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Subject Name: DESIGN OF R.C.C. STRUCTURES

Model Answer

Subject Code: 17604

Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.	Sub Q.	Answers	Marking		
No.	Ν.		Scheme		
Q.1	(A)	Solve any THREE:	(12)		
	(a)	Explain the concept of limit state of flexure. State various limit states.			
	Ans	Concept of limit state of flexure: It is to achieve an acceptable probability that a			
		tructure will not collapse in flexure in its life time, that is, it will not reach limit state of			
		ollapse (Flexure).			
		Various limit states:			
		1. Limit state of collapse-			
		i. Flexure/Bending.	01 M		
		ii. Shear.			
		iii. Torsion.			
		iv. Axial load (Tension and compression).			
		Limit state of Serviceability-			
		i. Deflection. 0			
		ii. Cracking.			
		iii. Vibration.			
Q.1	(A)(b)	Define 'characteristic strength' and 'characteristic load'.			
	Ans	Characteristic strength: It is the value of the strength of material below which not more	02 M		
		than 5 percent of the test results are expected to fall.			
		Characteristic load: It is the value of load which has a 95 percent probability of not being			
		exceeded during the life of the structure.			
Q.1	(A)(c)	Write the requirements of ductility for flexural members as per IS: 13920-1993.			
	Ans	Requirements of ductility for flexural members.			
		1. The factored axial stress on the member under earthquake loading shall not	01 M for		
		exceed 0.1 fck.	each		
		2. The member shall preferably have a width-to-depth ratio of more than 0.3.			
		3. The width of the member shall not be less than 200 mm.			
		4. The depth D of the member shall preferably be not more than I/4 of the clear			



		span.			
Q.1	(A)(d) Ans	Explain pre-tensioning and post-tensioning. Pre-tensioning method: It is done by stressing wires or strands, called tendons, to predetermine amount by stretching them between two anchorages called abutments prior to placing the concrete. The concrete is then placed and tendons become bonded to concrete throughout their length. After the concrete has hardened, the tendons are released by cutting them at the anchorages. The tendons tend to regain their original length by shortening and transfer compressive stress to concrete through bond.	02 M		
		Post-tensioning method: In this method first tendons are placed in position passing through flexible tube then concrete is placed in the mould. After gaining strength by concrete, tendons are stretched against concrete itself and then anchored at both ends. In this method, stress is transferred through bearing at ends of tendons.	02 M		
Q.1	(A)(e)	State various forms of shear reinforcement in beams.			
	Ans	Shear reinforcement in beams can be provided in any one of the forms given below.			
		1. Vertical stirrups.	04.14		
		 Inclined surrups. Bent up bars with stirrups 	04 101		
0.1	(B)	Solve any ONE:	(06)		
~	(a)	A beam having dimension 230 x 450 mm effective is reinforced with 4 bars of 16 mm	(00)		
		diameter on tension side. Calculate the ultimate moment of resistance of the beam if			
		M20 grade concrete and Fe415 steel are used.			
	Ans	b = 230 mm, d = 450 mm, Ast = 16 mm-4 bars., M-20, Fe-415, Mu = ?			
		Ast = $4 \times \pi \times \phi^2 / 4$			
		$= 4 \times \pi \times 16^{2} / 4 = 804.25 \text{ mm}^{2}$	01 M		
		Actual neutral axis xu = $(0.87 \text{ x fy x Ast}) / (0.36 \text{ x fck x b})$			
		$= (0.87 \times 415 \times 804.25) / (0.30 \times 20 \times 230)$ = 175.25 mm	01 M		
		-175.55 mm. Xumax = 0.48 x d	UT IVI		
		$= 0.48 \times 450$			
		= 216 mm.	01 M		
		Xu < xumax, hence beam is under reinforced.	01 M		
		Mu = 0.87 x fy x Ast (d – 0.42xu)			
		= 0.87 x 415 x 804.25 (450 – 0.42 x 175.35)			
		$= 109.28 \times 10^{6} \text{ N-mm.}$			
		OR	02 M		
		$Mu = 0.36 \times fck \times b \times xu (d - 0.42xu)$			
		$= 0.36 \times 20 \times 230 \times 1/5.35 (450 - 0.42 \times 1/5.35)$ = 100.28 × 10 ⁶ N mm			
0.1	(P)(b)	= 109.28 × 10 N-IIIII			
Q.1		m. If concrete M20 & Steel arade Fe500 are used, find area 0f steel required			
	Ans	b = 300 mm, d = 500 mm, Mu = 175 kN-m, M-20, Fe-500, Ast = ?			
		Mulim = $0.134 \text{ x fck x b x d}^2$			
		$= 0.134 \times 20 \times 300 \times 500^2$	02 M		
		$= 201 \times 10^{6} \text{ N-mm}$			
		Mu < Mulim, Hence beam is Under reinforced.	01 M		
		Ast = 0.5 x fck x b x d {1 – SQRT[1 – (4.6 x Mu) / (fck x b x d ²)]} / fy	01 M		



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		$= 0.5 \times 20 \times 300 \times 500 \{1 - SQRT[1 - (4.6 \times 175 \times 10^{6}) / (20 \times 300 \times 500^{2})]\} / 500$	01 M
		$= 957.94 \text{ mm}^2$.	01 M
Q.2		Solve any TWO:	(16)
	(a)	Design one way slab with following data, width of support = 230 mm, clear span = 3.5	
		m, Live load = 2 kN/m^2 , Floor finish = 1 kN/m^2 , concrete M20 & steel 415, M.F. = 1.4.	
		Sketch c/s of slab showing reinforcement details (No checks are required)	
	Ans	Support width = 230 mm, Clear span = 3.5 m, L.L. = 2 kN/m^2 , F.F. = 1 kN/m^2 ,	
		M-20, Fe-415, M.F. = 1.4.	
		Depth of slab required = span / (M.F. x 20)	
		= 3500 / (1.4 x 20)	01 M
		= 125 mm.	
		Assuming cover 25 mm, (Note: Students may assume different cover)	
		D = 125 + 25 = 150 mm.	
		Effective span:	
		1) Clear span + d = $3.5 + 0.125 = 3.625$ m.	
		2) Clear span + support width = $3.5 + 0.23 = 3.73$ m.	01 M
		Lesser is 3.625 m. Hence le = 3.625 m.	
		Loading:	
		1) Live load = 2.0 kN/m ⁻	
		2) Floor finish = 1.0 kN/m ⁻ 2) Salf weight = 0.45 w 25 = 2.75 kN/m ²	01.14
		3) Self weight = 0.15 X 25 = 3.75 KN/m Total $= 6.75 \text{ kN/m}^2$	
		$10lal = 0.75 \text{ kiv/m}^2$	
		$M_{\rm H} = 10.125 \times 0.75 = 10.125 \text{ km/m}$	
		16.62 kN m	
		Depth required for strength – SORT[Mu / (0.138 x fck x h)]	
		$= \text{SORT}[16.63 \times 10^6 / (0.138 \times 20 \times 1000)]$	01 M
		= 77.62 mm < assumed hence O K	01101
		Provide D = 150 mm	
		d = 125 mm.	
		Ast = 0.5 x fck x b x d $\{1 - SQRT[1 - (4.6 x Mu) / (fck x b x d^2)]\} / fy$	
		$= 0.5 \times 20 \times 1000 \times 125 \{1 - SQRT[1 - (4.6 \times 16.63 \times 10^{6}) / (20 \times 1000 \times 125^{2})]\} / 415$	01 M
		$= 394.5 \text{ mm}^2$.	
		Providing 8 mm dia. Bars Area of one bar A1 = $\pi x \phi^2 / 4 = \pi x 8^2 / 4 = 50.27 \text{ mm}^2$	
		(Note: Students may assume different bar dia.)	
		Spacing = 1000 x A1 / Ast	
		= 1000 x 50.27 / 394.5 = 127.4 mm.	
		Provide 8 mm dia. @ 125 mm c/c.	
		Distribution steel: Area = $0.12 \times 1000 \times 150 / 100$	
		$= 180 \text{ mm}^2$.	01 M
		Spacing for 8 mm dia. Bars = 1000 x 50.27 / 180 = 279.3 mm	
		Provide 8 mm dia. @ 275 mm c/c.	
		8 MM @ 125 MM C/C	FIB. 02 IVI
		3500 MM	



Q.2	(b)	Design a reinforced concrete slab panel for 6.55 m x 4.35 m simply supported on all			
		four sides. It carries a live load 2 kN/m2 & Floor finish load 1.0 kN/m2. Use M20			
		concrete & Fe415 steel. Sketch the c/s of slab along shorter span showing steel details (No checks). Use $Gx = 0.104$, $Gy = 0.046$, $M = -1.2$			
		(No checks). Use αx = 0.104, αy = 0.046. Μ.F. = 1.3.			
	Ans	Shorter span = 4.35 m, Longer span = 6.55 m, L.L. = 2 kN/m ² , F.F. = 1 kN/m ² , M-20,			
		Fe-415, M.F. = 1.3, ax = 0.104, ay = 0.046.			
		Aspect ratio = Longer span / Shorter span = 6.55 / 4.35 = 1.51 < 2.0 Hence Two way slab.			
		Depth of slab required = shorter span / (M.F. x 20)			
		= 4350 / (1.3 x 20)	01 M		
		= 167.31 mm.			
		Assuming cover 25 mm, (Note: Students may assume different cover)			
		D = 167.31 + 25 = 192.3 mm.			
		Assume overall depth (D) = 200 mm and Effective depth (d) = 175 mm.			
		Loading:			
		1) Live load = 2.0 kN/m^2			
		2) Floor finish = 1.0 kN/m^2			
		3) Self weight = $0.20 \times 25 = 5.0 \text{ kN/m}^2$	01 M		
		$Total = 8.0 \text{ kN/m}^2$			
		Factored load = $1.5 \times 8.0 = 12.0 \text{ kN/m}^2$			
		Ultimate bending moment calculations:			
		$Mux = \alpha x w u x lex^{2}$	01 14		
		$= 0.104 \times 12 \times 4.35^{-} = 23.62 \text{ kN-m}$			
		$Muy = Qy x wu x lex^{2}$	01 M		
		$= 0.046 \times 12 \times 4.35^{\circ} = 10.45 \text{ kN-m}.$			
		Depth required for strength = SQR1[Mux / $(0.138 \times fck \times b)$]	01 M		
		$= SQR[23.62 \times 10^{\circ} / (0.138 \times 20 \times 1000)]$			
		= 92.51 mm < assumed hence U.K.			
		$dy = 175 \text{ mm}$ and $dy = 175 \cdot 10 = 165 \text{ mm}$ (accuming bar dia 10 mm)			
		ux = 175 mm. and $uy = 175 = 10 = 105$ mm (assuming bar dia. 10 mm)	01 M		
		$= 0.5 \times 20 \times 1000 \times 175 / 1 = SORT[1 = (4.0 \times 1000) / (100 \times 1000) \times 175^{2}) / (100 \times 1000) \times 175^{2}) / (100 \times 1000) \times 175^{2}) / (100 \times 1000) \times 1000) \times 1000 \times 1000$	•= ···		
		$= 0.5 \times 20 \times 1000 \times 175 (1 - 50 \times 10 \times 25.02 \times 10^{7}) (20 \times 1000 \times 175))/(415)$ = 302 3 mm ²			
		Providing 8 mm dia Bars Area of one har $A1 - \pi x d^2 / A - \pi x 8^2 / A - 50.27 mm^2$			
		(Note: Students may assume different bar dia.)			
		Spacing = $1000 \times A1 / Ast$			
		$= 1000 \times 50.27 / 392.3 = 128 \text{ mm}.$			
		Provide 8 mm dia. @ 125 mm c/c along shorter span.			
		Asty = 0.5 x fck x b x dy $\{1 - SQRT[1 - (4.6 x Muy) / (fck x b x dy^2)]\} / fy$	01 M		
		$= 0.5 \times 20 \times 1000 \times 165 \{1 - SQRT[1 - (4.6 \times 10.45 \times 10^{6}) / (20 \times 1000 \times 165^{2})]\} / 415$			
		$= 179.6 \text{ mm}^2$.			
		Minimum Ast = $0.12 \times 1000 \times 200 / 100 = 240 \text{ mm}^2$.			
		Asty < Min. Ast, Hence provide minimum Ast.			
		Providing 8 mm dia. Bars Area of one bar A1 = $\pi x \phi^2 / 4 = \pi x 8^2 / 4 = 50.27 \text{ mm}^2$			
		(Note: Students may assume different bar dia.)			
		Spacing = 1000 x A1 / Ast			
		= 1000 x 50.27 / 240 = 209.5 mm.			
		Provide 8 mm dia. @ 200 mm c/c along longer span.			



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		∠— 8 MM @ 200 MM C/C	01 M for			
			fig.			
		— 8 MM @ 125 MM C/C				
		4350 MM				
		C/S ALONG SHORTER SPAN				
Q.2	(c)	Design a cantilever slab for Chajja with following data. Span = 1.5 m, L.L. = $2 kN/m^2$,				
		F.F. = 0.5 kN/m ² , Adopt M20 & Fe415, Modification factor = 1.3.				
	Ans	Span = 1.5 m, L.L. = 2 kN/m ² , F.F. = 0.5 kN/m ² , M-20, Fe-415, M.F. = 1.3.				
		Depth of slab required = span / (M.F. x 7)				
		$= 1500 / (1.3 \times 7)$	01 M			
		= 164.8 mm.				
		Assuming cover 25 mm, (Note: Students may assume different cover)				
		D = 164.8 + 25 = 189.8 mm.				
		Assume overall depth = 190 mm and effective depth = 165 mm.				
		Effective span:				
		1) Clear span + $d/2 = 1.5 + 0.165/2 = 1.5825$ m. (Note: Students may consider given				
		span as effective span)				
		$= 2.0 \text{ kN/m}^2$				
		$= 2.0 \text{ kN/m}^2$	01 M			
		3) Self weight = 0.19 x 25 = 4.75 kN/m ²				
		Total = 7.25 kN/m ²				
		Eactored load = $1.5 \times 7.25 = 10.875 \text{ kN/m}^2$				
		$M_{\rm H} = 10.875 \times 1.5825^2 / 2$	01 M			
		= 13.62 kN-m	01101			
		Depth required for strength = SORT[Mu / $(0.138 \times fck \times b)$]				
		$= SORT[13.62 \times 10^{6} / (0.138 \times 20 \times 1000)]$	01 M			
		= 70.25 mm < assumed hence O.K.				
		Provide D = 190 mm				
		d = 175 mm.				
		Ast = 0.5 x fck x b x d {1 – SQRT[1 – (4.6 x Mu) / (fck x b x d ²)]} / fy				
		= $0.5 \times 20 \times 1000 \times 175 \{1 - SQRT[1 - (4.6 \times 13.62 \times 10^6) / (20 \times 1000 \times 175^2)]\} / 415$	02 M			
		$= 235.7 \text{ mm}^2$.				
		Minimum Ast = $0.12 \times 1000 \times 190 / 100 = 228 \text{ mm}^2$.				
		Ast > Min. Ast, Hence O.K.				
		Providing 8 mm dia. Bars Area of one bar A1 = $\pi x \phi^2 / 4 = \pi x 8^2 / 4 = 50.27 \text{ mm}^2$				
		(Note: Students may assume different bar dia.)				
		Spacing = 1000 x A1 / Ast				
		= 1000 x 50.27 / 235.7 = 213.3 mm.				
		Provide 8 mm dia. @ 210 mm c/c.	02 M			
		Distribution steel: Area = $0.12 \times 1000 \times 190 / 100$				
		= 228 mm ² .				
		Spacing for 8 mm dia. Bars = $1000 \times 50.27 / 228 = 220.5$ mm				
		Provide 8 mm dia. @ 220 mm c/c.				
Q.3		Attempt any FOUR:	(16)			



	(a)	What is flange width of T-beam as per IS: 456? State meaning of each term used			
		therein.			
	Ans	Flange width of T-beam = $(I_0/6) + b_w + 6D_f$ but not greater than the width of web plus	02 M		
		half the sum of the clear distance to the adjacent beams on either side.			
		L_0 = Distance between points of zero moments in the beam.			
		b_w = width of web.	02 M		
		D_f = Depth of flange.			
Q.3	(b)	Find the moment of resistance of (T) beam with following data:			
		Df = 100 mm, bf = 1200 mm, bw = 250 mm, d = 500 mm, Ast = 1600 mm ² , M25 concrete			
		and Fe415 steel.			
	Ans	Dt = 100 mm, bt = 1200 mm, bw = 250 mm, d = 500 mm, Ast = 1600 mm ² , M-25, Fe-415.			
		Actual neutral axis xu = (0.87 x fy x Ast) / (0.36 x fck x bf)			
		$= (0.87 \times 415 \times 1600) / (0.36 \times 25 \times 1200)$			
		= 53.49 mm.			
		Xumax = 0.48 x d			
		= 0.48 x 500	01 M		
		= 240 mm.			
		Xu < xumax, hence beam is under reinforced.			
		Mu = 0.87 x fy x Ast (d - 0.42xu)			
		= 0.87 x 415 x 1600 (500 – 0.42 x 53.49)			
		$= 275.9 \times 10^6 \text{ N-mm.} $ 02			
		Mu = 0.36 x fck x bf x xu (d - 0.42xu)			
		$= 0.36 \times 25 \times 1200 \times 53.49 (500 - 0.42 \times 53.49)$			
• •		= 2/5.9 x 10° N-mm			
Q.3	(C)	Diameter of steel bar is 16 mm, Use Fe415 and design bond stress is 1.2 mPa. For plain			
	A	bar in tension. Fina development length in tension and compression.			
	Ans	$\phi = 16$ mm, Fe-415, Design bond stress = 1.2 mPa.	01 14		
		Bond stress for deformed bars in tension = $1.2 \times 1.6 = 1.92$ mPa.			
		Bond stress for deformed bars in compression = $1.2 \times 1.6 \times 1.25 = 2.4$ mPa.			
		Development length in tension = $0.87 \times 415 \times 167$ (4 x 1.92) = 752.2 mm.			
0.2	(-1)	Development length in compression = $0.87 \times 415 \times 167 (4 \times 2.4) = 601.75$ mm.			
Q.3	(a)	Define the development length. How it is calculated.	02.14		
	Ans	Development length: It is an additional length of a bar of given diameter that required	02 101		
		beyond a section for proper anchorage through bond.			
		Development length is calculated using following expression	02.14		
		Development length is calculated using following expression.			
0.2	(0)	$Lu = Actual stress in steel x \phi / 4 x design bond stress.$	(16)		
Q.5	(e)	Design an axiany loaded column 400 mm x 400 mm pinned at both ends with an	(10)		
		conscrete and EoA1E stool			
	Anc	$\int column 400 \text{ mm y 400 mm } l_0 = 2 \text{ m } P_{11} = 200 \text{ kN} \text{ M 20} \text{ For 415}$			
	AIIS	2 Column 400 mm x 400 mm, ie – 3 m, ru – 2300 kN, ivi-20, re-413.	01 M		
		$A_{\rm R} = 400 \times 400 = 100000 \text{ mm}$			
		A = A = A = A = 100000 = A = 100000 = A = 100000 = A = 100000 = A = 1000000 = A = 10000000 = A = 1000000 = A = 10000000 = A = 100000000 = A = 100000000 = A = 1000000000 = A = 10000000000			
		$r u = (0.4 \times 10^{3} + [0.4 \times 20 \times (160000 - 4cc)] \pm (0.67 \times 415 \times 4cc)$			
		= 1280000 = 84cc + 278054cc	01 M		
		$\frac{-1200000 - 0000 + 270.00000}{0.00000} = 0.000000000 = 0.0000000000000$			



Min. Asc = 0.8 x 400 x 400 / 100 = 1280 mm ² . 01 M Max. Asc = 6 x 400 x 400 / 100 = 9600 mm ² . 01 M Min. Asc < Asc < Max. Asc = theree 0. K. Provide 22 mm dia. 12 bars. (Note: Students may provide different combination of no. and dia. Of bars.) 01 M Lateral Ties: Diameter of bar: (Greater of below) i. X of main bar dia. = 22/4 = 5.5 mm 01 M I. K of main bar dia. = 22/4 = 5.5 mm ii. 6 mm. 01 M Provide 6 mm dia. bars. Pitch: (Least of below) i. 10 m i. Lateral Times: 00 mm. 01 M Pitch: (Least of below) i. 16 times dia. Of main bar = 15 x 22 = 352 mm. 01 M ii. Least ateral dim. = 400 mm. 11 M 01 M Hence provide 6 mm dia. @ 300 mm c/c. 02 M 01 M Q.4 (A) Attempt any THREE: (A) J. Due to clastic shortening. 1.0 Use to alstic shortening. 4ny four J. Due to clastic shortening. 01 M 4ny four J. Due to clastic shortening. 01 M Any four J. Due to clastic shortening. 01 M 4ny four J. Due to clastic shortening. 1.0 Us to slip of anc			$= 4517.7 \text{ mm}^2$.	
Max. Asc = 6 x 400 x 400 / 100 = 9600 mm ² . 01 M Min. Asc < Asc < Max. Asc < Hence D. K.			Min. Asc = $0.8 \times 400 \times 400 / 100 = 1280 \text{ mm}^2$.	
Min. Asc < Asc < Max. Asc			Max. Asc = $6 \times 400 \times 400 / 100 = 9600 \text{ mm}^2$.	01 M
Provide 22 mm dia. 12 bars. (Note: Students may provide different combination of no. and dia. Of bars.) Internet combination of no. and dia. Of bars.) Internet combination of no. and dia. Of bars.) Lateral Ties: Diameter of bar: (Greater of below) i. X of main bar dia. = 22/4 = 5.5 mm ii. ii. 6 mm. Provide 6 mm dia. bars. Provide form dia. bars. 01 M Pitch: (Least of below) i. 16 times dia. Of main bar = 16 x 22 = 352 mm. ii. 16 times dia. Of main bar = 16 x 22 = 352 mm. ii. ii. Least lateral dim. = 400 mm. iii. 300 mm. Provide pitch 300 mm. Provide pitch 300 mm. Provide pitch 300 mm. Hence provide 6 mm dia. @ 300 mm c/c. (12) State any four losses in pre-stressing and describe any one. Any four 1. Due to creep of concrete. . . Due to realaxition of steel. . 3. Due to relaxation of steel. . Due to relaxation of steel. . . 4. Due to relaxation of steel. 5. Due to relaxation of steel. 6. Due to sing of concrete takes plac			Min. Asc < Asc < Max. Asc Hence O. K.	
and dia. Of bars.) Lateral Ties: Diameter of bar: (Greater of below) 01 M i. K of main bar dia. = 22/4 = 5.5 mm 01 M ii. 6 mm. Provide 6 mm dia. bars. 01 M Pitch: (Least of below) i. 16 times dia. Of main bar = 16 x 22 = 352 mm. 01 M ii. Least lateral dim. = 400 mm. 16 times dia. Of main bar = 16 x 22 = 352 mm. 01 M iii. Least lateral dim. = 400 mm. 16 times dia. Of main bar = 16 x 22 = 352 mm. 17 M iii. Least lateral dim. = 400 mm. 16 times dia. Of molia. @ 300 mm c/c. 17 M Q.4 (A) Attempt any THREE: 18 Molia times dia. @ 300 mm c/c. 18 Molia times dia. @ 300 mm c/c. Q.4 (A) Attempt any THREE: 10 ue to relastic shortening. 19 Molia times dia. @ 10 mm c/c. Q.4 (A) Attempt any THREE: 10 ue to relastic shortening. Any four Due to relastic shortening. Due to relasation of steel. 10 Uz to reap of concrete. 10 UZ M for each S. Due to slip of anchorages. 1 Elastic shortening of concrete takes place. This foss occurs in pre-tensioning method while in post-tensioning method this loss can be avoided by stretching all tendons simultaneous shortening of pre-stressing steel.			Provide 22 mm dia. 12 bars. (Note: Students may provide different combination of no.	
Lateral Ties: Diameter of bar: (Greater of below) i. % of main bar dia. = 22/4 = 5.5 mm 01 M ii. 6 mm. Provide 6 mm dia. bars. Provide 5 mm dia. bars. 01 M Pitch: (Less of below) i. 16 times dia. Of main bar = 16 x 22 = 352 mm. 01 M iii. Least lateral dim. = 400 mm. iii. 10 mm. Provide pitch 300 mm. Provide pitch 300 mm. 10 mm. Hence provide 6 mm dia. @ 300 mm c/c. 12 12 Q.4 (A) Attempt any TMRE: 12 (a) State any four losses in pre-stressing and describe any one. 10 M four Losses in pre-stressing: 1. Due to creep of concrete. 40 M four 3. Due to shrinkage of concrete. 41 M four 4. Due to ship of anchorages. 1. Elastic shortening: When pre-stress is applied to the concrete, an elastic shortening of pre-stressing steel. This loss occurs in pre-tensioning method while in post-tensioning method this loss can be avoided by stretching all tendons simultaneous shortening of concrete: Shortening of concrete takes place. This results in an equal and simultaneous shortening of pre-stressing steel. Any one 02 M 3. Strinkage of concrete: Shortening of concrete takes place. This results in an equal and simultaneous shortening of pre-stressing steel.			and dia. Of bars.)	
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 Elastic shortening: When pre-stress is applied to the concrete, an elastic shortening of concrete takes place. This results in an equal and simultaneous shortening of pre-stressing steel. This loss occurs in pre-tensioning method while in post-tensioning method this loss can be avoided by stretching all tendons simultaneously. Creep of concrete: Creep is the property of concrete by which it continues to deform with time under sustained load at unit stresses within the accepted elastic range. Due to creep, shortening of concrete takes place. This results in an equal and simultaneous shortening of pre-stressing steel. Shrinkage of concrete: Shrinkage is defined as decrease in volume of concrete due to loss in moisture. Due to shrinkage, shortening of pre-stressing steel. Relaxation of steel: Relaxation is assumed to mean the loss of stress in steel under nearly constant strain at constant temperature. It is similar to creep of concrete. Friction: This loss occurs only in post-tensioning method. There are small frictional losses in the jacking equipment. There is also friction between tendons and surrounding materials. Slip of anchorages: This loss occurs only in post-tensioning method. After stretching and anchoring, tendons are released and the force is transferred to the aproparates. Due to this load anchorages nierce in the concrete resulting 				
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		shortening of tendons. This shortening of tendons results in decreasing stress in	
		tendons.	
Q.4	(A)(b)	Calculate working load carrying capacity of column 300 mm x 450 mm in dimension	
		and provided with 8-16 mm diameter bars. Use M20 & Fe500 steel.	
	Ans	Column 300 mm x 450 mm, M-20, Fe-500, Asc = 16 mm dia. 8 bars.	
		$Ag = 300 \times 450 = 135000 \text{ mm}^2$	
		Asc = $8 \times \pi \times 16^2 / 4 = 1608.5 \text{ mm}^2$	01 M
		Ac = Ag - Asc = 135000 - 1608.5 = 133391.5	
		Pu = (0.4 x fck x Ac) + (0.67 x fy x Asc)	
		= (0.4 x 20 x 133391.5) + (0.67 x 500 x 1608.5)	
		= 1605979.5 N. = 1605.98 kN.	02 M
		Working load = Pu / F.O.S.	
		= 1605.98 / 1.5	
		= 1070.65 kN	01 M
Q.4	(A)(c)	State the values of partial factor of safety for steel and concrete.	
	Ans	1) Partial factor of safety for steel = 1.15	02 M
		2) Partial factor of safety for concrete = 1.5	02 M
Q.4	(A)(d)	State four situations where doubly reinforced section is preferred.	
	Ans	Situations where doubly reinforced section is preferred.	
		1. When depth of beam is restricted and strength of beam having restricted depth is	
		inadequate.	01 M for
		2. When the section are subjected to reversal of bending moment.	each
		3. In continuous T-beam where the portion of beam over intermediate supports has to	
		be designed as doubly reinforced.	
		4. When the beams are subjected to eccentric loading, shocks or impact loads.	
Q.4	(B)	Attempt any ONE:	(06)
	(a)	An R.C.C. beam 230 mm x 450 mm effective is subjected to a factored moment of 140	
		kN-m. Calculate area of steel in tension and compression zone. Use M20 gratd	
		concrete & Fe415 steel. (Assume d' 45 mm and d'/d = 0.1, fsc = 353 N/mm ²)	
	Ans	b = 230 mm, d = 450 mm, Mu = 140 kN-m, M-20, Fe-415, d' = 45 mm, fsc = 353 N/mm ² .	
		$Mulim = Mu_1 = 0.138 x fck x b x d^2$	
		$= 0.138 \times 20 \times 230 \times 450^2$	
		= 128.547 x 10° N-mm.	01 M
		$Mu_2 = 140 \times 10^6 - 128.547 \times 10^6$	
		= 11.453 x 10° N-mm	01 M
		Xumax = 0.48 x 450 = 216 mm.	
		$Ast_1 = Mu_1 / [0.87 x fy x (d - 0.42 xumax)]$	
		$= 128.547 \times 10^{\circ} / [0.87 \times 415 \times (450 - 0.42 \times 216)]$	01 M
		$= 990.97 \text{ mm}^2$	
		$Asc = Mu_2 / [fsc x (d - d')]$	
		$= 11.453 \times 10^{\circ} / [353 \times (450 - 45)]$	
		= 80.11 mm ² .	01 M
		$Ast_2 = Mu_2 / [0.87 x ty x (d - d')]$	
		$= 11.453 \times 10^{\circ} / [0.87 \times 415 \times (450 - 45)]$	
		= 78.3 mm ² .	
			• • • •
		$\frac{OR}{OR}$	01 M
		$\frac{OR}{Ast_2} = (fsc \times Asc) / (0.87 \times fy)$	01 M



		$= 78.3 \text{ mm}^2$.			
		Total Ast = 990.97 + 78.3 = 1069.27 mm² .	01 M		
Q.4	(B)(b)	A beam 240 mm x 500 mm effective, it is reinforced with 4-16 mm diameter tension			
		side and 2-12 mm in compression zone, each an effective cover of 40 mm. Use M20			
		concrete & Fe415 steel. Find ultimate moment of resistance. Assume fsc = 352 N/mm ² .			
	Ans	b = 240 mm, d = 500 mm, Ast = 16 mm- 4, Asc = 12 mm – 2, M-20, Fe-415, d' = 40 mm,			
		fsc = 352 N/mm ² .			
		Ast = $4 \times \pi \times \phi^2 / 4$			
		$= 4 \times \pi \times 16^2 / 4 = 804.25 \text{ mm}^2$			
		Ast = $2 \times \pi \times \phi^2 / 4$	01 M		
		$= 2 \times \pi \times 12^2 / 4 = 226.19 \text{ mm}^2$			
		Actual neutral axis xu = [(0.87 x fy x Ast) – (fsc x Asc)] / (0.36 x fck x b)			
		$= [(0.87 \times 415 \times 804.25) - (352 \times 226.19)]/(0.36 \times 20 \times 240)$			
		= 121.97 mm.			
		Xumax = 0.48 x d			
		= 0.48 x 500	01 M		
		= 240 mm.			
		Xu < xumax, hence beam is under reinforced.			
		Mu = 0.36 x fck x b x xu (d – 0.42xu) + fsc x Asc (d – d')	02 M		
		= 0.36 x 20 x 240 x 121.97 (500 – 0.42 x 121.97) + 352 x 226.19 (500 – 40)			
		$= 131.21 \text{ x } 10^6 \text{ N-mm.}$			
Q.5		Attempt any TWO:			
	(a)	Design a doubly reinforced rectangular beam 300 mm x 660 mm overall size, for an			
		effective span of 5 m. The beam is subjected to udl of 55 kN/m. Assume effective cover			
		60 mm. Use M20 & Fe415 steel. d'/d = 0.1, fsc = 353 N/mm ² .			
	Ans	Le = 5 m., w = 55 kN/m, b = 300 mm, D = 660 mm, M-20, Fe-415, d' = 60 mm, fsc = 353			
		N/mm ² .			
		Factored load = $1.5 \times 55 = 82.5 \text{ kN/m}$	01 M		
		$Mu = 82.5 \times 5^2 / 8$	02 M		
		= 257.81 kN-m.			
		Effective depth d = $660 - 60 = 600 \text{ mm}$.	01 M		
		$Mulim = 0.138 \times 20 \times 300 \times 600^{2}$			
		= 298.08 kN-m	01 M		
		Mu < Mulim, Hence singly under reinforced beam is to be designed.	01 M		
		Ast = 0.5 x fck x b x d $\{1 - SQRT[1 - (4.6 x Mu) / (fck x b x d^2)]\} / fy$			
		$= 0.5 \times 20 \times 300 \times 600 \{1 - SQRT[1 - (4.6 \times 257.812 \times 10^{\circ}) / (20 \times 300 \times 600^{2})]\} / 415$	02 M		
		= 235.71424.7 mm ²			
Q.5	(b)	A beam 250 mm x 400 mm deep effective is reinforced with 3 bars of 16 mm diameter			
		of grade Fe415. The shear force at the support is 60 kN. Design the shear			
		reinforcement if grade of concrete used is M20. Use 6 mm or 8 mm diameter vertical			
		stirrups.			
	Ans	b = 250 mm, d = 400 mm, Ast = 16-3, Fe-415, V = 60 kN, M-20.			
		$Vu = 1.5 \times 60 = 90 \text{ kN}$	01 M		
		Nominal shear stress = Vu / (b x d)			
		$= 90 \times 10^{\circ} / (250 \times 400)$	01 M		
		$= 0.9 \text{ N/mm}^{2}$			
		Ast = $3 \times \pi \times 16^{2} / 4 = 603.19 \text{ mm}^{2}$			
		Pt% = 603.19 x 100 / (25 x 400) = 0.60%			



	Note: Values of permissible s	hear stress are not given; her	nce students may assume				
	different values. Hence accor	dingly marks shall be given)					
	Pt%	0.50 0.75		01 M			
	Permissible shear	[•] stress N/mm ² 0.48 0.56					
	For 0.6%, Permissible shear st	ress = 0.48 + {[(0.56 – 0.48) /	(0.75 – 0.50)] x (0.60 – 0.50)}				
		= 0.512 N/mm ²					
	Nominal shear stress > permis designed.	ear stress > permissible shear stress, hence shear reinforcement is to be					
	Vus = Vu – permissible shear	ermissible shear stress x b x d					
	$= 90 \times 10^3 - (0.512 \times 250)$	x 400)		01 M			
	= 38800 N.	3800 N.					
		For 6 mm dia. Stirrups	For 8 mm dia. stirrups				
	Asv = $2 \times \pi \times \phi^2 / 4$	56.54 mm ²	100.54 mm ²				
	Spacing =	210 5	274.22				
	0.87 x fy x Asv x d) / Vus	210.5 mm	374.23 mm	01 M			
	Spacing for min. stirrups	201	262				
	= (0.87 x fy x Asv) / (0.4 x b) 204 mm	363 mm	01 M			
	Max. spacing 0.75 d or	300 mm	300 mm				
	300 mm whichever lesser.	. 300 mm	300 mm	01 M			
	Provide	6 mm dia. @ 200 mm c/c	c 8 mm dia. @ 300 mm c/c	01 M			
Ans	Column 250 mm x 250 mm, P Note: Students may assume	u = 700 kN, SBC of soil = 150 k ultimate bearing capacity as 1	:N/m ² , M-20, Fe-415. I.5 times or 2 times SBC.				
	Ultimate bearing capacity	1.5 x 150 = 225 kN/m ²	2.0 x 150 = 300 kN/m ²				
	Self-weight of footing = 5%	35 kN	35 kN				
	of load on column.						
	Total ultimate load on soil	735 kN	735 kN	01 M			
	Area of footingrequired = Total ultimate load on soil / Ultimate bearing capacity of soil	735 / 225 = 3.27 m ²	735 / 300 = 2.45 m ²				
	Size = SQRT(Area)	1.81 m	1.565 m.	01 M			
	Provide size	1.85 m x 1.85 m	1.6 m x 1.6 m				
	Actual area provided	3.4225 m ²	2.56 m ²				
	Net ultimate upward	700 / 3.4225 = 204.5	700 / 2.56 = 273.5 kN/m ²				
	pressure (qnu) = Ultimate	kN/m ²					
	load on column / Actual			01 M			
	area provided						
	Projection (a)	1.85 – 0.25 / 2 = 0.8 m	1.6 – 0.25 / 2 = 0.675 m.	01 14			
	$Mu = qnu x a^2 / 2$	65.44 kN.m	62.31 kN-m				
	d required = SQRT(Mu /	SQRT(65.44 / 0.138 x 20 x	SQRT(62.31 / 0.138 x 20 x	01 14			
	0.138 x fck x b)	1000) = 154 mm	1000) = 150 mm				
	Overall depth D = d + cover	214 mm	210 mm				
	60 mm						



		Provide	D = 220 mm & d = 160 mm	D = 220 mm & d = 160 mm	
		Ast = 0.5 x fck x b x d {1 -	0.5 x 20 x 1000 x 160 {1 -	0.5 x 20 x 1000 x 160 {1 -	
		SQRT[1 – (4.6 x Mu) / (fck x	SQRT[1 – (4.6 x 65.44 x	SQRT[1 – (4.6 x 62.31 x	01 M
		$b x d^{2}$]]} / fv	10^{6}) / (20 x 1000 x 160 ²)]} /	10^{6}) / (20 x 1000 x 160 ²)]} /	
			$415 = 1380.5 \text{ mm}^2$	$415 = 1297.5 \text{ mm}^2$	
		Spacing for 16 mm dia.	145.6 mm	155 mm	
		Bars = 1000 x A1 / Ast			01 M
		Provided	16 mm dia. @ 140 mm c/c	16 mm dia. @ 150 mm c/c	
					01 M for fig.
Q.6		Attempt any FOUR:			(16)
	(a)	An R.C. T-beam section reinfor	rced for tension has the follo	wing dimension bf = 1250	
		mm, bw = 300 mm, d = 550 mm	m, Df = 100 mm, Ast = 1884 r	nm2. Use of M20 & steel	
		Fe415 is made. Calculate the li	imiting moment of resistanc	е.	
	Ans	Df = 100 mm, bf = 1250 mm, by	w = 300 mm, d = 550 mm, As	t = 1884 mm², M-250,	
		Fe-415.			
		Actual neutral axis xu = (0.87 x	fy x Ast) / (0.36 x fck x bf)		
		= (0.87 x	x 415 x 1884) / (0.36 x 20 x 12	250)	01 M
		= 75.58 r	mm.		
		xumax = 0.48	x d		
		= 0.48	x 550		01 M
		= 264 r	mm.		
		xu < xumax, h	ence beam is under reinforce	ed.	
		Mu = 0.87 x fy x Ast (d ·	– 0.42xu)		
		= 0.87 x 415 x 1884	l (550 – 0.42 x 75.58)		
		= 352.53 x 10 ^⁰ N-m	ım.		02 M
			<u>OR</u>		
		Mu = 0.36 x fck x bf x x	u (d – 0.42xu)		
		$= 0.36 \times 20 \times 1250$	x 75.58 (550 – 0.42 x 75.58)		
		1) = $352.53 \times 10^{\circ}$ N	N-mm		
Q.6	(b)	State the I.S. specification for,			
		i) Maximum reinforceme	ent in beams & slabs.		
		ii) Minimum reinforcemer	nt in slab.		
		iii) Minimum shear reinfor	rcement.		
	_	iv) Cover to reinforcement	t in beam and slab.		
	Ans	i. Maximum reinforceme	nt in slab and beam = 4% of §	gross area. (0.04 x b x D)	01 M
		ii. Minimum reinforcemer	nt in slab = 0.15 % for M.S. ar	nd 0.12% for deformed bars,	
		of gross area.			01 M
		III. Minimum shear reinfor	rcement, [Asv / (b x sv)] > or =	= [U.4 / (U.87 x fy)]	01 M
		IV. Cover to reinforcement	t in beams & slab.		01.14
		For beams, 20 mm to 70 r	nm depending upon fire resi	stance required.	UT M
	()	For slabs, 20 mm to 55 mm	m depending upon fire resist	ance required.	
Q.6	(c)	Calculate effective flange widt	th for T-beam for following a	letails.	
		Width of web = 230 mm.			



		Slab thickness = 100 mm.	
		Size of hall = 12 m x 6 m.	
		Width of support for beam = 230 mm.	
		C/c spacing of beams = 3 m.	
	Ans	bw = 230 mm, Df = 100 mm, Hall size = 12 m x 6 m., Support = 230 mm, C/c spacing of	
		beam = 3 m.	
		le = 6 + 0.23 = 6.23 m.	01 M
		Hence $I_0 = 6.23$ m.	
		$bf = (I_0/6) + bw + 6Df$	
		= (6230/6) + 230 + 6 x 100	02 M
		= 1868.3 mm. < C/c spacing (3000 mm)	
		Hence bf = 1868.3 mm.	01 M
Q.6	(d)	Write four I.S. specifications for the longitudinal reinforcement in columns.	
	Ans	 Minimum area of longitudinal reinforcement = 0.8% of gross area. 	
		Maximum area of longitudinal reinforcement = 6.0% of gross area.	Any four,
		3. Minimum number of bars = 04 for square column, 06 for circular column and 06	01 M for
		for column with helical reinforcement.	each
		4. Minimum diameter of bar = 12 mm.	
		5. Maximum spacing of bars measured along periphery of column = 300 mm.	
Q.6	(e)	Calculate the area of longitudinal steel for short circular column of diameter 400 mm	
		with effective length 4.5 m to carry a factored load of 900 kN. Use M20 and Fe500.	
	Ans	Column 400 mm diameter, le = 4.5 m, Pu = 900 kN, M-20, Fe-500.	
		Ag = $\pi \times 400^2 / 4 = 125663.71 \text{ mm}^2$	
		Ac = Ag – Asc = 125663.71 – Asc	01 M
		Pu = (0.4 x fck x Ac) + (0.67 x fy x Asc)	
		$900 \times 10^3 = [0.4 \times 20 \times (125663.71 - Asc)] + (0.67 \times 500 \times Asc)$	02 M
		= 1005309.68 – 8Asc + 335Asc	
		$Asc = (900 \times 10^3 - 1005309.68)/327$	
		$= (-) 322 \text{ mm}^2.$	
		Required area of compression steel is negative; hence minimum area of steel is to be	01 M
		provided.	
		Min. Asc = $0.8 \times 125663.71 / 100 = 1005.3 \text{ mm}^2$.	
		Provide Asc = 1005.3 mm ²	