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INSTITUTE OF
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IAT 1

Sub:	Design Of RC Structural Elements							Code:	18CV53
Date:	12/ 11 / 2021	Duration:	90 mins	Max Marks:	50	Sem:	5	Branch:	CIVIL

Note:Answer any 5 Questions.(Assume any missing data)

		Marks	OBE	
			CO	RBT
1	What are the assumptions made in limit state of design of collapse in flexure in single reinforced beam section?	[10]	CO1	L2
2	Distinguish between Balanced section, Under reinforced section and Over reinforced section with Sketches. Which section is preferable and why?	[10]	CO1	L2
3	Derive the expression for Depth of Neutral axis (N.A=0.42 X_u) in the case Rectangular RCC beam design.	[10]	CO1	L2
4	A Simply supported Rectangular beam section of 230mmX450mm having a effective length of 5.23m and having a #8 of 25 mm dia in tension side. What maximum UDL load is allowed on beam? Use M20 grade of concrete and Fe415. Assume clear cover 20mm.(Solve by Limit state method)	[10]	CO1	L2
5	Define Partial safety factor, characteristic strength and characteristic loads. Explain Short term deflection and Long term deflection.	[10]	CO1	L2
6	A Rectangular beam of 200mm and 400 mm deep up to the centre of reinforcement. Find the area of reinforcement required if it has to resist a moment of 25kNm.Use M20 concrete and Fe 415 steel. Also comment on type of section	[10]	CO1	L2

1

1) What are the assumptions made in limit state of design of collapse in flexure in single reinforced beam section?

(a) *Plane sections normal to the axis remain plane after bending.* It means that the strain at any point in the cross-section is proportional to the distance from the neutral axis.

(b) *The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.*

(c) *The relationship between the stress-strain distribution in concrete is assumed to be parabolic.*

For design purpose, the compressive strength of concrete is assumed to be parabolic, as shown in Fig. 4.1. For design purpose, the compressive strength of concrete is assumed to be 0.67 times the characteristic strength of concrete. The partial safety factor (rmc)=1.5 shall be applied in addition to this

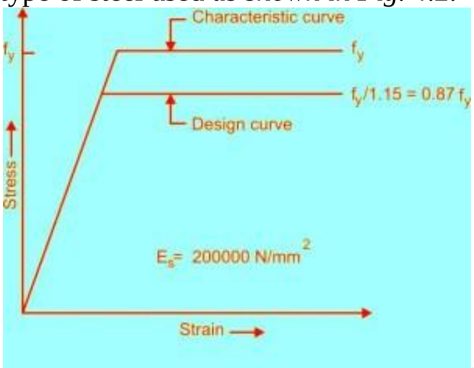
Maximum compressive stress in concrete =

$$0.67fck1.5$$

where fck= Characteristic strength of concrete.

(d) The tensile strength of the concrete is ignored.

(e) The stresses in the reinforcement are taken from the stress-strain curve for the type of steel used *as shown in Fig. 4.2.*



stresses in the reinforcement are taken from the stress-strain curve

For design purposes, the partial safety factor (rms) equal to 1.15 shall be applied.

(f) The maximum strain in the tension reinforcement in the section at failure shall not be less than

$$fy1.15Es+0.002$$

fy = Characteristic strength of steel

Es = Modulus of elasticity of steel.

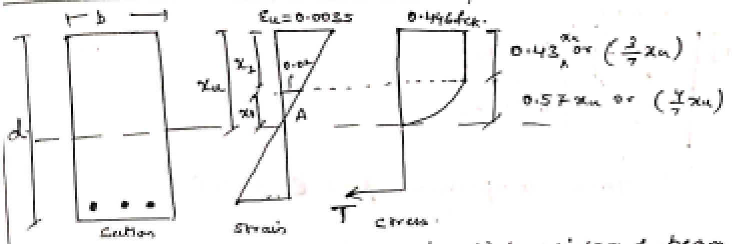
2

Distinguish between Balanced section, Under reinforced section and Over reinforced section with Sketches. Which section is preferable and why?

- **Under reinforced Section** An under reinforced section is a type of section in which we use steel for its ultimate tensile strength. Under reinforced beam section

	undergoes a tensile failure. The percentage of tensile reinforcement is less than the amount of reinforcement provided for a balanced section. As in this type of section reinforcement fails first i.e it undergoes a ductile failure. The main standout feature of a ductile failure is that it gives sufficient amount of safe time before failure. • **Balanced section-**In this type of section the ultimate strength of concrete and steel are reached simultaneously. At the same point of time concrete and steel fails and ultimately structure fails by crushing of concrete. • **An over reinforced section** is a type of section in which we use the concrete for its ultimate compressive strength strength. The yield strain of concrete is reached before the ultimate strength of steel. Over reinforced beam section undergoes a compressive failure. The percentage of tensile reinforcement is more than the amount of reinforcement provided for a balanced section. As in this type of section concrete fails first i.e it undergoes a brittle failure. The main disadvantage of this section is it undergoes a sudden failure without warning. We will not advice to select this type of section for the structure as it adds an extra cost, by increasing the percentage of reinforcement.It is always advisable to go for a under reinforce beam section as it is safer when we compare all the three beam section. Because of its ductile failure it provides sufficient time before collapse and reduces the intensity of hazard.		
3	Derive the expression for Depth of Neutral axis (N.A=0.42 X_u) in the case Rectangular RCC beam design.		

Stress Block Parameter



Stress & strain block for singly reinforced beam.

The diagram showing distribution of compressive stress in concrete across the depth of section is called stress block.

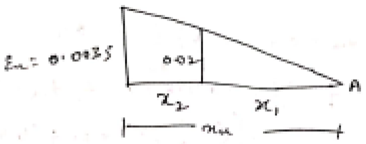
Assumption in strain block.

- Strain at neutral axis = 0
- Maximum or ultimate strain concrete fibre $E_{cu} = 0.003$
- strain at constant stress of $e_{cu} = 0.002$

Stress distribution.

- Stress at neutral axis (P.A) = 0
- Stress at 0.002 = 0.446 f_{ck}
- $T = \frac{0.87 f_y}{E_s} + 0.002$

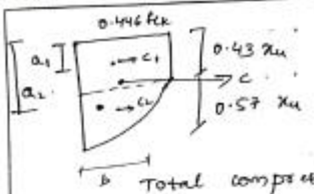
To find x_1 & x_2, consider, Apply similar triangle const.



$$\frac{x_u}{0.0035} = \frac{x_1}{0.002}$$

$\therefore$ $x_1 = 0.57 x_u$ or $\frac{4}{7} x_u$

$x_2 = 0.43 x_u$ or $\frac{3}{7} x_u$



Total compressive force $C = C_1 + C_2$

Compressive force = Stress x Area.

$$c_1 = 0.446 f_{ck} \times (b \times 0.43 x_u)$$

Area of parabola $= \frac{2}{3} \times b \times h$

$$c_2 = \left(\frac{2}{3}\right) 0.446 f_{ck} \times (b \times 0.57 x_u)$$

$$\therefore\ C = C_1 + C_2$$

$$= 0.446 f_{ck} \times (0.43 x_u \cdot b) + (0.446 f_{ck} \times 0.57 x_u \cdot b)$$

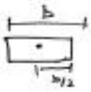
$$= 0.36 f_{ck} \cdot x_u \cdot b \qquad \left(\frac{N}{mm^2} \times mm \times mm\right)$$

N

Location of compressive force.

$$C\bar{x} = C_1 a_1 + C_2 a_2$$

here a_1 & a_2 = centroidal distance.

a_1 for  $= \frac{b}{2}$

a_2  $\cdot \frac{3}{8} b$

$$C\bar{x} = (0.446 f_{ck} \times 0.43 x_u b)\left(\frac{1}{2} \times 0.43 x_u\right) + \frac{2}{3} \times (0.446 \times 0.57 \times f_{ck} \cdot x_u \cdot b)\left[\left(\frac{3}{8} \times 0.57 x_u\right) + (0.43 x_u)\right]$$

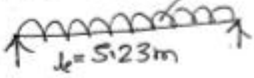
$$C \cdot \bar{x} = 0.041 x_u^2 \times b \cdot f_{ck} + 0.1 x_u^2 \cdot b \cdot f_{ck}$$

$$\bar{x} = \frac{0.15 f_{ck} \cdot b\, x_u^2}{0.36 f_{ck}\, x_u\, b}$$

$$\boxed{\bar{x} = 0.42 x_u}$$

4

A Simply supported Rectangular beam section of 230mmX450mm having a effective length of 5.23m and having a #8 of 25 mm dia in tension side. What maximum UDL load is allowed on beam? Use M20 grade of concrete and Fe415. Assume clear cover 20mm.(Solve by Limit state method)

sol	Comparing $\left(\frac{x_u}{d}\right)$ with Limiting Value $\left(\frac{x_u}{d}\right) > \left(\frac{x_{umax}}{d}\right)$ Hence the beam is Over reinforced Section (c) Moment of Resistance :— Using Balanced M.R. equation, $M_{u,lim} = 0.36 \frac{x_{umax}}{d}\left(1-0.42\frac{x_{umax}}{d}\right) bd^2 f_{ck}$. $= 0.36 \times 0.48(1-0.42 \times 0.48)230(415)^2 \times 20$ $M_{ulim} = 109.29 \times 10^6$ N-mm $= 109.29$ kN-m $\therefore M = \frac{M_u}{1.5} = \frac{109.29}{1.5} = 72.86$ kN-m $\omega = ??$ (DL+LL (d) The UDL :—  $M = \frac{\omega l_e^2}{8} = 72.86$ ~~109.29~~ 61 $\frac{\omega(5.23)^2}{8} = 72.86$ kN-m ~~109.29~~ $\therefore$ Total UDL $= \omega = 21.30$ kN/m (DL+LL) (a) From IS456 Page (47) Maximum percentage of steel $= 0.04\,bD$ 59 $\therefore A_{st} = 0.04 \times 230 \times 450$ $A_{st} = 4140\ mm^2$ Using Mild exposure, Take clear cover = 20mm (Page 47 IS456)	
5	Define Partial safety factor, characteristic strength and characteristic loads. Explain	

<table>
<tr><td></td><td>Short term deflection and Long term deflection.</td><td></td></tr>
<tr><td>Solu</td><td>Refer IS-456 code book for solution</td><td></td></tr>
<tr><td>6</td><td>A Rectangular beam of 200mm and 400 mm deep up to the centre of reinforcement. Find the area of reinforcement required if it has to resist a moment of 25kNm.Use M20 concrete and Fe 415 steel. Also comment on type of section</td><td></td></tr>
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...centre of reinforcement.
...required if it has to resist a moment of 25 kNm. Use M20 concrete mix
...Fe 415 steel.

Solution. Given:
$b = 20 \text{ cm} = 200 \text{ mm}$
$d = 40 \text{ cm} = 400 \text{ mm}$
$M = 25 \text{ kNm} = 25 \times 10^6 \text{ Nmm}$
$f_{ck} = 20 \text{ N/mm}^2$ [For M20 concrete]
$f_y = 415 \text{ N/mm}^2$ [For Fe 415 concrete]

■ Factored bending moment
$= \gamma \times BM$
$= 1.5 \times 25 \times 10^6$
$= 37.5 \times 10^6 \text{ Nmm}$ [γ = Load factor = 1.5]

■ Factored BM = Moment of resistance
$$M_u = 0.87 f_y A_{st} d \left(1 - \frac{f_y A_{st}}{f_{ck} bd}\right)$$
$$M_u = 0.87 \times 415 \times A_{st} \times 400 \left(1 - \frac{415 A_{st}}{20 \times 200 \times 400}\right)$$
$$37.5 \times 10^6 = 0.87 \times 415 \times 400 \times A_{st} \left(1 - \frac{415 A_{st}}{20 \times 200 \times 400}\right)$$
$$A_{st}(400 - 0.10375 A_{st}) = 103863.73$$
$$A_{st}^2 - 3855.4 A_{st} + 1001096.192 = 0$$
$$A_{st} = \frac{3855.4 \pm \sqrt{(3855.4)^2 - 4 \times 1001096.192}}{2}$$
$$A_{st} = 280 \text{ mm}^2$$

■ Depth of neutral axis
$$x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$$
$$= \frac{0.87 \times 415 \times 280}{0.36 \times 20 \times 200}$$
$$x_u = 70.2 \text{ mm}$$

■ Limiting depth of neutral axis ($x_{u\,max}$)
$$x_{u\,max} = 0.48\, d = 0.48 \times 400$$
$$x_{u\,max} = 192 \text{ mm} > x_u$$
■ $\because x_{u\,max} > x_u$, hence the section is under reinforced and design is OK.
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