Model Answer: WINTER 2016

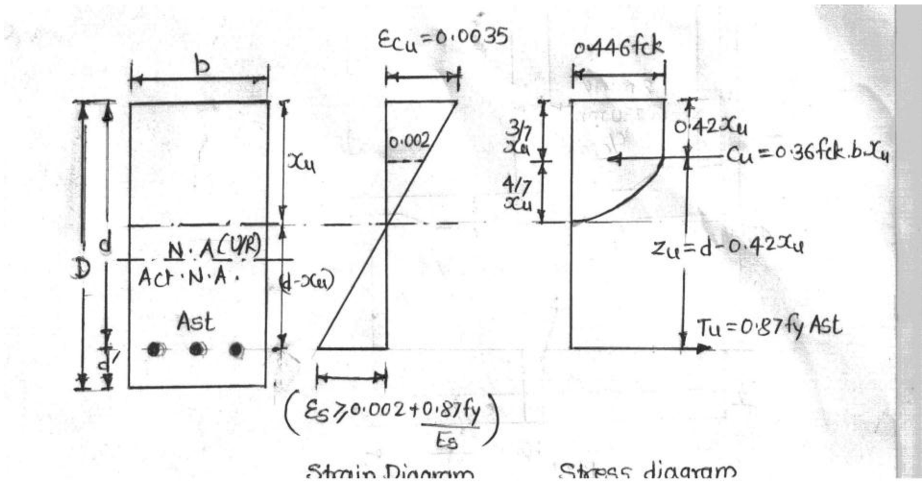
Subject: Design of RCC Structures **Subject Code: 17604**

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 the candidate and those in the 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 the model answer.
6) In case of some questions credit may be given by judgment 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.

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**a)**	**Attempt any THREE of the following:**		**12**
	(i)	**State any four assumptions made in design for the limit. State method.**		
	Ans.	Following are the assumptions made in design for the limit – a)Plane section normal to the axis remain plain after bending b)The maximum strain in concrete at the outermost compression fiber is taken as 0.0035 in bending c)The relationship between compressive stress distribution in concrete may be assumed to be rectangle, trapezoid, parabola or any other shape which results in prediction of strength. d)The tensile strength of concrete is ignored. e)The stresses in the reinforcement are derived from representative stress – strain curve for the type of steel used. f)The maximum strain in tension reinforcement in the section at failure shall not be less than: $(f_y /(1.15 E_s)) + 0.002$ Where fy – Characteristic strength of steel E_s – Modulus of elasticity of steel g)The maximum compressive strain in concrete in axial compression is taken as 0.002 h) the maximum compressive strain at highly compressed extreme fibre in concrete subjected to axial compression and bending when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at least compressed extreme fibre	**1 Mark each (any Four)**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
	(ii)	**Draw strain and stress distribution diagram for an under reinforced rectangular section showing all significant values for L.S.M**		
	Ans.	See diagram below	4	4



Strain diagram **stress diagram**

(Note- Strain diagram 2 Marks and Stress diagram 2 Marks)

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**a) (iii) Ans.**	**State the partial factor of safety for steel and concrete**		

Material	Limit state of	
	collapse	serviceability
Concrete	1.5	1.0
Steel	1.15	1.0

Marks: **2 Mark for each** — Total: **4**

(iv) **State various losses in prestressing. State their approximate percentage loss for post tensioned member.**

Ans. **Losses in prestressing: important causes are:**

i) Due to elastic shortening of concrete – 1%
ii) Due to creep of concrete - 5%
iii) Due to shrinkage of concrete - 6%
iv) Due to creep in steel - 3%
v) Due to frictional loss
vi) Due to slip at anchorages

Marks: **1 Mark each (any four)** — Total: **4**

(v) Ans. **State any three ductile detailing provision in IS : 13920 – 200**

Requirement for longitudinal reinforcement in flexural members:

1) The top as well as bottom reinforcement shall consist of at least two bars throughout the member length
2) The maximum steel ratio on any face at any section, shall not exceed $P_{max} = 0.025$
3) The positive steel at a joint face must be at least equal to half the negative steel at that face.

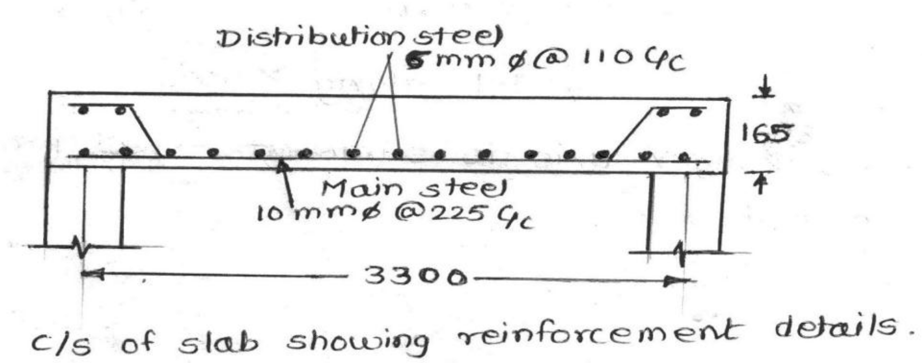
(Note : Any other members ductile detailing provisions should be considered)

Marks: **4** — Total: **4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**b**	**Attempt any ONE of the following :**		**6**
	(i)	**Find the moment of resistance M_u for a beam 300 x 600 mm, effective provided with 3 bars of 16 mm diameter and 2 bars of 12 mm diameter on tension side. M20 & Fe500 are used.**		
	Ans.	b = 300 mm d = 600 mm $fck = 20\ N/mm^2$ $Ast = 3 \times \pi/4 \times 16^2 + 2 \times \pi/4 \times 12^2$ $= 829.38\ mm^2$	1	
		Solution $X_u = (0.87fy\ Ast)/ (0.36\ fck.b)$ $= (0.87 \times 500 \times 829.38)/ (0.36 \times 20 \times 300)$ **= 167.03 mm**	1	6
		$X_u\ max = 0.46d$ $= 0.46 \times 600 = 276\ mm$	1	
		As $X_u < X_{u\ max}$, Section is under reinforced. $M_u = 0.87\ fy\ Ast\ (d - 0.42\ Xu)$ $= 0.87 \times 500 \times 829.38\ [600 - 0.42(167.03)]$ $= 191.158 \times 10^6\ Nmm = 191.158\ KNm$	3	
	(ii)	**Calculate depth and area of steel at mid span of a simply supported beam over as clear span 6 m. The beam is carrying all inclusive load 20 KN/m. Assume 300 mm bearings. Use M20 and Fe500**		
	Ans.	**Given** l = 6m $L_e = 6 + 0.3/2 + 0.3/2 = 6.3\ m$	1	
		w = 20 kN/m $fck = 20\ N/mm^2$ $fy = 500\ N/mm^2$ Solution **1) $M = w L_e^2/8$** $= (20 \times 6.3^2) / 8$ $= 99.225\ KNm$	1	
		2) Factored moment $M_d = \gamma_f \times M$ $= 1.5 \times 99.225$ $= 148.8375\ kNm$	1	
		3) $M_u\ lim = 0.133\ fck\ b\ d^2$ **4)Assume b = d/2** Equating M_u lim to M_d $0.133\ fck\ b\ d^2 = 148.83 \times 10^6$ $0.133 \times 20 \times (d/2) \times d^2 = 148.83 \times 10^6$ $d^3 \times 1.33 = 148.83 \times 10^6$ $d^3 = 111908270.7$ d = 481.89 mm say 490 mm	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	b) (i)	Assume d' = 40 mm D = d + d' = 490 + 40 = 530 mm Therefore b = 490 / 2 = 245 mm **5) $P_{t\ lim}$ = Ast/ bd x 100** = 0.038 fck (for Fe_{500}) = 0.038 x 20 = 0.76% Ast = 0.76 bd/100 = 0.76 x 245 x 490/100 = 912.38 mm^2 Therefore Ast = 912.38 mm^2 < Ast_{min} = $0.85bd/f_y$= (0.85x 245 x 490)/500 = 204.085 mm^2………………ok Assuming 20 mm ϕ bars to be used, No. of bars = 912.38 / (π/4 x 20^2) = 2.90 say 3 Nos Provide 3 bars of 20 mm dia with area = 942.48 mm^2	1 1	6
Q.2		**Attempt any TWO of the following.**		16
	a)	**A one way slab is to be designed for an effective span 3.3 m . The super imposed load including finishing is 4 KN/m².Taking modification factor 1.2.Design the slab. Sketch c/s of slab showing reinforcement details. Use concrete M20 and steel Fe 415 .**		
	Ans.	**Given :** Span=3.3 m, L.L.+F.F.= 4 KN/m^2, M.F.=1.2 **(Note : Answer may vary according to cover and bar diameter assumed.)** **1.Design Constant -** fy = 415 N/mm^2 fck =20 N/mm^2 Xu_{max} = 0.48d $Mu_{,lim}$ = 0.138fck b d^2 **2. Estimation of slab thickness,** d = span/ (20 x M. F) Therefore, d = 3300/(20 x 1.2) = 137.5 mm Assuming 10 mm Ø main bars and nominal cover as 20 mm D = d + d_c + Ø/2 = 137.5 + 20 + 10/2 = 162.5 mm Say D = 165 mm Therefore d_{avail} = D – d_c - Ø/2 = 165 -20 – 10/2 = 140 mm	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**a)**	**3. Effective span:** L_e = 3.3 m (given) **4. Load calculations: (considering 1 m wide strip)** Self wt. of slab = 1 x 1 x 0.165 x 25 = 4.125 Wt of F.F & L.L. = 1 x 1 x 4 = 4 Total load, w = 8.125 kN/m Therefore factored load, $w_d = \Upsilon_f$ x w = 1.5 x 8.125 = 12.1875 kN/m	**1**	**8**
		5. Factored (design) max B. M. : $M_d = (w_d \times l_e^2)/8$ $= (12.1875 \times 3.3^2) / 8$ = 16.59 KNm	**1**	
		6. Required overall depth and effective depth: Equating M_u, lim to M_d $0.138\ fck\ b\ d^2 = M_d$ $0.138 \times 20 \times 1000\ d^2 = 16.59 \times 10^6$ d = 77.53 mm $d_{available}$ = 140 mm > d_{reqd} Hence OK. Provide D = 165mm and $d_{available}$ = 140 mm	**1**	
		7. Area of main steel $Ast = 0.5\ fck / fy\ [1 - (\sqrt{1 - \frac{4.6\ Md}{(fck\ b\ d^2)}})]\ b\ d$ $= \frac{0.5 \times 20}{415}[1 - \sqrt{1 - \frac{4.6 \times 16.59 \times 10^6}{20 \times 1000 \times 140^2}}] \times 1000 \times 140$ $= 346.13\ mm^2$	**1**	
		Spacing of main reinforcement a) $S_{10\varnothing}$ = (1000 A Ø)/ Ast $= \frac{1000 \times \frac{\pi}{4} \times 10^2}{346.13}$ = 226.91 say 225 mm c/c Spacing = 225 mm c/c b) 3d = 3 x 140 = 420 mm c) 300 mm Ast provided = (1000 A Ø)/ 5 = (1000 x 78.54)/ 225 $= 349.06\ mm^2$	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	a)	**8. Area and spacing of distribution steel:** $Ast_{min} = Ast_d$ = 0.15/100 b D (mild steel is used) = (0.15/100) x 1000 x 165 = 247.5 mm^2 Spacing of 6 mm Ø M. S. distribution bars,= min of a,b,c a)S_d = [(A Ø d)/ (Ast d)] x b = (28.27/247.5) x 1000 = 114.22 mm say 110 mm c/c b) spacing, S = 5d = 5 x 140 = 700 mm c) 450 mm spacing = 114.22 mm ≈110mm Therefore As $S_d < S_{dmax}$ Provide 6 mm Ø distribution bars @ 110 mm c/c	1	
		9. Reinforcement details:  	1	
	b) Ans.	**Design a simply supported two way slab over a room 4.8 m x 4.0 m effective, subjected to UDL 5 kN/m² (inclusive of self wt.) Use M20 and Fe 415. Draw reinforcement detail check for shear may not be given. Take $\alpha_x = 0.084$ and $\alpha_y = 0.059$** **(Note- Answer may vary depending upon assumption of MF, diameter of bar & cover)** 1. **Given:** 4.8 m x 4 m effective, two way slab w = 5 kN/m^2 (inclusive of self wt) fck = 20 N/mm^2 fy = 415 N/mm^2 $\alpha_x = 0.084$ $\alpha_y = 0.059$ 2. **Design constants :** For Fe 415, $Mu_{lim} = 0.138\ fck\ b\ d^2$		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**b)**	**3. Estimation of slab thickness** Assume MF = 1.4 Therefore d = span/(20 x 1.4) = 4000/ (20 x 1.4) = 142.86 mm say 150 mm Assuming 10 mm Ø main bars, & c = 20 mm, D = d + c + (Ø/2) = 150 + 20 + (10/2) = 175 mm	**1**	
		4. Effecftive span : L_{xe} = 4000 mm, L_{ye} = 4800 mm Consider 1 m wide strip Load : $w_{given} = 5\ KN/m^2$ w = 1 x 1 x 5 = 5 kN/m factored load = w_d = 1.5 x 5 = 7.5 KN/m	**1**	
		5. Factored B. M : $\alpha_x = 0.084$ $\alpha_y = 0.059$ $M_{xd} = \alpha_x \cdot w_d \cdot L_{xe}$ $= 0.084 \times 7.5 \times 4^2$ = 10.08 KNm $M_{yd} = \alpha_y \cdot w_d \cdot L_{xe}^2$ $= 0.059 \times 7.5 \times 4^2$ = 7.08 kNm	**1**	
		6. Effective depth of slab: $0.138\ fck\ bd^2 = M_{xd}$ $0.138 \times 20 \times 1000\ d^2 = 10.08 \times 10^6$ d_{reqd} = 60.43 mm < ($d_{available}$ = 150 mm) Hence OK	**1**	
		7. Area and spacing of steel $Ast_x = 0.5fck/fy\ [1- \sqrt{1 - (\frac{4.6Mxd}{fck.bd2})}]\ bd$ $= \frac{0.5\times20}{415}\left[1-\sqrt{1-\left(\frac{4.6\times10.08\times10^6}{20\times1000\times150\times150}\right)}\right]\times1000\times150$ $= 191.278mm^2$		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks

Q.2 **b)**

Select 8 mm Ø bars,Spacing = min of a,b,c

a) $S_x = [(\pi/4 x 8^2 x\ 1000)/ 191.27] = 262.76$ say mm say 260 mm

$S_x = 260$ mm c/c

b) 3 d = 3 x 150 = 450mm

c) 300 mm …………..OK

Spacing = 260mmc/c

d' = d – Ø = 150 – 8 = 142 mm

$$Ast_y = \frac{0.5 \times f_{ck}}{f_y}\left[1-\sqrt{1-\left(\frac{4.6\times M_{yd}}{f_{ck}bd^2}\right)}\right]\times bd'$$

$$= \frac{0.5\times 20}{415}\left[1-\sqrt{1-\left(\frac{4.6\times 7.08\times 10^6}{20\times 1000\times 142\times 142}\right)}\right]\times 1000\times 142$$

$= 141.07\ mm^2$ **2**

Ast_{min} = (0.12/100) b D

= (0.12/100) x 1000 x 175

$= 210\ mm^2$ **1**

Ast_x calculated is very less.

Take Ast_x & $Ast_y = 210\ mm^2$

Therefore, Spacing of 8 mm dia. Bars,

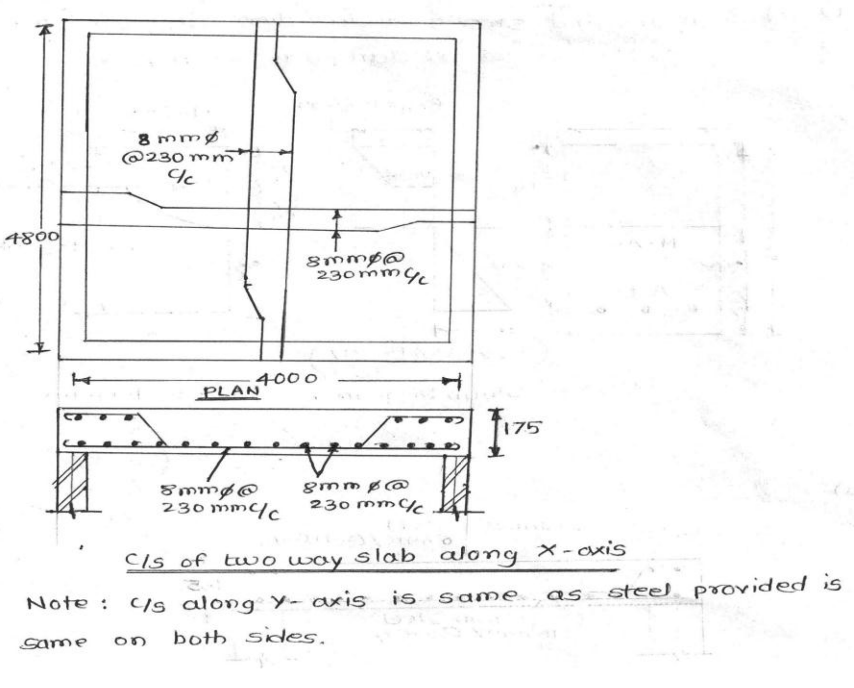
$$S_X = S_Y = \frac{\frac{\pi}{4}\times 8^2 \times 1000}{Ast_{min}}$$

$S_x = S_y$ = (50.26 x 1000)/ 210

= 239.33 mm say 230 mm c/c (< 3d or 300 mm)……… OK

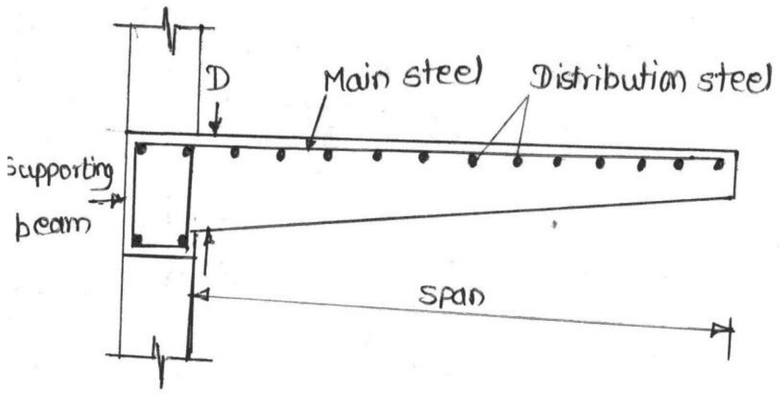
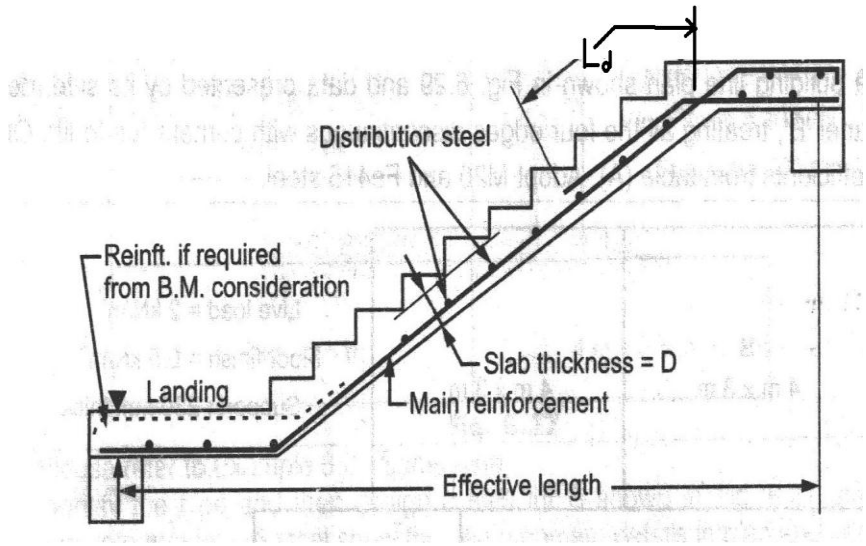
Provide 8mm Ø @ 230 mm c/ c in both directions

Reinforcement details:



1

Total Marks: **8**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	**c) i)**	**Draw detailed diagram showing reinforcement details in case of cantilever slab**		
	Ans:		**4**	**4**
	ii)	**Draw detailed diagram showing reinforcement details in case of dog legged staircase**		
	Ans:	 **Fig. Dog legged staircase** **(Note- 2 marks for sketch and 2 marks for labeling)**	**4**	**4**

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<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>Q.3</td><td>
a)

Ans:</td><td>Attempt any <u>FOUR</u> of the following.
State the IS specification for effective flange width of T and L beam.
The effective width of the flange may be taken as following in no case greater than the width of the web plus half the sum of the clear distance to the adjacent beam on the either side.
a) For T beam
$b_f = lo/6 + b_w + 6 D_f$
b) For L beam
$b_f = l_o/12 + b_w + 3D_f$
where,
b_f = effective width of flange
l_o = distance between points of zero moment in the beam
b_w = breath of web
D_f = thickness of flange
b = actual width of flange.</td><td>

2

2</td><td>16

4</td></tr>
<tr><td></td><td>b)

Ans:</td><td>Find the moment of resistance of T beam with the following data: b_f = 1200 mm, D_f =120 mm , b_w = 300 mm , d = 500 mm, steel on tension side = 5 bars of 20 mm diameter bars
(Note-answer may vary depending upon assumption of concrete and steel grade)
Given - b_f = 1200mm
D_f = 120mm
b_w = 300mm
d =500mm
Ast = 5 x π/4 x 20^2 =1570.79mm^2
To find = Mu = ?

Step1 –
To find X_u=?
$$x_u = \frac{0.87 f_y Ast}{0.36 f_{ck} b_f}$$
$$x_u = \frac{0.87 \times 415 \times 1570.79}{0.36 \times 20 \times 1200}$$
Xu = 65.64mm
Step2 - To find X_{umax}?
X_{umax} = 0.479 X d
= 0.479 X 500
X_{umax} =239.5mm
As, Xu < Xumax, so, beam is under reinforced.</td><td>

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1</td><td></td></tr>
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Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**b)**	**Step 3- to find Mu=?** Mu = Tu x Zu =0.87 x fy x Ast (d -0.42 Xu) =0.87 x 415 x 1570.79 (500 -0.42 x 65.64) = 567.13 x 10^3 (472.44) =267.93 x 10^6 N-mm **Mu = 267.093 KN-m**	2	4
	c)	**Find developement length of 20 mm diameter bar in tension and compression. Assume M20 concrete and Fe 500 grade steel. Use Z_{bd}= 1.2 N/mm^2**		
	Ans	Given data –ϕ=20mm fck = 20 N/mm^2 fy = 500N/mm^2 Bond stress = Z_{bd} = τ_{bd} =1.2 N/mm^2 To find L_d for 20 mm dia. bar in tension and compression. **a) Development length for bar in tension** $L_d = \frac{0.87 f_y \phi}{4T_{bd}}$ For Fe 500 steel value of τ_{bd} shall be increased by 60%. τ_{bd} = 1.2 x 1.6=1.92 N/mm^2 $L_d = \frac{0.87 \times 500 \times 20}{4 \times 1.92}$ L_d =1132.81mm	2	4
		b) Development length for bar in compression For bar in compression, the value of bond stress for bar in tension shall be increased by 25% τ_{bd} = 1.6 x 1.2 = 2.4N/mm^2 $L_d = \frac{0.87 \times 500 \times 20}{4 \times 2.4}$ = 906.25 mm	2	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**d) Ans**	**State I.S. specification for minimum shear reinforcement** minimum shear reinforcement in form of stirrup shall be provided such that, $A_{sv}/(b \times S_v) \geq 0.4/0.87f_y$ Where, A_{sv} = total cross section area of stirrups legs effective in shear S_v = stirrups spacing along the length of the member b = breadth of beam or web of flanged beam F_y = characteristic strength of stirrup reinforcement in N/mm^2 which shall not be taken greater than $415 N/mm^2$.	**2** **2**	**4**
	e) **Ans.**	**Design a R.C column to carry an axial working load 400 kN.The effective length of column is 2.5 m. check the column for min eccentricity. Use M20 and Fe 415 grades of concrete and steel.** **(Note: answer may vary according to shape of column assumed)** Given data- P = 400 **kN** $L_{eff.}$ = 2.5 m =2500mm F_{ck} = 20 N/mm^2 F_y = 415 N/mm^2 **Step 1- To find factored load** P_u = 1.5 P = 1.5 X 400 = 600 **kN** **Step 2- Assume 1% of steel in column** Area of steel, A_{sc} = 0.01 Ag Area of concrete A_c = Ag- Asc A_c = 0.99Ag **Step3- To find Ag** Pu = (0.4fck x Ac) + (0.67 fy x Asc) 600×10^3 = (0.4 x 20 x 0.99Ag) + (0.67 x 415 x 0.01Ag) Ag = 56072.14 mm^2 Ag = $56.07 \times 10^3 mm^2$ Assuming square shape, Each side = $\sqrt{56.07 \times 10^3}$ =236.79 m ≈240 mm	 ½ ½ 1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**e)**	**Step 4: Check for minimum eccentricity** e_{min} = L/500 + D/30 OR 20mm whichever is greater = 2500/500 + 240/30 e_{min} = 13mm OR 20mm whichever is greater e_{min} =20 mm $e_{min} < 0.05D$ 0.05D = 0.05 X 240 =12 mm But, e_{min} is more than 0.05 D So.check for minimum eccentricity is not satisfy. So, increase the dimension say 320mm X 320 mm Now, e_{min} =(2500/500 +320/30) e_{min} =15.67 mmm and 0.05D = 0.05 X 320 D = 16 mm $e_{min,} < 0.05D$ 15.67 mm < 16mm…… ok for minimum eccentricity. Revised size of column = 320mm x 320 mm Asc = 0.01 Ag = 0.01 X 320 X 320 Asc= 1024 mm^2 Provide 4 bars of 20 mm ϕ bar. **Step 5= Lateral ties** Diameter of ties = ¼ X diameter of longitudinal steel bar = ¼ X 20 = 5 mm But ϕ < 6 mm So, provide 6mm dia. lateral ties. Pitch should not be grater than i) Least lateral dimensions of column i.e. 320mm. ii) 16 x dia. of longitudinal steel =16 x ϕ 16 x 20 = 320 mm iii) 300mm (Select minimum of above values) Therefore, provide lateral ties 6mm ϕ @ 300mm c/c.	1 1	4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**a)**	**Attempt any THREE of the following.**		**12**
	i) **Ans**	**Write any four advantages of prestressed concrete .** **1.** Prestressed member is more durable.Prestressed concrete beams are generally free from cracks as high grade concrete is used. **2.** Fatigue strength is considerably higher than that of normal reinforced concrete. **3.** Deformations of such structure are significantly smaller than reinforced concrete structure. **4.** Prestressed concrete is economical for high spans and heavily loaded structural members. **5.** Considerable reduction in dead load of structure. **6.** Smaller section can be used with prestressed systems. Larger depths in compression are available in flexural due to pre compression. **7.** Prestressed concrete is resilient, deformation due to overloading are recovered.	**1 Mark each (any four)**	**4**
	ii) **Ans-**	**Define limit states and state types of various limit states.** Limit state may be defined as ,the acceptable limit for safety and serviceability of structure before failure occurs. Types of limit states- 1. Limit state of collapse a. Flexure b. Shear c. torsion 2. Limit state serviceability a. Deflection b. cracking	**2** **1** **1**	**4**

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<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>Q.4</td><td>iii)
Ans:</td><td>State two situations where doubly reinforced section is preferred.
1) When the singly reinforced beams need considerable depth to resist large bending moment, it becomes necessary to provide doubly reinforced section.
2) When the size of rectangular beam cross-section is limited because of architectural reasons or practical reasons then it becomes necessary.
3) When the sections are subjected to reversal of bending moment.
4) When it is required to reduce the long-term deflection, it becomes necessary to provide doubly reinforced section.
5) When a beam is continuous overall several supports; the beam is subjected to alternate sagging also it becomes necessary to provide doubly reinforced section.</td><td>2 Marks each (any two)</td><td>4</td></tr>
<tr><td></td><td>iv)</td><td>Calculate working load carrying capacity of column 230 x 230 mm. provided with 4 bars of 16 mm diameter . Use M 20 concrete and Fe 415 steel
Ans:
Given data :
Size of column = 230 x 230mm
Asc = $4\frac{\pi}{4}(16)^2$
= 804.24mm^2
fck = 20 N/mm^2
fy=415 N/mm^2
To find, working load carrying capacity of column = P = ?
<u>Step 1</u> : Gross area = Ag = 230x230
= 52900 mm^2

<u>Step 2</u> : Area of steel, Asc = 804.24 mm^2

<u>Step 3</u> : Area of concrete, Ac =Ag – Asc
= 52.095 x 10^3 mm^2
<u>Step 4</u> : Ultimate load carrying capacity, Pu
Pu = [0.4 . fck . Ac] + [0.67 . fy . Asc]
= [0.4 x 20 x 52.095 x 10^3] + [0.67 x 415 x 804.24]
Pu = 640.38 x 10^3 N = 640.38 kN
(Working load carrying capacity) P= $\frac{P_u}{\gamma_f}$
P= $\frac{640.38}{1.5} = 426.92kN$</td><td>

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Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**b i)**	**Attempt any ONE of the following –** **A doubly reinforced beam 300 mm x 500 mm effective is reinforced with 1035 mm² at 25 mm below top edge and 1840 mm² above bottom edge. Take M 20 concrete and Steel Fe 415. Find moment of resistance (M_u). Use f_{sc}= 355 N/mm² and neglect σ_{cc}**		**6**
	Ans:	Given data :- b = 300 mm d = 500 mm d' = 25 mm Asc = 1035 mm² Ast = 1840 mm² fck = 20 N/mm² fy = 415 N/mm²		
		Step 1 – To find Xu_{max} Xu_{max} = 0.479 d………for Fe415 = 0.479 x 500 = 239.5 mm	1	
		Step 2 - To find actual Xu , $f_{cc} = \sigma_{cc} = 0$ $Ast_2 = \frac{(f_{sc} - f_{cc})Asc}{0.87 f_Y}$	1	
		$Ast_2 = \frac{(355-0)1035}{0.87 \times 415}$ = 1017.656 mm²		6
		Ast_1= Ast – Ast_2 = 1840-1017.656 = 822.344 mm² $x_u = \frac{0.87 f_y Ast}{0.36 f_{ck} b_f}$	1	
		$x_u = \frac{0.87 \times 415 \times 822.344}{0.36 \times 20 \times 300} = 137.457$ As, Xu < Xumax section is under- reinforced.	1	
		Step 3 - To find moment of resistance, $Mu = 0.87 f_y Ast(d - 0.42u) + (f_{sc} - f_{cc})Asc(d - d')$ $Mu = 0.87 \times 415 \times 822.344(500 - 0.42 \times 137.457) + (355 - 0) \times 1035(500 - 25)$ $Mu = 305.83 \times 10^6 Nmm$ $Mu = 305.83 KNm$	2	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**b) ii)**	**A beam 250 mm x 600mm effective is subjected to a factored moment of 300 KNm. Assume d' = 30 mm and M15 and Fe 415 ,Find area of compression steel and tension f_{sc} = 355 N/mm^2 and neglect σ_{cc}**		
	Ans.	**Given data,** b =250mm d = 600mm Mu =300 KN.m d' = 30mm fck =15 N/mm^2 fy = 415 N/mm^2 fsc = 355 N/mm^2 **To find,** Asc = ? and Ast = ? **Step 1 – To find Xu_{max},** Xu_{max} = 0.479d ……….. for fe 415 = 0.479 x 600 Xu_{max} = 287.4 mm **Step 2 – To find Mu_{lim}** $Mu_{lim\,=}$ = 0.138 fck bd^2 for fe415 Mu_{lim} = 0.138 x 15 x 250 x 600^2 **Mu_{lim} = 186.3 x 10^6 N-mm**	1	
		Step 3 – find Ast_1 from Pt_{lim} , Pt_{lim} = 0.048fck = 0.048 x 15 = 0.72% for M15 & fe415 $Ast_1 = \frac{Pt_{lim} bd}{100}$ $Ast_1 = \frac{0.72 \times 250 \times 600}{100}$ **Ast_1 = 1080 mm^2**	1	6
		Step 4 – Mu_1 = Mu – Mu_{lim} = 300x 10^6 – 186.3x 10^6 = 113.7 x 10^6 N-mm	1	
		Step 5 – To find , Asc = ? Mu_1 = Asc (fsc – fcc) (d – d^1) fsc = 3555 N/mm^2 ………given σ_{cc} = fcc = should be neglected as per given σ_{cc} = fcc = 0 113.7 x 10^6 = Asc (355 – 0) (600 – 30) 113.7 x 10^6 = 202.35 x 10^3 x Asc $Asc = \frac{113.7 \times 10^6}{202.35 \times 10^3}$ **Asc = 561.89 mm^2**	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**ii)**	**Step 6 – To find Ast_2 = ?**		
		Asc (fsc – fcc) = Ast_2 x 0.87 x 415		
		561.89 (355 – 0) = Ast_2 x 0.87 x 415	**1**	
		$Ast_2 = \frac{199.47\times10^3}{361.05}$		
		Ast_2 = 552.47 mm^2		
		Total Ast = Ast_1 + Ast_2		
		= 1080 + 552.47 = **1632.47 mm^2**	**1**	
Q.5		**Attempt any TWO of the following:**		**16**
	a)	**Determine the ultimate moment capacity of beam b = 280mm, d = 500 mm d' = 50mm, Asf= 2450 mm^2, Asc = 400 mm^2, fsk = 30 N/ mm^2, fy= 415, fsc= 355 N/ mm^2**		
	Ans.	Given		
		b= 280mm; d= 500mm		
		d'= 50mm; Ast= 2450mm^2		
		Asc= 400mm^2; fsk= 30N/mm^2		
		fy= 415 N/mm^2; fsc= 355 N/mm^2		
		$\sigma_{cc} = f_{cc}$= 0 N/mm^2		
		Step 1 X_u max= 0.48d		
		= 0.48x500	**1**	
		= 240 mm		
		Step 2 fsc= 355 N/mm^2		
		fcc = 0……………………Given		
		Step 3 Ast_2 = (fsc-fcc) Asc/ 0.87 x fy		
		= (355-0) x 400/ 0.87x415		
		= 393.297 mm^2		
		Ast_1 = Ast- Ast_2	**3**	**8**
		= 2450-393.297		
		= 2056.703 mm^2		
		Step 4 Xu_1= 0.87fy Ast1/0.36fck b		
		= 0.87x 415x2056.703/0.36x30x280		
		= 245.559 mm		
		Xu1 greater than Xu max the section is over reinforced		
		Mu= M_u lim + M_{u2}		
		Mu= 0.138fck x bd^2+[(fsc - fcc)Asc(d-d')]	**4**	
		= 0.138x30x280x500^2 + (355-0)x400x(500-50)		
		= 353.7x 10^6 N.mm = 353.7 KNm		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5	**b)**	**Design the shear reinforcement for a beam of 8 m span having 30 KN/m udl beam size 300 mm x 610 mm overall 30 mm cover . The reinforcement consist of 6 bars of 25mm diameter Concrete is M 20 grade and steel of Fe415 grade**		

P	**1.0**	**1.25**	**1.5**	**1.25**	**2.0**
τ_c	**0.6**	**0.64**	**0.68**	**0.71**	**0.71**

Ans:

Given
Span= 8m w= 30KN/m b = 300 mm
D= 610 mm Cover = 30mm
6 bar, 25 mm dia bar
fck = 20 N/mm^2 fy= 415 N/mm^2

Step 1

d = D – cover
= 610- 30
= 580 mm

Step 2

Ast = 6 x π /4 x 25^2
= 2945.24mm^2

Step 3

W = w x γ_f
= 30 x1.5
= 45 KN/m

Design shear force
Factured V_u = (Wd x 1)/ 2
= (45x8)/2
= 180 KN — **1**

Step 4

Nominal shear stress
τ_v = Vu/bd
= 180x10^3 /300x580
= 1.034 N/mm^2 — **1**
τ_c max for M20= 2.8 N/mm^2

Step 5

Pt = Ast/bd x 100 — **1**
= (2945.24/300x580) x 100
= 1.69 %

From following table find τ_c

Pt%	τ_c		
		$pt_1 = 1.5$	$\tau_{c1} = 0.68$
1.5	0.68	$pt_1 = 1.5$	$\tau_{c1} = 0.71$
1.7	0.71	pt = 1.69	

τ_c = τ_{c1} + ((τ_{c2} - τ_{c1}) / (pt_2 - pt_1)) x (Pt- pt_1)
= 0.68 + ((0.71 – 0.68) / (1.75- 1.5)) x (1.69- 1.5)
= 0.703 N/mm^2 — **2**

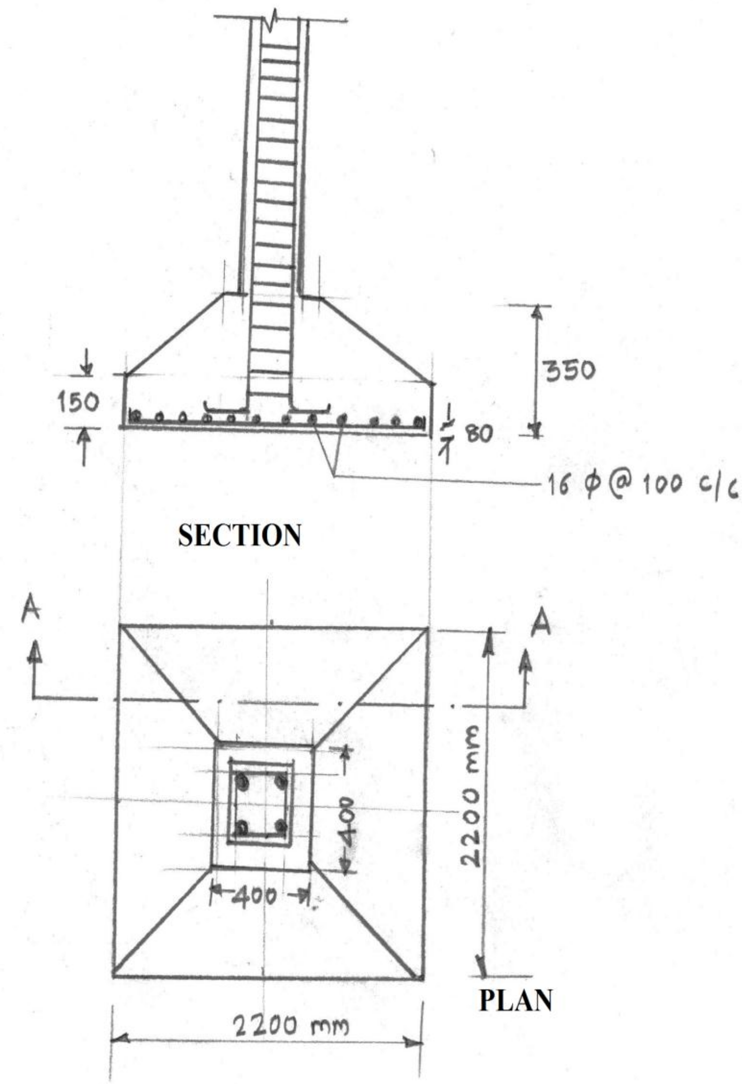
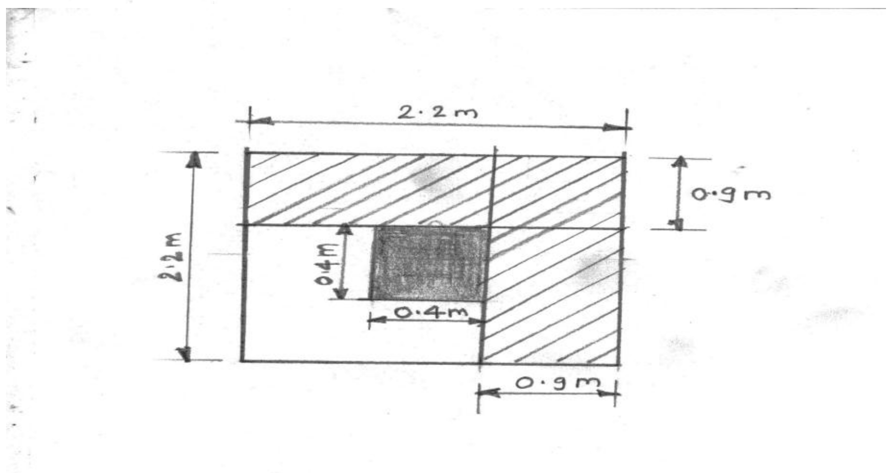
τ_v = 1.034N/mm^2 > τ_c = 0.703 N/mm^2

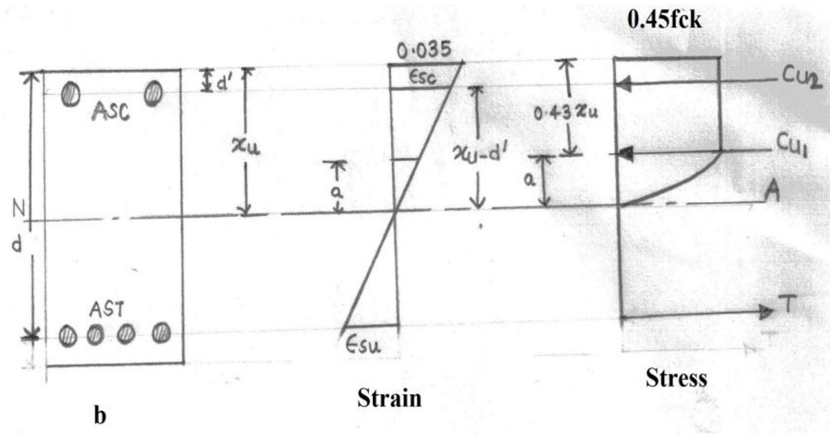
shear reinforcement is required

Total Marks: **8**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5	**b)**	**Step 6** Shear force for which shear reinforcement is required Vus = Vu - τ_c bd = $180 \times 10^3 - 0.703 \times 300 \times 580$ = 57678 N As bent up bars are not provided Vusv = Vus = 57678 N Provide 2- legged 8 mm dia stirrups	1	
		Step 7 Spacing = 0.87 fy Asv d / Vusv = $0.87 \times 415 \times 2 \times (\pi/4) \times 8^2 \times 580 / 57678$ = 364.993mm $S_{v\min} = \frac{0.87 f_y Asv}{0.4b}$ Sv min = $0.87 \times 415 \times 2 (\pi/4) \times 8^2 / 0.4 \times 300$ = 302.46 mm Sv max = 0.75d or 300mm = 0.75 X 580mm or 300mm = 435 or 300mm Sv= min of above values= 300mm Provide 2-legged 8mm dia. Stirrups @ 300mm c/c	2	8
	c) **Ans.**	**Design a RC column footing with following data:** **Size of column – 400mm x 400 mm** **Safe bearing capacity of soil – 200 kN/m^2** **Load on column – 1200 kN** **Use M20 and Fe 415 steel. Check for punching shear and one way shear need not be given** **Given-** Size of column – 400mm X 400 mm Safe bearing capacity of soil = 200 kN/m^2 Load on column is 1200 kN f_{ck}= 20N/mm^2 fy= 415 N/mm^2 **Step 1-** Ultimate S.B.C (q_u)= 2 X 200= 400 kN/m^2 **Step 2-** Size of footing- $W_U = W \times \gamma_f = 1200 \times 1.5 = 1800$ kN $A_f = 1.05 \times W_U / q_u$ = 1.05 X 1800/400 =4.725 m^2 L=B= $\sqrt{AF} = \sqrt{4.725}$ = 2.173m = say 2.20m	1	

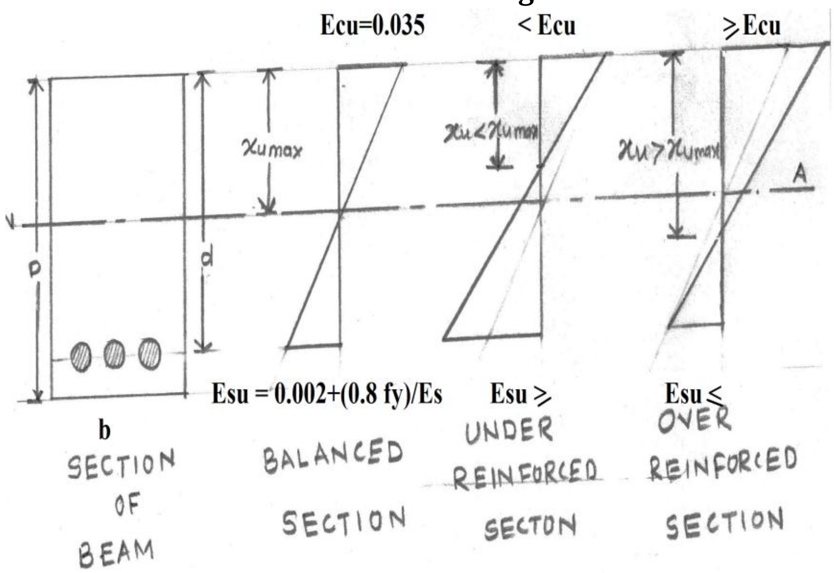
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5	**c)**	Adopt footing of size 2.20m X 2.20m **Step 3-** Upword soil pressure $p = W_u/(L \times B) = 1800/(2.2 \times 2.2) = 371.90\ KN/m^2$	1	
		Step 4 – Depth for flexure Let $X_1 = Y_1 =$ projection beyond column (2.2-0.4) / 2 = 0.9 $M_x = M_y = 1 \times X_1 \times p \times (X_1/2)$ $= 1 \times 0.9 \times 371 \times (0.9/2)$ 150.62 KN/m $d_{reqd} = \sqrt{Mx / q.fck.b}$ $d_{reqd} = \sqrt{(150.62 \times 10^6 / 0.138 \times 15 \times 1000)}$ =269.74 mm say 270mm. Adopt cover of 80 mm D= 270+80= 350mm	2	
		Step 5 – Ast = 0.5Fck/ Fy X $\left[1-\sqrt{1-\frac{4.6Mu}{Fck \times bd^2}}\right] bd$ Ast=Ast =(0.5 X 15)/ 415 X $\left[1-\sqrt{1-\frac{4.6 \times 150.62 \times 10^6}{15 \times 1000 \times 270^2}}\right] 1000 \times 270$ $=1925.936\ mm^2$ Using 16 mm diameter Spacing, $S_x = S_y = 1000 \times A\phi / Ast$ $= 1000 \times (\pi/4) \times 16^2 / 1926$ = 104.39 mm say 100 mm c/c Provide 16 mm ø @ 100 mm c/c both way	2	8
		Step 6 – Development length- $L_d = (0.87\ f_y \times \phi) / (4\ \tau_{bd})$ $= (0.87 \times 415 \times 16) / (4 \times 1.2 \times 1.6)$ = 752.187 mm say760 mm This length is available from face of column. Provide 350mm depth near the face of column and reduce depth of footing 150mm at the edge.	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5	**c)**	 REINFORCEMENT DETAILS 	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		**Attempt any FOUR of the following:**		**16**
	a)	**Draw stress strain diagram for doubly reinforced section in LSM. State meaning of each term shown in diagram.**		
	Ans:	wHERE 	2	
		Where, b = width of section section d = effective depth of section x_u = Depth of neutral axis A_{st} = area of steel at tension side A_{sc} = Area of steel at compression side C_{u1} = Compression force 1 C_{u2} = Compression force 2 T = tension force d' = effective cover to compression reinforcement	2	4
	b)	**Calculate effective flange width for a T –beam for following details:** **c/c distance between support = 8 m** **Slab thickness = 120mm** **c/c distance between beams4.2 m** **width of rib = 300mm** **effective depth = 580 mm** **width of support = 400 mm**		
	Ans:	c/c distance between supports -8 m Slab thickness= 120mm c/c distance between beams =4.2m width of rib=300mm effective depth=580mm width of support=400mm		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**b)**	Effective width of flange (b_f) bf = (lo/6) + bw +6Df = (8000/6) + 300 + (6 x 120) = 2553.33mm^2 **OR** c/c distance between beam = 4200mm whichever is less. b_f = 2353.333mm or 4200mm. **b_f= 2353.33mm**	**4**	**4**
	c) **Ans:**	**State the IS specification for pitch and diameter of lateral ties** **1) IS specification for pitch** a) The spacing of the link should not exceed the least of the following. **i)** The least lateral dimension of column. **ii)** Sixteen times the diameter of the smallest longitudinal bar. **iii)** 300mm	**2**	**4**
		2) IS specification for diameter of lateral ties a) The diameter of the links should be at least one fourth of the longitudinal steel b) In any case the links should not be less than 6mm in diameter. Largest diameter of a and b	**2**	
	d) **Ans:**	**State IS specification for longitudinal reinforcement ,cover and eccentricity in axially loaded column.** I.S. specification for **a) Longitudinal reinforcement** 1. Minimum percentage of steel = 0.8% of Ag 2. Maximum percentage of steel =6%of Ag 3. Minimum diameter of bar=12mm 4. Minimum number of bars For rectangular column=4 For circular column=6 5. Maximum spacing of bar=300 mm	**2**	**4**
		b)Cover i) Minimum cover=40mm	**1**	
		c)Eccentricity i. $e_{min.}$ = (Lo/500) + (D/30) but should not more than 20 mm Lo = unsupported length D = lateral diamension e_{max} = =0.05D	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6	**e)**	**Explain in detail the concept of under reinforced , over reinforced and balanced section. Draw related diagram.**		
	Ans.			



(Marks: 1)

Under reinforced section- When the percentage of steel provided in section is less than pt limit Then section is known as under reinforced section.

$$X_u < X_{umax}$$

The under reinforced section are preferred because the failure takes place by yielding of steel which is gradual type of failure and is proceeded by widening of crack and significant increase in deflection , hence necessary precautions can be taken before collapse take place.

(Marks: 1)

Over reinforced section- When the percentage of steel provided in section is more than pt limit. Then section is known as over reinforced section.

$$X_u > X_{umax}$$

The failure of an over reinforced section takes place by crushing of concrete alone and therefore sudden failure occurs without any signs.Therefore these sections are not allowed as per IS code.

(Marks: 1)

Balanced Section- in balanced section

$$P_t = P_{tlim.}$$

$$X_u = X_{umax}$$

When the ratio of steel in concrete in a section in such that maximum strain in steel and maximum strain in concrete reach their maximum value simultaneously, the section is referred to as balanced section or critical section.

(Marks: 1)

(Total Marks: 4)