Design of Structures
(3150612)

B.E. Semester 5 (Civil Engineering)

Shantilal Shah
Engineering College

Shantilal Shah Engineering College,
Bhavnagar
Academic Year: 2024 – 2025

Directorate of Technical Education
Gandhinagar, Gujarat

Shantilal Shah Engineering College, Bhavnagar

Certificate

This is to certify that Mr./Ms. _____ _____ Enrollment No. _____ of B.E. Semester 5th Civil Engineering of this institute (GTU Code: 043) has satisfactorily completed the tutorial work for the subject **Design of Structures (3150612)** for the academic year _____.

Place: Bhavnagar

Date: _____

Name and Sign of Faculty member

Head of the Department

DESIGN OF STRUCTURES

Important Instructions for Students

[1] Use A – 4 size blank pages to prepare design report.

[2] The report shall have following format (lay out)

	Main Heading	**Page No**
Margin for Bullets	**Sub heading** **Design calculation/write up**	**Margin to write references**

[3] Use only front side of page for write up as well as for sketches and detailing.

[4] Mark 1½" margins on both left and right. Use left margin to show bullets and right margin to show references like clause of code/page etc.

[5] Start new design problem on new page.

[6] Heading and sub heading shall be distinct than write up.

[7] Support the calculation/s with neat sketches wherever required.

[8] Attach A3 size sheets to furnish design detailing (Use AutoCAD Drawing for at-least one design problem).

[9] All design detailing shall be strictly as per relevant IS standards.

[10] Spiral bound is preferred as it is more convenient for reading.

[11] Student shall bring required IS codes and other references in class and tutorial hours as listed below.

[12] IS 456: 2000, IS 800: 2007, IS 875 (Part I to V), SP: 6 (Part-1)] all the Codes includes latest Amendment), steel table

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(Progressive Assessment Sheet)

Sr. No.	Name of Tutorial / Assignment	Page No.	Starting Date	Date of submission	Marks	Sign. of Teacher with Date	Remarks
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1	Introduction		22-07-2024	05-09-2024			
2	Beams		---	---			
(a)	Singly Reinforced Beam		22-07-2024	19-09-2024			
(b)	Doubly Reinforce Beam		22-07-2024	19-09-2024			
(c)	T Beam		22-07-2024	19-09-2024			
3	Slabs		22-07-2024	03-10-2024			
4	Columns		22-07-2024	10-10-2024			
5	Footing		22-07-2024	17-10-2024			
6	Bond, Development Length & Shear Reinforcement		22-07-2024	17-10-2024			
PART B: TUTORIAL: 7 to 10 (Steel Structures)							
7	Introduction & Tension Member		22-07-2024	26-09-2024			
8	Compression Member, Lacing and Battening		22-07-2024	10-10-2024			
9	Steel Beam		22-07-2024	17-10-2024			
10	Slab Base and Gusseted Base		22-07-2024	17-10-2024			
Total							

PART – A

TUTORIAL – 1 to 6

(Reinforced Concrete Structures)

DESIGN OF STRUCTURES

TUTORIAL – 1

INTRODUCTION

	COs	LEVEL
1. **Define** the aim of structural design.	1	R
2. **List out** various methods of structural design.	1	R
3. **Write down** the difference between Limit State Method (LSM) and Working Stress Method (WSM).	1	R
4. **Define** characteristic cube compressive strength of concrete (fck) and characteristic strength of steel (fy).	1, 2	R
5. **Define** tensile strength of steel (fct).	1, 2	R
6. **Write** advantage and disadvantages of RCC. **Why** steel is used as reinforcement in RCC**?**	1, 2	R
7. **List out** the combination of loads as per IS-1893.	1, 2	R
8. **Calculate** effective span for (a) Simply supported beam and slab (b) continuous beam and slab (c) cantilever beam as per IS 456(2000)	1, 2	E
9. **Define** basic values of span to effective depth ratios for Cantilever beam, simply supported beam and Continuous beam (a) for spans up to 10m. (b) Spans above 10m**.**	1, 2	R
10. **Explain** difference between column and strut.	1	U
11. **Explain** maximum diameter of bar used in slab.	1, 2	U
12. **Define** nominal cover to reinforcement in slab, footing, column and beam in moderate condition.	1, 2	R
13. **Define** max. and min. % of reinforcement required in beam.	1, 2	R
14. **Define** (1) Balance section (2) Under reinforced section (3) Over reinforced section	1, 2	R
15. **Explain** types of Load. **List out** various IS codes used for calculation of loads.	1, 2	R

DESIGN OF STRUCTURES

TUTORIAL – 2

BEAMS

	COs	LEVEL
(a) Singly Reinforced Beam		
1. For a limiting section 300 mm X 600 mm gross **Determine** the following if M:20 concrete mix and fy = 415 N/mm^2 steel is used (i) Maximum compressive stress and maximum tensile stress, (ii) Lever arm, (iii) Total compression, (iv) Total tension, (v) Limiting moment, (vi) Area of tensile steel.	**3,5**	**E**
2. A RCC beam rectangular in section 230 mm X 450 mm effective is singly reinforced by 4 no. of 16 mm dia. Bars of fe – 415 grade steel and M:20 grade of concrete. **Determine** moment of resistance of section.	**3,5**	**E**
3. **Determine** moment of resistance for a beam 230 mm X 350 mm overall size and effective cover 40 mm. The beam is reinforced with 5 no. 16 mm dia. Bars take fck = 20 N/mm^2, fy = 415 N/mm^2.	**3,5**	**E**
4. A singly R.C. beam effective section 300 mm X 600 mm, provide with 3 – 20 Φ + 3 – 16 Φ at effective cover of 50 mm is simply supported 4.50 m. span. Use fck = 20 N/mm^2, fy = 415 N/mm^2. **Evaluate** safe load (L.L.) on beam.	**3,5**	**E**
5. **Design** singly R.C. balance section for factored moment 225 kNm. Use Fe – 415 steel and M:20 grade of concrete. Take width to effective depth ratio for the beam 0.70.	**4, 5**	**C**
6. **Design** singly R.C. beam having width 230 mm, simply supported with effective span of 4.00 m. it is loaded with a U.D.L. of 15 kN/m excluding self weight. Use M:20 grade concrete and Fe – 415 steel. Check the beam for max. and min. steel and deflection.	**4, 5**	**C**
7. **Explain** Stress -Strain diagram for singly Reinforced concrete beam. **Derive** equation of Moment of Resistant for balanced section.	**1, 2**	**R**
8. **Determine** the moment of resistance of a beam section 230 mm X 600 mm effective depth reinforced with 3 nos. 25 mm diameter bars. M:20 grade concrete and Fe – 250 steel reinforcement is used. Also find out the moment of resistance if the materials are M:20 and Fe – 415. Comment on the answer.	**3, 5**	**E**
(b) Doubly Reinforce Beam		
1. **Explain** necessity of doubly R.C. beam	**3, 4**	**U**
2. **Explain** stress diagram for doubly R.C. beam.	**3, 4**	**U**

3. A doubly reinforced beam of 300 mm X 600 mm overall is reinforced with 5 – 16 Φ bars as compression reinforcement and 5 – 20 Φ bars as tensile reinforcement. Effective cover on both sides is 50 mm, grade of concrete M:25 and steel Fe – 415. **Determine** (i) Types of section, (ii) Moment resistance capacity of the section.	**3, 5**	**E**
4. A rectangular beam of size 200 mm X 350 mm effective depth is subjected to a factored moment of 150 kNm. **Determine** the reinforcement for flexure. The effective cover for the tensile and compression steel are 50 mm. The materials are M:25 grade concrete and HYSD reinforcement of grade Fe – 415.	**3, 5**	**E**
5. **Evaluate** the area of tensile and compression reinforcement required for a rectangular beam of size 230 mm X 500 mm effective for the factored moment of 325 kNm. The effective cover for the tensile and compression steel are 50 mm. The materials are M:20 grade concrete and HYSD reinforcement of grade Fe – 415.	**3, 5**	**E**
(c) <u>T Beam</u>		
1. A R.C.C. T – beam section reinforce for tension has the following data, Flange width = 1600 mm, Thickness of Flange = 125 mm, Effective depth = 700 mm, Width of rib = 325 mm, **Determine** the limiting moment of resistance of the section. Take M:20 concrete and Fe – 415 steel.	**3, 5**	**E**
2. **Calculate** limiting value of moment of resistance (M.R.) of T – beam with the following data, Flange width = 1900 mm, Depth of Flange = 130 mm, Effective depth of beam = 550 mm, Width of web = 300 mm, Take M:20 concrete and Fe – 415 steel 4 no. of 25 mm dia.	**3, 5**	**E**
3. **Determine** moment of resistance (M.R.) of T – beam with the following data, Flange width = 1500 mm, Depth of Flange = 115 mm, Effective depth of beam = 425 mm, Width of web = 300 mm, Take M:20 concrete and Fe – 415 steel 5 no. of 20 mm dia.	**3, 5**	**E**
4. **Determine** moment of resistance (M.R.) of T – beam with the following data, Flange width = 1500 mm, Depth of Flange = 115 mm, Effective depth of beam = 425 mm, Width of web = 300 mm, Take M:20 concrete and Fe – 415 steel 5 no. of 20 mm dia.	**3, 5**	**E**

DESIGN OF STRUCTURES

TUTORIAL – 3

SLABS

	COs	LEVEL
1. **Explain** various types of slabs with sketch.	**3, 4**	**U**
2. **Design** and detail simply supported slab on 300 mm wide brick masonry for a clear room size 4.00 m X 10.00 m. use material grade M:20 and Fe – 415. Take live load as 3.5 kN/m^2 and floor finish as 1 kN/m^2.	**4, 5**	**C**
3. **Design** for the slab of the hall of school building 10.00 m X 8.00 m with provision of two intermediate beams 300 mm X 500 mm at a clear distance of 3.50 m. the slab is resting on four walls of 300 mm thick and carrying live load of 3.50 kN/m^2. Show the details of reinforcement for the slab by sketch. Use M:20 and Fe – 415.	**4, 5**	**C**
4. A one-way continuous slab of 150 mm thickness resting on 300 mm wide brick masonry supports spaced at 4.00 m c/c. considering live load as 2.50 kN/m^2 and floor finish as 1.00 kN/m^2. **Design** and detail slab for span moment and support moment. Assume four spans of the slab. Take M:20 grade of concrete and Fe – 415 grade of steel.	**4, 5**	**C**
5. The 1 m wide single flight R.C.C. stair case is to be provided for a height of 2.60 m in a residential building. Staircase is supported at top and bottom risers by beams 300 mm wide. Waist slab is 180mm thick. Riser 200 mm and tread is 300 mm. **Evaluate** effective span, design load, reinforcement in waist slab. Prepare of sketch use M:20 and Fe – 415.	**3, 4, 5**	**E**
6. **Design** a simply supported slab of 3.00 X 4.50 m effective span supported on 300 mm thick walls on all four sides. Assume live load 3.00 kN/m^2 and floor finish load 0.50 kN/m^2. Use M:20 and Fe – 415. Corners are not held down.	**4, 5**	**C**
7. **Design** and detail Reinforced Concrete slab for a room 6.00 m X 5.00 m. The slab is to be cast monolithically over beams with corners held down. The width of supporting beams 230 mm. Slab carries superimposed load of 3.00 kN/m^2. Use M:20 and Fe – 415.	**4, 5**	**C**

DESIGN OF STRUCTURES

TUTORIAL – 4

COLUMN

	COs	LEVEL
1. Classify various types of columns based on its (a) Shape, (b) Bracing system, (c) Lateral and longitudinal reinforcement, (d) Effective Length of column, (e) Types of loading.	**3, 4**	**U**
2. State the assumptions in design of compression member.	**3**	**R**
3. A reinforced shot column of 400 mm X 450 mm in cross section is to carry an axial factored load of 1680 kN. **Calculate** the area of steel required and the spacing of 8 mm dia. Lateral ties. Use concrete M:20 and steel Fe – 415. Give detail sketch of the section.	**3, 5**	**E**
4. A short RCC rectangular column of 300 mm X 450 mm is reinforced with 6 no. Of longitudinal bars (4 no. of 25 mm dia. And 2 no. of 20 mm dia). D**etermine** load carrying capacity of the column if M:25 mix and Fe – 415 steel is used also design the column for lateral ties. Check the column for minimum eccentricity. Unsupported length of column is 3.20 m. Give detail sketch of the section.	**3, 5**	**E**
5. Design rectangular RC column for an axial load 1500 kN use M:20 concrete and Fe – 415 steel also check for eccentricity, unsupported length of column is 3.50 m.	**4, 5**	**C**
6. Design a short circular column for an axial compressive factored load of 950 kN. The grade of concrete M:25 steels Fe – 415 it is to be provided with minimum reinforcement sketch the detail.	**4, 5**	**C**

DESIGN OF STRUCTURES

TUTORIAL – 5

FOOTING

<table>
<tr><th></th><th>COs</th><th>LEVEL</th></tr>
<tr><td>1. A rectangular column of size 230 X 600 mm is loaded with 900 kN characteristic load. The safe bearing capacity of soil is 200 KN/m^2. Determine the dimension of the footing for the following cases.
a. If footing is square.
b. If the footing has equal projection in all four sides.
c. If the dimension parallel to the shorter side of column is restricted to 2.00 m.
d. If the dimension parallel to the longer side is restricted to 2.50 m.</td><td>3, 4, 5</td><td>E</td></tr>
<tr><td>2. Design an isolated square pad footing for a square column 300 X 300 mm for axial load of 1700 kN. Use concrete grade M:25 and Fe – 415 steel grade. Take safe bearing capacity of soil - 140 kN/m^2. Also draw neat sketch.</td><td>4, 5</td><td>C</td></tr>
<tr><td>3. Design a rectangular isolated sloped footing for a column of size 230 X 600 mm carrying an axial characteristic load of 1800 kN and reinforced with 8 nos 20 dia. Bars in M:25 grade concrete. The allowable bearing pressure on soil is 250 kN/m^2. The materials for footing are grade M:25 concrete and HYSD reinforcement of grade Fe – 415.</td><td>4, 5</td><td>C</td></tr>
<tr><td>4. Determine the plan dimensions of a combined footing for two axially loaded columns with following data if (1) Width is not restricted, considering 1.00 m projection from C1 (2) Width is restricted to 2.30 m. Assume self weight of footing is 15% of axial loads.
<table>
<tr><th>Columns</th><th>C1</th><th>C2</th></tr>
<tr><td>Type</td><td>Interior</td><td>Interior</td></tr>
<tr><td>Size</td><td>400 mm X 400 mm</td><td>400 mm X 400 mm</td></tr>
<tr><td>P</td><td>1000 kN</td><td>1200 kN</td></tr>
<tr><td>Spacing</td><td colspan="2">3.00 m c/c from C1 to C2</td></tr>
<tr><td>SBC/ABP</td><td colspan="2">150 kN/m^2 at 1.6 m depth</td></tr>
</table></td><td>3, 4, 5</td><td>E</td></tr>
<tr><td>5. Design a combine rectangular footing for 1200 kN and 1800 kN column loads spaced at 4.00 m. centre to centre. Consider following data for the design.
• Size of each column 450 mm X 450 mm, SBC = 250 kN/m^2
• Use M:20 concrete and Fe – 415 grade steel</td><td>4,5</td><td>C</td></tr>
</table>

DESIGN OF STRUCTURES

TUTORIAL – 6

BOND, DEVELOPMENT LENGTH AND SHEAR REINFORCEMENT

	COs	LEVEL
1. **Explain** anchoring of reinforcement.	**3**	**U**
2. A simply supported R. C. C. beam with clear span of 5.00 m, support width 230 mm, size of beam 230 wide and 420 mm deep, tension bars as 4 nos. of 16 mm dia. bars and clear cover of 25 mm. If it is loaded by an all inclusive factored udl of 60 kN/m, **Design** the shear reinforcement near support only using 2 legged 6 mm. mild steel stirrups.	**3, 4, 5**	**C**
3. **Explain** various types of shear reinforcement with sketch.	**3**	**U**

PART – B

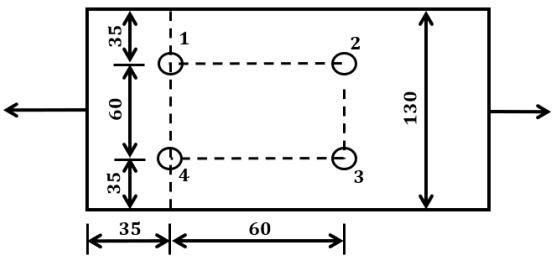
TUTORIAL – 7 to 10

(Steel Structures)

DESIGN OF STRUCTURES

TUTORIAL – 7

INTRODUCTION & TENSION MEMBER

	COs	LEVEL
1. Write down various advantages and disadvantages of steel structure.	**3, 4**	**R**
2. List out series of rolled steel (i) I-sections, (ii) Channel section, and (iii) Angle sections.	**3, 4**	**R**
3. Explain the advantages of bolted connections over riveted or welded connections.	**3, 4**	**U**
4. Elaborate the effect of shear leg in tension member with necessary sketch.	**3, 4**	**C**
5. Determine the design tensile strength of the plate 200 mm X 12 mm with the holes for 16 mm diameter bolts as shown in figure – 1 Steel use is of Fe – 415 grade quality. 	**3, 5**	**E**
6. A single unequal-leg angle 90 X 60 X 6 mm is connected to a 10 mm thick at the ends with 5 no. of bolts of 16 mm diameter bolts to transfer tensile force. **Determine** the design tensile strength of the angle. (i) if gusseted plate (G.P.) is connected to 90 mm angle, (ii) if G.P. is connected to 60mm angle	**3, 5**	**E**
7. Design and detail a connection for a truss member 2 ISA 60 X 60 X 8 mm connected back-to-back on both the sides of a 10 mm thick gusset plate using M:20 bolts of property class 4.6 grade. The axial tensile factored load in the member is 150 kN.	**4, 5**	**C**
8. Determine the tensile strength of a roof truss diagonal 100 X 75 X 6 mm having fy = 250 MPa connected to gusset plate by 4 mm welds of 140 mm long at top and 310 mm long at bottom. The longer edge of 100 mm was connected to plate of 8 mm thickness.	**3, 5**	**E**
9. Design a lap joint and butt joint between two plates each of width 120 mm. If the thickness of one plate is 16 mm and other is 12 mm. the joint has to transfer a design load of 160 kN. Plates are of Fe – 410 grade. Calculate the efficiency of the joint. Assume 4.6 grade bolts.	**4, 5**	**C**
10. Design a single angle section for a tension member of a roof truss to carry a factored tensile force of 225 kN. Take length of member 3.00 m. use M:20 mm shop bolt of grade 4.6.	**4, 5**	**C**

DESIGN OF STRUCTURES

TUTORIAL – 8

COMPRESSION MEMBER, LACING AND BATTENING

	COs	LEVEL
1. Explain different end conditions of columns with their effective length.	**3, 4**	**U**
2. Distinguish between behavior of short and long compression members.	**3, 4**	**N**
3. Explain IS 800 recommendations for compression member in trusses.	**3, 4**	**U**
4. Design axial load capacity of the column ISHB 300 @ 577 N/m if the length of column is 3.00 m and its both ends pinned.	**4, 5**	**C**
5. Calculate the compressive resistance of a compound column consisting of ISHB 300 with one cover plate 350 X 20 mm on each flange and having a length of 5 m. assume that bottom of the column is fixed and top is pinned, fy = 250 MPa	**3, 5**	**E**
6. Determine axial compressive load carrying capacity of a 2.30 m long single angle strut ISA 75 X 50 X 8 mm. The longer leg is connected to the gusset plate with two bolts at each end. Assume hinged condition.	**3, 5**	**E**
7. Calculate compressive strength of 2 ISA 80 X 80 X 8 mm placed on either side of gusset plate 8 mm thick with effective held in position at both ends but restrained against rotation at one end. The length of member is 3.00 m and fy = 250 MPa.	**3, 5**	**E**
8. Design a single angle strut connected to the gusset plate to carry 180 kN factored load. The length of the strut between centre to centre inter section is 3.00 m.	**4, 5**	**C**
9. Explain laced and battened columns with sketch.	**3, 4**	**U**
10. Design a laced column with two channels back to back of length 10m to carry an axial factored load of 1400 kN. The column may be assumed to have restrained in position but not in direction at both ends (hinged ends).	**4, 5**	**C**
11. Design a column to carry an axial factored load of 1200 kN. The actual length of column is 6.00 m with both ends effectively held in position and restrained against rotation. Select two channels back to back. Assume that the column is laced and fy = 250 MPa.	**4, 5**	**C**
12. Design a single lacing system for a column composed of 2 ISMC 300 @ 35.8 kg/m placed back to back at clear spacing of 200 mm. axial factored load on column is 1500 kN. Effective length of column is 5.00 m.	**4, 5**	**C**

DESIGN OF STRUCTURES

TUTORIAL – 9

STEEL BEAM

	COs	LEVEL
1. **Design** a simply supported steel beam of 7.00 m spam carrying a RC floor capable of providing lateral restraint to the top compression flange. The total factored U.D.L. subjected was 53.60 kN/m throughout and factored point load act at centre as 150 kN. Use ISMB section. Perform the check for web buckling only.	**4, 5**	**C**
2. A roof of a hall measuring 8.00 m X 12.00 m consist of 100 mm thick R.C. slab supported on steel I – beams spaced 3.00 m apart. The finishing load may be taken as 1.50 kN/m^2 and live load as 2.00 kN/m^2. **Design** the steel beam.	**4, 5**	**C**
3. **Design** a uniform section for Moment and shear capacity of two spans simply supported continuous beam ABC. Span AB is of 4.00 m length and carries a central concentrated load of 150 kN and span BC is of 6.00 m length and carries a central concentrated load of 200 kN. Assume the beam is to be laterally supported. Adopt plastic design procedure.	**4, 5**	**C**
4. **Determine** the maximum uniformly distributed load that can be carried by a laterally unrestrained ISMB 300 simply supported beam of 2.50 m effective length.	**3, 5**	**E**
5. A simple support beam is laterally supported over the span of 8.00 m and loaded by a super imposed load of 30 kN/m over the entire span and 100 kN and centre. **Design** the beam using ISMB section and check for all the safety.	**4, 5**	**C**
6. A beam of ISMB 550 has simple support span of 9.00 m and is laterally supported at centre only. **Calculate** the maximum all-inclusive factored udl it can support.	**3, 5**	**E**
7. **Design** an I – section purlin for an industrial building to support a galvanized corrugated iron sheet roof. **Given data:** Spacing of the trusses = 5.00 m, Spacing of purlins = 1.50 m, Inclination of main rafter to horizontal = 30 degree, Weight of galvanized sheets taking into account laps and connecting bolt = 130 N/m^2, Imposed snow load = 1.50 kN/$m^{2,}$ Wind load = 1.00 kN/m^2	**4, 5**	**C**
8. **Calculate** the moment carrying capacity of a 3.00 m long ISMB 350 beam which has full torsional restraint and no warping restraint at ends only. (Laterally unrestrained beam).	**3, 5**	**E**

DESIGN OF STRUCTURES

TUTORIAL – 10

Slab Base and Gusseted Base

	COs	LEVEL
1. Explain the design procedure of base plate.	**3, 4**	**U**
2. Explain the design procedure of gusseted base.	**3, 4**	**U**
3. Design a column base for a factored axial compressive load of 700 kN and a factored Bending moment (B.M.) of 150 kNm about major axis. The column section provided is ISHB 400 @ 806.4 N/m. Design the anchor bolts also, if required. The bearing pressure from concrete may be assumed to be 6.00 kN/m^2.	**4, 5**	**C**
4. Design a column cap for a truss transferring a reaction of 120 KN to a column section ISHB 450 @ 907.43 N/m.	**4, 5**	**C**

PART – C

TUTORIAL – 11

(R.C.C. and Steel Structures)

TUTORIAL – 11

1. **Prepare** a sketch book with at least 20 sketches of different RCC and Steel members with detailing.