 144 \text{ mm}^2$

so provide $A_{st} = 144 \text{ mm}^2$

Spacing of 8 mm. dia bars (area = 50 mm²) = $\frac{1000}{144/50}$ = 347 mm. > max. spacing = 300 mm.

So provide 8 mm. dia bars @ 300 mm. c/c

This is to be provided in radial direction, for a distance of $L_{dt} = 47\phi = 47 \times 8 = 376$ mm. say 400 mm.

## Check for Shear :-

Max. shear $V_u = \frac{w_u \cdot l}{2}$

$= \frac{9 \times 4}{2}$

or, $V_u = 18$ kN

Nominal shear stress $\tau_v = \frac{V_u}{bd}$

$= \frac{18 \times 1000}{1000 \times 100}$

$\therefore \tau_v = 0.18$ N/mm²

We can skip these steps as $\tau_v = 0.18$ N/mm² which is less than min. $\tau_c = 0.28$ N/mm² mentioning the same.

% steel provided at support

$= \frac{\overbrace{(1000/270)}^{\text{no. of bars}} \times \overbrace{78.5}^{\text{area of bar}}}{\underbrace{1000}_{b} \times \underbrace{100}_{d}} \times 100$

$= 0.29\%$

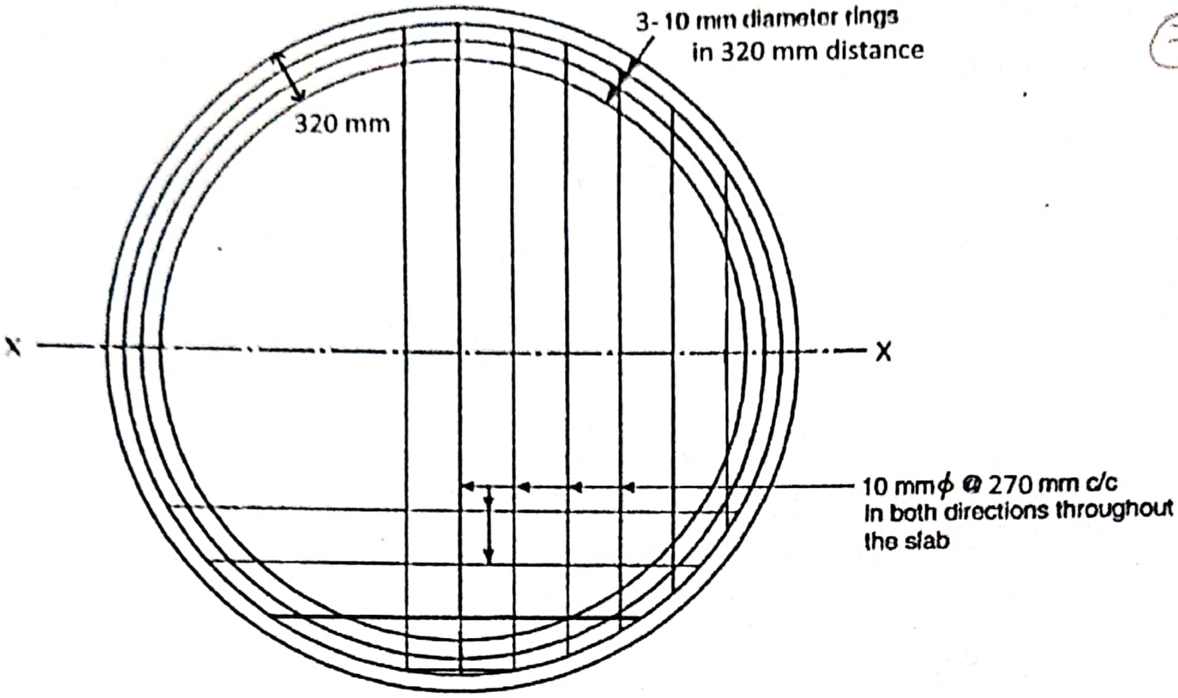
$\tau_c = 0.36 + \frac{(0.48-0.36)}{(0.50-0.25)} \times (0.29-0.25)$ --- from Table 19 IS 456:2000

$\therefore \tau_c = \cancel{37.92}\ 0.3792$ N/mm²

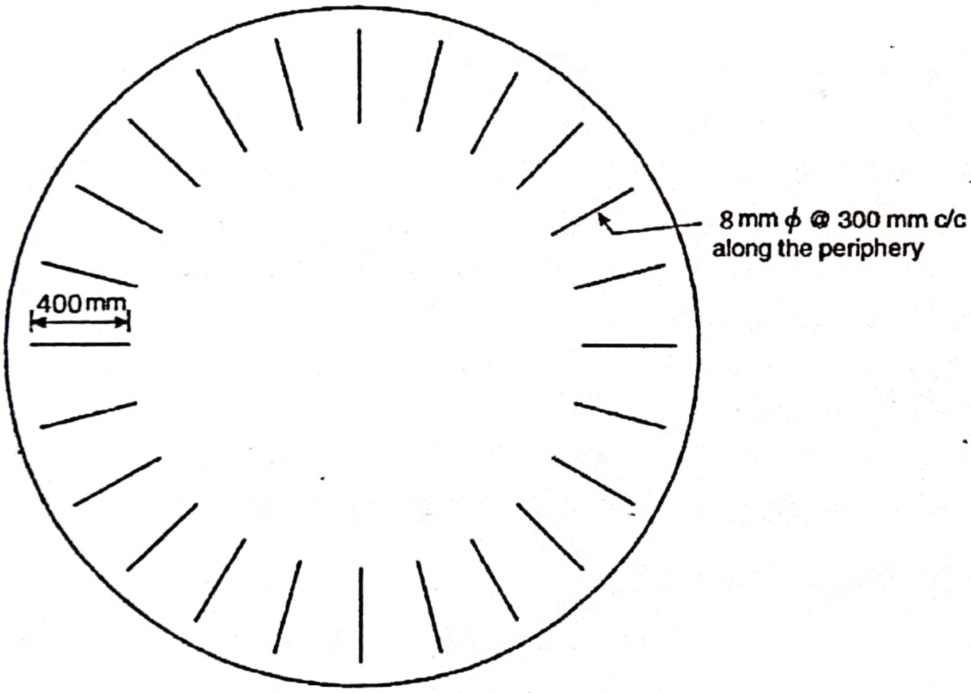
$k = 1.30$ for slab thickness < 150 mm. — " —

$k \cdot \tau_c = 0.3792 \times 1.30 = 0.493$ N/mm² > $\tau_v = 0.18$ N/mm²

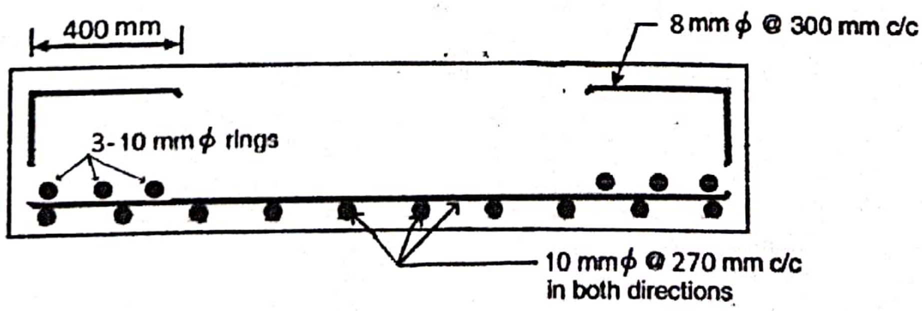
Hence, safe




(*a*) Plan of bottom reinforcement




(*b*) Plan of top reinforcement




(*c*) Section at X-X

END