

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

VI – Semester

Course Title: Advance Design of Structures

(Course Code: 4360609)

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

1. RATIONALE

After learning advance analysis of structures in fifth semester, this elective subject is introduced in 6th semester for those students willing to excel in the structural engineering field. This subject incorporates in depth knowhow for design of structural elements pertaining to Steel structures and Reinforced Concrete structures. In Steel structures, design of Tension member, Compression member and flexural member is included. Slab base foundation for steel column and under advance RCC design topics i.e. Doubly reinforced beam, T - Beam and Continuous slab are also incorporated. After learning this subject, diploma students will develop enhanced , in-depth, understanding of analysis and design of the structural members in the field of structural engineering and will be able to apply their knowledge ,design and analytical skills in the construction industry.

2. COMPETENCY

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

- **Analyse and Design important structural elemental members of R.C.C. and 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:

- Analyse and Design Tension and Compression members of Truss .
- Design axially loaded steel column and slab base foundation.
- Design Laterally restrained steel beam and purlin.
- Analyse RC T-Beam & Doubly reinforced beam and design Doubly Reinforced rectangular beam.
- Design a three span one way continuous RC slab.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
			C	CA	ESE	CA	ESE	
3	0	2	4	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) SP-16 Design Aid to IS-456 (4) SP-6 Handbook for Steel Structures will be allowed during Examinations.

5. SUGGESTED PRACTICAL 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	Analyse and Design Axially Loaded Tension Member made up of Angle Section Specify Equal or Unequal, ISA or 2ISA (1-Problem Each)	I	02*
2	Analyse and Design Strut made up of Angle Section (1-Problem Each)	II	02 *
3	Design Axially Loaded Steel Column (One ISHB Section) and Slab Base Foundation for that. (1-Problem)	II, IV	04*
4	Design laterally restrained steel beam and purlin.(1-Problem Each)	III	02*
5	Draw longitudinal and sectional view designed Tension Member , Compression member and Laterally restrained beam. Draw Plan and c/s Elevation of Slab Base Foundation under column made up of H section. Sheet No:01 – A2 Size	I, II, III, IV	02*
6	Analyse and Design Doubly reinforced rectangular beam.(1-Problem Each)	V	04*
7	Analyse T-Beam (1-Problem)	VI	02*
8	Design three span one way continuous slab (1-Problem)	VII	04 *
9	Draw longitudinal and sectional view of designed doubly reinforced beam. Draw designed three span One Way Continuous Slab in Plan and in Longitudinal cross section Sheet No:02 – A2 Size	VI,VII	02*
10	Hands on Practice session/ Interactive Seminar for design , Analysis of Structural components (steel and/or RCC) on relevant software	I TO VII	04 *
Total hours			28 Hrs.

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..	40
3	Presentation of sketches in sketchbook, neatness and cleanliness of sheets and writing reports.	20
4	Individual work, work as a team-member	15
5	Completion and submission of work in time.	15
Total		100

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 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 1st year
- ii. 'Organization Level' in 2nd year.
- iii. 'Characterization Level' in 3rd 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
Unit – I Tension Member	1a. Suggest the type of steel section to be used as tension member for given data. 1b. Compute the load carrying capacity of given tension member with given condition. 1c. Design given tension member for given data and condition.	1.1 Types of sections used as Tension Members in Steel Structures. 1.2 Design strength of Tension Member governed by Yielding, rupture of critical section and Block shear in Angle section according to provision of IS: 800-2007 1.3 Analysis and Design of Axially loaded tension members - Single and Double angle section with Bolted and welded connections. 1.4 Numerical of Analysis and design of tension members for single and double angle sections with bolted and welded connections.
Unit – II Compression Member (Strut & Column)	2a. Suggest the type of steel section to be used as compression member for given data. 2b. Compute the load carrying capacity of given compression member with given end conditions. 2c. Design the compression member for given data and condition.	2.1 Type of sections to be used as compression members in steel structures. Calculation of effective length, radius of gyration, slenderness ratio and its permissible value as per IS:800-2007. 2.2 Cross section classification, Buckling class, Imperfection factors as per IS:800-2007 2.3 Design compressive strength of (i) Axially loaded compression members (ii) Single angle struts (iii) Double angle struts as per IS:800-2007 2.4 Numerical of Analysis and design of compression members for single angle section, double angle section, with bolted and welded connections. 2.5 Numericals for Analysis and Design of Column (made up of single H section i.e. ISMB,ISHB only No Built Up Section)
Unit– III Laterally Restrained Beam and Purlin	3a. Design laterally restrained simply supported beams(only ISHB or ISMB) 3b. Design Purlin made up of Unequal Angle Section	3.1 Main Beam , Secondary Beam , Standard I Sections , Laterally restrained and unrestrained beam (only) symmetrically loaded with UDL and/or point load. 3.2 Plastic Section Modulus – Annexure –H , IS-800-2007 , Section classification as per Table 2 – IS-800-2007 , Shear buckling , Shear Strength and Bending

		Strength of Section as per Cl. 8.4.1 and Cl. 8.2.1.2 of IS-800-2007 , Deflection as per Table-6 of IS-800-2007 , Shear Leg Effect , Web Crippling
Unit– IV Slab Base Foundation	4a. Identify different types of column bases foundation. 4b. Design of Slab Base Foundation for Axially Loaded Column made up of Indian Standard Heavy Beam Section	4.1 Schematic comparison of various Slab Bases for Axially loaded columns. 4.2 Procedure to design Slab Base Foundation for axially loaded column made up of ISHB Section with bolted connection only. 4.3 Numerical to design slab base foundation for given data.
Unit– V Doubly Reinforced Beam	5a. Differentiate types of RC beams. 5b. Calculate moment of resistance of doubly reinforced beam. 5c. Design a Rectangular Doubly reinforced beam. 5d. Draw reinforcement detailing for the designed doubly reinforced beam section as per IS provision.	5.1 Requirements and conditions for providing doubly reinforced sections. 5.2 Stress diagram for doubly reinforced beam. Stress in compression reinforcement (f_{sc}) in doubly reinforced beams for different values of d'/d ratio. 5.3 Analysis and design of doubly reinforced section using IS:456-2000 method, SP:16 table method and SP: 16 chart method. 5.4 Numerical of Moment of resistance and Area of steel (tension and compression) for doubly reinforced beam.
Unit– VI T-Beam	6a. Identify importance of reinforced concrete flanged beams. 6b. Analyze T-beam for Flexure.	6.1 Concept of flanged beam-T-beam & L-beam. Requirement and advantage of T-beam. Effective width of flange. 6.2 Conditions for the beam to act as T-Beam i.e. (i) Neutral axis lies in flange [$X_u < D_f$] (ii) Neutral axis lies in web [$X_u > D_f$] Stress strain diagram of T- beam. 6.3 Numerical to find Limiting Moment of Resistance of Tee Beam using IS:456-2000 and SP-16.
Unit– VII One-Way Continuous Slab	7a. Identify conditions to use one way continuous slab. 7b. Design one way continuous slab as per given data and condition. 7c. Draw reinforcement details for the designed one way continuous slab as per IS provision.	7.1 Definition and requirement to use one way continuous slab. 7.2 IS 456:2000 provisions for three span one way Continuous Slab. Various coefficients of Bending moment and shear force for dead load and imposed load. 7.3 Numerical to design three span one way continuous slab only.

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	Tension Member	08	02	04	06	12
II	Compression Member (Strut & Column)	10	02	04	08	14
III	Laterally Restrained Beam and Purlin	06	02	04	04	10
IV	Slabs Base Foundation	04	02	02	02	06
V	Doubly Reinforced Beam	05	02	04	04	10
VI	T-Beam	04	02	02	04	08
VII	One-Way Continuous Slab	05	02	04	04	10
Total		42	14	24	32	70

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

Note: This specification table provides general guidelines to assist student 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 classroom and laboratory learning, following are the suggested student-related **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:

- Identify different situations with photographs of steel structural members where tensile force is predominant in the field.(bridge, Railway station)
- Identify different situations with photographs of steel structural members connection (Bolted & welded connection)
- Identify different situations with photographs of steel structural members where compressive force is predominant in the field.(Suspension bridge, Railway bridge)
- Identify different situations with photographs of RCC Structural components such as column ,doubly beams , continuous slabs etc..
- List out various softwares available for steel and RCC design and submit a review report.
- Use of computer program (software or excel worksheets) to compare the results of design and analysis problems solved manually

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:

- Massive open online courses (**MOOCs**) may be used to teach various topics/subtopics.
- 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.9**, 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 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 micro-project 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) Compare the design and analysis done manually with computer software or excel worksheets for at least one of the list below
 - a. Steel Design and analysis for Axially loaded Tension member, Axially loaded compression member, Simply Supported laterally restrained beams, Purlins and Slab base Foundation.
 - b. RCC Design and analysis of Doubly reinforced rectangular beam, 3 span one way continuous slab, T beam.
- b) Prepare a spreadsheet computer program to design at least one of the following
 - a. Steel Design for Axially loaded Tension member, Axially loaded compression member, Simply Supported laterally restrained beams, Purlins and Slab base Foundation.
 - b. RCC Design of Doubly reinforced rectangular beam, 3 span one way continuous slab.
- c) Prepare a spreadsheet computer program for at least one of the following
 - a. Steel Design for Axially loaded Tension member, Axially loaded compression member, Simply Supported laterally restrained beams, Purlins and Slab base Foundation.
 - b. Doubly reinforced rectangular beam, 3 span one way continuous slab.

- d) Analyse and design a steel roof truss or a residential block building with structural engineering software.

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 New Delhi 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:800-2007	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 construction.	BIS, New Delhi	BIS, New Delhi
9	SP:16-Design Aids for reinforced concrete to IS:456	BIS, New Delhi	BIS, New Delhi
10	SP:6-Handbook for Structural Engineers(Structural Steel Sections)	BIS, New Delhi	BIS, New Delhi
11	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 VI	Advance Analysis of Structures (Course Code: 4360609)						
	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>	<u>Analyse</u> and Design important structural elemental members of R.C.C. and Steel structures.						
Course Outcomes COa) Analyse and Design Tension and Compression members of Truss	2	3	3	2	2	2	2
COb) Design Axially loaded steel column and slab base foundation.	2	3	3	2	2	2	2
COc) Design laterally restrained steel beam and purlin.	2	3	3	2	2	2	2
COd) Analyse RC T-beam and Doubly reinforced beam and Design doubly reinforced rectangular beam	2	3	3	2	2	2	2
COe) Design a three span one way continuous RC slab.	2	3	3	2	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

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