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Internal Assesment test I

Sub:	Design of RC structural elements							Code	15CV51
Date:	06-09-19	Duration:	90 mins	Max Marks:	50	Sem:	05	Branch:	CIVIL

Note: Answer all the questions. Assume any missing data. Use of IS456 -2000 is permitted.

		Marks	OBE	
			CO	RBT
1 (a)	Clearly state the five differences between working stress method and limit state method.	[05]	C504.1 C504.1	L1
(c)	Derive stress block parameters for a singly reinforced beam.	[12]	C504.1	
2 (a)	A rectangular RCC beam 300 mm wide and 500 mm deep is reinforced with 4 bars of 16 mm dia. It is freely supported on an effective span of 6 m. Determine the max permissible imposed service load. Assuming M 20 grade concrete & Fe-500 steel.	[12]	C504.2 C504.2	L2 L1

3 (a)	Find the moment of resistance of a doubly reinforced rectangular section 230 mm wide and 450 mm effective depth with 2 bars of 20 mm diameter are placed in compression side with an effective cover of 40 mm. Tension steel consists of 3 bars of 25 mm diameter with an effective cover of 40 mm. Assume M 20 grade concrete and Fe-415 steel.	[07]	C504.2	L2
(b)	Determine the moment of resistance of T beam b_f = 1000 mm, D_f = 100 mm, b_w = 300 mm, effective cover = 50 mm, d = 450 mm, A_{st} = 1963mm^2. Use M 20 and Fe-415 grade steel.	[08]	C504.2	L2

IAT - 1

1) a)

Working Stress method	Limit state method
* Based on linear elastic theory	* based on actual stress - strain curves
* thicker sections, uneconomical	* thinner section, economical
* No check on serviceability	* check on serviceability
* Material strength is not fully utilized	* Material strength is fully utilized
* deterministic approach	* Non deterministic approach
* ultimate loads cannot be predicted	* ultimate loads can be predicted
* Factor of safety - permissible stresses	* partial safety factor

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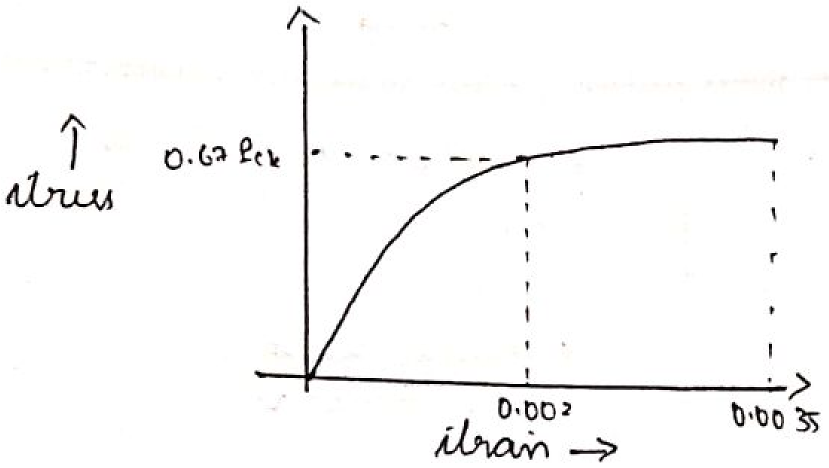
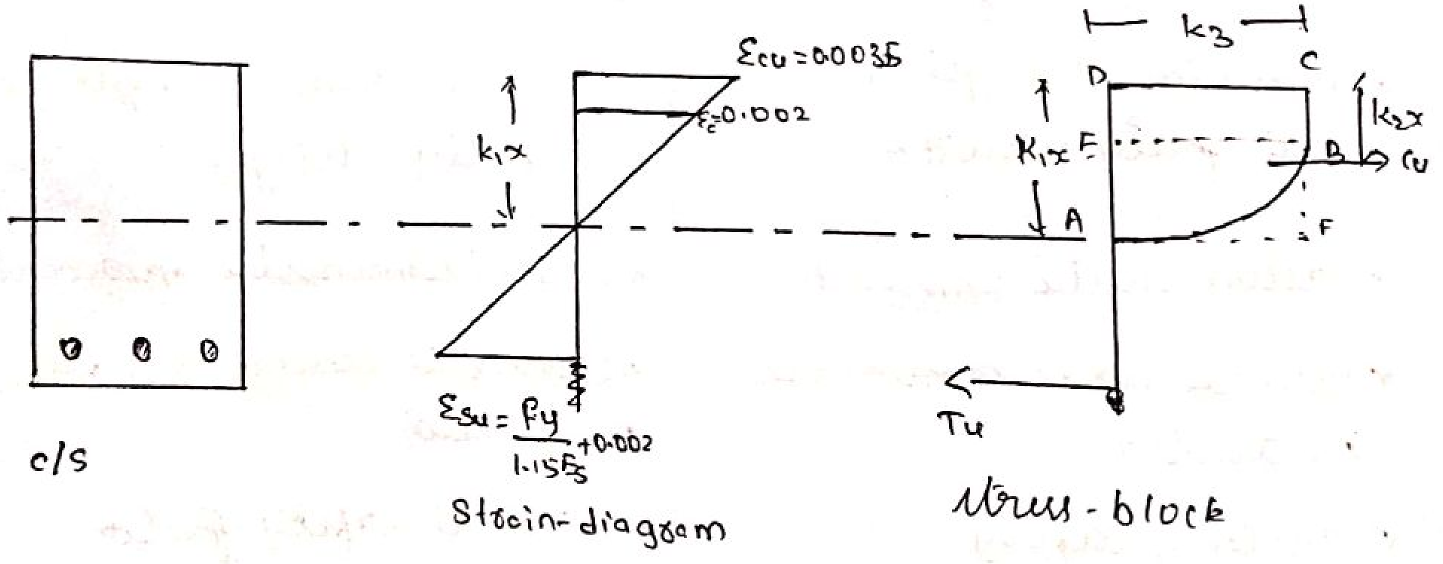
b) Stress-block parameter

The stress-strain relationship for a concrete cube is uniform, but it varies with depth under bending



εcu & εs



Let ε_{cu} : ultimate strain in concrete = 0.0035

ε_c : strain in concrete at yielding = 0.002

ε_{su} : ultimate strain in steel = $\frac{f_y}{1.15E_s} + 0.002$

k_1 = shape factor

k_2 = depth factor

k_3 : stress factor

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k_1 = shape factor = $\dfrac{\text{area of the stress block ABCDA}}{\text{area of rectangle AFCD}}$

NOW,

$$\frac{\varepsilon_{cu}}{\varepsilon_c} = \frac{0.0035}{0.002} = \frac{AD}{AE}$$

$$\frac{AE}{AD} = \frac{0.002}{0.0035}$$

$$\boxed{AE = \frac{4}{7} AD}$$

$$\frac{DE}{AD} = \frac{0.0015}{0.0035}$$

$$\boxed{DE = \frac{3}{7} * AD}$$

NOW,

$$k_1 = \frac{DC * DE + \frac{2}{3} * AE * BE}{AD \times DC}$$

$$= \frac{DC \times \frac{3}{7} \times AD + \frac{2}{3} \times \frac{4}{7} \times AD \times DC}{AD \times DC}$$

$$= \frac{AD \times DC \left(\frac{3}{7} + \frac{2 \times 4}{3 \times 7} \right)}{AD \times DC}$$

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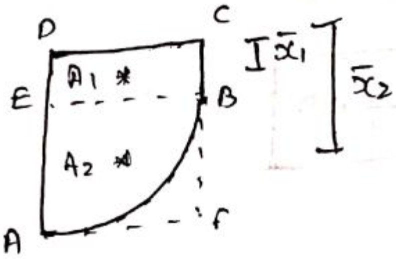
$K_2 x$ = depth factor = $\frac{A_1 \cdot \bar{x}_1 + A_2 \cdot \bar{x}_2}{A_1 + A_2}$

A_1 → area of rect. part, $\bar{x}_1$ → distance of centroid of rectangular part of stress block from top

A_2 → area of parabolic part of the stress block, $\bar{x}_2$ → its centroid from top



$\bar{x}_1 = \frac{DE}{2}$

$= \frac{3}{7} \times AD \times \frac{1}{2}$

$\boxed{\bar{x}_1 = \frac{3}{14} * AD}$

$\bar{x}_2 = DE + \frac{3}{8} * AE$

$= \frac{3}{7} * AD + \frac{3}{8} * \frac{4}{7} * AD$

$\boxed{\bar{x}_2 = \frac{9}{14} AD}$

W.k.t $A_1 = DE \times DC$

$\boxed{A_1 = \frac{3}{7} * AD * DC}$

$A_2 = \frac{2}{3} * AE * BE$

$= \frac{2}{3} * \frac{4}{7} \times AD \times DC$

$\boxed{A_2 = \frac{8}{21} \times AD \times DC}$

$\therefore K_2 x = \frac{\frac{3}{7} \times AD \times DC * \frac{3}{14} \times AD + \frac{8}{21} \times AD \times DC * \frac{9}{14} \times AD}{\frac{3}{7} \times AD \times DC + \frac{8}{21} \times AD \times DC}$

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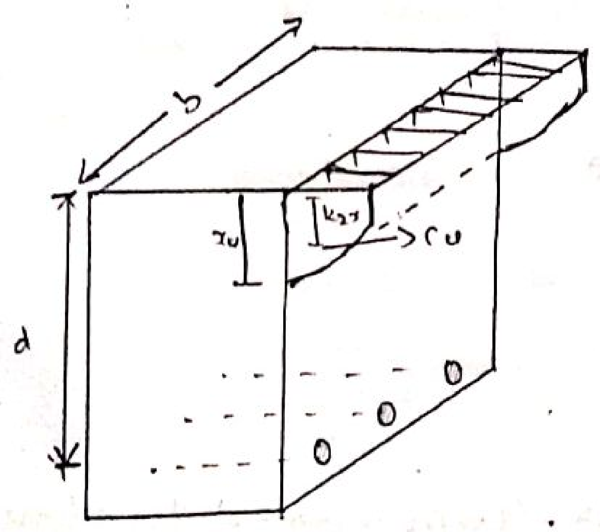
$$= \frac{\left(\frac{3}{7} \times \frac{3}{14}\right) AD + \left(\frac{8}{21} \times \frac{9}{14}\right) AD}{\frac{3}{7} + \frac{8}{21}}$$

$k_2 \cdot x = 0.42 AD$

but here $AD = x$

$\therefore K_2 = 0.42$

Stress factor



compressive force = compressive strength × area

compressive strength = $\frac{\text{compressive load/force}}{\text{area}}$

compressive strength = $0.67 f_{ck}$

$C_u = K_3 \cdot f_{ck} \times b \times x_u$

$K_3 = 0.67$

is the stress factor

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d)

a)

$b = 300mm$

$D = 500mm$

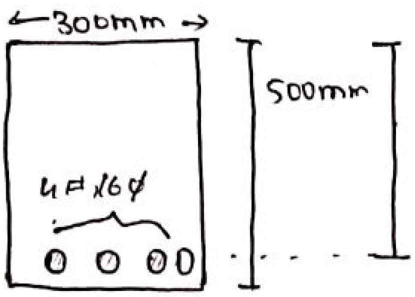
$A_{st} = 4 \times \frac{\pi}{4} \times 16^2 = 804.25 mm^2$

$l = 6m$

$w_L = ?$

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

$f_y = 500 N/mm^2$



effective depth, d = overall depth - (clear cover + $\frac{1}{2}$ dia of bars)

$$d = 500 - (25 + \frac{16}{2})$$

$$\boxed{d = 467mm}$$

Step 1: calculate depth of N.A

#96, 41.1, IS456-2000

$$\frac{x_u}{d} = \frac{0.87 \cdot f_y \cdot A_{st}}{0.36 * f_{ck} * b * d}$$

$$\frac{x_u}{d} = \frac{0.87 * 500 * 804.25}{0.36 * 20 * 300 * 467}$$

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$$\frac{x_u}{d} = 0.35$$

Step 2: Compare $\frac{x_u}{d}$ and $\frac{x_{u,max}}{d}$

$$\frac{x_{u,max}}{d} = 0.46$$ for Fe500 grade steel

P 70, IS 456-2000

0.35 < 0.46

$$\frac{x_u}{d} < \frac{x_{u,max}}{d}$$

∴ the section is under-reinforced

Step 3: To calculate moment of Resistance

$$M_u = 0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} \times f_y}{b \cdot d \cdot f_{ck}}\right)$$

$$= 0.87 \times 500 \times 804.25 \times 467 \left(1 - \frac{804.25 \times 500}{300 \times 467 \times 20}\right)$$

$$M_u = 139.93 \text{ kN-m}$$

Step 4: To calculate working moment of resistance

$$M_{u,working} = \frac{M_u}{F.S.F}$$

$$= \frac{139.93}{1.5}$$

$$M_{u,work} = 93.29 \text{ kN-m}$$

Step 5: Moment due to dead load

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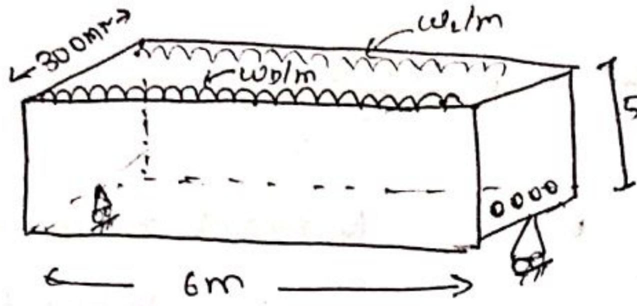
$\frac{wl}{2} \times \frac{l}{2} - \ldots$

$\frac{wl^2}{4} - \frac{wl^2}{8}$

$\frac{2wl^2 - wl^2}{8} = \frac{wl^2}{8}$



dead load = density of concrete * cross sectional area

$= 25 kN/m^3 * 0.3 \times 0.5$

$= 3.75 kN/m$

moment due to dead load

$$M_D = \frac{wl^2}{8} = \frac{3.75 \times 6^2}{8} = 16.88 \text{ kN-m}$$

Step 6: To find the imposed service load

$$M_{u,wood} = M_L + M_D$$

$$93.29 = \frac{w_L \times l^2}{8} + 16.88$$

$$w_L = \frac{(93.29 - 16.88) \times 8}{6^2}$$

$$\boxed{w_L = 16.98 \text{ kN/m}}$$

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3)

a) $b = 230mm$

$d = 450mm$

$A_{sc} = 2 \times \frac{\pi}{4} \times 20^2 = 628.32 mm^2$

$d'' = 40mm$

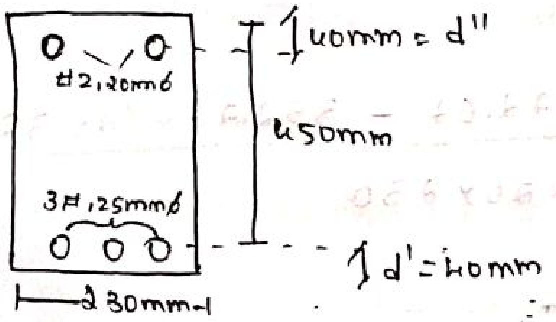
$A_{st} = 3 \times \frac{\pi}{4} \times 25^2 = 1472.62 mm^2$

$d' = 40mm$

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

$f_y = 415N/mm^2$

$M_u = ?$



Step 1: Find $x_{u,max}$

$\frac{x_{u,max}}{d} = 0.48$ for Fe415 steel , #70 IS456-2000

$x_{u,max} = 0.48 \times 450$

$x_{u,max} = 216mm$

Step 2: Calculate f_{sc}

f_{sc} value corresponding to a strain of $0.0035\left(\frac{x_{u,max} - d''}{x_{u,max}}\right)$

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$= 0.0035\left(\frac{216-40}{216}\right)$

$= 0.0028$

∴ from graph #23 A, page 70 IS 456-2000

f_{sc} value $= 0.85 f_y$

$f_{sc} = 0.85 * 415$

$f_{sc} = 352.75 \ N/mm^2$

Step 3: to find depth of N.A

$$x_u = \frac{0.87 f_y . A_{st} - f_{sc} . A_{sc}}{0.36 . f_{ck} . b}$$

$$= \frac{0.87 \times 415 \times 1472.62 - 352.75 \times 628.32}{0.36 \times 20 \times 230}$$

$x_u = 187.23 mm$

Step 4: Recalculate f_{sc}

f_{sc} value corresponding to a strain of $0.0035\left(\frac{x_u - d''}{x_u}\right)$

$= 0.0035\left(\frac{187.23-40}{187.23}\right)$

≈ 0.0027

from graph 23, A, # 70 IS 456-2000

$f_{sc} = 0.85 f_y$

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Step 5: compare x_u & $x_{u,max}$

$187.23 < 216 mm$

$x_u < x_{u,max}$

∴ the section is under-reinforced

Step 6: To find M_u.

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

$M_{u,lim} = 0.36 \cdot \frac{x_u}{d}\left(1 - 0.42\frac{x_u}{d}\right) \cdot b \cdot d^2 \cdot f_{ck}$ $\left(\because x_u < x_{u,max},\ x_{u,max} = x_u\right)$

$= 0.36 * \frac{187.23}{450}\left(1 - 0.42 \times \frac{187.23}{450}\right) * 230 * 450^2 * 20$

$= 115.14\ KN\text{-}m$

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

$= 115.14 \times 10^6 + 352.75 * 628.32(450 - 40)$

$M_u = 206.01\ KN\text{-}m$

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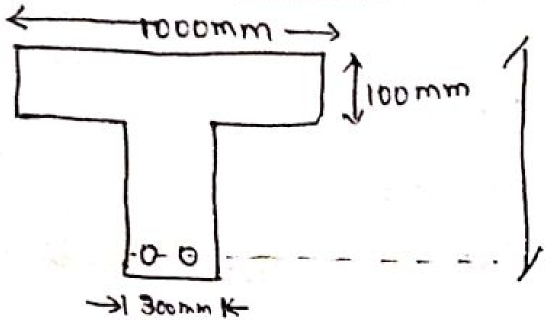
(3)



given:

$b_f = 1000mm$

$D_f = 100mm$

$b_w = 300mm$

$d' = 50mm$

$d = 450mm$

$A_{st} = 1963mm^2$

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

$f_y = 415N/mm^2$

Step 1: Find x_u

$$x_u = \frac{0.87 f_y \cdot A_{st}}{0.36 \times f_{ck} \times b_f}$$

$$= \frac{0.87 \times 415 \times 1963}{0.36 \times 20 \times 1000}$$

$$\boxed{x_u = 98.44mm}$$

Step 2: Compare x_u and D_f

$98.44mm < 1000mm$

$x_u < D_f$

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∴ Analyse the T-beam as a rectangular beam

Step 3: calculate $x_{u,max}$

$$\frac{x_{u,max}}{d} = 0.48 \quad \text{for Fe415 steel}$$

$$x_{u,max} = 0.48 \times 450$$

$$\boxed{x_{u,max} = 216mm}$$

$$x_u < x_{u,max}$$

∴ the section is under reinforced

Step 4: To find ultimate moment of resistance

$$M_u = 0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} \times f_y}{b_f \times d \times f_{ck}}\right)$$

$$= 0.87 \times 415 \times 1963 \times 450 \left(1 - \frac{1963 \times 415}{1000 \times 450 \times 20}\right)$$

$$\boxed{M_u = 290.06 kN\text{-}m}$$

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