SCHEME OF VALUATION

(Scoring Indicators)

Revision: 2015 **Course Code : 5015**

Course Title : Structural Design I

Qst No.	Scoring Indicator	Split up	Sub total	Total
I 1	Definition W/c ratio = Wt of water / Wt of cement W.c ratio $\propto \frac{1}{\text{Strength}}$	1 1		
2	• Development length - It the length extended to the concrete for a the steel bars to satisfy safe transfer of loads by bond stress • $l_d = \frac{\phi \sigma_s}{4 \tau_{bd}}$	1 1		
3.	Distribution reinf are to prevent temperature crack, ~~and~~ to with stand secondary moment, and to prevent shrinkage crack. It aligned ⊥ar to the main reinf.	2		
4.	Min = 0.8% Max = 4%	1 1		
5.	Slab - 20 - 25 mm beam - 20 - 30 mm column - 40mm footing - 50mm } Check the range & give ½ mark for each ½×4	2		
II 1.	IS 456, P- 69, 38.1 • 6 point required each having 1 mark	6		

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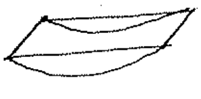
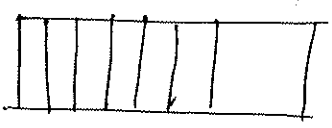
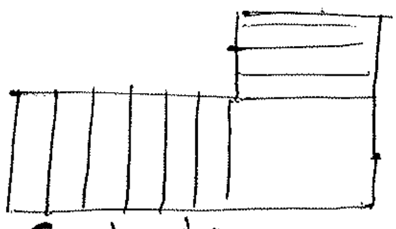
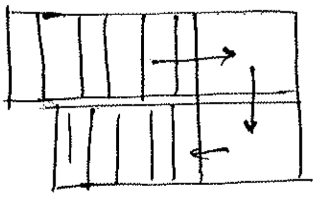
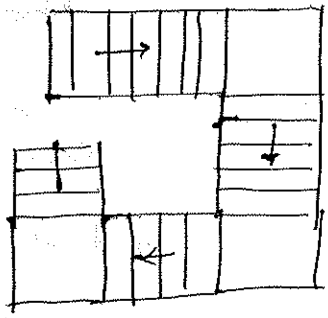
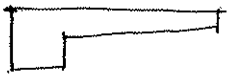
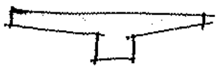
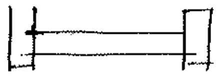
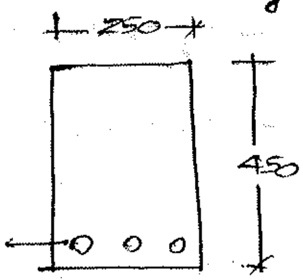
2.	• find $\tau_v = \frac{V_u}{bd}$ (Nom. shear stress)	1½		
	• Compare with τ_c			
	if $\tau_v < \tau_c \rightarrow$ Min shear reinf $\frac{A_{sv}}{bs_v} \geq \frac{0.4}{0.87 f_y}$	1½		
	if $\tau_v > \tau_c$ & $\tau_v < \tau_{c,max}$ provide reinf. for $V_u - \tau_c \cdot bd$ as per $V_u - \tau_c bd = \frac{0.87 f_y A_{sv} \cdot d}{S_v}$	1½		
	if $\tau_v > \tau_c$ & $\tau_v > \tau_{c,max}$ section is to be redesign	1½	6	
3.	One way slab / Two way slab			
	• $l_y/l_x > 2$ / • $l_y/l_x \leq 2$	1½		
	• Deflection along long span  / • Deflection along both span 	1½		
	• Main reinf along short span, accross dist^n (main) reinf / • Both ways Main reinf	1½		
	• Design based on 1m strip beam / • Design considering bothways Moments	1½	6	
4	1. According to Material			
	• Wood • concrete • steel • composite			
	2. Geometric Configurations			
	 Straight stairs			
	 Quarter turn			

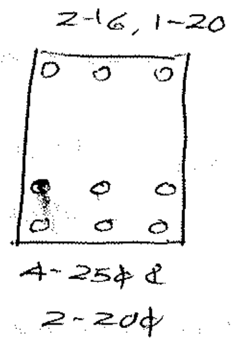
Qst No.	Scoring Indicator	Split up	Sub total	Total
	 Dog legged  Open Well			
	3. Structural classification  Cantilevered stair  Doubly Cantilevered,  Stair on Stringer beams			
	5 types we can give 6 Mark	6		
5.	Doubly reinforced beams When the load increases on a beam without changing the dimensions, we can increase the steel on the tension side. But the stress in the compression side increase the permissible stresses we provide steel on compression side	2		
	Advantages - More ductile - High load carrying capacity - We can limit depth for aesthetic look - Effective in stress reversal.	4	6	
	Definition - 2 each point 1 Mark			
6.	IS 456 - P-36 23.1.2 4 formulas each carry 1.5 mark	6		

Qst No.	Scoring Indicator	Split up	Sub total	Total
7	Long column — Short column • $\frac{l_{eff}}{\text{least lateral dimension}} > 12$ — $\frac{l_{eff}}{\text{least lat dim}} < 12$ • Fails by buckling — • Fails by crushing • Slenderness ratio > 45 — • slenderness ratio < 45 • Load carrying capacity less — • Capacity more Each point 1.5 Mark	6		

Qst No.	Scoring Indicator	Split up	Sub total	Total
III a)	Assume trial section, $b = 250$, $D = 600$			
	Eff span, $l = \begin{cases} 6.0 \\ (6 - 0.23) + 0.55 \end{cases} = \underline{6.0m}$ — Eff span	$1\frac{1}{2}$		
	$D = 600$			
	$d = 600 - 50$			
	• Loads — Load calculation	1		
	i) Self Wt = $25 \times 0.25 \times 0.6 = 3.75$ kN/m			
	Total DL = $3.75 + 5 = 8.75$ kN/m			
	LL = 10 kN/m			
	Factored load = $1.5(DL + LL) = 28.1$ kN/m			
	" Moment = $\frac{wl^2}{8} = 126$ kNm — BM	$1\frac{1}{2}$		
	• check the adequacy of depth			
	$d_{req} = \sqrt{\frac{M_u}{R_u b}} = \sqrt{\frac{126 \times 10^6}{0.138 \times 25 \times 250}} = \underline{381mm}$ — d required	$1\frac{1}{2}$		
	Adopt, $D = 450$mm			
	$d = 450 - 30 - 8 - 25/2 = \underline{399mm}$			
	• Finding Ast			
	$P_t = \frac{50 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{R_u b d^2}}\right] = 1.065$ — Ast required	$1\frac{1}{2}$		
	$A_{st} = \frac{1.065}{100} \times 250 \times 399 = 1062 mm^2$			
	check for Min & Max Ast — Detailing	1	9	
				

Qst No.	Scoring Indicator	Split up	Sub total	Total
b)	$d = 600 - 25 - 25/2 = 562.5\,mm$	1		
	$\frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b d}$ Substitution - 1, Result - 1	2		
	$= \frac{0.87 \times 415 \times 1472.62}{0.36 \times 25 \times 240 \times 562.5}$			
	$= 0.4376$			
	$\left(\frac{x_u}{d}\right)_{lim} = 0.4792 > \left(\frac{x_u}{d}\right)_{Actual}$	1		
	Section UR			
	$M_u = 0.87 f_y A_{st} \left\{ d \left[1 - \frac{A_{st} f_y}{b d f_{ck}} \right] \right\} \times 10^{-6}$ Substitution - 1, Result - 1	2	6	
	$= 244.919\,kNm$			
IV. a)	Assuming $C_c = 30\,mm$ & $\phi = 25\,mm$			
	$M_u = 325 \times 1.5 = 487.5\,kNm$	1		
	Limiting $MR = R_u b d^2 = 3.99 \times 300 \times (600 - 30 - 12.5 - 25)^2$	1		
	$= 339.42\,kNm$ distance b/w 2 layer $= 25$			
	$M_{u,Applied} > M_{u,lim}$			
	Section should be doubly reinforced	1		
	$A_{st1} = \frac{M_{u,lim}}{0.87 f_y (d - 0.42 x_u)}$	1		
	$= \frac{339.42 \times 10^6}{0.87 \times 500 \times (532.5 - 0.42 \times 244.95)}$			
	$= 1812.06\,mm^2$			

Qst No.	Scoring Indicator	Split up	Sub total	Total
	$M_u - M_{u,lim} = 148.08 \text{ kNm}$			
	$\varepsilon_{sc} = \frac{0.0035(244.95-40)}{244.95} = 0.0029$	1		
	So $f_{sc} = 0.85 f_y = 500 \times 0.85 = 425 \text{ MPa}$			
	$A_{sc} = \frac{148.08 \times 10^6}{425(532.5-30)} = 693.38 \text{ mm}^2$	1		
	$A_{st2} = \frac{A_{sc} \cdot f_{sc}}{0.87 f_y} = \frac{693.38 \times 425}{0.87 \times 500} = 677.85 \text{ mm}^2$	1		
	$A_{st} = A_{st1} + A_{st2} = 2489.9 \text{ mm}^2$	1		
	25ϕ bars ⇒ No = 5.07 Provide 4-25ϕ & 2-20ϕ $A_{sc} = 693.38$ ⇒ 2-16ϕ & 1-20ϕ	1	9	



Qst No.	Scoring Indicator	Split up	Sub total	Total
V a)	Assume clear cover = 30 mm			
	• Assume N.A within flange	1½		
	$\frac{x_u}{d} = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b_f d}$			
	Solving $x_u = 147.69$ mm			
	$x_u > D_f$ Assumption wrong			
	• Assuming N.A in web	2		
	$0.36 f_{ck} x_u b_w + 0.45 f_{ck} (b_f - b_w) y_f = 0.87 f_y A_{st}$			
	• where $Y_f = 0.15 x_u + 0.65 D_f$	1		
V 3a)	$0.36 \times 25 \times x_u \times 300 + 0.45 \times 25 (800 - 300) Y_f = 0.87 \times 415 \times 2945.24$			
	Solving $x_u = 172.62$ mm Assumption is right	2		
	$Y_f = 0.15 \times 172.62 + 0.65 \times 125 = 107.14$ mm $< D_f$ assumption right	1		
	$MR = 0.36 f_{ck} x_u b_w (d - 0.416 x_u) + 0.45 f_{ck} (b_f - b_w) Y_f (d - \frac{y_f}{2})$			
	$M_u = 527.37$ kNm	1½	8	

Qst No.	Scoring Indicator	Split up	Sub total	Total
b)	BM = 30kNm			
	SF = 100kN			
	TM = 45kNm			
	$V_t = \frac{1.6T}{b} = \frac{1.6\times45}{0.3} = 240kN$	1½		
	$M_t = \frac{T[1+D/b]}{1.7} = \frac{45(1+\frac{0.7}{0.3})}{1.7} = 88.24kNm$	1½		
	$M_t > M$			
	Design Moments			
	$M_{e1} = M+M_t = 30+88.24 = 118.24kNm$	1½		
	$M_{e2} = M_t-M = 88.24-30 = 58.24kNm$	1½		
	Design shear = 100+240 = 340kN	1	7	15
V) a)	i) 100kN			
	$\tau_v = \frac{V_u}{bd} = \frac{100\times10^3}{300\times(600-30-12.5)} = 0.597 N/mm^2$	1		
	$P_t = \frac{100\times\pi/4\times25^2\times5}{300\times557.5} = 1.466\%$	1		
	$\tau_c = 0.73 N/mm^2$			
	$\tau_v < \tau_c \Rightarrow$ Min shear reqt	1		
	$\frac{A_{sv}}{bs_v} \geq \frac{0.4}{0.87f_y}$ 2L-8ϕ			
	$\Rightarrow s_v = 302.2mm \Rightarrow$ 2L-8ϕ @ 280c/c	1½		

Qst No.	Scoring Indicator	Split up	Sub total	Total
	ii) 200kN			
	$\tau_v = \frac{200\times10^3}{300\times557.5} = 1.19 > \tau_c$	1		
	$\tau_v < \tau_{c\,max}$	1		
	$(1.19-0.73)\times300\times557.5 = \frac{0.87\times415\times2\times\pi/4\times8^2\times557.5}{S_v}$	1½		
	$77.907\times10^3 = \frac{(\quad)}{S_v}$			
	$S_v = 259$ c/c	1	9	
	$\Rightarrow$ 2L 8ϕ @ 250 c/c			
b)	$L_d = \frac{\phi\,\sigma_s}{4\tau_{bd}}$ $\quad \tau_{bd} = 1.2$			
	• Plain bar			
	Fe 250, $L_d = \frac{\phi\times0.87\times250}{4\times1.2} = 45.31\phi$			
	Fe415, $L_d = \frac{\phi\times0.87\times415}{4\times1.2} = 75.21\phi$			
	• Deformed bars			
	$\tau_{bd} = 1.2\times1.6 = 1.92$			
	Fe 250, $L_d = \frac{\phi\times0.87\times250}{4\times1.2\times1.6} = 28.32\phi$			
	Fe 415 $\Rightarrow$ $L_d = \frac{0.87\times415\times\phi}{4\times1.2\times1.6} = 47.01\phi$			

Qst No.	Scoring Indicator	Split up	Sub total	Total
VII	Assume beam width 300mm			
	clear spacing = $\frac{(14.5 - 0.3\times3)}{4} = 3.4m$	1		
	$L/B = 8/3.4 > 2$. One way anyway			
	• Consider 1 wide strip - Trial Section	1½		
	$(l/d)_{max} \approx 1.34\left(\frac{20+26}{2}\right) = 30$			
	$d_{min} = \frac{3500}{30} = 117m$ (effspan, $l = 3.5m$)			
	Overall Depth, D = 117 + 35 ≈ 160mm			
	take d = 125mm			
	• Eff. length	1		
	for end span, $l = 3400 + d/2 = 3463mm$			
	• Distributed load due to self wt	1½		
	$\Delta W_{DL} = 25kN/m^2 \times 0.16 = 4kN/m^2$			
	$W_{DL} = 4 + 1.5 = 5.5kN/m^2$			
	$W_{LL} = 4kN/m^2$ (given)			
	Factored loads $W_{u,DL} = 5.5\times1.5 = 8.25kN/m^2$			
	$W_{u,LL} = 4\times1.5 = 6kN/m^2$			
	• Factored Moments @ Critical sections			
	for end span, $l_{eff} = 3.463m$			
	$M_u = -\frac{W_{uDL}+W_{uLL}}{24} \cdot l^2 = -7.12kNm$ end support	2½		
	$\left(\frac{W_{uDL}}{12} + \frac{W_{uLL}}{10}\right) l^2 = 15.44kNm$ Midspan			
	$-\left(\frac{W_{uDL}}{10} + \frac{W_{uLL}}{9}\right) l^2 = -17.89$ at 1st Support			

Qst No.	Scoring Indicator	Split up	Sub total	Total

• For interior Span

$$M_u = \begin{cases} -\left(\frac{w_{u,DL}}{10} + \frac{w_{u,LL}}{9}\right) l^2 = -17.24 \text{ kNm/m} & \text{1st int support} \\ \left(\frac{w_{u,DL}}{16} + \frac{w_{u,LL}}{12}\right) l^2 = -11.74 \text{ kNm/m} & \text{Midspan} \\ -\left(\frac{w_{u,DL}}{12} + \frac{w_{u,LL}}{9}\right) l^2 = -15.65 \text{ kNm/m} & \text{at int support} \end{cases}$$

2½

At first int. support an average value of M_u should take

$$M_u = -\frac{(17.89 + 17.24)}{2} = -17.6 \text{ kNm/m}$$

• Determining Ast

$$P_t = \frac{100 \cdot 0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{R_u b d^2}}\right]$$

Assuming 10φ bars

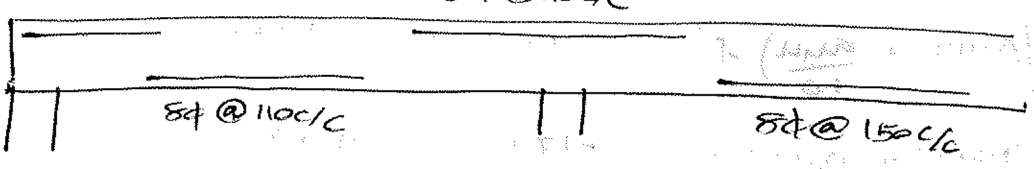
$$\text{Spacing} = \frac{1000 A_\phi}{A_{st}}$$

• Final Result

End span			Int. Span		
End	Mid	first int support	Midspan	int support	
-7.1	15.4	-17.6	11.7	-15.6	M_u
220 mm	110 mm	110 mm	150 mm	110 mm	Spacing 8φ bars

3

8φ 220c/c 8φ @110c/c

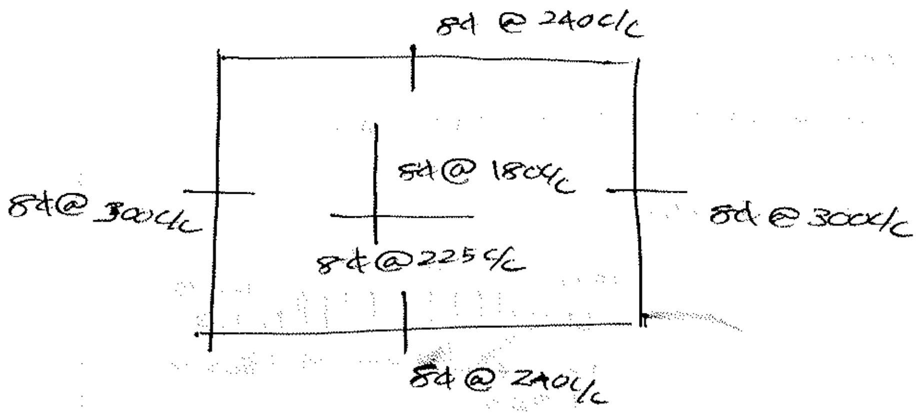


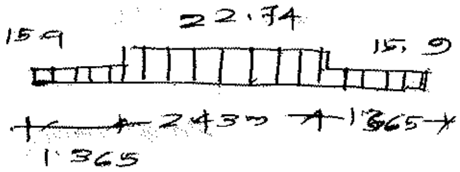
8φ @110c/c 8φ@150c/c

1

Qst. No.	Scoring Indicator	Split up	Sub total	Total
	• Distribution Reinf $= 0.0012bD$ 8ϕ @ 250 c/c			
	• Deflection control			
	Max midspan steel A_{st} = 8ϕ @ 110 c/c $= \frac{1000 \times 50.3}{110} = 457 mm^2/m$	1		
	cc = 30, $d = 160 - 30 - 8/2 = 126$			
	$P_t = \frac{100 \times 457}{1000 \times 126} = 0.363$, ~~fs~~ = 0.			
	$f_s = 0.58 \times 415 \times \frac{360}{45} = 189.6 N/mm^2$			
	$(l/d)_{max} = 1.76 \times \frac{20+26}{2} = 40.4$			
	$(l/d)_{provided} = \frac{3463}{126} = 27.5 < 40.4$ ok		15	15
VIII	• 4.0 x 5.0 - Trial Section			
	$l_x = 4000 + 150 = 4150 mm$	1½		
	$d_x = \frac{4150}{26 \times 1.5} = 107$			
	Assume clear cover 20 mm & 8ϕ bars			
	$D = 107 + 20 + 8/2 = 131 \simeq D = 135 mm$			
	• Effective depth $\begin{cases} d_x = 135 - 20 - 4 = 111 mm \\ d_y = 111 - 8 = 103 \end{cases}$	2		

Qst No.	Scoring Indicator	Split up	Sub total	Total
	Effective span = $l_x = 4000 + 111 = 4111$ mm; $l_y = 5000 + 103 = 5103$ mm	2		
	$\frac{l_y}{l_x} = \frac{5103}{4111} = 1.241$	½		
	Loading on slab Self wt @ 25 kN/m³ × 0.135 = 3.375 kN/m² Finishes = 1.0 kN/m² LL = 4.0 kN/m² Factored load = 1.5 (3.375 + 1 + 4) = 12.56 kN/m²	2½		
	• Moment Coefficients (short edge discontinuous) short span coefficient $\alpha_x = 0.037$ $\alpha_y = 0.028$	1½		
	• Bending Moments short span, M_{ux}^{+} 7.85 kNm $M_{ux}^{-} = 10.47$ kNm long span $M_{uy}^{-} = 5.94$ kNm $M_{uy} = 7.92$ kNm	2		
	• Reinforcements short span, $M_{ux}^{+} = 7.85 \Rightarrow A_{st} = 203.6$ mm²/m 8 ϕ @ 247 mm c/c	½		
	$M_{ux}^{-} = 10.47 \Rightarrow A_{st} = 275.5$ mm²/m	[illegible]		
	8 ϕ @ 183 mm c/c	½		

Qst No.	Scoring Indicator	Split up	Sub total	Total
	• Long span			
	$Mu_y^+ = 5.94\,kN/m \Rightarrow A_{st} = 165.2\,mm^2/m$			
	8ϕ @ 304mm c/c	½		
	$Mu_y^- = 7.92\,kN/m \Rightarrow A_{st} = 223\,mm^2/m$			
	8ϕ @ 225 c/c	½		
		1	15	15
IX.	Assume tread & Rise as R=160mm T=270mm			
	$\sqrt{R^2+T^2} = 314mm$	1		
	Effective span = c/c dist = 5.16m			
	• Trial section			
	Waist slab thickness = $l/20 = \frac{5160}{20} = 258 \rightarrow 260$			
	Assume 20mm clear cover (Mild) & 12ϕ bars	1½		
	$d = 260 - 20 - 12/2 = 234mm$			
	Slab thickness @ landing = 200mm			
	• Loads on Going			
	i) Self Wt = $25 \times 0.26 \times 314/270$ = 7.56 kN/m²			
	ii) " of Step = $25 \times ½ \times 0.16$ = 2.0 kN/m²	2½		
	iii) finishes = 0.6 kN/m²			
	iv) LL = 5.0 kN/m²			

Qst No.	Scoring Indicator	Split up	Sub total	Total
	Factored load = 15.16×1.5 = 22.74 kN/m^2			
	• Loads on Landing i) Self wt of slab = 25×0.2 = 5 kN/m^2 ii) Finish = 0.6 = 0.6 kN/m^2 iii) LL = 5.0 kN/m^2 Factored load = 10.60×1.5 = 15.9 kN/m^2	2½		
	• Design Moment Reaction, R = $15.90\times1.365 + \frac{22.74\times2.43}{2}$ = 49.33 kN/m  $M_u = 49.33\times2.58 - (15.90\times1.365)\times\left(2.58-\frac{1.365}{2}\right) - 22.74\times\frac{(2.58-1.365)^2}{2}$ = 69.30 kNm/m	2½		
	• Main Reinf P_t = 0.381% ⇒ Ast = 892 mm^2/m Spacing of 16mm bar = $\frac{201\times10^3}{892}$ = 225mm c/c 16φ @ 220 c/c	1½		
	• Distributors Ast = 312 mm^2 (0.0012bt) Spacing 10φ bars = 251mm 10φ @ 250 c/c	1½		

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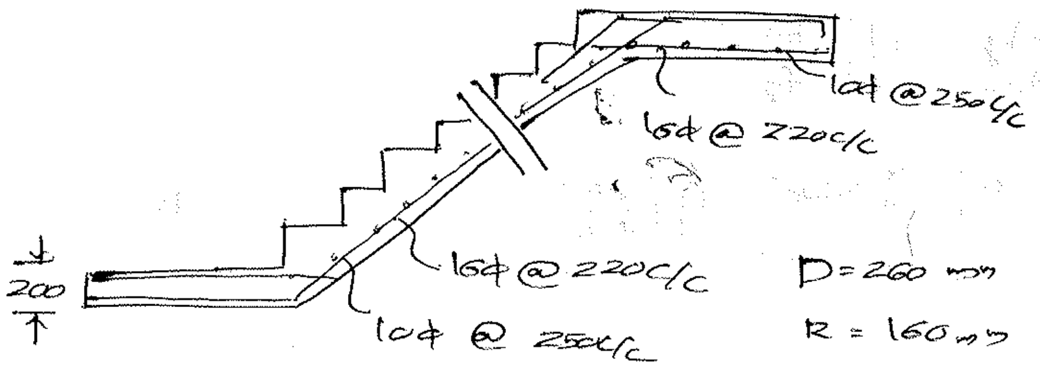
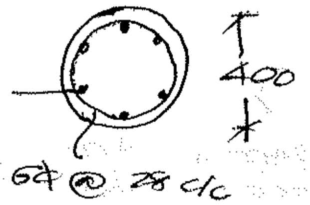
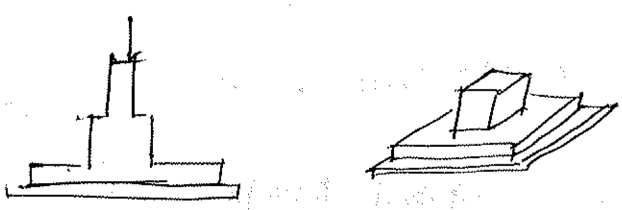
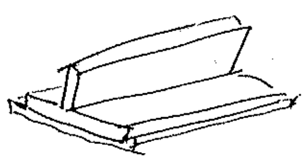
				
	D = 260 mm R = 160 mm T = 270 mm	2	15	15
X a)	l = 3400mm D = 400mm $l_e/D \leq \frac{3400}{400} = 8.5$ $l_e/D < 12$ short column	1		
	• Min eccentricity $e_{min} = \frac{3400}{500} + \frac{400}{30} = 20.1 > 20$			
	• Factored Load = 1500kN $1500 = 1.05\,[0.4 f_{ck} A_g + (0.67 f_y - 0.4 f_{ck}) A_{sc}]$ $A_g = \pi/4 \times 400^2$ A_{sc} = 642 mm² (0.51% gross Area) $A_{sc,min}$ = 0.8% = 1005 mm²	1		
	provide 6 No 16φ ⇒ $A_{sc} = 201 \times 6 = 1206\,mm^2$	2		
	• Design for Spiral Reinforcement $P_s = \frac{\text{Vol of Spiral reinf}}{\text{Vol. of core}} = \frac{\pi \times 6^2/4 \times \pi \times (320-6)/s_t}{\pi \times 320^2/4}$ $= \frac{0.3468}{s_t}$	1½		

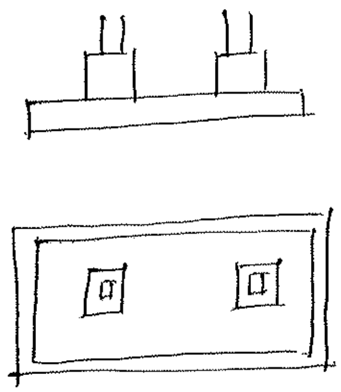
Qst No.	Scoring Indicator	Split up	Sub total	Total
	$P_s \geq 0.36 \left[\frac{A_g}{A_{core}} - 1\right]\left[\frac{f_{ck}}{f_y}\right]$			
	$\frac{0.3468}{S_t} \geq 0.36\left[\frac{\frac{\pi}{4}\times 400^2}{\frac{\pi}{4}\times 320^2} - 1\right]\left[\frac{25}{415}\right]$	1½		
	$S_t \leq 28.4\,mm$			
	• code restrictions.			
	$S_t < \begin{cases} 75\,mm \\ \frac{core\,dia}{6} = 53.3 \end{cases}$			
	$S_t > \begin{cases} 25\,mm \\ 5\phi_t = 18 \end{cases}$ ⇒ 6φ @ 28 mm c/c	1		
		1		
b)	Footing			
	Footing is a substructural element which transfer the loads into soil without any failure or settlement of soil. The pressure under footing will be less than safe bearing capacity	2		
	1. Isolated footing 			
	2. Strip footing 			

Qst No.	Scoring Indicator	Split up	Sub total	Total

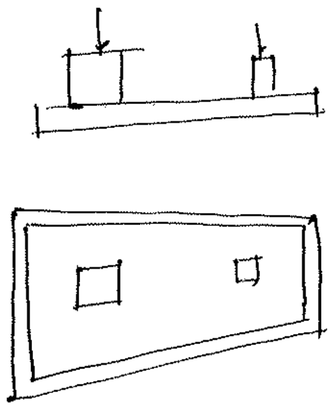
~~Strap footing~~ ~~Recta~~

• combined footing

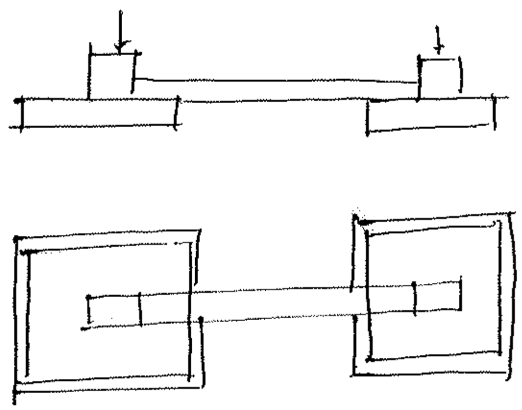
Rectangular footing



Trapezoidal footing



Strap footing



	4 types each having 1 Mark	4	6	15