CBCS SCHEME

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17CV/CT51

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Design of RC Structural Elements

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of IS 456-2000 and SP-16 is permitted.

Module-1

1 a. Explain balanced section, over reinforced section and under reinforced section. **(06 Marks)**

b. Derive the expression for limiting steel and find limiting percentage steel for M20 concrete and Fe415 steel. **(06 Marks)**

c. A doubly reinforced rectangular beam 250 × 550mm reinforced with 4-22mm diameter in tension 2-16mm diameter in compression E cover 50mm E span 12m Fe 415 steel. Check the deflection using modification factors. **(08 Marks)**

OR

2 a. Explain working stress method and limit state method of design. **(06 Marks)**

b. Explain the philosophy of structural design. **(06 Marks)**

c. Derive the expression for stress block parameters of compressive force C and its CG dist $\overline{Y}$. **(08 Marks)**

Module-2

3 a. A singly reinforced beam 250mm × 500mm is reinforced with 4-16mm diameter E-Cover 50mm E span 6m. Determine the central point load that can be applied at mid span adopt M20 concrete Fe 500 steel. **(10 Marks)**

b. Find the steel for a rectangular section 300mm × 600mm to support a load of 80kN/m E-span 6m E-Cover 50mm adopt M20 concrete Fe 415 steel. **(10 Marks)**

OR

4 a. A doubly reinforced concrete beam 250 × 450mm is reinforced with 4-20mm diameter in comp 6-20mm diameter in tension. Find ultimate moment take E cover 50mm adopt M20 concrete Fe415 steel. **(10 Marks)**

b. A T beam has a flange width 1200mm flange thickness 100mm E depth 600mm web 300mm. Find steel to support ultimate moment 700kN m adopt M20 concrete Fe510 steel. **(10 Marks)**

Module-3

5 Design a beam having clear span 5m supporting a love load 10kN/m for flexure and shear. Apply the check for deflection and bond. Adopt M20 concrete Fe415 steel. **(20 Marks)**

OR

6 A rectangular beam 250mm × 500mm to support a load 40kN/m including self wt (working load) E-span 5m E-cover 50mm. Design the beam for flexure and shear and apply check for deflection and bond. **(20 Marks)**

Module-4

7 Design a two way slab for a room 6m × 4m wall thickness 230mm. All edges discontinuous and corners are held down live load $4kN/m^2$ floor finish $1kN/m^2$ thickness of slab 150mm adopt M20 concrete Fe415 steel. **(20 Marks)**

OR

8 An open well stair case is to be provided for a stair hall 3.25m × 3.25m. The size of open well at centre 1.25m × 1.25m Floor height 3.6m size of landing at each corner is 1m × 1m thickness of stair wall 230mm. The stair slab is embedded into wall by 200mm live load $3kN/m^2$ design the stair. **(20 Marks)**

Module-5

9 a. An axially loaded RCC column un supported length 2.75m has to carry an axial load 2000kN design a square section column. **(12 Marks)**

b. Design a column using SP-16 having a section 300mm × 400mm subjected to ultimate load 1200kN ultimate moment M_u = 200kN m. Take effective cover 50mm. Assume steel on two sides only. **(08 Marks)**

OR

10 A square column 400mm sides carries a load of 900kN. Design footing SBC of soil $100kN/m^2$ adopt M20 concrete Fe415 steel. Apply the check for one way shear and two way shear and bond. Assume depth of edges 300mm (Isolated footings). **(20 Marks)**

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Design of RCC -17CV51

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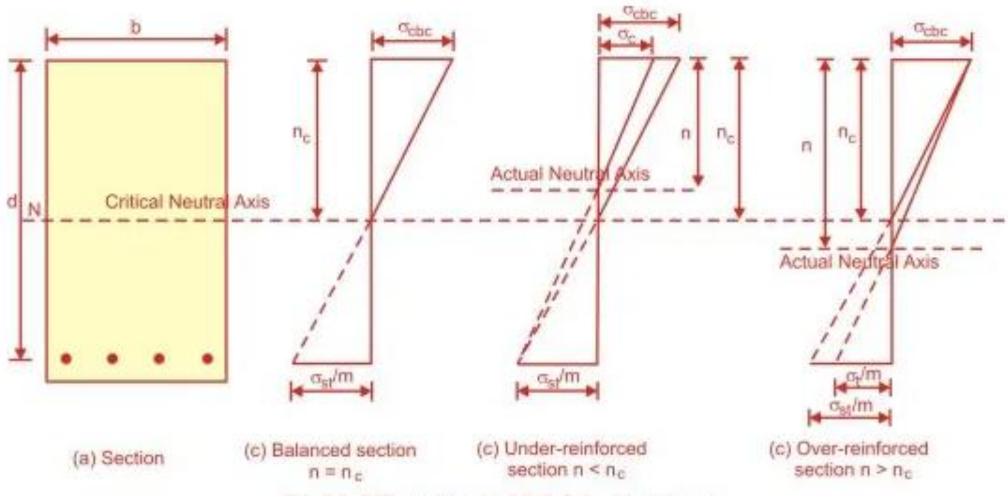

- A balanced sections is that in which stress in concrete and steel reach their permissible value at the same time. This means that stress diagram is as shown in Fig. *The percentage of steel corresponding to this section is called as balanced steel and the neutral axis is called as critical neutral axis n_c*
- In an under reinforced section, the percentage of steel provided is less than that provided in balanced section. So the actual neutral axis will shift upwards i.e., $n_c > n$ as shown in Fig. 2.6(c). In under reinforced section, the stress in steel first reaches it permissible value, while the concrete is under stressed.
- In an over reinforced section the percentage of steel provided is greater than the balanced section. So the actual neutral axis shift downward i.e., $n > n_c$

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Sr. No.	Working Stress Method	Limit State Method
4	It does not give any idea about margin of safety available for loads to assess the extent of overloading without collapse.	It gives an idea about the excess load which a structure can carry beyond the working load without collapse.
5	The method follows a deterministic approach as it assumes that the loads, factor of safety and permissible stresses are accurately known.	The method follows a non-deterministic approach as it adopts probable loads and probable strength of materials as per actual or based on experience or observations depending upon the situation.
6	Material strengths are not fully utilized in designing the member.	Material strengths are fully utilized in designing the member.
	Merits / Demerits	
1	It is a simple method. (merit)	It is a somewhat complicated method involving more calculations. (demerit)
2	Due to its simplicity, it is still used for design of some complex structures such as Overhead water tanks, bunkers, silos etc. (merit)	The method is still evolving for the design of more complex structures. (demerit)

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Three Major Design Philosophies:

Design of RCC -17CV51

Working Stress Method/ Allowable Stress Design

Working stress method is used for the design of Reinforced concrete, Steel and Timber structures. The main assumption in the WSM is that the behaviour of structural material is restricted with in linear-elastic region and the safety of it is ensured by restricting the stresses coming on the members by working loads. Thus the allowable stresses will come in the linear portion (i.e., initial phase) of the stress-strain curve. Thus a factor of safety was introduced to the design

"Factor of safety is the ratio of strength of material to the permissible stress"

Ultimate Load Method

This is also known as load factor method or ultimate strength method. In this we make use of the nonlinear region of stress strain curves of steel and concrete. The safety is ensured by introducing load factor.

"Load factor is the ratio of ultimate strength to the service loads"

Limit State Method

This philosophy is an advancement over the traditional design philosophies. It considers the safety at the ultimate load and serviceability at the working load, sort of extension of the WSM and ULM.

"Limit state is the state of impending failure, beyond which a structure ceases to perform its intended function satisfactorily, in terms of either safety or serviceability."

1)
b)

$$C = T$$

$$0.36 f_{ck} \, b \cdot x_{umax} = 0.87 f_y A_{st\,lim}$$

$$A_{st\,lim} = \frac{0.36 f_{ck} \, b \cdot x_{umax}}{0.87 f_y}$$

$$= 41.4 \, f_{ck}/f_y \, \frac{x_{umax}}{d}$$

For M 20 & Fe-415 steel.

$$A_{st\,lim} = 0.958\text{-}1 .$$

1)
c)

$$\left(\frac{l}{d}\right)_{basic} = \frac{20 \times 10}{d} = 16.67$$

$$\left(\frac{l}{d}\right)_{Achieved} = 24 \cdot K_t \cdot 0.95 \, K_c$$

$$\therefore \left(\frac{l}{d}\right) = 17.42 < 24 \quad \therefore \text{safe}.$$

3) a) $\frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} \cdot b \cdot d} = 0.43 < 0.46$ [2]

under reinforced section.

$M_u = 0.87 f_y A_{st} d \left(1 - A_{st} f_y / b \cdot d f_{ck}\right)$ [4]

$= 129.26$

Self wt $= 3.125$ kN/m,

$B.M = \frac{Wl^2}{8} + \frac{WL}{4} = 48$ kN.

3) b) Self wt $= 0.3 \times 0.6 \times 1 \times 25$

$= 4.5$ kN/m

Total load $= 84.5$ kN/m.

$M_u = \frac{Wl^2}{8} = 570.4$ kN m

$M_{u\,lim} = 0.138 f_{ck} bd^2 = 250.5$ kN m < 570.4

Doubly Reinforced beam

$\frac{d'}{d} = 0.1$

$M_u = M_{u\,lim} - f_{sc} A_{sc} (d' - d)$

$\therefore A_s = 1812.4$ mm²

$A_{st1} = \frac{0.36 \times 20 \times 300 \times 0.48 \times 550}{0.87 \times 415} = 1577.4$ mm²

$A_{st2} = 353$

$\therefore \quad A_{st} = 3351\ mm^2$

4)

a) $\frac{d'}{d} = 0.15 \Rightarrow f_{sc} = 342\ N/mm^2$

$C = T, \quad 0.36 \times 20 \times 250\ x_u + (342 \times 1256)$

$x_u = 139.3\ mm$

$M_u = 0.36\ f_{ck}\ b.\ x_u\ (d - 0.42 x_u) + f_{sc} A_s\ (d - d')$

$= 253.9\ kN\,m.$

b) $M_u = 0.36\ f_{ck}\ B_f\ d_f\ (d - 0.42 D_f)$

$= 482.1\ kN\,m.$

$\frac{D_f}{d} = \frac{100}{600} = 0.166 < 0.2$

$M_{u\,lim} = 0.138\ f_{ck}\ b_w d^2 + 0.45\ f_{ck}\ (b_f - b_w)\ D_f (d - \frac{d_f}{2})$

$= 743.6\ kN\,m \quad > 700\ kN\,m.$

$x_u = 235\ mm$

$A_{st} = 3649.4\ mm^2 \quad \left[\frac{0.36 f_{ck} b_w x_u}{0.87 f_y} + \frac{0.45 f_{ck} (b_f - b_w) D_f}{0.87 f_y} \right]$

5) Cross section , 230 x 450 mm , d = 410 mm

Self wt ~~25~~ . - 2.58 kN/m.

W_u = 18.87 kN/m

5) M_u = 66.25 kNm

Req. d = $\sqrt{\frac{M_u}{0.138 f_{ck} b}}$

= 323 < 410 mm Safe.

M_u lim = 106.6 > 66.25

A_{st} = 503.56 mm^2

Shear design V_u = 47.17 kN.

τ_v = 0.5 N/mm^2

% of steel $\frac{A_s}{b \cdot d}$ = 0.64 %.

τ_c = 0.53 > τ_v

∴ shear reinfo not required.

Check for deflection $\left(\frac{l}{d}\right)_{basic}$ = 20 $\left(\frac{l}{d}\right)_{actual}$

= 12.93

P_t = 0.64%. , K_t = 1.14

$\left(\frac{l}{d}\right)$ = 26 x 1.14 = 22.5 > 12.93

Scanned with CamScanner

CMR

6) Max B.M = $\frac{Wl^2}{8}$ = 187.5 kNm.

→ * $M_{u\,lim}$ = $0.138 f_{ck} b d^2$

= 139.7 kNm < 187. kNm ∴ Doubly reinforce.

$\frac{d'}{d}$ = 0.1 ⇒ f_{sc} = 353 N/mm²

* $M_u - M_{u\,lim}$ = f_{sc} d − d' A_{sc} = 338.5 mm²

— A_{st_1} = $0.36 f_{ck}$ b . x_{umax}

= 1076.8 mm².

— A_{st_2} = $\frac{f_{sc} . A_{sc}}{0.87 f_y}$ = 330.9

∴ A_{st} = 1407.7 mm.

Provide = 4 − 22 mm φ = 1520 mm².

* Shear design = 3 − 12 mm φ = 339 m²

Max S.F = V_u = 150 kN.

τ_v = 1.33 N/mm²

τ_c = 0.69 ∴ $\tau_v > \tau_c$ Shear reqd.

* check for deflection.

P_t = 1.35 %, P_c = 0.34.

K_t = 0.9, K_c = 1.1

CMR

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

$= 11.11 \left(\frac{l}{d}\right)_{allowable}$

$= 19.8 > 11.11$ safe

Check for bond.

7) $D = 150$ mm, $d_x = 130$ mm, $d_y = 120$ mm

$l_y = 6.13$ m, $l_x = 4.12$, $\frac{l_y}{l_x} = 1.484$

$W_u = 13.125$, $\alpha_x = 0.059$, $\alpha_y = 0.056$

$M_x = 19.82$ kN-m, $M_y = 12.48$

$d_{req} = 84.74 < 130$

$A_{stx} = 455.6$. provide 10 mm dia @ 170mm

Spacing $= 204.2$

Corner reinforcement $A_t = \frac{3}{4} A_{stx} = 341.7$

Spacing 8mm @ 140mm c/c

CMR

(8) Floor ht =

Assume 150 mm rise & Tread $- \frac{1250}{5} = 250$

E = 3.45m , W = 7.6 kN/m²

Mu = 17 kN.m

Req = 78.4 < 139

Ast = 358 , 10mm @ 200mm c/c

Distance @ 0.12 %. , Spaing 8m c/c.

Draw fig.

(9) Assume 2%. of steel, 475 x 475 section.

$\frac{e_{min}}{b} < 0.05$

$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_s$

$3000 \times 100 = 0.4 \times 20 (475^2 - A_s) + 0.67 \times 415 \times A_s$

lateral ties $\not\, \frac{1}{4}$ main bar.

Spaing $\not\,$ 475 or 16 dia.

Provide 8mm @ 300 mm c/c.

(b) $\frac{d'}{d} = 0.15$, $P_u / f_{ck} b d = 0.05$