

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**  
**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**  
 Semester-VI  
**Course Title: Design of Structures**  
 (Course Code: 4360601)

Diploma programme in which this course is offered	Semester in which offered
Civil Engineering	Sixth Semester

### 1. RATIONALE

After learning Mechanics of rigid bodies in 2<sup>nd</sup> semester and Mechanics of deformable bodies in 3<sup>rd</sup> semester, this subject "Design of Structures" introduced in 6<sup>th</sup> semester, as it deals with the design and analysis of R.C.C. and Steel structures, is the backbone of Civil Engineering Course. The design of prime members like Slabs, Beams, Columns and Footing in R.C.C. and In Steel structures some Introductory topics like design of connections and calculations of various loads on Roof Truss are intended to incorporate in this subject of design of structures.

### 2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Analyze and Design important structural members of R.C.C. and primary knowledge of bolted and welded connections for Steel structures and various loads for steel structures.**

### 3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- a. Analyze and Design singly reinforced rectangular beam for flexure and shear.
- b. Design One way and Two way slabs for simply supported conditions.
- c. Design axially loaded short column and pad footing.
- d. Design Bolted and Welded Connections for steel structures.
- e. Determine Dead Load, Live Load and Wind Load on Roof Truss

### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	CA	ESE	CA	ESE	
3	0	4	5	30*	70	25	25	150

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.

**Note: Subject related Indian Standard Codes (1) IS:456-2000 (2) IS:800-2007 (3) IS: 8751987 (Part- I,II,III) (4) SP-16 Design Aid to IS-456 (5) SP-6 Handbook for Steel Structures will be allowed during Examinations.**

#### 5. SUGGESTED ASSIGNMENTS/ EXERCISES :

The following practical outcomes (PrOs) are the subcomponents of the COs. *Some of the PrOs marked ‘\*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Interpret IS Code provisions for Limit state R.C.C. Design from IS:456-2000 and SP-16	I	02 *
2	Analyse Singly Reinforced Beams for Moment of Resistance from given data (2-Problems).	II	04*
3	Design of singly reinforced beams for flexure and shear and apply necessary checks from given data (1-Problem).	II,III	04 *
4	Design of One way simply supported slabs and apply necessary checks from given data (1-Problem).	IV	04*
5	Draw sketches (not to scale) showing reinforcement details of singly and doubly reinforced beams and one way simply supported slab in longitudinal and cross sectional view.	II,III,IV	02*
6	Draw structural details of the designed beam , simply support a one way slab in A2 size drawing sheet with scale. (Sheet-1)	II,III,IV	04*
7	Design of Two way simply supported slabs and apply necessary checks from given data. (Corners not held down condition only)- (1-Problem)	IV	04*
8	Analyse and design axially loaded short square column and design pad footing of same column from given data.	V	06*
9	Draw sketches (not to scale) showing reinforcement details of axially loaded short rectangular, Circular columns and isolated pad and slope footing in plan and sectional view in longitudinal and cross sectional view.	IV,V	02*
10	Draw structural details of the designed two way slab, column and footing in A2 size drawing sheet with scale. (Sheet-2)	IV,V	04*

11	Interpret IS Code provisions for Limit state Steel Design from IS:800-2007 and SP-6	VI	02 *
12	Draw sketches (not to scale) showing details for standard rolled steel sections, built up sections, Beam to Beam and Beam to Column connections (Bolted and Welded).	VI,VII	02*
13	Design a bolted connection for the given data of steel section as per IS: 800-2007.	VII	04*
<b>Sr. No.</b>	<b>Practical Outcomes (PrOs)</b>	<b>Unit No.</b>	<b>Approx. Hrs. Required</b>
14	Design a welded connection for the given data of steel section as per IS: 800-2007.	VII	04*
15	Interpret IS provision for dead load, live load and wind load for steel roof truss from IS 875-1987 (Part- I to III)	VIII	02*
16	Draw sketches (not to scale) for types of roof trusses, components of roof truss and important four joints like ridge joint, eave joint, bottom middle joint and intermediate joint.	VIII	02*
17	Calculate dead load, live load and wind load for the given data of steel roof truss with graphical method (sheet-3) and prepare a force table.	VIII	04*
	<b>Total hours</b>		<b>56 Hrs.</b>

**Note**

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Interpretation of given data and its understanding.	10
2	Selection of sketches/Process of designing of the given structural components using relevant I.S.codes and preparing of report of site visit..	30
3	Presentation of sketches in sketchbook, neatness and cleanliness of sheets and writing reports.	30
4	Individual work, work as a team-member	10
5	Completion and submission of work in time.	20
	<b>Total</b>	<b>100</b>

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Drawing tools and other design aids (for all PrOs)
1	Drawing boards and drawing instruments.
2	Scientific calculator and all relevant IS codes.
3	Computers and Printers.
4	Available CAD software( Not mandatory)

## 7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

- a) Work as a leader/a team member.
- b) Follow safety practices while using equipment.
- c) **Realize the importance of green energy. (Environment related)**

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1<sup>st</sup> year
- ii. 'Organization Level' in 2<sup>nd</sup> year.
- iii. 'Characterization Level' in 3<sup>rd</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
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<b>Unit – I Fundamentals of R.C.C. Design</b>	1a. Identify components and their characteristics for RCC structures. 1b. Use limit states conditions for analysis and design of RCC structures. 1c. Use IS Code provisions for General Design Consideration.	1.1 Reinforced Cement Concrete, necessity of steel in concrete, normal location of steel in beams, slabs, column & footing. 1.2 Limit State, Limit State of Collapse Flexure, Shear, Compression, Torsion, Limit State of Serviceability-deflection and Cracking. 1.3 Characteristic Strength of concrete and steel, partial safety factor of concrete and steel and partial safety factors for loads. 1.4 Nominal Cover, Effective depth, Effective span.
<b>Unit – II Singly Reinforced Beam</b>	2a. Differentiate types of RC beams. 2b. Calculate moment of resistance for given type of section. 2c. Design a singly RC beam section for given condition. 2d. Apply check for deflection 2e. Draw reinforcement detailing for the designed beam section as per IS provision.	2.1. Types of beam: Singly reinforced beam, Doubly reinforced beam, Tbeam, L-beam. Difference among various beams. 2.2. Stress-strain diagram for singly RC section. Under reinforced, over reinforced and balanced section. 2.3. Analysis of Singly RC beam: Determination of lever arm, total tension, total compression, percentage area of reinforcement and Moment of resistance. Numerical based on this.
		2.4. Design and detailing of Singly RC beam: Determination size of section, area and number of reinforcement bars. Combination of different diameters of reinforcement bars. Check for spacing and cover. Numerical based on this with checking design for deflection.
<b>Unit– III Shear and Development Length</b>	3a. Identify the pattern of shear failure in beams and slabs. 3b. Design shear reinforcement in beams as per given Conditions. 3c. Calculate development length as per given conditions. 3d. Check for development length in R.C.C. Design	3.1 Shear: Definition of shear, IS code specifications, single legged and two legged shear reinforcement. 3.2 Vertical stirrups, Incline stirrups, benefit of bent up of main tension reinforcement. Spacing of stirrups. Numerical based on this. 3.3 Effect of shear in slabs. IS code provision. 3.4 Development Length: Definition of development length, IS provision for determination of development length for tension and compression zone. Numerical based on this.

<p><b>Unit– IV Slabs</b></p>	<p>4a. Suggest types of slab for given support conditions.</p> <p>4b. Design one way and two way simply supported slabs as per given data.</p> <p>4c. Examine suitability of designed slab by applying deflection and cracking criteria.</p> <p>4d. Draw reinforcement detailing for the designed slab as per IS provision.</p>	<p>4.1 Slab: Types of slabs. One way simply supported slab. Two way slab and one way continuous slab.</p> <p>4.2 IS provision for main reinforcement, distribution reinforcement, minimum and maximum steel area, effective span, effective depth, effective cover.</p> <p>4.3 Depth of Slab from deflection criteria, Dead Load, Live Load and Floor finish load on Slab. Bending moment due to loads.</p> <p>4.4 Design and detailing of one way simply supported and cantilever slabs. Check limit state of serviceability. Numerical based on this.</p> <p>4.5 Design and detailing of two way simply supported slab (only corners not held down condition). Check the limit state of serviceability. Numerical based on this.</p>
<p><b>Unit– V Axially loaded short column and pad footing.</b></p>	<p>5a. Identify the type of column based on load condition.</p> <p>5b. Analyze and Design axially loaded short columns.</p> <p>5c. . Design Isolated Pad Footing for column.</p> <p>5d. Draw reinforcement details of column and footing.</p>	<p>5.1 Column: Types of column, Long Column, Short column, Axially loaded column, uniaxially loaded column and biaxially loaded column.</p> <p>5.2 Limit state of collapse: Compression, assumptions, effective length, slenderness ratio, minimum eccentricity. IS provision for reinforcement in</p>
		<p>column, lateral reinforcement as tie only for column,</p> <p>5.3 Load analysis of axially loaded short columns.</p> <p>5.4 Design of axially loaded short columns. Check for minimum eccentricity.</p> <p>5.5 Footing: Types of isolated footing, pad and sloped footing. IS specification for reinforcement in pad footing only.</p> <p>5.6 Design of isolated pad footing. Check for bending, one way shear and two way shear, check for development length in footing. Numerical based on this with reinforcement details.</p>

<b>Unit– VI Fundamental of Steel Design</b>	6a. Identify relevant steel structure from given condition. 6b. Identify the components of the given steel structure. 6c. Choose properties of the given steel section.	6.1 Steel versus RCC as a building material. Advantages and disadvantages of steel. Types of steel sections normally in use. 6.2 Characteristic strength and design strength, Stress-strain curve for mild steel. Partial safety factors for load and materials as per IS provision. 6.3 Limit state of strength and serviceability.
<b>Unit– VII Bolted and Welded connections</b>	7a. Select type of connection for the given steel structure. 7b. Compute the strength of bolted and welded connection for the given condition. 7c. Design bolted and welded connection for given condition.	7.1 Types of connections in steel structures Bolted connection: Types of bolts, Black Bolts, Turned Bolts, HSFG Bolts, Grade of Bolts Lap and Butt Joint, Minimum and Maximum Pitch, Tack Bolting, Edge Distance, Gauge Distance, Bolt Hole. 7.2 Shear Capacity of Bolt – $V_{dsb}$ , Bearing Capacity of Bolt – $V_{dpb}$ as per IS-800-2007, Bolt Value, Efficiency of Joint. 7.3 Analysis and design of bolted connection of plate and Angle sections. Numericals based on this. 7.4 Welded connection: Types of weld, Fillet Weld and its symbol, tack welding, minimum and maximum size of weld, effective throat thickness, end returns. 7.5 Analysis and design of Fillet weld in plate and angle section as per IS-8002007. Numericals based on this.
<b>Unit– VIII Load Calculation for Roof Truss</b>	8a. Identify the type of steel roof truss. 8b. Compute dead load, live load and wind load per panel point	8.1 Types of Truss for various spans, Pitch of Truss, Rise, Spacing of Truss, Members of Truss: Purlin, Principal Rafter, Main Tie, Sag Tie. Joints: eave

	as per given condition. 8c. Derive design load and check load from different load combinations.	joint, ridge joint, intermediate joint and middle bottom joint. Roofing material- GI and AC Sheets. 8.2 Types of load and load combinations for roof truss as per IS 875 codal provisions. 8.3 Dead Load of Truss per panel point: self weight ,weight of Purlin , Wind Bracing , and weight of Roofing Material . 8.4 Live Load per panel point on purlin and Truss. 8.5 Wind Load per panel point on roof truss 8.6 Numericals on dead load, live and wind load for roof truss.
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### 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of R.C.C. Design	02	00	02	02	04
II	Singly Reinforced Beam	08	02	04	06	12
III	Shear and Development Length	04	02	02	04	08
IV	Slabs	08	02	04	06	12
V	Axially loaded short column and pad footing.	06	02	04	04	10
VI	Fundamentals of Steel Design	02	00	02	02	04
VII	Bolted and Welded connections	06	02	02	06	10
VIII	Load Calculation for Roof Truss	06	02	02	06	10
<b>Total</b>		<b>42</b>	<b>12</b>	<b>24</b>	<b>34</b>	<b>70</b>

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

**Note:** This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.

### 10. SUGGESTED STUDENT ACTIVITIES

Other than the conventional teaching and learning, following are the suggested studentrelated **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare

reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- a) Collect different photographs of nearby structures (RCC or Steel) showing different components clearly to create a self site visit.
- b) Collect the photographs of different types of footings/foundations being constructed nearby with their primary details.
- c) Collect different photographs of steel structural members (by visiting railway station, warehouse or industrial sheds) where connections can be shown actually implemented at site.
- d) Collect the photographs of five different types of rolled steel sections.
- e) Collect the information with photographs of structural failure of RCC components due to any reason.
- f) Collect the information with photographs of world famous steel structures from journals or websites.
- g) Collect the information with photographs of structural members having well known structures of India.

#### 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/subtopics.
- b) Guide student(s) in undertaking micro-projects.
- c) '**L**' in **section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on environment and sustainability.
- g) Guide students for using data manuals.

#### 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be field application based, internet-based, workshop-based, laboratory-based or theory (analysis or design) based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work

and give a seminar presentation of it before submission. The duration of the microproject should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- a) Determine the moment of resistance of different cross sections for beams having the same area and different grades of concrete.
- b) Compare the price of different grades of steel bars by actual market survey and prepare the report.
- c) Prepare spreadsheet or computer program to determine moment of resistance of singly reinforced beam for three grades of steel and concrete.
- d) Prepare spreadsheet or computer program to determine development length for different grades of steel , concrete, dia. of bar in tension and compression.
- e) Prepare spreadsheet or computer program to calculate load carrying capacity of axially loaded short RC column.
- f) Prepare drawing in Autocad for Dead load, Live load and Wind Load for given roof truss and compare answers with manual drawing.
- g) Carry out market survey for steel sections which are available in market but not included in steel table or SP:6.

### 13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Design of Reinforced Concrete Structures	N Krishna Raju	CBS Publishers & Distribution Pvt. Ltd. NewDelhi ISBN: 9789385915369
2	Design of Reinforced Concrete Structures	N Subramanian	Oxford Publisher ISBN: 0198086946
3	Reinforced Concrete Vol.I	Dr.H.J.Shah	Charotar Publication ISBN: 9789385039478
4	Design of Steel Structures By Limit State Method as per IS:800-2007	S.S.Bhavikatti	Dreamtech press <a href="#">New Delhi</a> ISBN:9389307058
5	Limit State design of Steel structures	S.K.Duggal	Mc Graw Hill ISBN: 9353164877
6	Limit State design of Steel structures As per IS:8002007	S.Kanthimathinathan	Dreamtech press New Delhi ISBN:9389447577

7	IS:456-2000- Plain and Reinforced concrete code of practice.	BIS, New Delhi	BIS, New Delhi
8	IS:800-2007-Indian Standard Code of practice for use of structural steel in general building	BIS, New Delhi	BIS, New Delhi
<b>Sr. No.</b>	<b>Title of Book</b>	<b>Author</b>	<b>Publication with place, year and ISBN</b>
	construction.		
9	IS: 875-1987 part 1 to 5, Indian Standard Code for Loading Standards	BIS, New Delhi	BIS, New Delhi
10	SP:16-Design Aids for reinforced concrete to IS:456	BIS, New Delhi	BIS, New Delhi
11	SP:6-Handbook for Structural Engineers(Structural Steel Sections)	BIS, New Delhi	BIS, New Delhi
12	SP:34-Handbook on Concrete Reinforcement and Detailing	BIS, New Delhi	BIS, New Delhi

#### 14. SOFTWARE/LEARNING WEBSITES

- a) NPTEL Course :-Reinforced Cement Concrete by IIT, Kharagpur  
<https://archive.nptel.ac.in/courses/105/105/105105105/>
- b) NPTEL Video series for Steel design by IIT, Kharagpur  
<https://archive.nptel.ac.in/courses/105/105/105105162/>

#### 15. PO-COMPETENCY-CO MAPPING

Semester III	Design of Structures (Course Code: 4360601)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

<u>Competency</u>	Analyze and Design important structural members of R.C.C. and primary knowledge of bolted and welded connections for Steel structures and various loads for steel structures.						
Course Outcomes COa) Analyze and Design singly reinforced rectangular beam for flexure and shear.	3	3	3	2	3	2	2
COb) Design One way and Two way slabs for simply supported conditions.	2	3	3	2	2	2	2
COc) Design axially loaded short column and pad footing.	2	3	3	2	2	2	2
COd) Design Bolted and Welded Connections for steel structures.	2	3	3	3	2	2	2
COe) Determine Dead Load, Live Load and Wind Load on Roof Truss.	2	3	3	3	2	2	2

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

### GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Shri P.V. Rayjada, HOD Applied Mechanics	L.E. College (Diploma), Morbi	9824281646	<a href="mailto:satwikpr@gmail.com">satwikpr@gmail.com</a>
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