Important Instruction to Examiners:-

1) The answers should be examined by key words & not as word to word as given in the model answers scheme.

2) The model answers & answers written by the candidate may vary but the examiner may try to access the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance.

4) While assessing figures, examiners, may give credit for principle components indicated in the figure.

5) The figures drawn by candidate & model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credit may be given step wise for numerical problems. In some cases, the assumed contact 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 judgment on part of examiner of relevant answer based on candidates understanding.

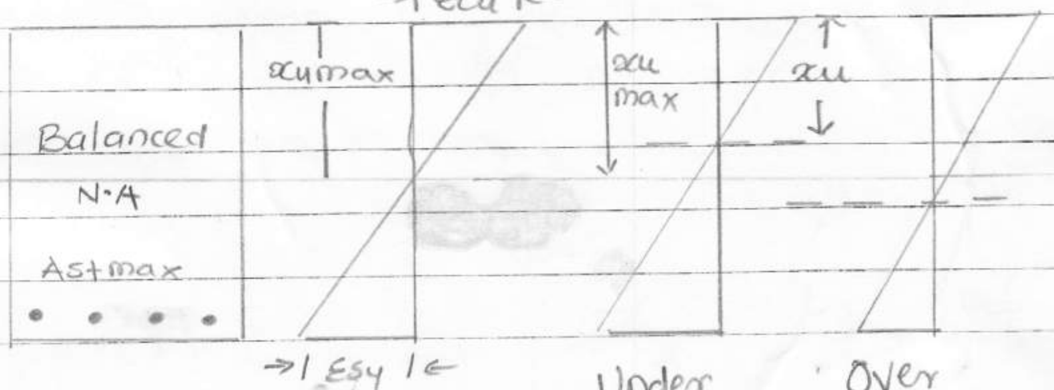
7) For programming language papers, credit may be given to any other programme based on equivalent concept.

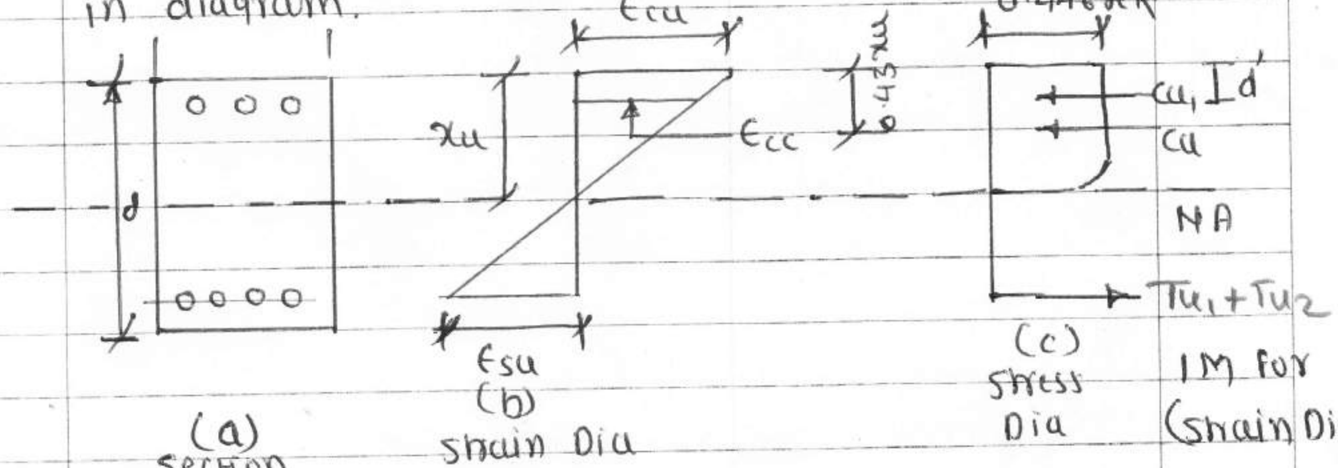
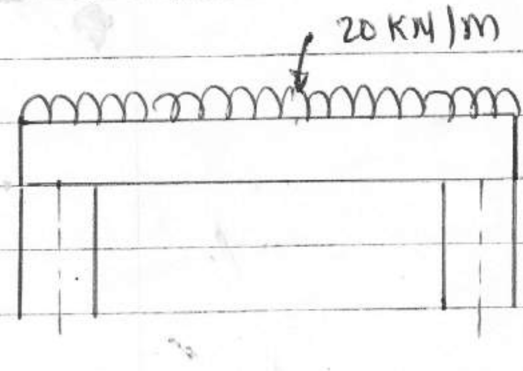
Important notes to examiner

1) In Q.6(c) the hall size 3mm x 4.5mm is given in problem but it is actually 3m x 4.5m so accordingly check the given problem

Q .NO	SOLUTION	MARKS
1. a)		
i)	State four assumptions made in working stress method.	4M
Ans.:-	Assumptions made in W.S.M. :- (any four)	
	1] At any c/s, plane sections normal to axis of beam before bending remains plane after bending.	(1M) for each Assumption
	2] The stress - strain relationship for concrete & steel under working load is linear.	
	3] The modular Ratio (m) has the value $\frac{280}{3\sigma_{cbc}}$.	
	4] All tensile stresses are taken by Reinforcement only and concrete does not resist any tensile stress except as otherwise permitted.	
	5] There exists a perfect bond betn steel & concrete.	
ii]	State I.S. code clauses for deciding diameters of bar for lateral ties and for deciding pitch of lateral ties in case of columns.	

Q .NO	SOLUTION	MARKS
Ans :-	As per I.S. 456-2000, clauses for lateral ties for its Diameter & pitch in case of column is Clause 26.5.3.2 (c).	4M
iii]	Define balance, under reinforced and over reinforced section with neat sketch and state w.r.t. LSM which section is performed?	
Ans :-		
	1] Balanced Section :- A section is called as balanced section if for same applied moment the strain in concrete and strain in steel reach their limiting values simultaneously.	01M
	2] Under Reinforced Section :- A section in which steel reaches yield strain at loads lower than loads at which concrete reaches failure strain are called as under reinforced section.	01M

Q .NO	SOLUTION	MARKS
	3] Over Reinforced section :- A section in which failure strain in concrete is reached earlier than yield strain of steel is reached are called over reinforced section.	
	With respect to LSM, it is advisable to design reinforced section as under reinforced section since there will be clear warning of failure of member in form of large deflections associated with cracks before final failure.	01M
		01M for Dia
	Balanced ($x_u = x_{umax}$) section Under r/f section ($x_u < x_{umax}$) Over r/f section ($x_u > x_{umax}$)	

Q.NO	SOLUTION	MARKS
iv)	Draw stress-strain diagram for doubly reinforced section in LSM state meaning of each term shown in diagram.	
		1M for (strain Dia) 1M for (stress Dia)
	Meaning of terms N.A = Neutral axis b = width d = effective Depth Asc = Area of steel comp. Ast = Area of steel in tension d' = Effective cover ϵ_c = Strain in concrete ϵ_s = Strain in steel x_u = Depth of N.A. fck = characteristic strength of concrete	(02M) for meaning
Q-1 (b)	i) Design of R.C rectangular beam having effective span of 5m. it carries a udl of 20 KN/m (inclusive of self wt) through out its span. Take width of beam as 230 mm use M-20 & fe 415	
ANS →	given $f_{ck} = 20\ N/mm^2$ $f_y = 415\ N/mm^2$ $b = 230\ mm$ $l = 5m$ 	

Q.NO	SOLUTION	MARKS
	Working load = 20 kN/m	
	Factored load = 1.5 × 20	
	= 30 kN/m	
	Step 1:-	
	Factored Bending Moment (Mu)	
	$\therefore Mu = \frac{wl^2}{8} = \frac{30 \times 5^2}{8}$	
	$= 93.75 \times 10^6$ N-mm	(01M)
	Step 2:-	
	Depth of section:-	
	We know,	
	For Fe415, $Mu\,lim = 0.138\,Fck.b.d^2$	
	Now find effective depth (d) by equating Mu & Mu lim,	
	$\therefore Mu = Mu\,lim$	
	$\therefore 93.75 \times 10^6 = 0.138 \times 20 \times 230 \times d^2$	
	$\therefore d^2 = \frac{93.75 \times 10^6}{0.138 \times 230 \times 20}$	
	$\therefore d = 384.29$ mm	
	$\boxed{\therefore d = 390 \text{ mm}}$	(01M)
	Provide cover of 50 mm (Assumed)	
	∴ Overall depth of Beam (D):	
	$D = d + d'$	
	$= 390 + 50$	
	$\boxed{D = 440 \text{ mm}}$	(01M)

Q.NO	SOLUTION	MARKS
	$x_{umax} = 0.479\,d$	
	$x_{umax} = 0.479 \times 390$	
	$x_{umax} = 186.81\,mm$	01M
	$A_{st} = \dfrac{0.36\,f_{ck}\,b \cdot x_{umax}}{0.87 \times f_y}$	01M
	$A_{st} = \dfrac{0.36 \times 20 \times 230 \times 186.81}{0.87 \times 415}$	
	$\boxed{A_{st} = 856.82\,mm^2}$	01M

Q .NO	SOLUTION	MARKS

ii] A R.C.C. Beam 230 mm wide and 400 mm deep (effective) is supported over an effective span of 6 m and reinforced with 4 - 20 mm φ along tension side. Calculate working load which the beam can carry including self weight. Use M20 concrete and Fe415 steel.

Ans:-

* Given :-

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

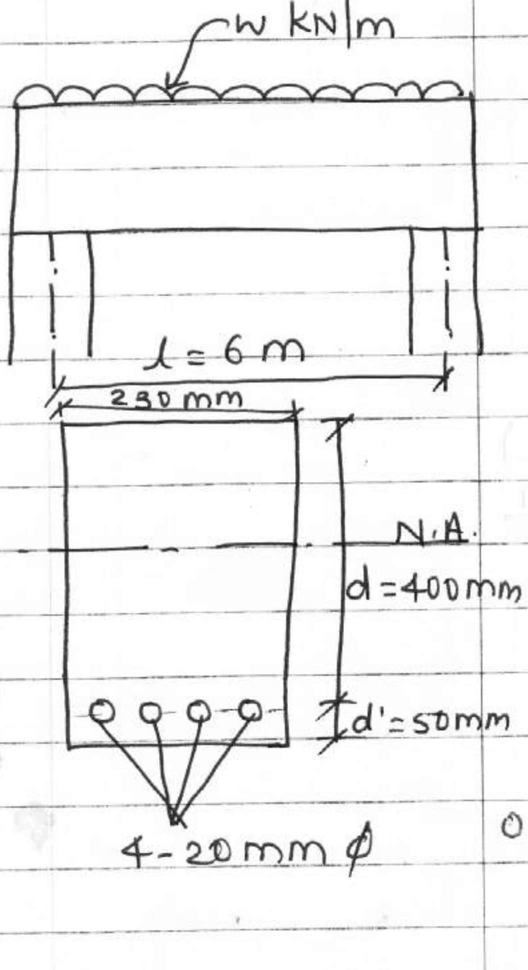
$f_y = 415\ N/mm^2$

$b = 230\ mm$

$d = 400\ mm$

$d' = 50\ mm$

$l = 6\ m$



* Ast = 4 - 20 mm φ

$\therefore A_{st} = (\pi/4 \times 20^2) \times 4$

$$\boxed{\therefore A_{st} = 1256.63\ mm^2}$$

01M

Q.NO	SOLUTION	MARKS
	Step :-	
	* Find $x_u\ max$:-	
	∴ For Fe415	
	$\therefore x_u\ max = 0.479 \times d$	(½M)
	$= 0.479 \times 400$	
	$\boxed{\therefore x_u\ max = 191.6\ mm}$	(½M)
	* Find Actual x_u :-	
	$\therefore x_u = \dfrac{0.87 \times fy \times Ast}{0.36 \times fck \times b}$	(½M)
	$= \dfrac{0.87 \times 415 \times 1256.63}{0.36 \times 20 \times 230}$	
	$\boxed{x_u = 273.97\ mm}$	(½M)
	Comparing x_u and $x_u\ max$,	
	$x_u > x_u\ max$	
	$273.97 > 191.6\ mm$	

Q .NO	SOLUTION	MARKS
	Hence beam section is over R/F As over R/F section are not allowed, consider it as a balanced section.	(1/2 M)
	step-2 $M_u = 0.138 f_{ck} b d^2 = 101.568 \times 10^6$ N.mm	
	Step 3:-	
	We know that,	
	Factored Moment, $M_d = \frac{W_u l^2}{8}$	
	$= \frac{W_u \times 6^2}{8}$	
	$\boxed{M_d = 4.5 W_u}$	(1/2 M)
	Step 4:-	
	To calculate working load:-	
	Equating Md & Mu,	
	$\therefore M_d = M_u$	
	$\therefore 4.5 W = 101.568$ KN/m	
	$\boxed{W_u = 22.57 \text{ KN/m}}$	(01 M)
	$W = \frac{W_u}{1.5}$	
	* safe working load $= \frac{\text{Factored load}}{\text{F.O.S.}}$	
	$W = \frac{22.57}{1.5}$	
	$W = 15.04$ KN/m	
	$\therefore$ Working load including self wt. is 15.04 KN/m	(01 M)

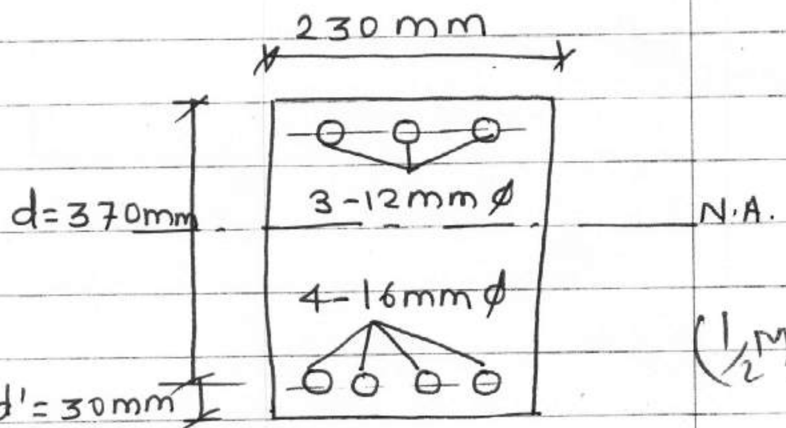
Q.NO	SOLUTION	MARKS

Q. 2

a) Calculate ultimate Moment of resistance of R.C. section 230mm x 370 mm effective in diamensions. It is reinforced by 3 bars of 12 mm ϕ as compression steel with an effective cover of 30mm, where as 4 bars of 16 mm ϕ are placed on tension side. Use M20 & Fe415 steel. Take $F_{sc} = 352.75\ N/mm^2$

Ans:-

* Given :-



(½M)

- $f_{ck} = 20\ N/mm^2$
- $f_y = 415\ N/mm^2$
- $F_{sc} = 352.75\ N/mm^2$
- $b = 230\ mm$
- $d = 370\ mm$

* $A_{sc} = 3 \times (\pi/4 \times 12^2)$

$= 339.29\ mm^2$ (½M)

* $A_{st} = 4 \times (\pi/4 \times 16^2)$

$= 804.24\ mm^2$ (½M)

Q .NO	SOLUTION	MARKS
	Step 1 :-	
	* stress in concrete in compression :-	
	$F_{cc} = 0.446\,F_{ck}$	
	$= 0.446 \times 20$	
	$= 8.92\ N/mm^2$	(01M)
	* Stress in steel in Compression:	
	$F_{sc} = 352.75\ N/mm^2$	
	* Additional Area of steel (A_{st_2})	
	$C_{u_2} = T_{u_2}$	
	$\therefore A_{sc}(F_{sc} - F_{cc}) = 0.87 \times f_y \times A_{st_2}$	(½M)
	$\therefore 339.29 \times (352.75 - 8.92) = 0.87 \times 415 \times A_{st_2}$	
	$\therefore 116.65 \times 10^3 = 361.05 \times A_{st_2}$	
	$\boxed{\therefore A_{st_2} = 323.08\ mm^2}$	(½M)
	* Balanced steel in Tension (A_{st}) :-	
	$\therefore A_{st} = A_{st_1} + A_{st_2}$	
	$\therefore 804.24 = A_{st_1} + 323.08$	
	$\boxed{\therefore A_{st_1} = 481.16\ mm^2}$	(½M)

Q.NO	SOLUTION	MARKS
	Step 2:-	
	Depth of N.A. (x_u):-	
	$\therefore x_u = \dfrac{0.87 \times fy \times Ast_1}{0.36 \times fck \times b}$	
	$= \dfrac{0.87 \times 415 \times 481.16}{0.36 \times 20 \times 230}$	
	$\boxed{x_u = 104.90 \text{ mm}}$	(½M)
	Step 3:-	
	Calculate $x_{u}max$:-	
	$x_{u}max = 0.479 \times d$ --- for fe415	(½M)
	$= 0.479 \times 370$	
	$\boxed{x_{u}max = 177.23 \text{ mm}}$	(½M)
	Comparing x_u & $x_{u}max$	
	$x_u < x_{u}max$	
	$104.90 < 177.23$ mm	
	Hence section is Under Reinforced Section.	(½M)
	Step 4:-	
	Moment of Resistance (Mu):-	
	$Mu = Cu_1 \times Z + C_2 + Z_2$	(½M)

Q .NO	SOLUTION	MARKS
	$Mu = 0.36 \times fck \times xu \times b \times (d - 0.416\, xu) + Asc\,(fsc - fcc) \times (d - d')$	(½M)
	$= 0.36 \times 20 \times 104.90 \times 230 \times (370 - 0.416 \times 104.9)$	
	$+ 339.29 \times (352.75 - 8.92) \times (370 - 30)$	
	$\boxed{Mu = 96.357 \text{ kN-m}}$	(01M)
b)	Design simply supported RCC slab for a roof of a hall 3.5 x 8 m (inside dimension) with 300 mm walls all around. Assume a Live Load of 3 kN/m² and floor finish 1 kN/m². Use M25 & Fe415. Draw neat section & plan giving dimensions & R/F details.	
Ans:-	* Given Data :-	
	$fck = 25\ N/mm^2$	
	$fy = 415\ N/mm^2$	
	$L.L. = 3\ kN/m^2$	
	$F.F. = 1\ kN/m^2$	
	Hall = 3.5 x 8mm	
	Walls = 230 mm	

Q .NO	SOLUTION	MARKS
	Step 1 :-	
	Thickness of slab (D):-	
	$l_y / l_x = 2.20 > 2$ i.e one way slab	(½M)
	∴	
	M.F. = 1.6 (assume)	
	$\therefore d_{assu.} = \frac{span}{20 \times M.F.}$	
	$\therefore d_{assumed} = \frac{3730}{20 \times 1.6}$	
	= 116.56 mm	(½M)
	say d = 110 mm	
	Assuming cover 15 mm,	
	D = d + d'	
	D = 110 + 15	
	$\boxed{D = 125 mm}$	(½M)
	Step 2 :-	
	Effective span 'leff' :-	
	∴ leff = Clear span + Eff. depth	
	= 3.5 + 0.11	(½M)
	$\boxed{leff = 3.61 m}$	

Q .NO	SOLUTION	MARKS
	Step 3:-	
	Loading for 1m wide strip,	
	1) Self weight $= 0.125 \times 1 \times 25 = 3.125$	
	2) Live Load $= 3$ kN/m	
	3) Floor Finish $= 1$ kN/m	
	Total (w) $= 7.125$ kN/m	
	∴ Factored load $= 1.5 \times 7.125$	
	$= 10.69$ kN/m	(01M)
	Step 4:-	
	Factored Moment (Md):-	
	$Md = \frac{Wl^2}{8} = \frac{10.69 \times 3.61^2}{8}$	½M
	$\boxed{Md = 17.41 \text{ kN-m}}$	
	Step 5:-	
	Required depth (d) for bending:-	
	For Fe415,	
	$Md = 0.138\, f_{ck}\, bd^2$	(½M)
	$\therefore 17.41 \times 10^6 = 0.138 \times 25 \times 1000 \times d^2$	
	$\boxed{\therefore d_{req.} = 71.03 \text{ mm}}$	(½M)
	$d_{req.} < d_{assumed}$	

$71.03 < 110$ mm

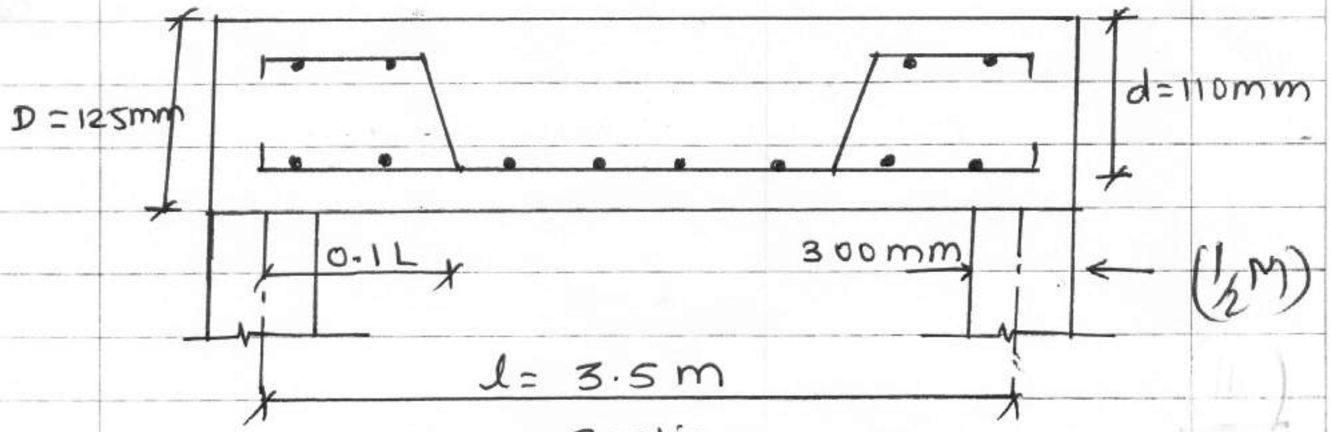
∴ safe for Bending

Q.NO	SOLUTION	MARKS
	Step 6 :-	
	Area of Main steel (Ast):-	
	$* \; Ast = \frac{0.5 \, fck}{fy}\left[1-\sqrt{1-\frac{4.6 \, Mu}{bd^2 . fck}}\right] b \times d$	
	$= \frac{0.5 \times 25}{415}\left[1-\sqrt{1-\frac{4.6 \times 17.41 \times 10^6}{1000 \times 110^2 \times 25}}\right] \times 1000 \times 110$	
	$\boxed{Ast = 472.24 \; mm^2}$	(½M)
	Using 10 mm ϕ bars,	
Note	student may be assume 8/10 dia examiner should consider	
	Spacing (s) = $\frac{\text{Area of One bar}}{Ast} \times 1000$	(½M)
	$= \frac{(\pi/4 \times 10^2)}{472.24} \times 1000$	
	$= 166.31 \; mm$	
	say 165 mm c/c.	
	check, $s \not> 3d$ or 300 mm	(½M)
	Hence o.k.	
	Step 7:-	
	Area of Distribution steel :-	
	Using 6 mm ϕ as distribution steel,	
	$Astd = 0.15 \%$ of Agross	
	$= \frac{0.15}{100} \times 125 \times 1000$	

$Astd. = 187.5 \; mm^2$ (½M)

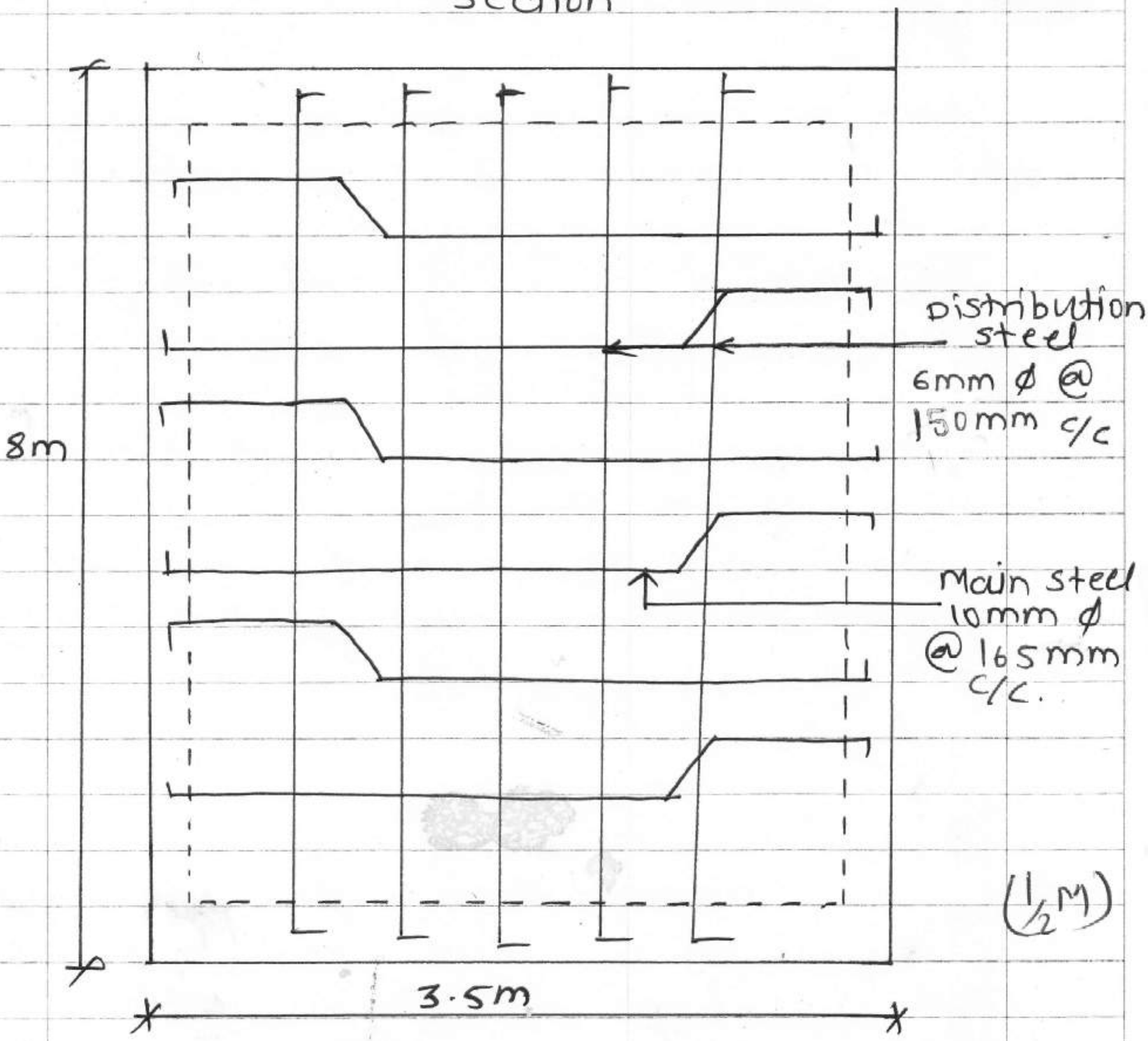
Q .NO	SOLUTION	MARKS
	spacing of 6mm ϕ distribution bar.	
	$S = \frac{\text{Area of one bar}}{A_{std}} \times 1000$	
	$= \frac{(\pi/4 \times 6^2)}{187.5} \times 1000$	
	$= 150.72$ mm	
	say 150 mm c/c	
	check $S \ngtr 5d$ or 450 mm	(1/2 M)
	Hence O.K.	

Q .NO	SOLUTION	MARKS



Section

(1/2 M)



(1/2 M)

Plan

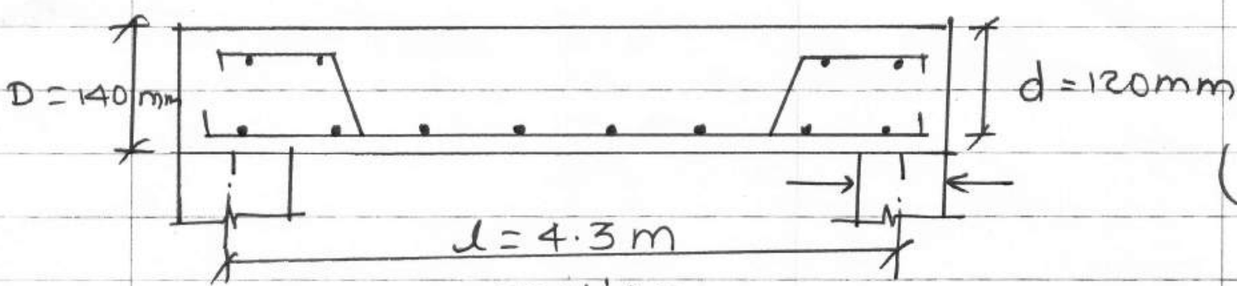
Q .NO	SOLUTION	MARKS
c]	Design R.C.C. slab for room 4.3 x 5m effective. The slab carries load of 5.48 kN/m. The corner's are free to lift. Use grade of concrete M20 & Fe415 M.F. = 1.8 , $\alpha x = 0.086$ & $\alpha y = 0.058$	
Ans:-	Given :-	
	$F_{ck} = 20\ N/mm^2$	
	$F_y = 415\ N/mm^2$	
	Room = 4.3 x 5 m	
	udl = 5.48 kN/m	
	$\frac{l_y}{l_x} = \frac{5}{4.3} = 1.16 < 2$	(½M)
	∴ slab is Two way slab.	
	Step 1.	
	Slab thickness (d) :-	
	$d = \frac{l_x}{M.F. \times 20} = \frac{4300}{20 \times 1.8}$	
	$= 119.44$	
	d assumed ≈ 120 mm say.	(½M)
	Assuming eff. cover = 20 mm	
	$D = d + d' = 120 + 20$	
	$= 140$ mm	

Q.NO	SOLUTION	MARKS
	Effective span,	
	$lx = 4.3\,m$	
	$ly = 5\,m$	
	Step 2:-	
	Loading for 1m wide strip.	
	Total load $= 5.48\ kN/m$	
	Factored load $= 1.5 \times 5.48$	
	$= 8.22\ kN/m$	(1/2M)
	Step 3:-	
	Factored Moment:-	
	$Mdx = \alpha x \times W \times lx^2$	
	$= 0.086 \times 8.22 \times 4.3^2$	
	$= 13.07\ kN\text{-}m$	(01M)
	$Mdy = \alpha y \times W \times lx^2$	
	$= 0.058 \times 8.22 \times 4.3^2$	
	$= 8.815\ kN\text{-}m$	(01M)
	Step 4)	
	Depth required for B.M.	
	For Fe415,	
	$Mu_{max} = 0.138\,bd^2$	
	compare Mu & Mumax	
	$13.07 \times 10^6 = 0.138 \times 20 \times 1000 \times d^2$	

Q .NO	SOLUTION	MARKS
	$d_{req} = 68.82$ mm	(½M)
	∴ dreq < dassumed ∴ safe for bending.	
	step 5: * Area of main steel along shorter direction. (Ast_x) :-	
	$Ast_x = \frac{0.5\,fck}{fy}\left[1-\sqrt{1-\frac{4.6\,M_{dx}}{bd^2\,fck}}\right] b \times d$	(½M)
	$= \frac{0.5 \times 20}{415}\left[1-\sqrt{1-\frac{4.6 \times 13.07 \times 10^6}{1000 \times 120^2 \times 20}}\right] \times 1000 \times 120$	
	$\boxed{Ast_x = 319.46\ mm^2}$	(½M)
	By using 10 mm ϕ bars,	
	spacing (s) $= \frac{\text{Area of 1 bar}}{Ast_x} \times 1000$	(½M)
	$= \frac{\pi/4 \times 10^2}{319.46} \times 1000$ $= 245.85$ mm ≈ 245 mm say	
	check, s $\ngtr$ 3d or 300 mm Hence OK.	(½M)

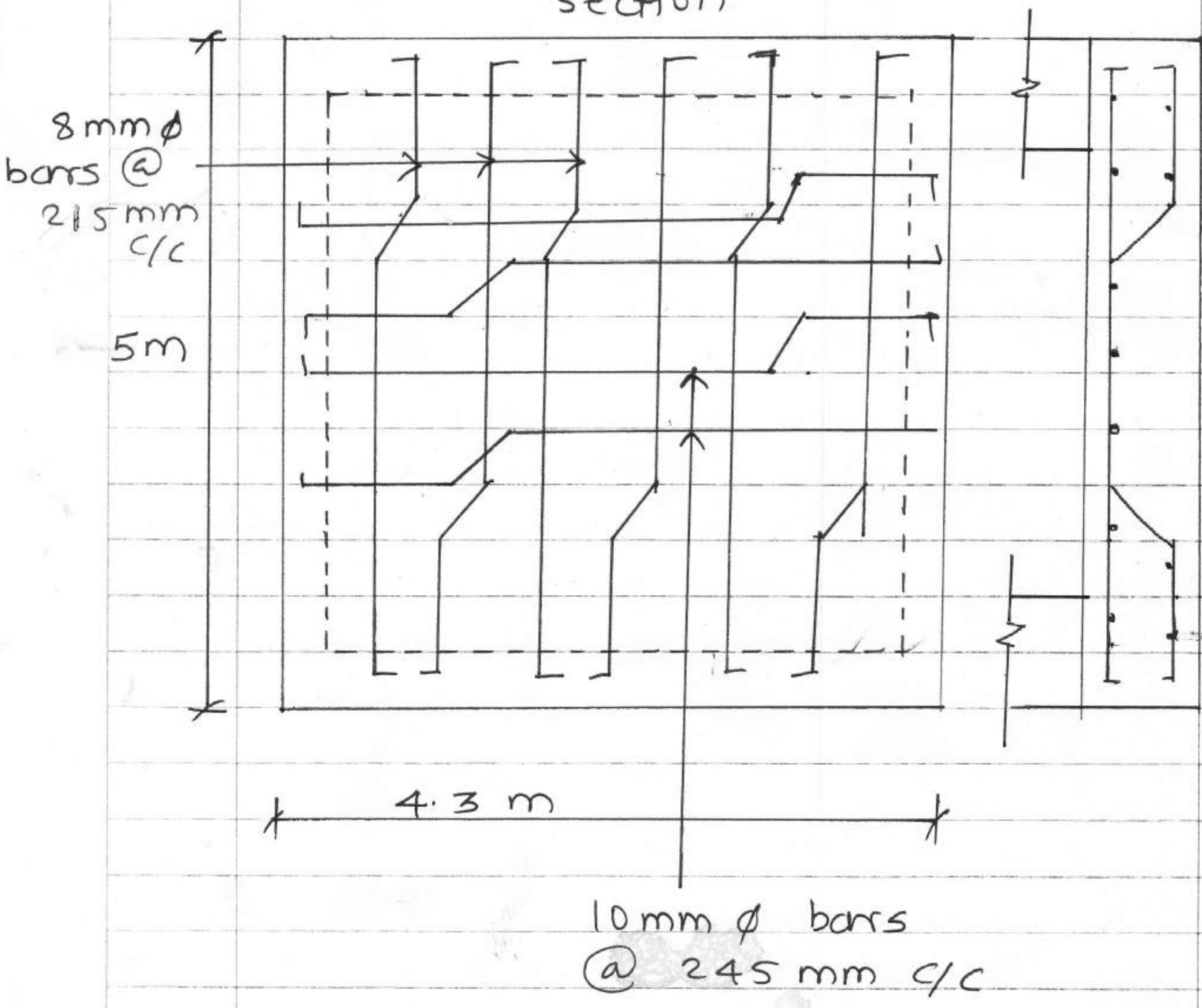
Q .NO	SOLUTION	MARKS
	* Area of main steel along longer direction (Asty) :-	
	$$Asty = \frac{0.5\ fck}{Fy}\left[1-\sqrt{1-\frac{4.6\ Mdy}{fck\ bd^2}}\right] b \times d$$	
	$d_2 = d_0 - \phi$ $d_2 = 120 - 10$ $\boxed{d_2 = 110mm}$	
	$$Ast = \frac{0.5 \times 20}{415}\left[1-\sqrt{1-\frac{4.6 \times 8.815 \times 10^6}{1000 \times 110^2 \times 20}}\right] \times 1000 \times 110$$	
	$\boxed{Asty = 232.23\ mm^2}$	(1/2 M)
	By using 8 mm ϕ bars,	
	$$spacing\ (s) = \frac{\pi/4 \times 08^2}{232.23} \times 1000$$ $= 216.3292\ mm$ ≈ 215 mm say	
	Check $s \ngtr 3d$ or 300 mm Hence O.K.	(1/2 M)

Q .NO	SOLUTION	MARKS



section

(1/2 M)



(1/2 M)

Plan

Q.NO	SOLUTION	MARKS

Q-3 a) A beam 230 x 560 mm effective reinforced with 6 bars of 25 mm diameter, effective span is 8 m and loaded with 25 KN/m. Design shear reinforcement for beam. Take M-20 grade of concrete and Fe415 use following table.

% Pt	1.0	1.25	1.50	1.75	2.0
τ_c	0.6	0.64	0.68	0.71	0.70

b = 230 mm , d = 560 mm

$L_{eff} = 8$ m

$w = 25$ KN/m

∴ factored load = $w_d = 1.5 \times 25 = 37.5$ KN

∴ factored shear force $V_u = \frac{w_d \times L_{eff}}{2}$ (½ M)

$$V_u = \frac{37.5 \times 8}{2} = \underline{150 \text{ KN}}$$ (½ M)

$$A_{st} = 6 \times \frac{\pi}{4} \times 25^2 = 2945.24 \text{ mm}^2$$

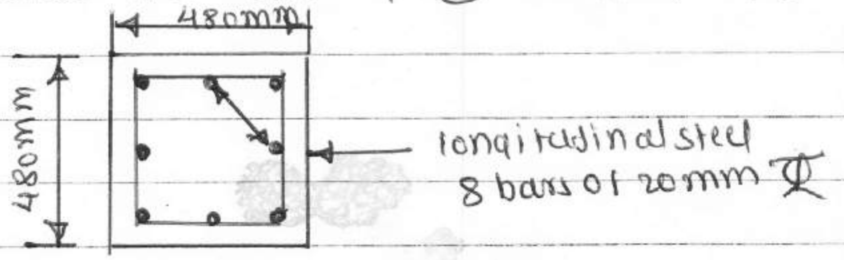
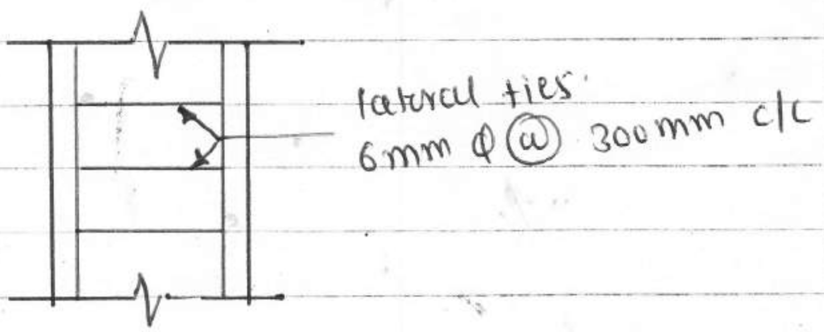
∴ $p_t = \frac{A_{st}}{b \times d} \times 100$ (½ M)

$$= \frac{2945.24 \times 100}{230 \times 560}$$

$p_t = 2.286$ % (½ M)

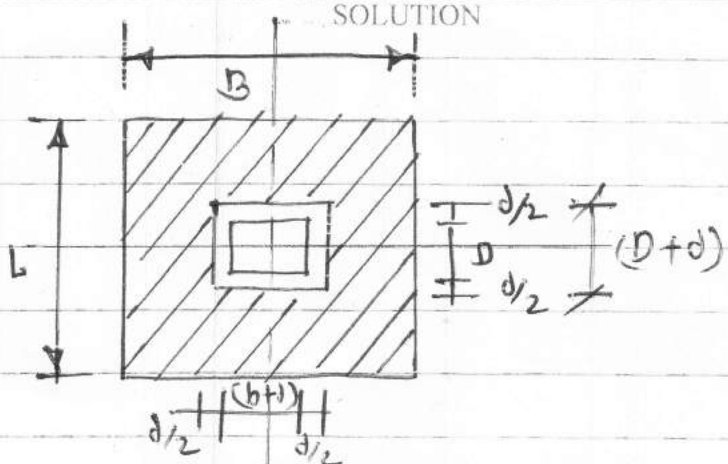
Q.NO	SOLUTION	MARKS
	hence $\tau_c = 0.7$ from given table	
	calculate nominal shear stress	
	$\tau_v = \frac{V_u}{b \times d}$	(½M)
	$\tau_v = \frac{150 \times 10^3}{230 \times 560} = 1.164\ N/mm^2$	(½M)
	check for τ_{max}	
	$\tau_{max} = 2.8\ N/mm^2$ for M20	
	$\tau_v < \tau_{max}$	
	$\tau_v > \tau_c$ --- hence shear reinforcement reqd.	(½M)
	Shear force to be resisted by vertical stirrups	
	$V_{us} = V_u - \tau_c\, b.d$ $\quad V_{us} = 150 \times 10^3 - 0.70 \times 230 \times 560$	
	$\boxed{V_{us} = 59.84\ kN}$	01M
	spacing of 8 mm - 2 legged stirrups	
	$S_v = \frac{0.87\, f_y\, A_{sv} . d}{V_{us}} = \frac{0.87 \times 415 \times 2 \times \pi/4 \times 8^2 \times 560}{59.84 \times 10^3}$	01M
	$S_v = 339.67$ say 330 mm	½M
	check for minimum shear reinforcement	
	$S_v = \frac{0.87\, f_y\, A_{sv}}{0.4 \times b} = \frac{0.87 \times 415 \times 2 \times \pi/4 \times 8^2}{0.4 \times 230}$	½M
	$S_v = 394$ mm	½M
	check for maximum spacing	½M
	$S_v \ngtr 0.75 d$ or 300 mm	
	$S_v \ngtr 0.75 \times 560$ or 300 mm	
	$S_v \ngtr 420$	
	∴ provide 8 mm Φ 2-legged vertical stirrups @ 300 mm c/c	½M

Q.NO	SOLUTION	MARKS
Q-3 b)	Design a column to carry an axial load of 1600 KN. use M-20 & Fe415 steel. Design suitable link Sketch the reinforcement details.	
	i) factored load $Pu = 1.5 \times 1600$	
	$Pu = 2400$ KN	($\frac{1}{2}$M)
	Assume 1% of steel	
	Area of steel = $Asc = 0.01\ Ag$	($\frac{1}{2}$M)
	Area of concrete = $A_c = Ag - Asc$	
	$= Ag - 0.01 Ag$	
	$Ac = 0.99 Ag$	($\frac{1}{2}$M)
	$Pu = (0.4\ fck\ Ac) + (0.67\ fy\ Asc)$	($\frac{1}{2}$M)
	$2400 \times 10^3 = (0.4 \times 20 \times 0.99\ Ag) + (0.67\ fy\ Asc)$	
	$= (7.92\ Ag) + (2.7805 Ag)$	($\frac{1}{2}$M)
	$2400 \times 10^3 = 10.70\ Ag$	
	$Ag = 224499.06\ mm^2$	($\frac{1}{2}$M)
	Assuming square shape	
	each side = $\sqrt{Ag} = \sqrt{224499.06}$	($\frac{1}{2}$M)
	∴ each side = 473.60 mm say 480mm	
	∴ Area of steel $= 0.01 \times Ag$	
	$= 0.01 \times 480 \times 480$	
	$Asc = 2304\ mm^2$	($\frac{1}{2}$M)

Q .NO	SOLUTION	MARKS
	provide 8 bars of 20 mm Φ giving area of steel equal to 2513.2 mm^2	
	Design of links (lateral ties)	(1/2 M)
	Diameter of lateral ties $\nless \frac{1}{4}$ x dia of longitudinal steel	
	$\nless \frac{1}{4} \times 20 = 5mm$	
	$\nless$ 6 mm	(1/2 M)
	provide lateral ties of 6mm ϕ	
	pitch of lateral ties $\ngtr$ following	
	a) least lateral dimension's i.e. 480 mm	
	b) 16 x dia of longitudinal steel = 16 x 20 = 320 mm	
	c) 300 mm	
	∴ provide pitch = 300 mm	(01M)
	Summary	
	i) column size 480x480 mm	
	ii) longitudinal steel 8 bars of 20 mm Φ	(01M)
	iii) lateral ties 6mm ϕ @ 300 mm c/c	
		
		(01M)

Q .NO	SOLUTION	MARKS
Q-3 (c)	Design a square isolated footing for column 300 X 230 mm subjected to axial load of 800 KN safe bearing capacity of soil is 200 KN/m². use M-20 & Fe 415 Design for moment and two way shear.	
	i) size of footing	
	load of column = 800 KN	
	Assume load of footing @ 5% = 40 / 840	
	Area of footing = $\frac{840}{200} = 4.2 m^2$	½M
	for square footing length of one side	
	$A = \sqrt{4.2} = 2.05$ say $\underline{2.1 m}$	½M
	upward soil pressure = $\frac{800 \times 1.5}{2.1 \times 2.1} = 272.10$ KN/m²	
	$\tau_v \leq K_s \tau_c$	
	$K_s = 0.5 + \beta_c$	
	$= 0.5 + \frac{230}{300} = 1.27 > 1$	
	$\tau_c = 0.25\sqrt{f_{ck}} = 0.25\sqrt{20}$ $K_s = 1$	½M
	$\tau_c = 1.118$ KN/mm²	
	= 1118 KN/m²	½M
	check for two way shear	

Q .NO	SOLUTION	MARKS



shear force on shaded area

$$V_u = [2.1^2 - (0.3+d)(0.23+d)]\ 272.10 \quad (1)$$ ½M

shear force resisted by concrete

$$V_u = \tau_c\, b \times d$$ ½M

Here

$$b = 2(0.3+d) + 2(0.23+d)$$
$$= 1.06 + 4d$$

$$V_u = 1118 \times (1.06 + 4d)\,d \quad (2)$$ ½M

$$2.1^2 - [(0.3+d)(0.23+d)\ 272.10] = 1118 \times (1.06 + 4d)\,d$$ ½M

$$4.41 - [(0.069 + 0.3d + 0.23d + d^2)\ 272.10] = 1118d\ (1.06 + 4d)$$

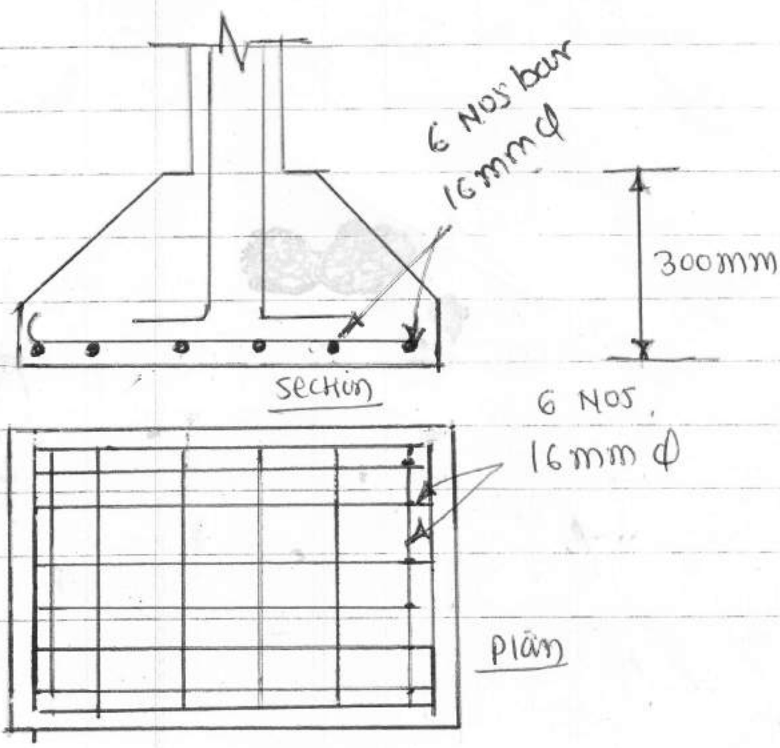
$$4.41 - [(d^2 + 0.53d + 0.069)\ 272.10] = 1185.08d + 4472d^2$$

$$4.41 - [272.10d^2 + 144.213d + 18.77] = 1185.08d + 4472d^2$$

$$4.41 - 272.10d^2 - 144.213d - 18.77 = 1185.08d + 4472d^2$$

$$4472d^2 + 272.10d^2 + 1185.08d + 144.213d + 14.36 = 0$$

Q.NO	SOLUTION	MARKS
	$4744.1\,d^2 + 1329.29d + 14.36 = 0$	
	$\boxed{d = 268\,mm}$ provide $\underline{300\,mm}$	01 M
	Bending moment per metre width of footing	
	$M_x = 1 \times 0.935 \times 272.10 \times \frac{0.935}{2} = 118.94\ KN.m$	½ M
	$M_y = 1 \times 0.935 \times 272.10 \times \frac{0.3}{2}$	
	$M_y = 38.16\ KN.m$	½ M
	effective depth reqd	
	$M_{ulim} = M_y$	
	$0.138\ f_{ck} \cdot b \times d^2 = M_{uy}$ (max. B.M.)	
	$0.138 \times 20 \times 1000 \times d^2 = 118.94 \times 10^6$	
	$2760\,d^2 = 118.94 \times 10^6$	
	$d^2 = 43.09 \times 10^3$	
	$d = 207.59\ mm < 300\ mm$	
	provided depth	
	Hence -- (OK)	½ M
	steel provided for maximum bending moment in both direction	
	$x_u = \frac{0.87\ f_y\ A_{st}}{0.36\ f_{ck}\ b} = \frac{0.87 \times 415 \times A_{st}}{0.36 \times 20 \times 1000}$	
	$x_u = 0.05\ A_{st}$	
	$M_u = 0.87\ f_y\ A_{st}\ (d - 0.42\,x_u)$	

Q.NO	SOLUTION	MARKS
	$118.94\times10^6 = 0.87\times415\times A_{st}(300-0.42(0.05A_{st}))$	
	$118.94\times10^6 = 361.05\,A_{st}(300-0.021\,A_{st})$	
	$118.94\times10^6 = 108.3\times10^3\,A_{st} - 7.58205\,A_{st}^2$	
	$-7.58205\,A_{st}^2 + 108.3\times10^3\,A_{st} - 118.94\times10^6 = 0$	
	$\boxed{A_{st} = 1198.86\,mm^2}$	½M
	providing 16 mm ϕ bar	
	No. of bars $= \frac{1198.86}{201} = 5.96$ say 6 Nos	½M
	∴ provide 16 mm ϕ bar 6 No in both directions	
	summary of design	
	$D = d + \phi/2 + \text{cover} = 300 + \frac{16}{2} + 100 = 408\,mm$	
	cover = 100 mm say 450mm	
		½M

Q .NO	SOLUTION	MARKS
Q 4. a)	**Attempt ANY THREE of following**	12
(i)	**State Two advantages and Two Disadvantage of Pre-stressed concrete**	04
	Advantages 1. Prestressed member is free from crack, so the resisting impact, shock and reversal of stresses is much more than reinforced concrete. 2. It is more durable than reinforced concrete. 3. The section of prestressed concrete member is less compared to RCC member as it utilizes the maximum tension and compression of concrete, so it reduces the cost. 4. Prestressed concrete can be used in **long spans** as the section of member can be reduced. 5. As the sections are lighter, they can be transported easily. 6. The concrete diagonal tension can also be reduced. 7. Shear resistance can be increased using curved tendons. **Disadvantages of Prestressed Concrete** The major pre-stressed concrete disadvantages include the followings. 1. The major problem with pre-stressed concrete is that it needs specialized construction machineries like jacks anchorage etc. 2. Advanced technical knowledge and strict supervision is very important. 3. For concrete pre-stressing, high tensile reinforcement bars are needed which costs greater than generally used mild steel reinforcement bars. 4. Highly skilled labor is needed for pre-stressed concrete constructions.	02 M for ANY TWO 02 M for ANY TWO
(ii)	**State four losses in pre-stressing**	04 M
	a) Elastic shortening b) Shrinkage of concrete c) Creep of concrete d) Frictional loss e) Relaxation of steel f) Anchorage take-up	01 M Each
(iii)	Define: 1)Characteristics strength of material 2)Partial safety factor	04 M
	1) Characteristics strength of material Characteristics strength of material is defined as that value of resistance below which not more than a prescribed percentage of test results may be expected to fall. In design, usually characteristic yield strength is defined as yield stress below which not more than 5% of the test values may be expected to fall, i.e. the strength of materials is expected to be exceeded by 95% of the cases. **2) Partial safety factor** The ratio of Characteristics strength of the material to Design strength of the material for concrete and steel should be taken as 1.5 and 1.15	02 M 02 M

Q .NO	SOLUTION	MARKS
(iv)	**Write four IS-Specifications for longitudinal** reinforcement in column	**04 M**
	(a) The minimum amount of steel should be at least 0.8 per cent of the gross cross-sectional area of the column required if for any reason the provided area is more than the required area. (b) The maximum amount of steel should be 4 per cent of the gross cross sectional area of the column so that it does not exceed 6 per cent when bars from column below have to be lapped with those in the column under consideration. (c) Four and six are the minimum number of longitudinal bars in rectangular and circular columns, respectively. (d) The diameter of the longitudinal bars should be at least 12 mm. (e) Columns having helical reinforcement shall have at least six longitudinal bars within and in contact with the helical reinforcement. The bars shall be placed equidistant around its inner circumference. (f) The bars shall be spaced not exceeding 300 mm along the periphery of the column. (g) The amount of reinforcement for pedestal shall be at least 0.15 per cent of the cross-sectional area provided.	**01 M For Each Write any Four**

Q.NO	SOLUTION	MARKS
Q-4 (b)	i) A T-beam is to be provided for a span of 3m and c/c distance betn beam is 4m. calculate the effective flange width if width of web is 230mm and depth of flange is 120mm	
→	Span = 3m ... assuming it is effective span	
	$L_o = 3m$	01M
	c/c distn betn beam = 4m	
	$b_w = 230$ mm	
	$D_f = 120$ mm	01M
	$b_f = \frac{L_o}{6} + b_w + 6D_f$	02M
	$= 3000/6 + 230 + 6(120) < 4000$ mm	01M
	$b_f = 1450$ mm = effective width of flange.	01M
	ii) A T-beam flange width of 1200 mm and an effective depth of 400mm. the slab thickness is 100mm & the breadth of web is 230 mm. the beam is reinforced on tension side only with total steel area of 2000 mm2 calculate limiting moment of resistance if M-20 & MS grade I is used.	
	i) find x_u	
	$0.36 f_{ck} x_u b_f = 0.87 f_y A_{st}$	01M
	$0.36 \times 20 \times x_u \times 1200 = 0.87 \times 250 \times 2000$	
	$10800 x_u = 435000$ $\boxed{x_u = 50.34 mm}$	

Q .NO	SOLUTION	MARKS
	$x_u < D_f$	
	$50.34 < 100$ mm	
	ii) find x_{umax}	
	$x_{umax} = 0.53 \times d$	(1/2M)
	$= 0.53 \times 400$	
	$x_{umax} = 212$ mm	(01M)
	As $x_u < x_{umax}$ ---- beam is under reinforced.	(01M)
	iii) find Mu	
	$M_u = T_u \times Z_u$	
	$= 0.87\, f_y\, A_{st}(d - 0.42 x_u)$	(01/2M)
	$= 0.87 \times 250 \times 2000 (400 - (0.42 \times 50.34)]$	(01M)
	$M_u = 164.80 \times 10^6$ N-mm	
	$\boxed{M_u = 164.80 \text{ KN.m}}$	(01M)
	or	
	$M_u = 0.36\, f_{ck}\, b_f\, x_u (d - 0.42)$	
	$M_u = 0.36 \times 20 \times 1200 \times 50.34 (400 - 0.42 \times 50.34)$	or
	$\boxed{M_u = 164.78 \text{ KN.m}}$	01

Q.NO	SOLUTION	MARKS
Q-5(a)	A doubly Reinforced beam 250 X 600 mm overall has to resist a factored moment of 310 KN/m find the amount of steel required on compression & tension side, if cover on both sides is 50mm concrete M-20 & mild steel are used.	
	i> steel required for balanced section (A_{st_1})	
	b = 250mm d = 550 mm	
	$x_{umax} = 0.531d$	
	$x_{umax} = 0.531 \times 550$	
	$x_{umax} = 292.05$ mm	½M
	$M_{ulim} = 0.149\ f_{ck}\ b \cdot d^2$	
	$= 0.149 \times 20 \times 250 \times 550^2$	
	$= 225.36 \times 10^6$ KN-m	½M
	$A_{st_1} = \dfrac{M_{ulim}}{0.87 f_y (d - 0.42 x_{umax})}$	
	$A_{st_1} = \dfrac{225.36 \times 10^6}{0.87 \times 250 (550 - 0.42 \times 292.05)}$	
	$A_{st_1} = 2424.62\ mm^2$	½M
	$A_{st_2} = \dfrac{M_u - M_{ulim}}{0.87 f_y (d - d_c')}$	
	$A_{st_2} = \dfrac{(310 - 225.36) \times 10^6}{0.87 \times 250 (550 - 50)}$	
	$A_{st_2} = \dfrac{84.64 \times 10^6}{108.75 \times 10^3}$ $\boxed{A_{st_2} = 777.93\ mm^2}$	½M

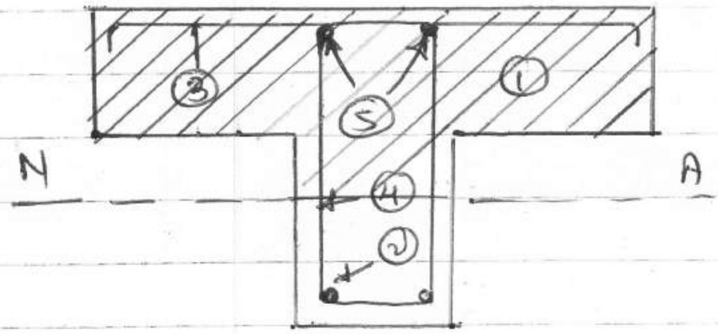
Q.NO	SOLUTION	MARKS
	iii) Total steel in tension	
	$A_{st} = A_{st_1} + A_{st_2}$	
	$= 2424.62 + 777.93$	
	$A_{st} = 3202.55\ mm^2$	½M
	iv) compression reinforcement	
	$\frac{d'_c}{d} = \frac{50}{550} = 0.090$	
	d'_c/d f_{sc}	
	0.075 354	
	0.090 x	
	0.1 353	
	$0.025 - 1$	
	$0.015 - x$	
	$0.025x = 0.015$	
	$x = 0.6$	
	$f_{sc} = 353.4\ N/mm^2$	½M
	$A_{sc} = \frac{Mu - Mulim}{(f_{sc} - 0.466 f_{ck})(d - d'_c)}$	½M
	$= \frac{\times 10^6}{(353.4 - 0.466 \times 20)(550 - 50)}$	
	$= \frac{84.64 \times 10^6}{172.04 \times 10^3}$	
	$\boxed{A_{sc} = 491.97\ mm^2}$	½M

Q .NO	SOLUTION	MARKS
Q-5 (b)	Define Bond stress. state types of bond.	
	i) Define – The tangential or shear stress developed along the contact surface of the reinforcing bar and the surrounding concrete is genrally termed as Bond stress	(01 M)
	ii) State types of bond stress	
	a) flexural Bond stress (Local Bond)	(01 M)
	b) Average (Anchorage) Bond stress	(01 M)
	c) Development Bond	(01 M)

Q.NO	SOLUTION	MARKS
Q-5(c)	given:	
	$V_u = 175$ KN $\tau_c = 0.55$ $f_{ck} = 15$ Mpa $f_y = 250$ Mpa	
	$b = 300$ mm $d = 600 - 25$ (assumed)	
	$d = 575$ mm	
	$V_{uc} = \tau_c bd$	
	$V_{uc} = 0.55 \times 300 \times 575 = 94.875$ KN	½M
	shear to resisted by stirrups	
	$V_{us} = V_u - V_{uc}$	½M
	$V_{us} = 175 - 98.875$	
	$V_{us} = 76.125$ KN	½M
	Assume 8mm - 2legged stirrups	
	$A_{sv} = 2 \times \frac{\pi}{4} \times 8^2 = 100.48$ mm²	½M
	spacing $= \frac{0.87 \times 250 \times 100.48 \times 575}{94.875 \times 10^3}$	½M
	$= 132.45$ say 130 mm < 300 or 3d hence OK	½M
	spacing for minimum stirrups	
	$= \frac{0.87 \times 250 \times 100.48}{0.4 \times 300}$	
	$= 242.82$ mm say 240 mm	01M

Q.NO	SOLUTION	MARKS

Q-5 (d) i)



T - section

1) compression in concrete
2) Tension in steel 3) Transverse steel
4) stirrups for shear
5) Anchorage stirrups

02M for fig

ii)

a) if the main reinforcement of slab is parallel to the beam, it is necessary to provide transverse reinforcement shall not be less than 60% of the main reinforcement at mid span of slab.

b) Transverse reinforcement should be provided at the top portion of the beam. For a length equal to $l/4$ from the face of the beam on each side of the beam

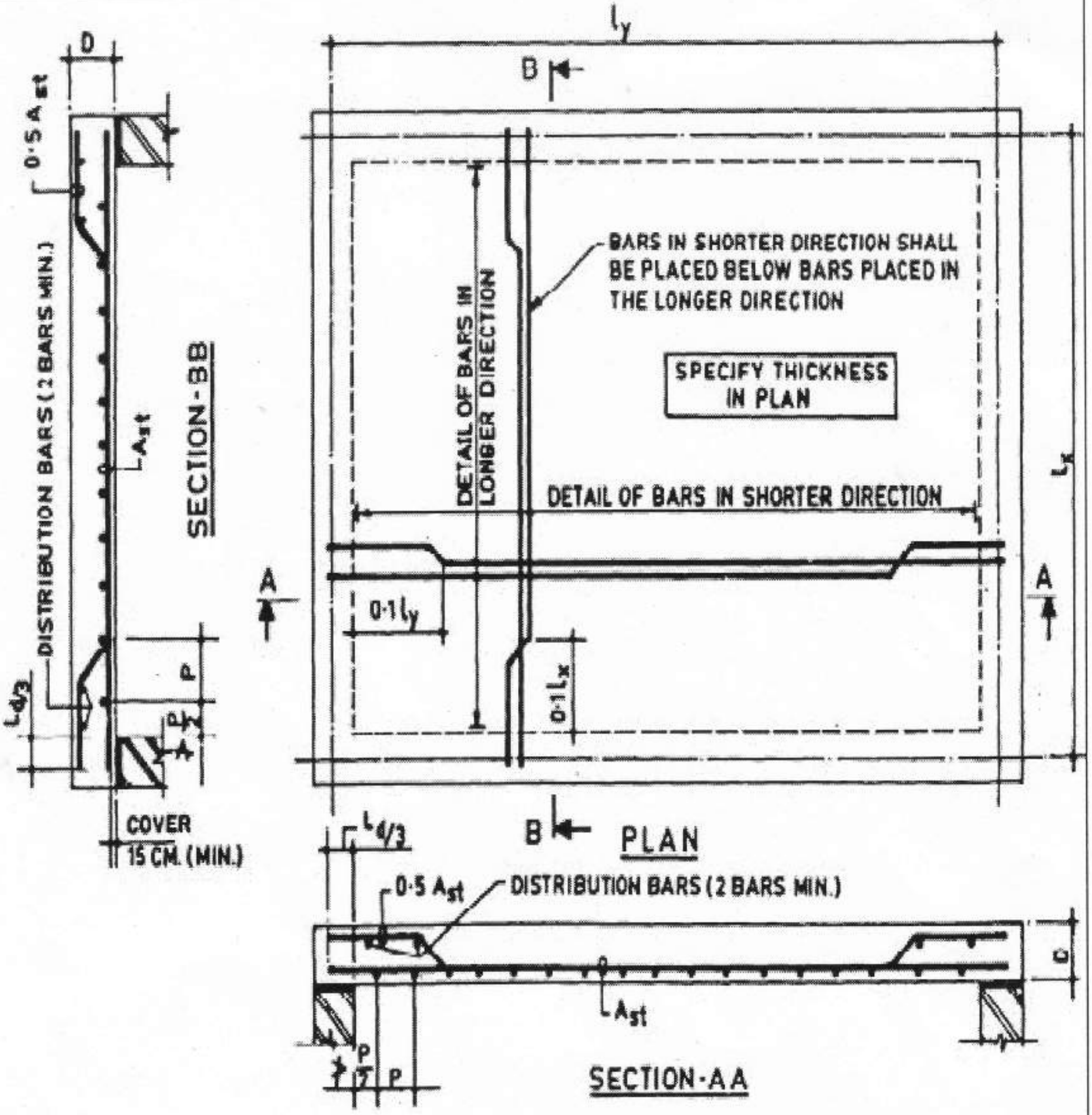
c) the beam & slab should be casted together 02M

d) when the slab is continuous.

Q.NO	SOLUTION	MARKS
Q-5 (e)	Distinguish between one-way slab & two-way slab giving two points each.	

one way slab	two way slab.	
i) supported beams only two sides	i) Supported by all four sides	(2M) for each point write Any TWO
ii) longer to shorter span ratio should be greater than 2	ii) longer to shorter span ratio should be less than 2	
iii) Main reinforcement for one way slabs only go in one direction	iii) Main reinforcement for two way slab go in two direction.	
iv) one way slabs will behave in the same manner as a support beam.	iv) two way slabs is evenly distributed and will reduce bending and shifting.	

Q.NO	SOLUTION	MARKS
Q-6 (a)	A cantilever slab of effective span 1.75m is subjected to the design moment of 20 kN·m calculate the depth of the slab and the area of reinforcement required. M20 and mild steel are used. Take modification factor of 1.5	
	→ i) Basic L/d ratio = 7	
	∴ allowable L/d ratio $= \alpha \times 7$ $= 1.5 \times 7$ $= 10.5$	(½M)
	∴ Required $d = \frac{L}{10.5} = \frac{1.75 \times 1000}{10.5}$	(½M)
	∴ $d = 166.67$ mm say $d = 170$ mm	(½M)
	ii) Area of steel calculation	
	$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{f_{ck} b d^2}}\right] b \times d$	(½M)
	$= \frac{0.5 \times 20}{250}\left[1 - \sqrt{1 - \frac{4.6 \times 20 \times 10^6}{20 \times 1000 \times 170^2}}\right] 1000 \times 170$	
	$A_{st} = 0.04\,[1 - 0.91696] \times 1000 \times 170$	
	$A_{st} = 564.62\ mm^2$	(02M)

Q .NO	SOLUTION	MARKS
Q No -6 b)	**Draw a labelled sketch of Reinforcement details of Two way slab in cross along longer and shorter span.**	
		02M for each cross section

Q .NO	SOLUTION	MARKS
Q-6 (c)	Design a slab for a hall 3m x 4.5m carrying a load of 3 KN/m^2 and floor finish of 1.2 KN/m^2 supported on walls of 300 mm, all the four corners are free to lift using M-20 concrete and fe415 steel, use $\alpha x = 0.104$ & $\alpha y = 0.046$	
	→ Step-I) Determine the effective Lx/Ly ratio	
	eff. $Ly = 4.5 + \frac{0.3}{2} + \frac{0.3}{2} = 4.8\,m$	
	eff. $Lx = 3.0 + \frac{0.3}{2} + \frac{0.3}{2} = 3.3\,m$	
	$\frac{Ly}{Lx} = \frac{4.8}{3.3} = 1.45 < 2$ Hence design the slab as two way slab	
	Step-II) Trial depth for a slab with shorter span Lx is upto 3.3m and fe415, also loading class is up to 3 KN/m^2, the effective Lx/D ratio shall be taken as (20 to 28)	
	Students can assume any value bet 20 to 28 let us assume $\frac{Lx}{D}$ as 20	
	$\therefore \frac{Lx}{D} = 20$	

Q.NO	SOLUTION	MARKS
	$\frac{3.3 \times 10^3}{D} = 20 \times M.F$	
	∴ solving the above eq^n we will get the value of D	
	$D_{reqd} = \frac{3.3 \times 10^3}{20 \times 1.6} = 103.125 \text{ mm} \simeq 110 \text{ mm}$	
	{But the [illegible]	
	Assume $p_t = 0.2\%$	
	$M.F = 1.6$ }	
	Assuming cover 15 mm	
	$D_{assumed} = 110 + 15 = 125 \text{mm}$	(½M)
	Loading for 1m wide strip	
	a) Dead load $= 0.125 \times 1 \times 25 = 3.125 \text{ KN/m}$	
	b) Live load $= 3 \text{ KN/m}^2 \times 1\text{m} = 3 \text{ KN/m}$	
	c) floor finish $= 1.2 \text{ KN/m}^2 \times 1\text{m} = 1.2 \text{ KN/m}$	
	Total load $= 7.325 \text{ KN/m}$	
	ultimate load $= 7.325 \times 1.5 = 10.98 \text{ KN/m}$ (W_d)	(½M)
	Factored moment	
	$\alpha_x = 0.104 \quad \alpha_y = 0.046$	
	$M_{ux} = \alpha_x W_d (l_x)^2$	
	$= 0.104 \times 10.98 \times (3.3)^2$	
	$= 12.44 \text{ KN-m}$	(½M)

Q .NO	SOLUTION	MARKS
	$M_{uy} = \alpha_y \cdot W_d (l_x)^2$ $= 0.046 \times 10.98 \times (3.3)^2$ $= 5.5$ kN-m	(½M)
	Depth required for bending for fe415 $M_d = 0.136 f_{ck} b d^2$ equating M_{ux} & M_d $12.44 \times 10^6 = 0.136 \times 20 \times 1000 d^2$ $12.44 \times 10^6 = \cancel{2720 d}\ 2.72 \times 10^3 d^2$ $d = 67.62$ mm $d_{reqd} < d_{assumed}$ $67.62\ mm < 110$ mm ----- Safe for bending	(½M)
	Determination of steel i) Along short span Find actual value of x_u $x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$ $= \frac{0.87 \times 415 \times A_{st}}{0.36 \times 20 \times 1000}$ $x_u = 0.05014 \cdot A_{st}$ $M_d = 0.87 f_y A_{st} (d - 0.42 x_u)$ $12.44 \times 10^6 = 0.87 \times 415 \times A_{st} (110 - 0.42 \times 0.05014 A_{st})$	

Q .NO	SOLUTION	MARKS
	$12.44\times10^6 = 0.87\times415\times A_{st}(110-0.021A_{st})$	
	$12.44\times10^6 = 361.05\,A_{st}(110-0.021A_{st})$	
	$12.44\times10^6 = 39.71\times10^3 A_{st} - 7.58A_{st}^2$	
	$39.71\times10^3 A_{st} - 7.58A_{st}^2 - 12.44\times10^6 = 0$	
	$A_{st} = 334.64\,mm^2$	($\frac{1}{2}$M)
	Assuming 10mm ϕ bar	
	spacing $= \dfrac{1000\,A\phi}{A_{st}}$	
	$A\phi$ = area of 10 mm ϕ bar	
	$= \dfrac{1000\times78.54}{436.0}$	
	$= 180.137$ say 180mm c/c	
	check $S \not> 3d$ & $S \not> 300$	
	Along long span	
	$M_d = 0.87 f_y A_{st}(d' - 0.42x_u)$	
	$d' = 110 - 10 = 100\,mm$	
	$5.5\times10^6 = 0.87\times415 A_{st}(100-(0.42\times0.05014A_{st}))$	
	$5.5\times10^6 = 0.87\times415\times A_{st}(100-0.021A_{st})$	
	$5.5\times10^6 = 361.05A_{st}(100-0.021A_{st})$	
	$5.5\times10^6 = 36.105\times10^3 A_{st} - 7.582A_{st}^2$	
	$0 = -7.582A_{st}^2 + 36.105\times10^3 A_{st} - 5.5\times10^6$	
	$A_{st} = 157.54\,mm^2$	($\frac{1}{2}$M)

Q .NO	SOLUTION	MARKS
	spacing of 5 10mm ϕ bar.	
	$S = \frac{1000 \times A\phi}{Ast}$	
	$S = \frac{1000 \times 78.54}{198.43} = 395.8$ mm	
	check $S \ngtr 3d$ & $S \ngtr 300$mm	
	provide 10mm ϕ spacing along long span as 300 mm	
	summary	
	i) Thickness of slab = 125 mm	
	ii) cover = 15mm	
	iii) steel along short span = 10mm ϕ @ 180 mm c/c	
	iv) steel along long span = 10mm ϕ @ 300mm c/c	
		(½M)

Q.NO	SOLUTION	MARKS
Q-6 (d)	Write I.S. specification for minimum eccentricity and transverse reinforcement of an axially loaded short column.	
	i) $e_{min} = \left[\frac{L}{500} + \frac{D}{30}\right]$ but not less than 20mm	
	where L = unsupported length. D = lateral dimensions in the plane of bending	(02M)
	ii) Transverse reinforcement.	
	i) Links should be so arranged that every corner and alternate longitudinal bar, if spaced not more than 75mm, should have lateral support provided by the corner of a link having an internal angle of not more than 135°.	
	ii) the diameter of the links should be at least on fourth of the largest diameter of the longitudinal steel. in any case, the links should not be less than 6mm in diameter.	
	iii) The spacing of the links should not exceed the least of the following	
	a) The least lateral dimension of column.	
	b) Sixteen times the diameter of the smallest longitudinal bar.	(02M)
	c) 300mm	

Q .NO	SOLUTION	MARKS
	iv) proper cover should be provided for the link Nominal cover of 40mm can be reduced to 25 mm. if column size is 200mm or less and main steel 12mm in diameter is used.	
Q-6 (e)	calculate the safe load carrying capacity of column 300x300mm provided with 8 bars of 12mm ϕ use M-20 and fe415 steel	
	i) $A_g = 300 \times 300 = 90000\ mm^2$	
	ii) Area of steel $A_{sc} = 8 \times \frac{\pi}{4} \times 12^2 = 904.78\ mm^2$	(1M)
	iii) Area of concrete $= A_g - A_{steel}$ $A_c = 90000 - 904.78$ $= 89095.22\ mm^2$	(1M)
	iv) $P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{steel}$ $= 0.4 \times 20 \times 89095.22 + 0.67 \times 415 \times 904.78$ $= 712.76176 \times 10^6 + 253.574 \times 10^3$	
	$\boxed{P_u = 964.33\ KN}$	(1M)
	Safe load $P = \frac{P_u}{1.5} = \frac{964.33}{1.5}$	
	$\boxed{P = 642.89\ KN}$	(1M)