Internal Assessment Test 3 – January 2023

SOLUTION

Sub:	Design Of RC Structural Elements					SubCode:	18CV53	Branch:	Civil
Date:	20.01.2023	Duration:	90 mins	Max Marks:	50	Sem/Sec:	V		

1 A simply supported RC beam supports a service live load of 8kN/m over a clear span of 3m. Support width is 200mm. Adopt M20 grade concrete and Fe415 grade steel. Design the beam for flexure and shear. No checks to be done.

A simply supported RC beam supports a service live load of 8 kN/m over a clear span of 3m. Support width is 200mm. Adopt M20 grade concrete and Fe415 grade steel. Design the beam of flexure and shear. Check the beam depth for control of deflection using empirical method. Sketch the reinf details. (VTU- June/July 2015)

Solution:-

PART A. Design for flexural M_{max}.

Factored moment M_u due to applied load.

Let $D = \frac{span}{10} = \frac{3000}{10} = 300mm$

Let us assume clear cover = 20mm.

$\therefore$ Effective cover $= 20 + 8 + \frac{12}{2} \approx 35mm$

$d = 300 - 35 = 265mm$

Effective span is least of
- → Clear span + d $= 3000 + 265 = 3265mm$.
- → c/c distance of supports $= 3000 + \frac{200}{2} + \frac{20}{2} = 3200mm$.

$\therefore$ Effective span $= l_{eff} = 3200mm = 3.2m$.

Assuming width of beam = 200mm.

Live load = 8 kN/m.

Self wt of beam $= 0.2 \times 0.3 \times 1 \times 25 = 1.5 kN/m$.

Total udl on beam $= 8 + 1.5 = 9.5 kN/m$.

$\therefore$ Factored load $w_u = 9.5 \times 1.5 = 14.25 kN/m$.

$\therefore$ Factored Moment $= M_u = \frac{w_u l_{eff}^2}{8}$

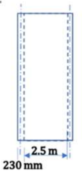
$\therefore M_u = \frac{14.25 \times 3.2^2}{8} = 18.24 kN\text{-}m$.

2 A simply supported slab of a corridor of a hospital building has a clear span 2.5 m and is supported on walls of 230 mm thickness. Design the slab, if it is carrying a live load of 5 kN/m^2. Use M20 concrete and HYSD Fe415 bars. No checks to be done.

	(solution continued below)

Problem #1

A simply supported slab of a corridor of a hospital building has a clear span 2.5 m and is supported on walls of 230 mm thickness. Design the slab, if it is carrying a live load of 5 kN/m^2. Use M20 concrete and HYSD Fe415 bars.



Solution:-

Step 1: –To find the effective depth of slab

Bearing width = 230mm

Effective depth $d = \frac{L}{25} = \frac{2500}{25} = 100\ mm$

d =100 mm

Assuming 8 mm diameter bars

Assuming clear cover of 15 mm.

$D = 100 + 15 + \frac{8}{2} = 119\ mm$

Assuming an overall depth D = 120 mm

$d = 120 - 15 - \frac{8}{2} = 101\ mm$

l = Clear span + support width OR Clear span + d

Effective span $l = 2500 + 230 = 2730\ mm$ OR

$l = 2500 + 101 = 2601\ mm$ (least)

Step 2: –To find the total factored load on slab

Selfweight of slab $= 0.120 * 1 * 1 * 25 = 3\ kN/m^2$

Live load on slab = $= 5\ kN/m^2$

Total load on slab = $= 8.kN/m^2$

Total factored load on slab = W_u $= 12\ kN/m^2$

Factored moment $= M_u = \frac{W_u * l^2}{8} = \frac{12 * 2.6^2}{8}$

$M_u = 10.14\ kNm/m$

Factored Shear $= V_u = \frac{W_u * l}{2} = \frac{12 * 2.6}{2} = 15.6\ kN$

Step 3: –Check for effective depth

$M_u = M_{ulim} = 0.138 * f_{ck} * b * d^2$

$d_{req} = \sqrt{\frac{M_u}{0.138 * f_{ck} * b}} = \sqrt{\frac{10.14 * 10^6}{0.138 * 20 * 1000}}$

$d_{req} = 60.61\ mm < d_{prov} = 101\ mm$ Hence Safe

Step 4: –To find slab reinforcement

Using SP16, Referring table 37 (74/97)

For $M_u = 10.14\ kN-m/m$

Provide 8 mm ∅ bar @ 160 mm c/c along Shorter span

Area of single 8 mm dia bar $= A_b = \frac{\pi}{4} * 8^2 = 50.265\ mm^2$

Area of tension reinforcement $= A_{st} = \frac{1000 * A_b}{spacing}$

$A_{st} = \frac{1000 * 50.265}{160} = 314.16\ mm^2$

$p_{tprov} = \frac{A_{st}}{b * d} * 100 = \frac{314.16}{1000 * 101} * 100 = 0.311\%$

Maximum spacing $= 3 * d = 3 * 101 = 301$ OR

=300mm whichever is least

Hence OK

Step 5: –To find distribution reinforcement

$A_{stdist} = A_{stmin} = 0.12\% bD = \frac{0.12 * 1000 * 120}{100} = 144\ mm^2$

Provide minimum reinforcement A_{stmin} along the longer span

Using 8 mm dia bar , Spacing $= \frac{1000 * 50.265}{144} = 349.1\ mm$

Provide 8 mm ∅ bar @ 300 mm c/c along longer span.

Maximum spacing $= 5 * d = 5 * 101 = 501$ OR

= 450mm whichever is least

Also, $A_{stprov} = 314.16\ mm^2 > A_{stmin} = 144\ mm^2$ Hence OK

Step 6: –Check for shear

$V_u = 15.6\ kN$

$\tau_v = \frac{V_u}{b * d} = \frac{15.6 * 10^3}{1000 * 101} = 0.1545\ MPa$

$p_{tprov} = 0.311\%$

Refer Table 19 on page 73 of IS 456:2000 (73/86)

$100\frac{A_{st}}{bd}$	τ_c for M20
0.25	0.36
0.311	0.389
0.5	0.48

For slabs design shear strength $= k * \tau_c$

Refer page 72 of IS456:2000

For D <150 mm , k = 1.3

$k * \tau_c = 1.3 * 0.389 = 0.51\ MPa$

$\tau_v < k * \tau_c$ Hence safe

Step 7: –Check for deflection

$\left(\frac{l}{d}\right)_{max} = \left(\frac{l}{d}\right)_{basic} * K_t$

Considering $A_{stprov} = A_{streq}$

Refer figure 4 on page 38 of IS456:2000(38/51)

$f_s = 0.58 * f_y \frac{A_{stprov}}{A_{streq}} = 0.58 * f_y$

$f_s = 0.58 * 415 = 240.7\ MPa$

$p_{tprov} = 0.311\%$

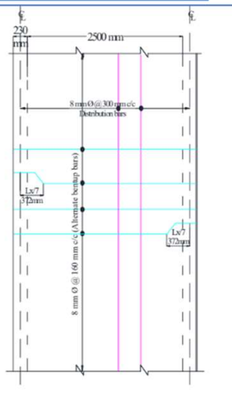
$K_t = 1.5$

$\left(\frac{l}{d}\right)_{basic} = 20$

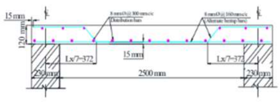
$\left(\frac{l}{d}\right)_{max} = 20 * 1.5 = 30$

$\left(\frac{l}{d}\right)_{prov} = \frac{2600}{101} = 25.74$

$\left(\frac{l}{d}\right)_{max} > \left(\frac{l}{d}\right)_{prov}$ Hence safe



BOTTOM PLAN SHOWING SLAB REINFORCEMENT DETAILS



SECTION ALONG THE SHORT SPAN OF SLAB

3	Design a dog legged stairs for an office building in a room measuring 2.8m x 5.8 m clear. Vertical distance between the floors is 3.6m. Width of flight is to be 1.25m. Allow a live load of 3 kN/m^2. Sketch the details of the reinforcements. Use M20 concrete and Fe415 steel. Assume the stairs are supported on 230 mm walls at the end of outer edges of landing slabs.

Let us select steps of rise 150 mm

Floor to floor height = 3.6 m.

Height of one flight = $\frac{3.6}{2}$ = 1.8 m = 1800 mm.

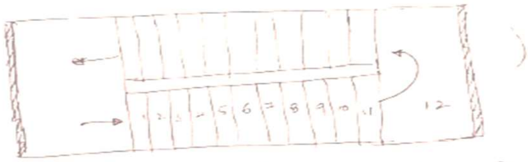
Number of Risers = $\frac{1800}{150}$ = 12

Hence number of treads = 12 − 1 = 11.

Width of stair = 1.25 m

For 11 treads we need a length of 11 × T.

Selecting tread T = 300 mm, the steps may be.



Effective span: − Centre to center distance of walls.

= 1.25 + 3.3 + 1.25 + 0.23 = 6.03 m.

loads: − $\frac{\text{Span}}{24}$ = 251 = d ≈ 250 mm. D = 280 mm.

Weight of waist slab = $25t\frac{\sqrt{R^2+T^2}}{T}$

= $25 \times 0.28 \times \frac{\sqrt{0.3^2 + 0.15^2}}{0.3}$ = 7.83 kN/m

Weight of steps = $\frac{1}{2} \times R \times 25 = \frac{1}{2} \times 0.15 \times 25$ = 1.875 kN/m.

Dead load = 9.7 kN/m.

adding finishing load, we get

Total dead load = 9.7 + 0.8 = 10.5 kN/m

In landing portion

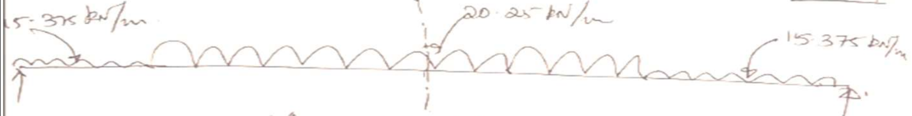
DL = 0.25 × 1 × 25 = 6.25 kN/m

With finishing material, = 7.25 kN/m.

live load = 3 kN/m²

Factored load on going = 1.5 (10.5 + 3) = 20.25 kN/m

Factored load on landing slab = 1.5 × (7.25 + 3) = 15.375 kN/m



M_u = 87.5 kN−m.

V_u = 54.40 kN.

A_{st} = 1063 mm²

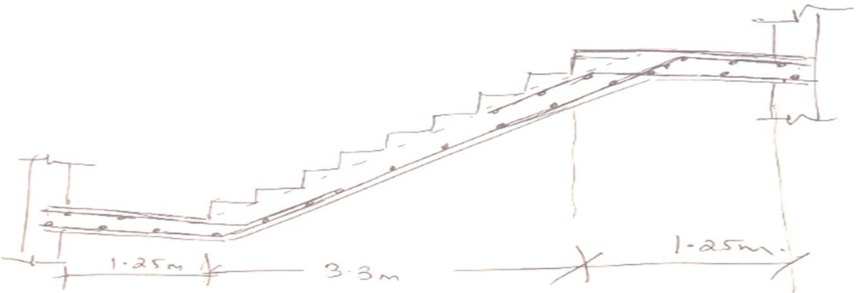
Spacing = 180 mm c/c

Distribution steel

$A_{st\,dist}$ = 0.12% bD.

= $\frac{0.12}{100}$ × 1000 × 280 = 336 mm².

Spacing = 233 mm.



4	Design a circular column of diameter 400 mm with helical reinforcement subjected to a working load of 1200 kN. Use M25 concrete and Fe415 steel. The column has unsupported length of 3m and is effectively held in position at both ends, but not restrained against rotation.

Sol^n:-

Unsupported length $l = 3m$.

Ends are hinged. $\rightarrow L = l = 3m$.

Slenderness ratio $= \frac{L}{d} = \frac{3000}{400} = 7.5 < 12$

$\therefore$ It may be designed as short column.

Minimum Eccentricity :-

$e_{min} = \frac{L}{500} + \frac{D}{30} = \frac{3000}{500} + \frac{400}{30} = 19.33 < 20\,mm$

$\boxed{e_{min} = 20\,mm}$

Hence, it is axially loaded column.

Main reinforcement :-

$P_u = 1.05\,[0.4\,f_{ck}\,A_{cc} + 0.67\,f_y\,A_{sc}]$

$P = 1200$

$P_u = 1.5 \times 1200 = 1800\,kN$

let $A_g = A_{cc} + A_{sc}$

$A_{cc} = A_g - A_{sc}$

$A_g = \pi/4 \times 400^2 = 125663.706\,mm^2$

$\therefore 1800 \times 10^3 = 1.05\,[0.4 \times 25 \times (125663.706 - A_{sc}) + 0.67 \times 415 \times A_{sc}]$

$\therefore A_{sc} = 1707.3\ mm^2$

Provide 20mm dia bars.

$\therefore$ No. of bar = 5.4 ≈ 6 bars.

$\therefore$ Provide #6 nos. of 20mm dia bars.

Helical reinforcement-

Using 8mm φ spirals at pitch 'S'

Core diameter = 400 − 2(50) = 300mm

Area of core = $A_c = \left(\frac{\pi}{4} \times 300^2\right) - \left(6 \times \frac{\pi}{4} \times 20^2\right)$

$\therefore \boxed{A_c = 68800\ mm^2}$

length of one spiral of 8mm diameter

$= \pi(300-8) = 292\pi$

Volume of core per pitch height S, = 68800 × S.

As per. Volume of one spiral = $V_{us} = \frac{\pi}{4} 8^2 \times 292\pi$

$= 46110\ mm^2$

As per IS 456

$$\frac{V_{us}}{V_c} \leq 0.36\left(\frac{A_g}{A_c} - 1\right)\frac{f_{ck}}{f_y}$$

$$\frac{4610}{68800\,S} \leq 0.36\left[\frac{125663.7}{68800} - 1\right]\frac{25}{415}$$

$S \geq 37.4\ mm.$

Max^m pitch → 75 mm or $\frac{1}{6}$(core diameter) $= \frac{1}{6} \times 300 = 50mm$

Min^m pitch → 25 mm or 3 × (diameter of helical reinf)

3×8 = 24mm

$\therefore$ Provide 8mm Spirals @ 40mm pitch.