Roll No. | | | | | | | | | | | | |

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem. 2019-20 — **Date:** 01.10.2019

Course Code: CIV 211 — **Time:** 2:30PM to 3:30PM

Course Name: DESIGN OF RC STRUCTURAL ELEMENTS — **Max Marks:** 40

Programme & Sem: B. Tech (CIV) & V — **Weightage:** 20%

Instructions:

i. Assume any suitable data wherever required
ii. IS 456 and SP 16 charts are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks. (3Qx4M=12M)

1. Discuss the different limit states to be considered in reinforced concrete design. (C.O.NO.1) [Knowledge]
2. Explain under reinforced, over reinforced and balanced sections with sketch showing the variation of x_u. (C.O.NO.1) [Knowledge]
3. Define partial safety factor for loads and materials, Characteristic load, Characteristic strength. (C.O.NO.1) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries eight marks. (2Qx8M=16M)

4. Derive the expression for stress block parameter for compressive forces C_u, tensile force T and locate the depth of neutral axis (x_u) from the top of the beam. (C.O.NO.1) [Comprehension]
5. Design a singly reinforced beam of clear span 5m to support a design working live load of 20 kN/m. Use M20 concrete and Fe 415 HYSD bars. Take span/depth ratio of 15. (C.O.NO.2) [Application]

Part C [Problem Solving Questions]

Answer the Question. The Question carries twelve marks. (1Qx12M=12M)

6. Determine the ultimate moment of resistance for the doubly reinforced section having width of 300mm and reinforced with 5 bars of 25mm diameter at an effective depth of 600mm. The compression steel is made up of 2 bars of 16mm diameter at an effective cover of 50mm. Adopt M 20 concrete and Fe 415 steel. (C.O.NO.2) [Application]

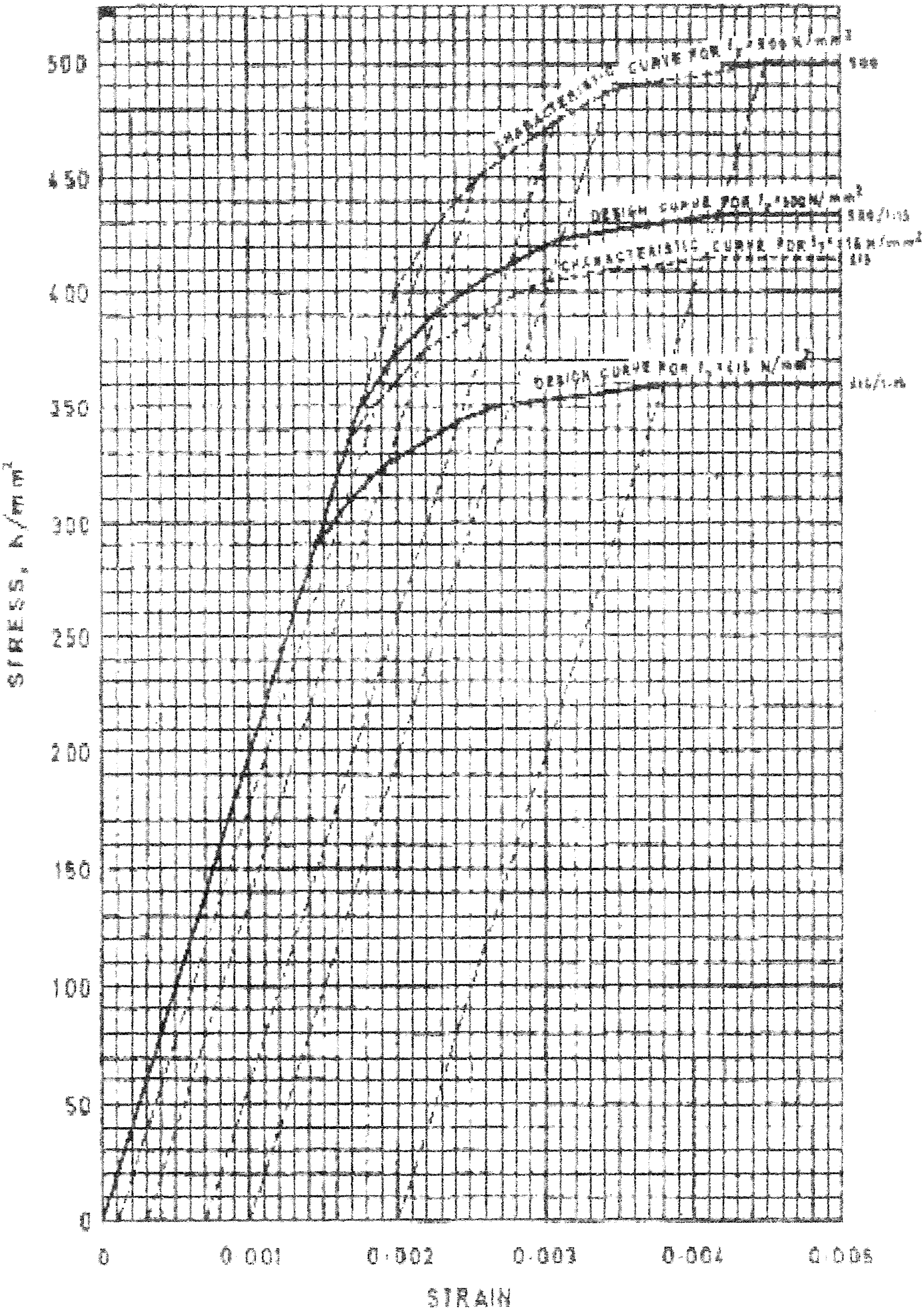


FIG. 3 STRESS-STRAIN CURVES FOR COLD-WORKED STEELS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

SOLUTION

Date: 01 Oct 2019
Even Semester: 2019-20
Time: 1 Hour
Course Code: CIV 211
Max Marks: 40
Course Name: Design of RC Structural Elements
Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	1	1. Introduction to limit state of design	4									4
2	1	1. Introduction to limit state of design	4									4
3	1	1. Introduction to limit state of design	4									4
4	2	1. Design of beam				8						8
5	2	1. Design of beam							8			8
6	2	1. Design of beam							8			8
	Total Marks		12			12			16			

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Dayalan]

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

SOLUTION

Date: 01 Oct 2019

Even Semester: 2019-20

Time: 1 Hour

Course Code: CIV 211

Max Marks: 40

Course Name: Design of RC Structural Elements

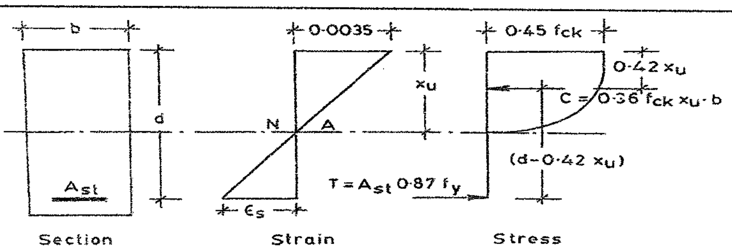
Weightage: 20%

Part A (3Q x 4M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Limit states of collapse deal with strength, overturning, sliding, buckling, fatigue fracture etc. Limit state of collapse: Flexure, Shear and bond, torsion, Compression Serviceability limit states which deals with discomfort to occupancy and/ or malfunction, caused by excessive deflection, crack width, vibration leakage etc., and also loss of durability etc.	**Each definition (2x2 =4 M)**	**5 minutes**

2	Reinforced concrete beam sections in which the tension steel also reaches yield strain simultaneously as the concrete reaches the failure strain in bending are called **balanced sections.** Reinforced concrete beam sections in which the steel reaches yield strain at loads lower than the load at which the concrete reaches failure strain are called **under-reinforced sections.** Reinforced concrete beam sections in which the failure strain in concrete is reached earlier than the yield strain of steel is reached, are called **over-reinforced beam sections.**	**Definitions (3x1 = 3M)** **Sketch (1 M)**	**5 minutes**
3	When the structures are subjected to overloading , the designed loads are obtained by multiplying the characteristic loads with suitable factors of safety depending on the nature of loads or their combinations, and the limit state being considered. These factors of safety for loads are termed as partial safety factors (γ_f) for loads The term 'characteristic load' means that value of load which has a 95 percent probability of not being exceeded during the life of the structure. **The** term 'characteristic strength' means that value of the strength of the material below which not more than 5 percent of the test results are expected to fall.	**Partial safety factor** **For material (1M)** **For load (1M)** **Characteristics strength (1M)** **Characteristics load (1M)**	**5 minutes**

Part B (2Q x 8M = 16Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4	 Consider a rectangular beam section shown in Fig. 6.2. Let b = width of section. d = Effective depth. A_{st} = Area of tension reinforcement. x_u = depth of neutral Axis. For equilibrium of forces at the limit state of collapse, Total tension (T) = Total compression (C) $(A_{st} \cdot 0.87 f_y) = 0.36 f_{ck} . b . x_u$ $\left(\frac{x_u}{d}\right) = \left[\frac{0.87 f_y A_{st}}{0.36 f_{ck} b.d}\right]$	Stress block diagram (2 marks) Derivation of x_u (4 marks) Location of neutral axis from top (2m)	**10 minutes**

5	**Step1 : Cross sectional dimensions** Span/depth = 15, depth = 5000/15 = 333mm , adopt d = 350mm Overall Depth D = 400mm, assume width b = 200mm Effective span = 5+0.35 = 5.35m **Step 2: Loads :** Self-weight of beam = 0.2xx0.4x25 = 2 kN/m Live load = 20 kN/m Total Load = 1.5 x 20 = 30 kN/m Ultimate moment Mu = 0.125 wL^2 = 0.125x30x5.35^2 = 107.33kNm **Step 3 : Reinforcement** $M_{u,lim}$ = 0.138fckbd^2 = 68 kNm : Mu < $M_{u,lim}$ Mu = 0.87fyA_{st}d(1- $A_{st}f_y/bdf_{ck}$) => A_{st} = 650mm^2	Step 1: 2M Step 2: 4M Step 3: 2 M	**15 minutes**

Part C (1Q x12 M =12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	Ast = 5x31.4x25^2/4 =2454 mm^2 Asc = 2x31.4x16^2/4 =402 mm^2 Xu,max = 0.48d = 0.48x600 = 288mm Xu = (0.87x415x2454-(0.87x415-0.446x20)*402/(0.36x20x300) = 344 mm > Xu,max Hence it is over reinforced Find Xu by strain compatibility method **Xu = (2454f_{st} – 402f_{sc} +3618)/2160** Mu = Cux(d- 0.42xu)+Cus (d-d')	Calculation of areas (2 M) Calculation of xu (2M) Strain compatibility method (6M) Calculation of moment (2M)	**20 minutes**

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 2

Sem & AY: Odd Sem 2019-20
Course Code: CIV 211
Course Name: DESIGN OF RC STRUCTURAL ELEMENTS
Programme & Sem: B.Tech (Civil) & V

Date: 19.11.2019
Time: 2.30 PM to 3.30 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Assume any suitable data wherever required
(ii) IS 456 and SP 16 charts are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks. **(3Qx4M=12M)**

1. Discuss different types of cracks in shear **(CO3, Knowledge)**
2. Distinguish between one way slab and two way slab. **(CO4, Knowledge)**
3. Explain the different forms of shear reinforcement as per IS456 **(CO3, Knowledge)**

Part B [Thought Provoking Questions]

Answer bpth the Questions. Each Question carries eight marks. **(2Qx8M=16M)**

4. Determine the moment of resistance of T- section using the following data: width of the flange = 1300mm, depth of flange = 100mm, width of web = 325mm, effective depth =600mm, A_{st} = 4000mm^2. Use M20 Concrete and Fe415 steel. **(CO2, Application)**
5. A RC beam of width 300mm is reinforced with 4 bars of 25mm at an effective depth of 600mm. The beam has to resist a factored shear force at support section is 400kN. Use M25 Concrete and Fe415 steel. Design the vertical stirrups for the section. **(CO3, Application)**

Part C [Problem Solving Questions]

Answer the Question. The Question carries twelve marks. **(1Qx12M=12M)**

6. Design a simply supported slab for an interior room, with clear dimensions of 4m × 10m, for a building located in moderate exposure condition. The slab is resting on 230 mm thick masonry walls. Assume live load as 4.0 kN/m^2 and dead load due to finish, partition, etc., as 1 kN/m^2. Use M25 concrete and Fe 415 steel. Ignore check for deflection control. **(CO4, Application)**

Table 19 Design Shear Strength of Concrete, τ_c, N/mm^2

(*Clauses* 40.2.1, 40.2.2, 40.3, 40.4, 40.5.3, 41.3.2, 41.3.3 *and* 41.4.3)

$100\frac{A_s}{bd}$	Concrete Grade					
	M 15	M 20	M 25	M 30	M 35	M 40 and above
(1)	(2)	(3)	(4)	(5)	(6)	(7)
≤ 0.15	0.28	0.28	0.29	0.29	0.29	0.30
0.25	0.35	0.36	0.36	0.37	0.37	0.38
0.50	0.46	0.48	0.49	0.50	0.50	0.51
0.75	0.54	0.56	0.57	0.59	0.59	0.60
1.00	0.60	0.62	0.64	0.66	0.67	0.68
1.25	0.64	0.67	0.70	0.71	0.73	0.74
1.50	0.68	0.72	0.74	0.76	0.78	0.79
1.75	0.71	0.75	0.78	0.80	0.82	0.84
2.00	0.71	0.79	0.82	0.84	0.86	0.88
2.25	0.71	0.81	0.85	0.88	0.90	0.92
2.50	0.71	0.82	0.88	0.91	0.93	0.95
2.75	0.71	0.82	0.90	0.94	0.96	0.98
3.00 and above	0.71	0.82	0.92	0.96	0.99	1.01

NOTE — The term A_s is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at support where the full area of tension reinforcement may be used provided the detailing conforms to 26.2.2 and 26.2.3

Table 20 Maximum Shear Stress, $\tau_{c\,max}$, N/mm^2

(*Clauses* 40.2.3, 40.2.3.1, 40.5.1 *and* 41.3.1)

Concrete Grade	M 15	M 20	M 25	M 30	M 35	M 40 and above
$\tau_{c\,max}$, N/mm^2	2.5	2.8	3.1	3.5	3.7	4.0

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BENGALURU

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Date: 19 Nov 2019

Even Semester: 2019-20

Time: 1 Hour

Course Code: CIV 211

Max Marks: 40

Course Name: Design of RC Structural Elements

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	3	Module 2	4									4
2	4	Module 3	4									4
3	3	Module 2	4									4
4	2	Module 2				8						8
5	3	Module 2							8			8
6	4	Module 3							12			12
	Total Marks		12			12			18			40

K =Knowledge Level   C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

PRESIDENCY UNIVERSITY
BENGALURU

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Even Semester: 2019-20
Course Code: CIV 211
Course Name: Design of RC Structural Elements

Date: 19 Nov 2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Part A (3Q x 4M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Diagonal Tension Failure:** This type of failure is caused due to inadequate shear reinforcement. The diagonal shear crack forms in the member at 45 deg. and propagates rapidly causing failure. **Shear Compression Failure:** This is crushing of concrete near the tip of the inclined crack in compression zone. This is caused by inadequate concrete strength. **Shear Tension Failure:** This failure occurs due to diagonal crack propagating horizontally along the longitudinal tensile reinforcement. This occurs due to inadequate anchorage of reinforcement	**Each definition (3x1 =3 M) Diagram 1 M**	**5 minutes**
2	1. In one way slab, the slabs are supported by the beams on the two opposite sides. In two way slab, the slabs are supported on all the four sides. 2. In one way slab, the loads are carried along one direction. In two way slab, the loads are carried along both directions. 3. In one way slab, the ratio of Longer span to shorter span is equal or greater than 2. (i.e $l/b \geq 2$). In two way slab, the ratio of l/b is less than 2 (i.e $l/b < 2$).	**4 points (4x1 = 4M)**	**5 minutes**

3	**Vertical Stirrups** These are the steel bars vertically placed around the tensile reinforcement at suitable spacing along the length of the beam. Their diameter varies from 6 mm to 16 mm. The free ends of the stirrups are anchored in the compression zone of the beam to the anchor bars (hanger bar) or the compressive reinforcement. **Bent up Bars along with Vertical Stirrups** Some of the longitudinal bars in a beam can be bent up near the supports where they are not required to resist bending moment (Bending Moment is very less near the supports). These bent up bars resist diagonal tension. Equal number of bars are to be bent on both sides to maintain symmetry. The bars can be bent up at more than one point uniformly along the length of the beam. **Inclined Stirrups** Inclined stirrups are also provided generally at 45° for resisting diagonal tension They are provided throughout the length of the beam.	**Each type 3x1=3M** **Diagram =1 M**	**5 minutes**

Part B (2Q x 8M = 16Marks)

Q No	**Solution**	**Scheme of Marking**	**Max. Time required for each Question**
4	Depth of Neutral Axis: Assume the neutral axis to fall within the flange $X_u = \frac{0.87fy\ Ast}{0.36fckb} = \frac{0.87x415x4000}{0.36fckb0.36x20x1300}$ =154.3mm > D_f	2	**15 minutes**
	Neutral Axis falls outside the flange. (D_f/d) =(100/600) =0.166 < 0.2 The neutral axis doeth can be calculated by compatibility of forces: $C_1+C_2 = T$ $0.36f_{ck}.b_w.x_u + 0.45f_{ck}(b_f-b_w).D_f = 0.87fy A_{st}$ 2340Xu + 877500 = 14442000 ➔ **Xu = 242.18mm**	4	
	$M_u = 0.36\frac{x_{u.max}}{d}\left(1-0.42\frac{x_{u.max}}{d}\right)f_{ck}b_w d^2 + 0.45f_{ck}(b_f-b_w)D_f\left(d-\frac{D_f}{2}\right)$ **=764.84 kNm**	2	
5	**Nominal shear stress:** **Vu =400kN, ζ=Vu/bd = 2.22 N/mm²** Shear resisted by concrete:	1	**10 minutes**
	Pt=100 Ast/bd = 1.09 From table 19 , shear stress = 0.658 N/mm^2 < 2.22 N/mm^2 Hence shear reinforcement is to be provided	3	

	Design of Stirrups: Stirrups are to be designed for Vuc =0.658x300x600 = 118.4 kN Balance shear = 400 -118.4 = 281.6 kN Spacing of stirrups (Use 10mm 2 legged stirrups) Sv= 0.87fy Asv/Vus = 120.7mm	3	
	Check for spacing : Sv,max = 0.75d =450mm or 300mm	1	

Part C (1Q x12 M =12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	Span/depth = 25 → d = 160mm, Overal Depth D = 160+20 = 180mm Effective span (L) = 4+0.16 = 4.16m	2	**20 minutes**
	Loads: Self weight = 0.180x1x25 = 4.5 kN/m^2 LL = 4 kN/m^2 Floor finish = 1 kN/m^2 Factored load = 1.5(4.5+1+4) = 14.25 kN/m^2	2	
	Max BM = 0.125wL^2 = 30.82 kNm Max shear force V = wL/2 = 29.64 kN Mu.lim = 0.138fckbd2 = 88.3 kNm	2	
	Calculation of Reinforcements: Mu = 0.87fy Ast.d [1 – Ast.fy/bdfck] Ast = 566.86mm^2 Spacing of 10mm dia =138mm Distribution reinforcement = 216mm^2	4	
	Check for shear :Nominal shear stress Pt = 100Ast/bd =.35 → shear stress = 0.8N/mm^2 Hence safe.	2	

Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 **Date**: 28 December 2019

Course Code: CIV 211 **Time**: 9.30 AM to 12.30 PM

Course Name: DESIGN OF RC STRUCTURAL ELEMENTS **Max Marks**: 80

Program & Sem: B.Tech.(CIV) & V **Weightage**: 40%

Instructions:

(i) Assume any suitable data if required

(ii) Use of IS456 and SP16 charts are allowed

Part A [Memory Recall Questions]

1. Answer all the Questions. Each Question carries 2 marks. **(10Qx2M=20M)**

i) Define clear cover. (C.O.No.1) [Knowledge]

ii) Define Slenderness ratio. How columns are classified based on slenderness ratio.
(C.O.No.2) [Comprehension]

iii) Write down the formula for calculating minimum eccentricity for two directions.
(C.O.No.2) [Comprehension]

iv) Write the difference between one way slab and two way slab
(C.O.No.2) [Comprehension]

v) What is the Partial factor of safety for concrete and steel ? (C.O.No.3) [Comprehension]

vi) What are the different types of reinforcement provided against the shear failure of beam, explain with a sketch. (C.O.No.1) [Knowledge]

vii). Define effective cover. (C.O.No.1) [Knowledge]

viii) What is the minimum diameter of longitudinal bars of a column? and What is the minimum and maximum percentage of reinforcement can be provided for a column?
(C.O.No.4) [Comprehension]

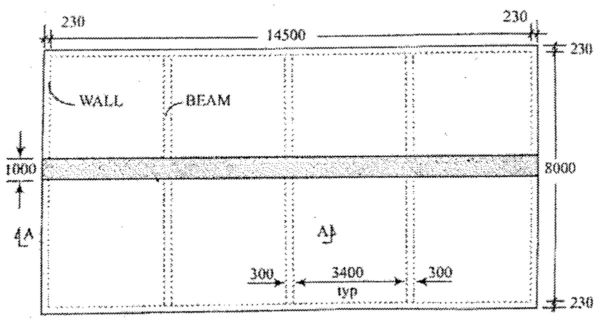
ix) What is uni-axial bending? (C.O.No.3) [Knowledge]

x) Draw a simple footing, stepped footing and sloped footing. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 10 marks. (3Qx10M=30M)

2. The plan in a floor slab system, covering an area 8m x 14.5m (clear spans) is shown in the below figure. The slab rests on a 230mm thick masonry wall all around. For economy, the span of the slab is reduced by providing three equally spaced intermediate beams along the 8m direction as shown. The specified floor loading consists of a live load of $4 kN/m^2$ and a dead load of $1.5 kN/m^2$. Assume Fe415 and M20 grade concrete subjected to moderate exposure conditions.



(a) PLAN

(C.O.No.4) [Application]

3. Design the reinforcement in a column of size 230mmx450mm subjected to axial load of 1600kN under service and live loads. The column has an unsupported length of 3m. Use M25 concrete and Fe415 steel. (C.O.No.3) [Comprehension]

4. Design the longitudinal reinforcement for a rectangular concrete column of size 400mmx600mm subjected to a factored load of 1800 kN and a factored moment of 300 kNm with respect to major axis. Assume M30 concrete and Fe415 steel. Provide reinforcement equally on two sides. (C.O.No.4) [Application]

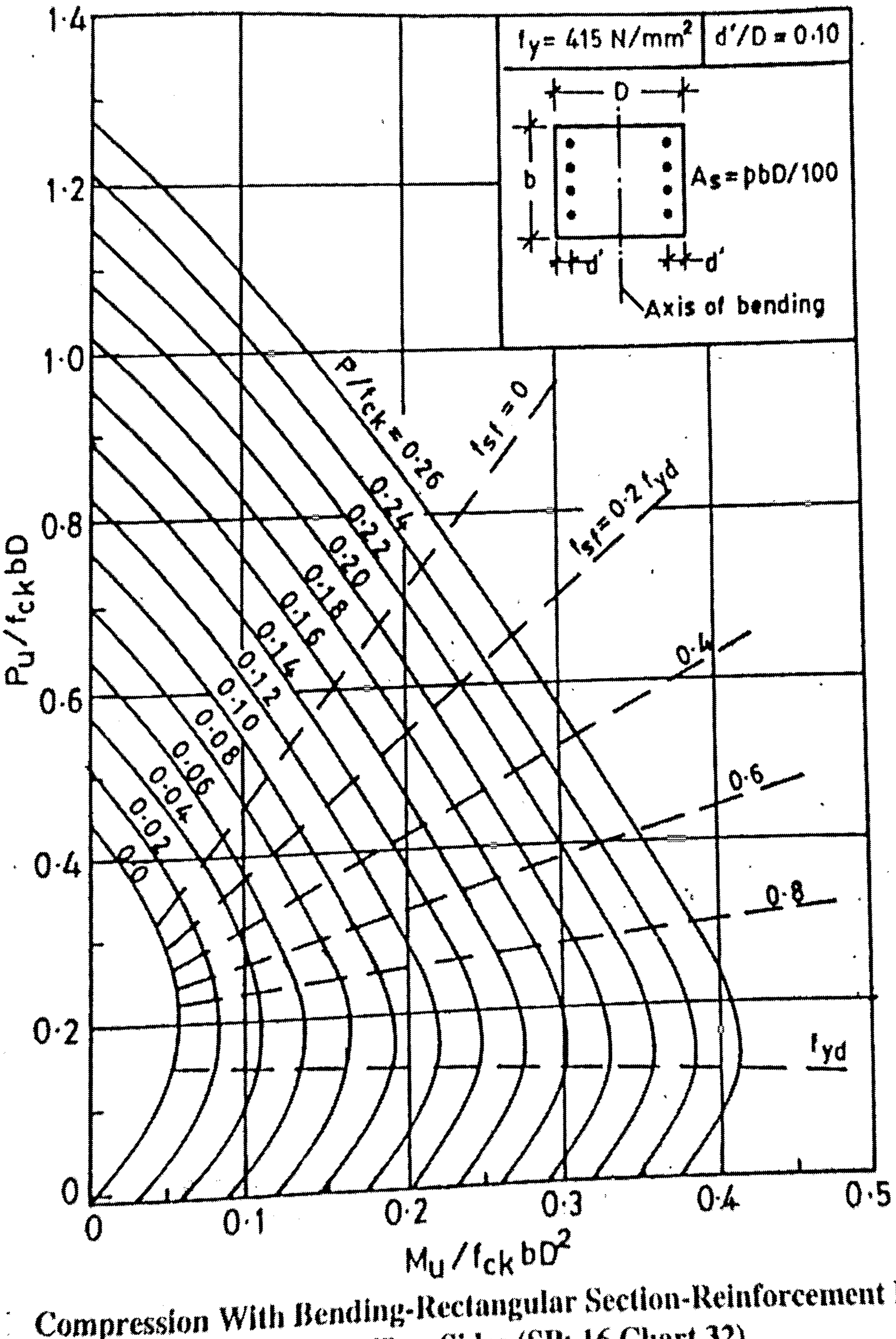
Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks. (2Qx15M=30M)

5. Design a slab to cover a room of internal dimensions 4m x 5m simply supported on all the sides on load bearing masonry walls of 230mm thick. Assume live load of $3 kN/m^2$ and finish load of $1 kN/m^2$. Use M20 concrete and Fe415 steel. Ignore check for deflection.

(C.O.No.3) [Application]

6. Design an isolated footing for a square column of size 450 mm × 450 mm, supporting a service load of 2300 kN. Assume SBC of soil as 300 kN/m2 at a depth of 1.5 m below the ground. Assume M20 concrete and Fe 415 steel for the footing (C.O.No.4) [Application]



Compression With Bending-Rectangular Section-Reinforcement Distributed Equally on Two Sides (SP: 16 Chart 32)

SCHOOL OF ENGINEERING
END TERM FINAL EXAMINATION

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type Bloom's Levels	Thought provoking type Bloom's Levels	Problem Solving type	Total Marks
			K	C	A	
PART A Q. NO1	CO 01 CO 02 CO 03 CO 04	All the 4 modules	20 [6+6+4+4]			20
PART B Q.NO.2	CO 02	MODULE 03 Design of two way slab	-	-	10	10
PART B Q.NO.3	CO 02	MODULE 04 Design of Columns	-	10	-	10
PART B Q.NO.4	CO 02	MODULE 04 Design of Columns	-	10	-	10
PART C Q.NO.5	CO 03	MODULE 03 Design of one way slab	-	-	15	15
PART C Q.NO.6	CO 04	MODULE 04 Design of Footings	-	-	15	15
	Total Marks		20	20	40	80

K =Knowledge Level C = Comprehension Level, A = Application Level
Note: While setting all types of questions the general guideline is that about 60%
Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.
I hereby certify that all the questions are set as per the above guidelines.
Faculty Signature:
Reviewer Comment: 17/12/19

Dr. Ratna Tej Reddy
17/12/19

Format of Answer Scheme

SCHOOL OF ENGINEERING
SOLUTION

Semester : Odd Semester: 2019 - 20

Course Code: CIV 211

Course Name: Design of RC Structural Elements

Program & Sem: B. Tech.(Civil) & V

Date: 28 Dec 2019

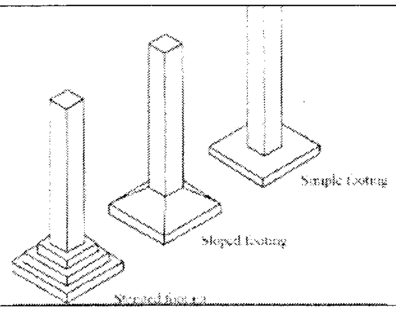
Time: 9.30am to 12.30 pm

Max Marks: 80

Weightage: 40 %

Part A (10Q x 2M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question(min)
i	The distance between the bottom of the bars and bottom most edge of the beam is called clear cover.	2x1 =2 M	5
ii	Slenderness ratio (λ) = $Effective\ length/\ Least\ lateral\ dimension$ Short λ < 12 and long column λ > 12	1x2 =2 M	3
iii	$ex\ min = l/500 + D/30$, $ey\ min = l/500 + b/30$	1x2 =2 M	3
iv	One way slab ly/lx > 2 Two way slab ly/lx < 2	1x2 =2 M	5
v	$\gamma c = 1.5$ $\gamma s = 1.15$	2 M	5
vi	Vertical Stirrups Bent bars Inclined bars diagram	I mark and 1 mark for diagram	5
vii	$Effective\ cover = clear\ cover + diameter\ of\ bar/\ 2$	2 M	5
viii	12mm and 0.8% and 6% of the gross cross sectional area of the column.	1x2 = 2M	4

ix	Axial load and bending moment along one direction are applied simultaneously on the column.	**Definition 2 mark**	**5**
x		**2 marks**	**5**

Part B (3Q x 10M = 30 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question (min)
2	i) **Thickness of slab** Assume span/depth ratio with modification factor Effective length =clear span + effective depth **ii) Calculation of loads** 1.5X(LL+DL+Floor finish) iii) **factored moments at critical section** from Table 12 of Code: iv) **Check for depth** Mulim = $0.138 f_{ck}.b.d^2$ **v) Calculation of reinforcement using max BM** **vi) calculation of distribution reinforcement** Ast = 0.0012bD *Solution* • Assuming each beam to be 300 mm wide, the clear spacing betw beams is equal to $(14.5 - 0.3 \times 3)/4 = 3.4$ m. Each slab panel (with c spans 3.4 m × 8.0 m) has an *L/B* ratio greater than 2.0, and hence ı be treated as *one-way* (*continuous*) [refer Section 1.5.1]. ***Determining Values of M_u at Critical Sections*** Consider a 1-m wide design strip [Fig. 5.4(a)]. • *Thickness of slab* Assume a uniform thickness for both *end span* and *interior sp* The 'end span', which is critical, is discontinuous on one edge ε continuous at the other. Accordingly, assuming $(l/d)_{max} \approx 1.34 \times (20 + 26)/2^{\dagger} = 30$, $d_{min} \approx 3500/30 = 117$ mm (for an assumed effective span of $l = 3.5$ m Assume overall depth D ≈ 117 + 35 ≈ 160 mm for all spans and $d = 1$ mm. • *Effective length l*: As the beam width (300 mm) exceeds 3400/12 = 2 mm, $l = 3400$ mm (clear span) for the interior span—as per Cl. 22.2(of Code. For the *end span*, $l = 3400 + d/2 = 3400 + 125/2 = 3463$ mm	2 2 4 2 4 1	**35**

- *Distributed load due to self-weight*

$$\Delta w_{DL} = 25\ \text{kN/m}^3 \times 0.16 = 4.0\ \text{kN/m}^2$$

$$\therefore \quad w_{DL} = 4.0 + 1.5 = 5.5\ \text{kN/m}^2;\ w_{LL} = 4.0\ \text{kN/m}^2\ \text{(given)}$$

- $\therefore$ Factored loads

$$\begin{cases} w_{u,DL} = 5.5 \times 1.5 = 8.25\ \text{kN/m}^2 \\ w_{u,LL} = 4.0 \times 1.5 = 6.00\ \text{kN/m}^2 \end{cases}$$

- *Factored Moments at critical sections*

  As the spans are almost equal, uniformly loaded and more than three number, the simplified analysis using *moment coefficients* [Table 12 Code] can be applied [Fig. 5.4(b)].

  For end span (l = 3.463 m),

$$M_u = \begin{cases} -\left(\dfrac{w_{u,DL} + w_{u,LL}}{24}\right) l^2 = -7.12\ \text{kNm/m} & \text{at end support} \\ +\left(\dfrac{w_{u,DL}}{12} + \dfrac{w_{u,LL}}{10}\right) l^2 = +15.44\ \text{kNm/m} & \text{at midspan} \\ -\left(\dfrac{w_{u,DL}}{10} + \dfrac{w_{u,LL}}{9}\right) l^2 = -17.89\ \text{kNm/m} & \text{at interior support} \end{cases}$$

  For interior span (l = 3.400 m),

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

  At the first interior support, an average value of M_u should be considered:

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

Determining A_{st}

- For the maximum moment, $M_u = -17.6$ kNm/m at the first interior support,

3	**i)Check for Min. eccentricity** (L/500+d/30)	2	20
	ii) Design of main reinforcement $Pu = 0.4f_{ck}.A_g + (0.67-0.4f_{ck}).A_{sc}$	4	
	iii) Design of Lateral ties Tie diameter > d/4 or 6mm whichever is max or 8mm Tie spacing < 16d or 300mm whichever is less	3	
	Diagram of reinforcement details	1	

b = 230 D = 450 Axial load = 1600kN ; Unsupported length = 3m

M-25 , Fe 415

① Slenderness Ratio $= \frac{L}{D} = \frac{3000}{450} = 6.6$ which is < 12

② Min eccentricity $= \left[\frac{L}{500} + \frac{D}{30}\right]$

$$= \frac{3000}{500} + \frac{450}{30} = 21$$

$$\frac{3000}{500} + \frac{230}{30} = 13.6$$

③ Cal of Asc

$$P_u = 1.5 \times 1600 = 2400$$

$$P_u = 0.4 f_{ck} \cdot A_g + (0.67 f_y - 0.4 f_{ck}) A_{sc}$$

$$2400 \times 10^3 = 0.4 \times 25 \times 230 \times 450 + (0.67 \times 415 - 0.4 \times 25) A_{sc}$$

$$2400 \times 10^3 = 1035000 + 268 A_{sc}$$

$$2400 \times 10^3 - 1035 \times 10^3 = 268 A_{sc}$$

$$A_{sc} = 5093 \text{ mm}^2$$

Assume. 25 dia bar

$$\text{No of bar} = \frac{A_{sc}}{\frac{\pi d^2}{4}} = \frac{5093}{\frac{\pi \times 25^2}{4}} = 10.2$$

Ties $\Rightarrow \frac{1}{4} \times d \Rightarrow \frac{1}{4} \times 25 = 6.25 \simeq 8$mm

Spacing $\Rightarrow 16 \times d = 16 \times 25 = 400 \Rightarrow 300$mm (300)

4	Pu/fck.b.D = Mu/fck.bD^2 = **Main reinforcement** : **Design of Lateral ties** Tie diameter > d/4 or 6mm whichever is max or 8mm Tie spacing < 16d or 300mm whichever is less Diagram	3 3 3 1	**20**

	$b = 400$, $D = 600$, $P_u = 1800$, $M_u = 300$, M30, Fe415 NDP-Values $\frac{P_u}{bD.f_{ck}} = \frac{1800 \times 10^3}{400 \times 600 \times 30} = \underline{0.25}$ $\frac{M_u}{bD^2 f_{ck}} = \frac{300 \times 10^6}{400 \times 600^2 \times 30} = \underline{0.069}$ $\frac{P}{f_{ck}} = 0.02$ | $P\% = 0.02 \times 30 = 0.6\%$ $A_{st} = P\% \times b \times D \Rightarrow \frac{0.6 \times 400 \times 600}{100} = \underline{1440\ mm^2}$ Assume 16 dia bar No of bars $= \frac{1440}{\frac{\pi \times 16^2}{4}} = 7.1 \simeq \underline{8\ bars}$ Ties $\frac{1}{4}$ of Main bar $\Rightarrow \frac{1}{4} \times 16 \Rightarrow 4mm \simeq \underline{6mm}$ Tie spacing $\Rightarrow$ 16×16 (or) 300 $= \underline{256}$ ✓		

Part C (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question(min)
5	**i) Calculation of depth of slab** Span/depth =25 **ii) Effective Span** = clear span + effective span **iii) Calculation of design loads** Dead load + LL+floor finish **iv) Ultimate design moments and shear forces** Moment coefficients (Table 27 of IS456) Calculation of Moment Mux = a_x.w.L^2 Muy = ay. w.L^2 **vi) Calculation of reinforcement**	1 1 2 3 3	25

$l_y = 5m$; $l_x = 4m$; $f_{ck} - 20$; $f_y - 415$; LL - 3 kN/m²
FF - 1 kN/m²

① Thickness of Slab

eff depth ~ $\frac{l_x}{d} = 30$

* Assume 10 dia bar
* Assume cover 20 mm

$d = \frac{4000}{30} = 133 \simeq 145$

$D = d + cc + \frac{d}{2} \Rightarrow 145 + 20 + 5 = 170mm$

② Eff. Span. = Clear span + eff. depth.

$L_x = 4 + 0.145 = 4.145m$

③ Loads

DL = $0.17 \times 25 = 4.25 \text{ kN/m}^2$
LL&FF = 4
Total = 8.25 kN/m^2
Fact Load = $1.5 \times 8.25 = 12.3 \text{ kN/m}^2$

④ Moment

$\frac{l_y}{l_x} = \frac{5}{4} = 1.25$ by Table 27

$\alpha_x = 0.076$; $\alpha_y = 0.056$ [Linear interpolation or Nearest value.]

$M_{ux} = \alpha_x w_u L_x^2$
$= 0.076 \times 12.3 \times 4.145^2 = 16 \text{ kNm}.$

$M_{uy} = \alpha_y w_u L_x^2$
$= 0.056 \times 12.3 \times 4.145^2 = 11.8 \text{ kNm}$

$V_{ux} = \frac{w_u \cdot L_x}{2} = \frac{12.3 \times 4.145}{2} = 25.49 \text{ kN}$

⑤ Moment

$M_{ux} = 0.87 f_y A_{st} d_x \left[1 - \frac{A_{st} \cdot f_y}{b \cdot d_x \cdot f_{ck}}\right]$ * Short span.

$$M_{uy} = 0.87 f_y A_{st} d_y \left[1 - \frac{A_{st} f_y}{b \cdot d_y f_{ck}}\right]$$ * long

$$M_{uy} \Rightarrow 0.87 f_y A_{st} \cdot (145-10) \left[1 - \frac{A_{st} f_y}{10^3 (145-10) \cdot f_{ck}}\right]$$

$$11.8 \times 10^6 = 0.87 \times 415 \times A_{st} \times 135 \left[1 - \frac{415}{10^3 \times}\right.$$

$A_{st} =$ ~~223 mm²~~

$$M_{ux} = 0.87 f_y A_{st} (d_x) \left[1 - \frac{A_{st} f_y}{b \cdot d_x \cdot f_{ck}}\right]$$

$$16 \times 10^6 = 0.87 \cdot A_{st} \cdot 415 \times 145 \left[1 - \frac{415 A_{st}}{10^3 \times 20 \times 145}\right]$$

~~Ast~~ = $A_{st} \Rightarrow$

Mulim $= 0.138 f_{ck} b d^2$

$= 0.138 \times 20 \times 10^3 \times 145^2$

$= \sqrt{\frac{16 \times 10^6}{0.138 \times 20 \times 10^3}} = 76\ mm < 145\ mm$

Spacing

$A_{st} \div$ (bar area) = No. of bars

$\frac{1000}{\text{No. of bars}}$ = Spacing.

6	**i) Size of footing** Load+10% Load/SBC		
	ii) Calculating factored net soil pressure Factored load/Area of footing provided	2	
	iii) Check for One way shear Assume Pt and find shear stress	2	
	One-way shear resistance = shear stress*area	4	**35**
	iv) Check for two way shear Two way shear resistance = Ks.*Shear stress	4	
	v)Design of reinforcement calculation of moment	3	
	calculation of area of steel Spacing		

$P_u = 2300\ kN$; Col = 450×450 ; SBC = 300 kN/m

(1) **Size of footing**

$P = 2300 + 10\%$ of P

$= 2300 + 230 = 2530\ kN$

$\text{Area of foot} = \frac{\text{Load}}{SBC} = \frac{2530}{300} = 8.4\ m$

$\Rightarrow \sqrt{8.4} = 2.89 \simeq \underline{3m}$

(2) **Net soil press**

$q_{net} = \frac{FoS \times P_u}{\text{Area provided}} \Rightarrow \frac{1.5 \times 2300}{3 \times 3}$

(3) **One way shear** ;

$\tau_c \times L \times d = q_{net} \times L \times \left(\frac{L - l}{2} - d\right)$

Assume P% = 0.2% for τ_c in Table 19

$0.32 \times 3000 \times d = 0.383 \times 3000 \times \left[\left(\frac{3000-}{}\right.\right.$

$960 d = 0.383 \times 3000 \,(1275 - d$

$960 d = 1464975 - 1149 d$

$d = \frac{1464975}{2109} = \underline{694}\ mm$

(4) **2-way shear** = upward press × Shaded a

$= \frac{q_{net} \times \left(L^2 - (l+d)^2\right)}{4(l+d) \times d}$

$$\Rightarrow \frac{0.383 \times (3000^2 - (450+694)^2)}{4(450+694)\,694} \simeq 0.92$$

Perimissable Shear stress.

$= 0.25\sqrt{f_{ck}}$

$= 0.25\sqrt{20} \Rightarrow 1.118$

$0.92 < 1.118$

(5) **Bending Moment.**

$$M_u = q_{net} \times L \times \frac{(L-l)^2}{8}$$

$$= 0.383 \times 3000 \times \frac{(3000-450)^2}{8}$$

$= \underline{\underline{933 \times 10^6}}\ Nmm$

(6) **Area of Steel**

$$M_u = 0.87 f_y\, d.\, Ast \left(1 - \frac{Ast\, f_y}{bd\, f_{ck}}\right)$$

$$= 0.87 \times 415 \times 694 \times Ast \left(1 - \frac{415 Ast}{3000 \times 694 \times 20}\right)$$

$= Ast$ in mm^2

(7) No. of bars $= \frac{Ast}{\text{bar ast}}$

(8) Spacing $= \frac{\text{width of footn.}}{\text{No. of bars}}$