GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Civil Engineering
Subject Code: BE05006051
Subject Name: Advanced Structural Analysis

w. e. f. Academic Year:	2024-25
Semester/Year	5
Category of the Course:	Professional Elective Course - 1

Prerequisite:	**Basic Structural Analysis**
Rationale:	The syllabus provides a strong foundation in structural analysis by integrating classical and modern methods. It develops understanding of stiffness and plastic behavior, introduces finite element techniques, and covers specialized structures like domes. Practical exposure to professional software enhances analytical skills, enabling students to model, analyze, and design efficient and realistic engineering structures. The course contributes to the development of **safe, sustainable, and resilient infrastructure**, aligned with Sustainable Development Goals.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	% weightage
CO-1	Apply the stiffness method (member approach) to analyze beams, plane trusses, plane frames, and plane grids including the effects of support settlements, temperature changes, and symmetry/anti-symmetry conditions. *(RBT Level: Apply, Analyze)*	20
CO-2	Analyze stress–strain behavior in structural elements and formulate finite element models by deriving shape functions, strain-displacement relations, and element stiffness matrices for one-dimensional problems. *(RBT Level: Analyze)*	20
CO-3	Analyze indeterminate structures using plastic analysis methods by evaluating plastic moment capacity, collapse load, and load factor using equilibrium and mechanism approaches. *(RBT Level: Apply, Analyze)*	20
CO-4	Apply structural analysis concepts to evaluate stresses and internal forces in conical and spherical domes subjected to different loading conditions, including openings and concentrated loads. *(RBT Level: Apply, Evaluate)*	20
CO-5	Develop and analyze structural models using professional software (e.g., STAAD, ETABS, SAP) by defining geometry, material properties, boundary conditions, and loading, and interpreting structural responses through post-processing tools. *(RBT Level: Create, Evaluate)*	20

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Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no. of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	30	00	15	90	3	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Course Content:

Sr. No.	Name of Topic	Teaching Hours	% Weightage
1	**Unit-1: Stiffness Method (Member Approach)** Types of skeletal structures, Internal forces and deformations. Principle of Virtual work Introduction and application of stiffness member approach to analyze Beams, Plane Trusses, Plane Frames, Plane Grids. **Special topics:** Various secondary effects like deformation of support, prestrain & temperature. Symmetry and Anti-symmetry	20	55
2	**Unit-2 : Finite Element Method** Theory of Stresses: State of stress and strain at a point in two and three dimensions, stress and strain invariants, Hooke's law, Basic steps of FEM, Principles of discretization, Derivation of global equilibrium equation using Principle of minimum potential energy approach, Derivation of Shape functions, Strain displacement matrix and element stiffness matrix using Cartesian Coordinate System for the spring and bar elements. Application of FEM to One-dimensional (Spring and bar) problems.	10	45
3	**Unit-3 : Plastic Method** Introduction, Assumptions, Idealized Stress Strain Curve, Plastic Moment of Resistance, Plastic Modulus and Shape	10	

	Factor, Concept of Plastic Hinge. Collapse load, load factor, Static Method (Equilibrium Method), Kinematic Method (Mechanism Method). Analysis of Simply Supported, Propped Cantilever, Fixed and Continuous Beam.		
4	**Unit-4 : Analysis of Domes** Uses of domes, types of domes, nature of stresses in conical and spherical domes, analysis of conical and spherical domes subjected to uniformly distributed load, concentrated load at crown, analysis of domes with opening.	05	
3	**Unit-5: Computer Applications in Structural Engg. (for Laboratory only)** Use of professional software such as STAAD-Pro, SAP, ETABS etc. for determining response of frames structure of the topics related to this course Create Modelling, Apply properties, boundary conditions, loading, perform analysis, post processing tools.	This portion to be covered in Laboratory	Theory Weightage shall be 0%

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**20**	**30**	**20**	**10**	**10**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

The syllabus of **Advanced Structural Analysis** directly contributes to

SDG 4	**Quality Education:** Unit 1 & 2: Equips students with advanced analytical and mathematical skills through member approach stiffness and finite element modeling. Unit 5: Provides hands-on technical proficiency in industry-standard software like STAAD-Pro, SAP, and ETABS. It enhances **technical competency, lifelong learning, and digital skills**
SDG 9	**Industry, Innovation and Infrastructure:** Unit 1 & 2: Enables precise analysis of complex structures to design resilient

	infrastructure using state-of-the-art computational methods. Unit 3: Utilizes plastic design methods to optimize material consumption, fostering innovative and efficient resource use in industrial structures. Unit 4: Advances the engineering design of spatial structures like domes to support modern, large-span industrial and public infrastructure.
SDG 11	**Sustainable Cities and Communities:** Unit 1: Accounts for support deformations and environmental variations to ensure long-term structural safety in urban high-rise buildings. Unit 3: Determines accurate collapse loads and safety factors to protect communities against catastrophic structural failures. Unit 4 & 5: Applies professional software modeling to design safe public spaces, domes, and framing systems for expanding sustainable urban areas.
SDG 12	**Responsible Consumption and Production:** Unit 3: Leverages the plastic method to reduce over-design, minimizing the consumption of raw materials like steel and concrete. Unit 2 & 5: Uses finite element discretization and soft-computing tools to achieve optimized, material-efficient structural dimensions. It promotes sustainable procurement by safely minimizing material waste without compromising global structural integrity.
SDG 13	**Climate Action:** Unit 1: Evaluates temperature-induced stresses and prestrains to ensure structures withstand extreme weather and changing climate loads. It lowers the carbon footprint of construction projects through material optimization driven by accurate software-based structural modeling.

References/Suggested Learning Resources:
(a) Books:

1. Gere & Weaver; Matrix Analysis of framed structures, CBS Publications
2. Bhavikatti; Finite Element Analysis, New Age International Publishers
3. Desai & Abel; Finite Element Method, Tata Mcgraw hill
4. Meghre& Deshmukh; Matrix Analysis of Structures, Charotar Publication
5. Logan D. L.; A First Course in the Finite Element Method
6. Selvam Monika; Elements of Matrix and Stability Analysis of Structures
7. Junnarkar S. B. & Shah H.J, Mechanics of Structures Vol-II, Charotar publishing house, Anand.
8. Reddy C.S., Basic Structural Analysis, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

9. Neal B G, Plastic Analyisis, Mc Graw hill Publication.

(b) Open source software and website:

1. http://nptel.ac.in/

Suggested Course Practical/Assignment List:

The students will have to solve at least five examples and related theory from each topic as an assignment/tutorial. Students will have to perform following experiments in laboratory and prepare the laboratory manual.

1. Perform computer analysis of statically indeterminate framed structures & verify with Stiffness method (Member approach).
2. Perform computer analysis of 1D problems & verify with Finite Element method.

List of Laboratory/Learning Resources Required:

1. Professional software such as STAAD-Pro, ETAB, SAP

List of suggested activities for Problem based learning (PBL):

Sl. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1.	Micro Project	Micro project in the area of subject or Real-world case studies	Duration 10 hrs.	05 Marks Based on in-depth study, technical depth, data collected, fact finding, Report preparation, Presentation etc.
2.	Industry/Field visit	visit to sustainable infrastructure projects such as ○ Metro structures ○ Smart city projects • Green buildings	Visit = 5h, Report preparation = 5h Total = 10h	05 Marks Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
3.	Video based learning	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	05 Marks Report /presentation based on the video learning outcomes.
4.	Assignment	Assignment writing. Numerical based	5 assignments of 2h each. Total =	05 Marks Based on the assignment

		assignment is preferable.	10h	submitted.
5.	Problem solving/Coding	Problem solving/Coding using Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding-based assignment of 2h each. Total = 10h	05 Marks Based on the coding solution submitted.
6.	Online courses	On-line courses related to the subjects	Minimum duration of the course should be 10h.	05 Marks Examination based assessment at the end of course. Based on the certificate produced.
7.	Poster/chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 h	03 Marks Based on poster/chart preparation and presentation skills
8.	Model preparation	Working or computer simulation on technical topics	Working = 12 h Non- working = 8 h	05 Marks Based on inter department/external evaluation
9.	Group discussion	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	01 Mark/1 hr.GD Based on performance in group discussion, technical depth, knowledge etc.

Note:

1. All the suggested activity should be related to the subject.
2. The activity suggested at sr. no.1 is compulsory and rest of the activities can be done to satisfy the PBL hours mentioned in the syllabus.
3. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
4. Minimum 03 activities shall be covered per subject.
5. Rubrics for the evaluation can be prepared by the faculty.

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