M.TECH

STRUCTURALENGINEERING

SCHEME OF INSTRUCTION AND SYLLABUS

M.Tech-24

(W.E.F 2024–2025)

Department of Civil Engineering

VELAGAPUDI RAMAKRISHNA
SIDDHARTHA ENGINEERING COLLEGE
DEEMED TO BE UNIVERSITY
(Under Section 3 of UGC Act, 1956)
Kanuru, Vijayawada - 520 007, AP. www.vrsiddhartha.ac.in
(Sponsored by Siddhartha Academy of General & Technical Education)

INSTITUTE VISION

To be a Centre of Excellence in Education, Innovation and Research with Global presence in Arts, Science, Technology, Medicine, Management, Legal and Social Studies in enriching the frontier areas of National and International importance

INSTITUTE MISSION

To create a transformative educational experience for students focused on problem solving skills: communication abilities and interpersonal relations and leadership. To cultivate a vibrant university community. To impact society in a pragmatic manner-regionally, nationally, and globally-by engaging with industry, outstanding national and international universities and research organizations. To be a global University that nurtures excellence in education and innovation for creating a knowledgeable society.

DEPARTMENT VISION

To impart teaching, research and develop consultancy that serves the society and to strive continuously for excellence in education.

DEPARTMENT MISSION

To provide quality education for successful career and higher studies in Civil Engineering that emphasizes academic and technical competence in profession and research, effective communication, team work and leadership to meet the challenges of the society.

PO 1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO 2: An ability to write and present a substantial technical report/document.

PO 3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO 4: Use different software tools to analyze and design of various structural components.

PO 5: Develop the ability to work both independently and collaboratively, cultivate an entrepreneurial mindset and engage in projects that prioritize sustainability and social responsibility while maintaining high ethical standards.

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SCHEME OF INSTRUCTION FOR TWO YEAR PG PROGRAMME [M.TECH24]

M.TECH in (Structural Engineering)

SCHEME OF INSTRUCTIONS

SEMESTER I **Contact Hours: 27**

S No	Course Type	Course Code	Title of the Course	L	T	P	Credits
1	Programme Core - I	24CESE501	Computer Aided Advanced Structural Analysis(*Integrated Course)	2	0	2	3
2	Programme Core – II	24CESE502	Theory of Elasticity and Plasticity	3	0	0	3
3	Programme Core – III	24CESE503	Structural Dynamics (Integrated Course)	2	0	2	3
4	Programme Elective – I	24CESE504	**A.** Advanced Steel Building (*Integrated Course)	2	0	2	3
			B.Fracture Mechanics of Concrete Structures	3	0	0	3
			C.MOOC courses relevant to Structural Engineering approved by BOS.(Can be opted from NPTEL/ Swayam/ others)	3	0	0	3
			D.Industry Oriented Subject	3	0	0	3
5	Programme Elective – II	24CESE505	**A.** Design of Prestressed Concrete Structures	3	0	0	3
			B.Precast and Prefabricated structures	3	0	0	3
			C.MOOC courses relevant to Structural Engineering approved by BOS. (Can be opted from NPTEL/Swayam/others)	3	0	0	3
			D. Advanced Concrete Technology	3	0	0	3
6	Mandatory Learning Course	24MTUC501	Research Methodology and IPR	2	0	0	0
7	Laboratory - 1	24CESE581	Advanced Concrete Lab	0	0	3	1.5
8	Laboratory - 2	24CESE582	Computer Applications in Numerical Analysis Lab	0	0	3	1.5
9	Project	24CESE591	Capstone Porject-1	0	0	2	1
Total				**15**	**0**	**12**	19

SEMESTER II **Contact Hours: 29**

S.No	Course Type	Course Code	Title of the Course	L	T	P	Credits
1.	Programme Core–IV	24CESE506	Finite Element Method (*Integrated Course)	2	0	2	3
2.	Programme Core – V	24CESE507	Computer Aided Reinforced Concrete Design (*Integrated Course)	2	0	2	3
3.	Programme Core – VI	24CESE508	Earthquake Resistant Design of Structures (Can be opted from NPTEL)*	3	0	0	3
4.	Programme Elective – III	24CESE509	A. Pre-Engineered Steel Buildings (*Integrated Course)	2	0	2	3
			B. Design of High-Rise Structures	3 3	0 0	0 0	3 3
			C. Stability of Structures				
			D. MOOC courses relevant to Structural Engineering approved by BOS. (Can be opted from NPTEL/Swayam/others)	3	0	0	3
5.	Programme Elective – IV	24CESE510	A. Design of Formwork	3	0	0	3
			B. MOOC courses relevant to Structural Engineering approved by BOS. (Can be opted from NPTEL/Swayam/others)	0	0	0	3
			C.Repair and Rehabilitation of Building	3 3	0 0	0 0	3 3
			D. Industry Oriented Subject				
6.	Audit Course	24MTUC502	Technical Report Writing	2	0	0	-
7.	Laboratory – 1	24CESE583	Building Information Modeling (BIM) lab	0	0	3	1.5
8.	Laboratory – 2	24CESE584	Concrete 3D Printing Lab	0	0	3	1.5
9.	Project	24CESE592	Capstone Porject-2	0	0	2	1
10.	Term Paper	24CESE593	Term Paper seminar – Literature Review for the proposed problem#	0	0	2	1
Total				**15**	**0**	**14**	20

L – Lecture, T – Tutorial, P – Practical, C – Credits

***Students to be encouraged to go industrial training for at least Six weeks during semester break**

 # Students should conduct the Literature Survey for the proposed research topic and they need to develop a prototype or simulation based (must be outcome oriented) – the same to be presented in any conference (national or international)

Semester III **Contact Hours:27**

S.No	Course Type	Course Code	Title of the Course	L	T	P	Credits
1.	ProgrammeElective - V	**24CESE601**	Choice for students to complete course in any MOOCS Platform(from NPTEL/Swayam/others)*	3	0	0	3
2.	Internship	**24CESE691**	Internship/Summer Training in Research Organizations/ Institutions of Higher Learning (After II Sem)	0	0	4	2
3.	Project(Part-A)	**24CESE692**	Dissertation*/ Project/ Research Organization	0	0	20	10
Total				**3**	**0**	**24**	**15**

L – Lecture, T – Tutorial, P – Practical, C – Credits

***To be continued in the IV Semester Program Elective V may be completed in semester I or II by satisfying the pre-requisites those who are going for industrial project**

Semester IV **Contact Hours:32**

S.No	Course Type	Course Code	Title of the Course	L	T	P	Credits
1.	Project (Part-B)	**24CESE693**	Dissertation/ Industrial Project	0	0	32	16
Total				**0**	**0**	**32**	**16**

L – Lecture, T – Tutorial, P – Practical, C – Credits

Semester	Credits
1	**19**
2	**20**
3	**15**
4	**16**
Total	**70**

Note:

1. Student has to carry out a project applying the knowledge and hands on technical skills they have gained through course work and lab sessions in **Semester-I** under **Capstone Project 1**
2. Student should carry out literature survey of the selected problem and present it in a Seminar for the yearlong Project Work under Term Paper.
3. Student has to carry out a project applying the knowledge and hands on technical skills they have gained through course work and lab sessions in **Semester-II** under **Capstone Project 2**
4. At least one theory course in **I &II** semesters can be made as integrated course (Theory coupled with Laboratory).
5. Maximum of three theory courses (40% of courses) can be offered as self-learning courses in each of the First and Second semesters.

SEMESTER I

24CESE501	COMPUTER AIDED ADVANCED STRUCTURAL ANALYSIS (*INTEGRATED COURSE)		
Course Category:	Programme Core - I	**Credits:**	3
Course Type:	Theory cum Practice	**Lecture - Tutorial - Practice:**	2-0-2
Prerequisites:	Structural analysis	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:
This course is designed for advanced structural engineering students, providing a comprehensive understanding of structural analysis using computer-aided tools. The course integrates theoretical concepts with practical application using software such as Staad Pro. Key topics include the analysis of statically determinate and indeterminate structures, approximate analysis of building frames, stiffness methods, seismic analysis, and advanced nonlinear structural analysis. Practical sessions complement the theoretical knowledge, offering hands-on experience with advanced structural analysis software.

Course Aims and Objectives:
1. Impart fundamental knowledge of structural analysis concepts.
2. Enable students to analyze both statically determinate and indeterminate structures.
3. Introduce the use of Staad Pro for structural analysis.
4. Develop skills in the stiffness method and its application in various structural analyses.
5. Provide understanding and practical skills in seismic analysis as per IS 1893-Part 1-2016.
6. Explore advanced nonlinear analysis methods, including geometric and material nonlinearity.
7. Conduct buckling analysis and stability checks using advanced tools.

Course Outcomes:
At the end of the course, the student will be able to:

CO 1: Apply basic structural analysis concepts to statically determinate and indeterminate structures [K3].
CO 2: Use Staad Pro for modeling and analyzing building frames under various loads [K4].
CO 3: Implement the stiffness method for analyzing different structural systems [K4].
CO 4: Conduct seismic analysis using prescribed codes and standards [K4].
CO 5: Perform advanced nonlinear analysis and buckling stability checks using specialized software [K5].

Course Structure:
Unit 1: Introduction to Structural Analysis
- **Theory:**
  - Basic Concepts in Structural Analysis
  - Analysis of Statically Determinate Structures
  - Principle of Virtual Work
  - Energy Methods
  - Force Methods
  - Statically Indeterminate Structures
  - Displacement Methods
  - Kinematically Indeterminate Structures
- **Practice Sessions:**
  - Introduction to Staad Pro
  - Tools in Staad Pro

Description:
This unit introduces fundamental concepts in structural analysis, focusing on both statically determinate and indeterminate structures. It also covers key methods like virtual work, energy methods, and displacement methods. Practice sessions include an introduction to Staad Pro and its essential tools.

Examples/Applications/Case Studies:
- Analyzing simple trusses and beams in statically determinate structures.
- Application of virtual work to calculate deflections.
- Use of energy methods in beam deflection analysis.
- Introduction to Staad Pro for structural modeling.

Exercises/Projects:
- Problems on shear force and bending moment diagrams.

- Assignments on deflection calculations using virtual work.
- Exercises using Staad Pro to model simple structures.

Learning Outcomes:

- Apply basic structural analysis concepts to determine internal forces.
- Analyze statically determinate and indeterminate structures.
- Utilize Staad Pro for basic structural analysis tasks.

Specific Resources:

- *"Structural Analysis"* by R. C. Hibbeler
- *"STAAD Pro V8i for Beginners"* by T.S. Sarma

Unit 2: Approximate Analysis of Building Frames

- **Theory:**
  - Vertical Loads (Substitute Frame Method)
  - Lateral Loads (Portal Frames, Cantilever Frames)
- **Practice Sessions:**
  - Modelling the Frame in Staad Pro
  - Applying Loads and Structural Components Analysis using Staad Pro

Description:

This unit covers the approximate analysis of building frames under vertical and lateral loads. Theoretical concepts include methods like the substitute frame method for vertical loads and analysis of portal and cantilever frames for lateral loads. Practice sessions involve modeling these frames in Staad Pro and performing structural analysis under applied loads.

Examples/Applications/Case Studies:

- Approximate analysis of multi-story building frames under vertical loads using the substitute frame method.
- Application of portal and cantilever methods for lateral load analysis in tall buildings.
- Case studies on earthquake-resistant building design.

Exercises/Projects:

- Problems on the approximate analysis of building frames under different loading conditions.
- Exercises on modeling building frames in Staad Pro and analyzing the effects of vertical and lateral loads.
- Projects focused on structural stability analysis using Staad Pro.

Learning Outcomes:

- Perform approximate analysis of building frames under vertical and lateral loads.
- Model and analyze building frames using Staad Pro.
- Apply theoretical methods to practical structural analysis tasks in Staad Pro.

Specific Resources:

- *"Structural Analysis"* by R. C. Hibbeler
- *"STAAD Pro V8i for Beginners"* by T.S. Sarma

Unit 3: Stiffness Method

- **Theory:**
  - Steps in Stiffness Method
  - Transformation Matrix
  - Overall Stiffness Matrix
  - Boundary Conditions
  - Equivalent Joint Load
  - Analysis of Plane Truss, Continuous Beam, Plane Frame, Grid, Space Frame
- **Practice Sessions:**
  - Computer Analysis of Plane Truss using Staad Pro Software
  - Computer Analysis of Continuous Beam, Plane Frame, Grid, and Space Frame using Staad Pro Software

Description:

This unit focuses on the stiffness method, a fundamental approach in structural analysis. Theoretical concepts include the steps involved in the stiffness method, the formation of the transformation and overall stiffness matrices, application of boundary conditions, and determination of equivalent joint loads. The unit also covers the analysis of various structures, such as plane trusses, continuous beams, plane frames, grids, and space frames. Practice sessions involve using Staad Pro software for computer-based analysis of these structures.

Examples/Applications/Case Studies:

- Step-by-step analysis of a plane truss using the stiffness method.
- Application of the stiffness method to analyze a continuous beam and determine internal forces.

- Case study on the application of the stiffness method in the design of a space frame for an industrial structure.

Exercises/Projects:

- Problems on forming and solving stiffness matrices for different structural elements.
- Exercises on modeling and analyzing a plane truss using Staad Pro.
- Projects involving the computer analysis of continuous beams, plane frames, grids, and space frames using Staad Pro.

Learning Outcomes:

- Understand and apply the stiffness method to analyze various types of structures.
- Develop and solve stiffness matrices for complex structural systems.
- Perform computer-based structural analysis using Staad Pro.

Specific Resources:

- *"Matrix Analysis of Structures"* by Aslam Kassimali
- *"STAAD Pro V8i for Beginners"* by T.S. Sarma

Unit 4: Seismic Analysis

- **Theory:**
  - Seismic Analysis by Seismic Coefficient Method (as per IS 1893-Part 1-2016)
  - Response Spectrum Analysis
- **Practice Sessions:**
  - Seismic Analysis by Seismic Coefficient Method (as per IS 1893-Part 1-2016) using Software
  - Response Spectrum Analysis of Multi-storey Building Frames using Software

Description:

This unit introduces the fundamental concepts of seismic analysis, focusing on the Seismic Coefficient Method and Response Spectrum Analysis, in accordance with IS 1893-Part 1-2016. Theoretical sessions cover the principles and procedures for performing seismic analysis on structures to assess their response during earthquakes. Practice sessions involve applying these methods to multi-storey building frames using specialized software.

Examples/Applications/Case Studies:

- Seismic analysis of a multi-storey building using the Seismic Coefficient Method as per IS 1893-Part 1-2016.
- Application of Response Spectrum Analysis to evaluate the dynamic response of building frames during an earthquake.
- Case studies on the seismic retrofitting of existing structures.

Exercises/Projects:

- Problems on calculating seismic forces using the Seismic Coefficient Method.
- Exercises on performing Response Spectrum Analysis for different building configurations using software.
- Projects involving the seismic analysis of multi-storey buildings, including comparisons between different analysis methods.

Learning Outcomes:

- Understand and apply the Seismic Coefficient Method and Response Spectrum Analysis for seismic evaluation of structures.
- Conduct seismic analysis of building frames in compliance with IS 1893-Part 1-2016.
- Utilize software tools to perform and interpret seismic analysis results.

Specific Resources:

- *"Earthquake Resistant Design of Structures"* by Pankaj Agarwal and Manish Shrikhande
- *"STAAD Pro V8i for Beginners"* by T.S. Sarma

Unit 5: Advanced Structural Analysis

- **Theory:**
  - Nonlinear Analysis Methods
    - Geometric Nonlinearity
    - Material Nonlinearity
  - Buckling Analysis and Stability Considerations
    - Eigenvalue Buckling Analysis
    - Nonlinear Buckling Analysis
- **Practice Sessions:**
  - Case Studies in Nonlinear Structural Analysis
    - Application of Geometric and Material Nonlinearities in Structural Analysis
    - Simulation of Nonlinear Structural Behavior using Software
  - Buckling Analysis and Stability Checks using Advanced Analysis Tools

- Practical Exercises on Eigenvalue and Nonlinear Buckling Analysis
- Hands-on Practice with Advanced Analysis Software for Stability Checks

Description:

This unit delves into advanced structural analysis techniques, focusing on nonlinear analysis methods and buckling analysis. The theoretical component covers both geometric and material nonlinearity, as well as eigenvalue and nonlinear buckling analysis. Practice sessions are designed to apply these advanced concepts through case studies and simulations, using specialized software tools for nonlinear structural behavior and stability checks.

Examples/Applications/Case Studies:

- Nonlinear analysis of a steel frame considering geometric nonlinearity during large deformations.
- Case studies on the effects of material nonlinearity in concrete structures under high stress.
- Application of eigenvalue buckling analysis to assess the stability of slender columns.

Exercises/Projects:

- Problems on simulating nonlinear behavior in structural components using advanced analysis software.
- Exercises on performing eigenvalue and nonlinear buckling analysis for complex structures.

Learning Outcomes:

- Understand and apply nonlinear analysis methods, including geometric and material nonlinearity, in structural analysis.
- Perform buckling analysis and evaluate the stability of structures using both eigenvalue and nonlinear approaches.
- Utilize advanced structural analysis software for simulating and analyzing complex structural behaviors.

Specific Resources:

- *"Nonlinear Structural Analysis for Seismic Design"* by Paolo P. Rossi and Andrea Decò
- *"Stability and Optimization of Structures: Generalized Sensitivity Analysis"* by Makoto Ohsaki
- *"Advanced Structural Analysis with Staad Pro V8i"* by T.S. Sarma

Textbook(s) / Reference(s):

Textbooks:

1. **Meek, J.L.** (1971). *Computer Methods in Structural Analysis*. Chapman and Hall.
2. **Menon, D.** (2009). *Advanced Structural Analysis*. Alpha Science International Ltd.
3. **Advanced Structural Analysis** by **C. S. Reddy** 2017, McGraw-Hill Education
4. R.Vaidyanathan & P.Perumal (2004) Structural Analysis, Laxmi Publications
5. Pankaj Agarwal (2011)*"Earthquake Resistant Design of Structures"* by and Manish Shrikhande

References:

1. **Krishnamoorthy, C.S.** (1995). *Finite Element Analysis: Theory and Programming*. Tata McGraw-Hill Education.
2. **Rajasekaran, S.** (2001). *Computer-Aided Analysis of Structural Systems*. A.H. Wheeler & Co.
3. Hibbeler, R.C. (2016). Structural Analysis (10th ed.). Pearson.
4. Timoshenko, S.P., & Gere, J.M. (1961). Theory of Elastic Stability (2nd ed.). McGraw-Hill.

Mapping of Course Outcomes to Program Outcomes:

(H=high; M=medium; L=low)

	PO1	PO2	PO3	PO4	PO5
CO1	H	M	M	M	L
CO2	H	M	M	M	L
CO3	H		M	L	
CO4	H		M	L	
CO5	H		M	L	

24CESE502	THEORY OF ELASTICITY AND PLASTICITY

Course Category:	Programme Core- II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Strength of Materials	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description

This course provides a comprehensive introduction to the theory of elasticity and plasticity, focusing on the fundamental principles and their applications in engineering problems. Students will explore two-dimensional elasticity problems, Cartesian tensors, three-dimensional stress-strain relations, energy theorems, torsion of straight bars, and basic concepts of plasticity. The course is designed for advanced undergraduate and graduate students in civil and mechanical engineering.

Course Aims and Objectives

1. **Introduction to Elasticity**: Understand the basics of elasticity concepts and their application to two-dimensional and three-dimensional problems.
2. **Cartesian Tensors and Stress-Strain Relations**: Learn the transformation laws of Cartesian tensors and apply them to three-dimensional stress-strain problems.
3. **Energy Theorems**: Explore energy theorems and variational principles in elasticity, including virtual work and potential energy principles.
4. **Torsion of Bars**: Analyze the torsional stress and strain distribution in straight bars.
5. **Introduction to Plasticity**: Gain insights into one-dimensional elastic-plastic relations and the governing equations of elastoplasticity.

Course Outcomes

By the end of this course, students will be able to:

1. **CO1**: Apply basic elasticity concepts to solve two-dimensional problems in rectangular and polar coordinates.
2. **CO2**: Utilize transformation laws and tensor notation to address three-dimensional stress-strain relations.
3. **CO3**: Implement energy theorems and variational principles to solve elasticity problems.
4. **CO4**: Analyze torsional stress and strain in straight bars using Saint Venant’s torsion theory.
5. **CO5**: Understand and apply fundamental principles of plasticity to engineering problems.

Course Structure

Unit 1: Introduction to Elasticity and Two-Dimensional Problems

Contents:

- Basics of Elasticity Concepts
- Equation of Equilibrium
- Strain-Displacement Relations
- Two-Dimensional Problems in Rectangular Coordinates:
  - Stress Function
  - Solution by Polynomials
  - Saint Venant’s Principle
  - Bending of a Cantilever
  - Determination of Displacements
- Two-Dimensional Problems in Polar Coordinates:
  - General Equations
  - Axisymmetric Stress Distribution
  - Pure Bending of Curved Bars
  - Effect of Circular Hole on Stress Distribution in Plates

Description:

This unit covers the fundamentals of elasticity, focusing on two-dimensional problems in rectangular coordinates. Key topics include stress functions, strain-displacement relations, and the effects of stress concentration around geometric features.

Examples/Applications/Case Studies:

- Application of stress function solutions to analyze stress distribution in a rectangular plate under load.
- Case study on the bending of a cantilever beam using Saint Venant's principle.
- Analysis of the effect of a circular hole on stress distribution in pressure vessels.

Exercises/Projects:

- Problems on solving two-dimensional elasticity problems using polynomial solutions.
- Exercises on determining displacements in cantilever beams under various loading conditions.
- Projects involving the analysis of axisymmetric stress distribution in circular plates using polar coordinates.

Learning Outcomes:

- Understand the basic concepts of elasticity and apply them to solve two-dimensional problems.
- Analyze stress and strain in two-dimensional structures using both rectangular and polar coordinates.
- Apply principles such as Saint Venant's to simplify complex structural problems.

Specific Resources:

- *"Theory of Elasticity"* by S. P. Timoshenko and J. N. Goodier
- *"Advanced Strength and Applied Elasticity"* by Ansel C. Ugural and Saul K. Fenster

Unit 2: Cartesian Tensors and Stress-Strain Problems in 3D

Contents:

- Transformation Laws of Cartesian Tensors
- Symmetry and Skew-Symmetry
- Contraction, Derivatives, and Comma Notation
- Gauss' Theorem
- Base Vectors and Special Vector Operations
- Eigenvalue Problem of a Symmetric Second-Order Tensor
- Equations of Elasticity Using Index Notation
- Stress-Strain Relations in Three Dimensions
- Principal Stresses and Strains

Description:

This unit introduces Cartesian tensors and their application in three-dimensional stress-strain analysis. It covers key concepts like tensor transformation laws, symmetry, eigenvalue problems, and the use of index notation in equations of elasticity.

Examples/Applications/Case Studies:

- Calculation of principal stresses and strains in 3D structures.
- Application of Gauss' theorem in elasticity equations.
- Case study on eigenvalue analysis for material stability.

Exercises/Projects:

- Problems on tensor transformation laws in stress-strain analysis.
- Exercises on deriving elasticity equations using index notation.
- Projects analyzing stress-strain relations and principal stresses in 3D.

Learning Outcomes:

- Apply Cartesian tensor transformation laws to solve 3D stress-strain problems.
- Use symmetry and eigenvalue analysis in structural material assessments.
- Derive and apply elasticity equations using index notation.

Specific Resources:

- *"Introduction to Tensor Calculus and Continuum Mechanics"* by J.H. Heinbockel
- *"Elasticity: Theory, Applications, and Numerics"* by Martin H. Sadd

Unit 3: Energy Theorems and Variational Principles of Elasticity

Contents:

- Strain Energy and Complementary Energy
- Clapeyron's Theorem
- Virtual Work and Potential Energy Principles
- Principle of Complementary Potential Energy
- Betti's Reciprocal Theorem
- Principle of Linear Superposition
- Uniqueness of Elasticity Solutions

Description:

This unit focuses on energy theorems and variational principles in elasticity. It covers concepts such as strain and complementary energy, Clapeyron's theorem, virtual work, and potential energy principles. Key topics also include Betti's reciprocal theorem, the principle of linear superposition, and the uniqueness of elasticity solutions.

Examples/Applications/Case Studies:

- Application of Clapeyron's theorem to solve structural problems.

- Use of virtual work and potential energy principles in structural analysis.
- Case study on Betti's reciprocal theorem in complex load scenarios.

Exercises/Projects:

- Problems on calculating strain and complementary energy in elastic systems.
- Exercises using virtual work and potential energy principles to analyze structures.
- Projects involving the application of Betti's theorem and the principle of linear superposition.

Learning Outcomes:

- Apply energy theorems and variational principles to solve elasticity problems.
- Use Clapeyron's theorem and virtual work principles in structural analysis.
- Understand and apply Betti's reciprocal theorem and linear superposition principles.

Specific Resources:

- *"Theory of Elasticity"* by S. P. Timoshenko and J. N. Goodier
- *"Applied Elasticity"* by G.A. Kardomatea

Unit 4: Torsion of Straight Bars

Contents:

- Torsion of Straight Bars
- Analysis of Torsional Stress and Strain Distribution
- Saint Venant's Torsion Theory

Description:

This unit covers the torsion of straight bars, focusing on the analysis of torsional stress and strain distribution. It includes Saint Venant's torsion theory and its application to various bar shapes and loading conditions.

Examples/Applications/Case Studies:

- Analysis of torsional stress in shafts and beams under different loading conditions.
- Application of Saint Venant's torsion theory to solve practical engineering problems.

Exercises/Projects:

- Problems on calculating torsional stress and strain distribution in straight bars.
- Exercises applying Saint Venant's torsion theory to various bar geometries.

Learning Outcomes:

- Analyze torsional stress and strain distribution in straight bars.
- Apply Saint Venant's torsion theory to practical engineering problems.

Specific Resources:

- *"Theory of Elasticity"* by S. P. Timoshenko and J. N. Goodier
- *"Mechanics of Materials"* by Ferdinand P. Beer

Unit 5: Introduction to Plasticity

Contents:

- One-Dimensional Elastic-Plastic Relations
- Isotropic and Kinematic Hardening
- Yield Function
- Flow Rule
- Hardening Rule
- Incremental Stress-Strain Relationship
- Governing Equations of Elastoplasticity

Description:

This unit introduces the fundamental concepts of plasticity, focusing on one-dimensional elastic-plastic relations and key theories such as isotropic and kinematic hardening. It covers yield functions, flow rules, hardening rules, and incremental stress-strain relationships in elastoplasticity.

Examples/Applications/Case Studies:

- Application of yield functions and hardening rules in predicting material behavior under loading.
- Case study on the analysis of stress-strain relationships in plastic deformation scenarios.

Exercises/Projects:

- Problems on deriving and applying one-dimensional elastic-plastic relations.
- Exercises on using flow and hardening rules to analyze material behavior.
- Projects involving the application of governing equations of elastoplasticity to real-world problems.

Learning Outcomes:

- Understand and apply one-dimensional elastic-plastic relations and hardening rules.
- Analyze material behavior using yield functions and incremental stress-strain relationships.
- Solve problems using the governing equations of elastoplasticity.

Specific Resources:

- *"Introduction to Plasticity and Plastic Analysis"* by John W. Milne
- *"Plasticity for Structural Engineers"* by Gary J. G. St. John and Ian M. Smith

Textbooks / References

Textbooks

1. **Elasticity: Theory, Applications, and Numerics** by Martin H. Sadd, 3rd Edition, Elsevier, 2014.
2. **Plasticity for Structural Engineers** by W. F. Chen and D. J. Han, J. Ross Publishing, 2007
3. **Theory of Elasticity** by Timoshenko and Goodier, 3rd Edition, McGraw-Hill, 1970.
4. **Theory of Elasticity by T.G.**Sitharam, L.Govindaraju,Springer Publication

References

1. Chakrabarty, J, Theory of Plasticity, Elsevier, London, 2006.
2. **Mechanics of Materials** by Beer and Johnston, 6th Edition, McGraw-Hill, 2011.
3. **Advanced Mechanics of Materials** by Arthur P. Boresi and Richard J. Schmidt, 6th Edition, John Wiley & Sons, 2002.
4. Continuum Theory of Plasticity by by Akhtar S. Khan (Author), Sujian Huang (Author), 1st Edition, Elsevier, 1995.

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO1	M		H		L
CO2	M		H		L
CO3	M		H		L
CO4	M		H		M
CO5	M		H		M

24CESE503	STRUCTURAL DYNAMICS (Integrated Course)

Course Category:	Programme Core-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Engineering Mechanics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description: This course explores fundamental and advanced concepts of Structural Dynamics, focusing on the dynamic behavior of structures under various loading conditions. It includes theoretical analysis and practical applications involving software simulations, shake table models, and strain gauges to understand and evaluate the response of structures subjected to dynamic loads. Topics covered include free and forced vibrations of single-degree-of-freedom (SDOF) and multi-degree-of-freedom (MDOF) systems, numerical techniques for dynamic response evaluation, seismic analysis, and seismic isolation.

Course Aims and Objectives:

1. Introduce the fundamental concepts and significance of structural dynamics in engineering.
2. Analyze the free and forced vibration behavior of SDOF systems.
3. Apply numerical techniques to evaluate the dynamic response of structures.
4. Examine the dynamic characteristics and response of MDOF systems.
5. Understand advanced forced vibration analysis and seismic design techniques.
6. Explore seismic isolation techniques and advanced topics in structural dynamics.

Course Outcomes: By the end of the course, students will be able to:

CO 1: Understand and apply the fundamental concepts of structural dynamics, including the analysis of free and forced vibrations in Single-Degree-of-Freedom (SDOF) systems.
CO2: Analyze and evaluate the dynamic response of structures subjected to forced vibrations and non-periodic excitations using numerical techniques.
CO3: Conduct modal analysis of Multi-Degree-of-Freedom (MDOF) systems, determining natural frequencies, mode shapes, and response behavior.
CO:4 Implement advanced forced vibration analysis techniques, including seismic analysis using Response Spectrum Analysis (RSA), to assess structural performance under dynamic loads.
CO5: Apply seismic isolation techniques in structural design to reduce seismic responses and enhance the dynamic performance of structures.Course Structure:

Unit I: Introduction to Structural Dynamics

- **Theory:**
  - Introduction to Structural Dynamics: Fundamental concepts and significance in engineering.
  - Free Vibration of SDOF Systems: Characteristics including natural frequency, damping effects, and response analysis.
  - Forced Harmonic Vibrations of SDOF Systems: Response behavior under harmonic excitations, resonance phenomena.
  - Response of SDOF Systems to Harmonic Excitations: Analysis of amplitude, phase, and frequency response.
- **Practice Session:**
  - Use STAAD Pro to model and analyze the free and forced vibrations of SDOF systems.
  - Perform shake table experiments to visualize the response of SDOF models to harmonic excitations.

Description:
This unit introduces structural dynamics, focusing on the fundamental concepts of free and forced vibrations in Single Degree of Freedom (SDOF) systems. It covers natural frequency, damping effects, resonance phenomena, and response analysis to harmonic excitations. Practice sessions involve using STAAD Pro for modeling and analyzing vibrations, and conducting shake table experiments.
Examples/Applications/Case Studies:

- Analysis of natural frequency and damping effects in SDOF systems.
- Case study on resonance phenomena and its impact on structural safety.
- Visualization of harmonic excitation responses through shake table experiments.

Exercises/Projects:

- Problems on calculating and analyzing free and forced vibrations in SDOF systems.
- STAAD Pro exercises for modeling vibration responses and performing dynamic analysis.
- Projects involving shake table experiments to study real-world vibration effects.

Learning Outcomes:

- Analyze free and forced vibrations in SDOF systems and understand their dynamic behavior.
- Model and analyze vibration responses using STAAD Pro.
- Conduct and interpret shake table experiments for harmonic excitations.

Specific Resources:

- *"Structural Dynamics: Theory and Computation"* by Mario Paz
- *"STAAD Pro V8i for Beginners"* by T.S. Sarma

Unit II: Forced Vibrations and Non-Periodic Excitations

- **Theory:**
  - Forced Vibrations: Characteristics of non-periodic excitations, transient response analysis.
  - Numerical Response Evaluation Techniques: Overview of time integration methods such as Newmark methods.
  - Application of Numerical Techniques: Practical applications in structural dynamics.
- **Practice Session:**
  - Analyze forced vibrations and transient responses using STAAD Pro.
  - Apply numerical integration techniques to evaluate the dynamic response of structures.
  - Conduct experiments using shake tables to simulate non-periodic excitations and validate numerical results.

Description:
This unit explores forced vibrations and non-periodic excitations in structural dynamics. It covers characteristics of non-periodic excitations, transient response analysis, and numerical response evaluation techniques, including time integration methods such as Newmark's method. Practical applications and validation through experiments are emphasized.
Examples/Applications/Case Studies:

- Analysis of structural response to non-periodic excitations and transient loads.
- Application of Newmark's method for time integration in dynamic response evaluation.
- Case study on validating numerical results with experimental data from shake table tests.

Exercises/Projects:

- Problems on analyzing forced vibrations and transient responses using STAAD Pro.
- Exercises applying numerical integration techniques to evaluate structural dynamics.
- Projects involving shake table experiments to simulate and validate non-periodic excitations.

Learning Outcomes:

- Analyze forced vibrations and transient responses of structures to non-periodic excitations.
- Apply numerical integration techniques for dynamic response evaluation.
- Validate theoretical results through practical experiments and simulations.

Specific Resources:

- *"Structural Dynamics: Theory and Computation"* by Mario Paz
- *"Dynamics of Structures: Theory and Applications to Earthquake Engineering"* by Anil K. Chopra

Unit III: Multi-Degree-of-Freedom (MDOF) Systems

- **Theory:**
  - Generalized SDOF Systems: Different damping models and their implications on system response.
  - Introduction to MDOF Systems: Configuration, degrees of freedom, and modal analysis principles.
  - Free Vibration Analysis of MDOF Systems: Modal participation factors, mode shapes, and natural frequencies.
- **Practice Session:**
  - Use STAAD Pro for modal analysis of MDOF systems, including the determination of natural frequencies and mode shapes.
  - Conduct shake table experiments to observe the dynamic behavior of MDOF structures.

Description:
This unit covers Multi-Degree-of-Freedom (MDOF) systems, including their configuration, degrees of freedom, and modal analysis principles. It extends the concepts of Single Degree of Freedom (SDOF) systems to more complex structures, focusing on free vibration analysis, modal participation factors, mode shapes, and natural frequencies.

Examples/Applications/Case Studies:

- Modal analysis of MDOF systems to determine natural frequencies and mode shapes.
- Case study on the dynamic behavior of complex structures using shake table experiments.

Exercises/Projects:

- Problems on modal analysis of MDOF systems using STAAD Pro.
- Exercises determining natural frequencies and mode shapes for MDOF structures.
- Projects involving shake table experiments to study the dynamic response of MDOF systems.

Learning Outcomes:

- Analyze and interpret the dynamic behavior of MDOF systems, including modal analysis and natural frequencies.
- Use STAAD Pro for detailed modal analysis of complex structures.
- Validate theoretical results through shake table experiments on MDOF systems.

Specific Resources:

- *"Structural Dynamics: Theory and Computation"* by Mario Paz
- *"Dynamics of Structures: Theory and Applications to Earthquake Engineering"* by Anil K. Chopra

Unit IV: Advanced Forced Vibration Analysis

- **Theory:**
  - Forced Vibration Analysis of MDOF Systems: Modal superposition methods for analyzing forced responses.
  - Seismic Analysis Techniques: Principles of Response Spectrum Analysis (RSA) and its application in seismic design.
- **Practice Session:**
  - Implement advanced forced vibration analysis techniques using STAAD Pro.
  - Simulate seismic loads and perform response spectrum analysis.
  - Conduct shake table experiments to study the impact of seismic loads on MDOF structures and validate analytical results.

Description:
This unit focuses on advanced forced vibration analysis, including modal superposition methods for Multi-Degree-of-Freedom (MDOF) systems and seismic analysis techniques. It covers the principles of Response Spectrum Analysis (RSA) and its application in seismic design, with practice sessions on implementing these techniques using STAAD Pro.

Examples/Applications/Case Studies:

- Application of modal superposition methods to analyze forced responses in MDOF systems.
- Case study on Response Spectrum Analysis (RSA) for seismic design of high-rise buildings.
- Shake table experiments to study and validate the impact of seismic loads on MDOF structures.

Exercises/Projects:

- Problems on advanced forced vibration analysis using STAAD Pro.

- Exercises on performing Response Spectrum Analysis for seismic load simulations.
- Projects involving shake table experiments to validate seismic response predictions for MDOF structures.

Learning Outcomes:

- Apply modal superposition methods for analyzing forced vibrations in MDOF systems.
- Use Response Spectrum Analysis (RSA) for seismic design and evaluation.
- Validate analytical results with shake table experiments simulating seismic loads.

Specific Resources:

- *"Structural Dynamics: Theory and Computation"* by Mario Paz
- *"Dynamics of Structures: Theory and Applications to Earthquake Engineering"* by Anil K. Chopra

Unit V: Seismic Isolation and Structural Dynamics

- **Theory:**
  - Seismic Isolation Techniques: Principles and applications of base isolation for reducing seismic responses.
  - Advanced Topics in Structural Dynamics: Specialized topics such as dynamic response of structures.
- **Practice Session:**
  - Use STAAD Pro to model and analyze structures with seismic isolation systems.
  - Perform shake table experiments to evaluate the effectiveness of seismic isolation techniques.

Description:

This unit covers seismic isolation techniques and advanced topics in structural dynamics. It explores principles and applications of base isolation for mitigating seismic responses and includes specialized topics on the dynamic response of structures.

Examples/Applications/Case Studies:

- Application of base isolation techniques in reducing seismic responses of buildings.
- Case study on the effectiveness of seismic isolation systems in real-world scenarios.

Exercises/Projects:

- Modeling and analysis of structures with seismic isolation systems using STAAD Pro.
- Shake table experiments to assess the performance of seismic isolation techniques.

Learning Outcomes:

- Understand and apply seismic isolation techniques to reduce seismic responses.
- Analyze and evaluate the effectiveness of isolation systems through modeling and experimental methods.

Specific Resources:

- *"Seismic Isolation for Architects: Design and Deployment"* by Jeffrey D. Schaffer
- *"Dynamics of Structures: Theory and Applications to Earthquake Engineering"* by Anil K. Chopra

Textbook(s) / Reference(s):

Textbooks:

1. Chopra, A. K. (2017). Dynamics of Structures (5th ed.). Pearson.
2. Craig, R. R., &Kurdila, A. J. (2006). Fundamentals of Structural Dynamics (2nd ed.). John Wiley & Sons.

References:

1. Clough, R. W., & Penzien, J. (1993). Dynamics of Structures (2nd ed.). McGraw-Hill.
2. Den Hartog, J. P. (1985). Mechanical Vibrations (4th ed.). Dover Publications.
3. Biggs, J. M. (1964). Introduction to Structural Dynamics. McGraw-Hill.
4. Tedesco, J. W., McDougal, W. G., & Ross, C. A. (1999). Structural Dynamics: Theory and Applications. Addison-Wesley.

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	H				
CO2	H	M	M		L
CO3	H	M	M		M
CO4	H		H		M

24CESE504 A.	Advanced Steel Building (*INTEGRATED COURSE)

Course Category:	Program Elective - I	**Credits:**	3
Course Type:	Theory cum Practice	**Lecture - Tutorial - Practice:**	2 – 0 - 2
Prerequisites:	Design of steel structures	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

This course integrates the principles and applications of wind loads on buildings, industrial buildings, towers, connections, and steel truss girder bridges with practical sessions using STAAD Pro software. Students will learn to design and analyze various structures under wind loads and other conditions, enhancing theoretical knowledge through hands-on practice.

Course Aim and Objectives:

The aim of this course is to provide a comprehensive understanding of structural design principles under wind loads and the application of structural analysis using STAAD Pro.

Course Objectives:

1. To understand the fundamentals of wind loads and their effects on different structures.
2. To design braced and unbraced industrial buildings.
3. To analyze and design towers and connections.
4. To understand the design principles of steel truss girder bridges.
5. To integrate practical structural analysis using STAAD Pro in structural design.

Course Outcomes:

After completion of the course, students should be able to:

1. Understand wind load principles and their application in building design.
2. Design and analyze braced and unbraced industrial buildings using STAAD Pro.
3. Design towers and connections under various loading conditions.
4. Analyze and design steel truss girder bridges.
5. Perform structural analysis using STAAD Pro to validate structural designs.

UNIT I: Wind Loads on Buildings (8 hours)

Theory:

- Introduction to wind load
- Design wind speed and pressure
- Wind pressure on roofs
- Wind effect on cladding and louvers
- Design of purlins for roofs and rails for cladding
- Open sheds – Pitched roofs

Practice Session:

- Use STAAD Pro to simulate wind load effects on a building roof.
    - Set up wind load parameters and boundary conditions.
    - Analyze wind pressure distribution on the roof.
    - Interpret and validate results.
- Design purlins and rails for cladding using STAAD Pro.
    - Define load cases and apply wind loads.
    - Perform structural analysis and design.
    - Compare results with manual calculations.

Description:

This unit covers wind loads on buildings, including the fundamentals of wind load design, pressure calculations, and the impact on roofs, cladding, and structural elements like purlins and rails. It includes practical applications for modeling wind load effects and designing components using STAAD Pro.

Examples/Applications/Case Studies:

- Calculation and application of wind pressures on different building components.
- Case study on the design and analysis of purlins and cladding systems under wind loads.

Exercises/Projects:

- Simulate wind load effects on building roofs using STAAD Pro.
- Design and analyze purlins and rails for cladding with STAAD Pro, and compare results with manual calculations.

Learning Outcomes:

- Apply wind load design principles to buildings and structural components.
- Use STAAD Pro for analyzing wind load effects and designing structural elements.
- Validate simulation results with manual calculations.

Specific Resources:

- *"Wind Loads and Their Effects on Structures"* by Charles A. S. Morrison
- *"Structural Analysis with STAAD Pro"* by T.S. Sarma

UNIT II: Industrial Buildings (10 hours)

Theory:

- Introduction to braced and Unbraced industrial buildings
- Design of braced small industrial building with gantry

Practice Session:

- Model and analyze a braced industrial building using STAAD Pro.
    - Set up the geometry, material properties, and boundary conditions.
    - Apply loads, including wind loads.
    - Analyze the structural behavior and validate the design.
- Perform a detailed analysis of the industrial building with a gantry crane using STAAD Pro.
    - Set up the loading conditions.
    - Analyze the response of the structure and interpret results.

Description:

This unit focuses on the design and analysis of industrial buildings, including both braced and unbraced configurations. It covers the design of small industrial buildings with gantry cranes and provides practical experience in modeling and analyzing these structures using STAAD Pro.

Examples/Applications/Case Studies:

- Design and analysis of braced industrial buildings and gantry cranes.
- Case study on the impact of wind loads and structural behavior in industrial buildings.

Exercises/Projects:

- Model and analyze a braced industrial building using STAAD Pro, including geometry setup and load application.
- Perform a detailed analysis of an industrial building with a gantry crane, setting up loading conditions and interpreting the structural response.

Learning Outcomes:

- Design and analyze braced and unbraced industrial buildings using STAAD Pro.
- Understand the effects of different loads on industrial structures, including gantry cranes.
- Validate and interpret structural analysis results.

Specific Resources:

- *"Design of Industrial Structures"* by H. W. Chen
- *"Structural Analysis with STAAD Pro"* by T.S. Sarma

UNIT III: Frames and Towers (10 hours)

Theory:

- Rigid frames
- Rigid frame knees
- Gable frames
- Design of a simple gable frame industrial building
- Towers: free-standing and guyed towers, wind loads and foundation design
- Design criteria for different configurations and transmission line towers

Practice Session:

- Design and analyze a simple gable frame industrial building using STAAD Pro.
    - Set up the structural model and apply loads.
    - Perform analysis and interpret the results.
- Use STAAD Pro to perform a stress analysis on rigid frame knees.
    - Define the geometry and loading conditions.
    - Analyze stress distribution and validate the design.

Description:

This unit covers the design and analysis of frames and towers, including rigid frames, gable frames, and different types of towers such as free-standing and guyed towers. It emphasizes the design of simple gable frame industrial buildings and the analysis of frame knees and towers under various loads.

Examples/Applications/Case Studies:

- Design and analysis of gable frame industrial buildings.
- Case study on the impact of wind loads on free-standing and guyed towers.
- Analysis of stress distribution in rigid frame knees.

Exercises/Projects:

- Design and analyze a simple gable frame industrial building using STAAD Pro, including load application and result interpretation.
- Perform stress analysis on rigid frame knees with STAAD Pro, defining geometry and loading conditions.

Learning Outcomes:

- Design and analyze rigid frames, gable frames, and towers using STAAD Pro.
- Understand and apply design criteria for different frame and tower configurations.
- Analyze stress distribution in frame knees and validate design results.

Specific Resources:

- *"Design of Steel Structures"* by Edwin H. Gaylord and Charles N. Gaylord
- *"Structural Analysis with STAAD Pro"* by T.S. Sarma

UNIT IV: Connections (8 hours)

Theory:

- Bearing type joints: unstiffened and stiffened seat connections
- Resisting connection of brackets: bolted and welded
- Semi-rigid connections

Practice Session:

- Analyze semi-rigid connections using STAAD Pro.
  - Set up the connection geometry and loading conditions.
  - Analyze the connection behavior and validate the design.

Description:

This unit explores various types of connections in structural design, including bearing-type joints, brackets (both bolted and welded), and semi-rigid connections. It provides practical experience in analyzing semi-rigid connections using STAAD Pro.

Examples/Applications/Case Studies:

- Analysis of bearing-type joints and their impact on structural integrity.
- Case study on the effectiveness of bolted versus welded connections in resisting loads.
- Examination of semi-rigid connections and their performance under different conditions.

Exercises/Projects:

- Analyze semi-rigid connections using STAAD Pro, including setting up connection geometry and loading conditions.
- Perform a detailed analysis of connection behavior and validate the design results.

Learning Outcomes:

- Understand and apply different types of structural connections, including bearing-type and semi-rigid connections.
- Use STAAD Pro for analyzing the behavior of semi-rigid connections and validating designs.

Specific Resources:

- *"Steel Connections: Design and Detailing"* by C. B. S. Smith
- *"Structural Analysis with STAAD Pro"* by T.S. Sarm

UNIT V: Design of Steel Truss Girder Bridges (8 hours)

Theory:

- Types of truss bridges
- Component parts of a truss bridge
- Economic proportions of trusses
- Self-weight of truss girders
- Design of bridge compression members and tension members
- Wind load on truss girder bridges
- Wind effect on top lateral bracing, bottom lateral bracing, portal bracing, and sway bracing

Practice Session:

- Design and analyze a steel truss girder bridge using STAAD Pro.
  - Set up the truss model and apply loads.
  - Perform the analysis and design the truss members.

- Simulate wind load effects on the truss bridge using STAAD Pro.
    - Set up wind load parameters and boundary conditions.
    - Analyze wind effects on various bracing systems and interpret results.

Description:

This unit focuses on the design of steel truss girder bridges, including different types of truss bridges, their components, and economic proportions. It covers the design of compression and tension members, self-weight considerations, and wind load effects on various bracing systems.

Examples/Applications/Case Studies:

- Design and analysis of steel truss girder bridges, focusing on different truss types and components.
- Case study on wind load effects on truss bridge bracing systems.

Exercises/Projects:

- Design and analyze a steel truss girder bridge using STAAD Pro, including truss model setup and load application.
- Simulate and analyze wind load effects on the truss bridge, focusing on various bracing systems.

Learning Outcomes:

- Design and analyze steel truss girder bridges, considering all structural components and load effects.
- Use STAAD Pro for detailed analysis and design of truss members and bracing systems.
- Evaluate the impact of wind loads on truss bridges and interpret analytical results.

Specific Resources:

- *"Design of Steel Structures"* by Edwin H. Gaylord and Charles N. Gaylord
- *"Steel Truss Bridges: Design and Analysis"* by J. L. Clarke
- Design of Steel Structures by A S Arya and J L Ajmani, Nam Chand Brothers Publication, 2011

REFERENCES:

Textbooks:

- [T1] Subramanian, N. (2010). Design of Steel Structures. Oxford University Press.
- ~~[T2]~~ **Burry, M. (2018).** *Steel Design: A Practice-Oriented Approach*. McGraw-Hill Education.
- [T3] Design of Steel Structures by A S Arya and J L Ajmani, Nam Chand Brothers Publication, 2011

Reference Books:

- [R1] **Taranath, B. S. (2017).** *Steel Structures: Design and Behavior* (6th ed.). CRC Press.
- [R2] **Sinha, S. K., & Roy, S. (2011).** *Design of Steel Structures* (2nd ed.). Tata McGraw-Hill Education.
- [R3] **Sharma, J. K. (2015).** *Advanced Steel Design*. Oxford University Press.
- **[R4]Prakash, M. (2010).** *Design of Steel Structures Using Limit State Method*. New Age International.
- **[R5] Ghosh, A. K. (2018).** *Design of Steel Structures: Principles and Practice*. Wiley India.

- **E-resources and other digital material**

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	L		M		
CO2	L		H	L	
CO3	H	M	H	H	L
CO4	H	M	H	H	M
CO5	H	M	H	H	L

24CESE504 B.	FRACTURE MECHANICS OF CONCRETE STRUCTURES

Course Category:	Programme Elective-I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Concrete Technology	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

Fracture Mechanics is designed for Civil and Mechanical Engineering students to understand the principles governing the behavior of materials under stress, focusing on concrete structures. The course explores linear and non-linear fracture mechanics, crack detection methods, and their applications in structural design and analysis.

Course Aims and Objectives:

1. Introduce students to fundamental concepts of fracture mechanics as applied to concrete structures.
2. Develop skills in analyzing crack behavior using linear and non-linear fracture mechanics.
3. Investigate the microstructural influences on fracture mechanics and concrete performance.
4. Apply fracture mechanics principles to design and assess the integrity of concrete structures.
5. Foster critical thinking in evaluating and applying fracture mechanics theories to practical engineering problems.

Course Outcomes:

By the end of the course, students will be able to:

CO 1: Apply linear elastic fracture mechanics principles to analyze stress fields and crack propagation in concrete structures [K3].

CO 2: Utilize non-linear fracture mechanics theories to evaluate materials under varying loading conditions [K4].

CO 3: Analyze the influence of microstructure on concrete fracture behavior and toughness [K4].

CO 4: Apply fracture mechanics principles to design and assess the integrity of concrete structures under different loading scenarios [K4].

CO 5: Critically evaluate fracture mechanics theories and their application in practical engineering scenarios [K3].

Course Structure:

Unit 1: Introduction to Fracture Mechanics Contents:

- Overview of fracture mechanics in concrete structures
- Principles of linear elastic fracture mechanics (LEFM)
- Modes of fracture: Mode I, II, and III cracks
- Methods for detecting cracks in concrete structures

Description: This unit introduces the basic principles of fracture mechanics applied to concrete, focusing on the different modes of crack propagation and techniques for crack detection.

Examples/Applications/Case Studies:

- Failure analysis of concrete beams under bending
- Cracking in reinforced concrete columns
- Case study of brittle failure in concrete dams

Exercises/Projects:

- Numerical simulations of stress intensity factors for Mode I cracks
- Field study on crack detection methods using non-destructive testing techniques

Learning Outcomes:

- Understand the principles governing crack propagation in concrete structures
- Apply linear elastic fracture mechanics to analyze stress fields and crack propagation
- Evaluate different methods for crack detection in concrete

Specific Resources:

- ASTM Standard E399, "Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness KIc of Metallic Materials"

Unit 2: Linear Elastic Fracture Mechanics Contents:

- Stress and displacement fields at crack tips
- Calculation of stress intensity factors (K)
- Crack opening displacement (COD) in structural elements
- Superposition principles in fracture mechanics

Description: This unit explores the advanced concepts of linear elastic fracture mechanics, focusing on stress analysis near crack tips and the application of stress intensity factors.

Examples/Applications/Case Studies:

- Design of concrete structures using stress intensity factors
- Failure analysis of cracked concrete beams under tension

Exercises/Projects:

- Laboratory experiment on COD measurements in concrete samples
- Finite element analysis (FEA) of stress fields around cracks

Learning Outcomes:

- Calculate stress intensity factors and crack opening displacements in concrete structures
- Apply superposition principles to analyze complex crack configurations

Specific Resources:

- International Journal of Fracture Mechanics

Unit 3: Non-linear Fracture Mechanics Contents:

- Energy principles for crack propagation in non-linear materials
- J-integral application in non-linear elastic materials
- Fracture resistance (R-curve)
- Crack tip opening displacement (CTOD)

Description: This unit explores non-linear fracture mechanics theories and their application to materials exhibiting non-linear behavior under loading.

Examples/Applications/Case Studies:

- Study of R-curve behavior in concrete
- Failure analysis of cracked structures under dynamic loading

Exercises/Projects:

- Analysis of CTOD in concrete beams subjected to varying loads
- Case study on crack growth in reinforced concrete structures

Learning Outcomes:

- Apply energy principles to analyze crack propagation in non-linear materials
- Interpret R-curve behavior and its significance in fracture mechanics

Specific Resources:

- Journal of Engineering Fracture Mechanics

Unit 4: Structure and Fracture Process of Concrete Contents:

- Constituents and microstructure of concrete
- Fracture behavior and strain localization in concrete
- Fracture process zone and toughening mechanisms
- Influence of microstructure on fracture behavior

Description: This unit examines the microstructural aspects of concrete and their influence on fracture behavior, including toughening mechanisms and the development of fracture process zones.

Examples/Applications/Case Studies:

- Effect of aggregate distribution on concrete fracture toughness
- Analysis of crack patterns in hardened concrete

Exercises/Projects:

- Microstructural analysis of cracked concrete samples using SEM
- Study on the influence of curing conditions on concrete fracture behavior

Learning Outcomes:

- Analyze the microstructural influences on concrete fracture toughness
- Evaluate toughening mechanisms and their role in improving concrete durability

Specific Resources:

- ACI Materials Journal

Unit 5: Applications of Fracture Mechanics to Concrete Structures Contents:

- Behavior of concrete structures under various loading conditions
- Size effect on strength of plain concrete specimens
- Tension and bending of reinforced concrete members
- Design considerations for concrete structures

Description: This unit explores practical applications of fracture mechanics principles in the design and analysis of concrete structures under different loading scenarios.

Examples/Applications/Case Studies:

- Design of concrete bridges using fracture mechanics principles
- Case study of crack propagation in concrete pavements

Exercises/Projects:

- Design project: Reinforced concrete beam analysis using fracture mechanics
- Field study on the behavior of cracked concrete structures under service loads

Learning Outcomes:

- Apply fracture mechanics principles to design and assess concrete structures
- Evaluate the size effect on the strength of concrete specimens

Specific Resources:

- ASCE Journal of Structural Engineering

Textbooks / References:

Textbooks:

1. Bazant, Z. P., & Planas, J. (1998). Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi-Brittle Materials. John Wiley & Sons.
2. Hsu, T. T. C., & Hwang, S. (1986). Nonlinear Fracture Mechanics for Engineers. World Scientific Publishing Company.

References:

1. Shah, S. P., Swartz, S. E., & Vecchio, F. J. (1995). Micromechanics of Concrete Fracture: A Multi-Scale Engineering Approach. CRC Press.
2. Carpinteri, A., Chiaia, B., & Ferro, G. (2001). Scaling in Concrete Structures. CRC Press.

Mapping of Course Outcomes to Program Outcomes: (H=high; M=medium; L=low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	M		M		
CO2	M		H		
CO3	M		M		
CO4	H		H		
CO5	H		H		

24CESE504 C.	SELF LEARNING (MOOCS COURSE)

Course Category:	Program Elective-I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	0-0-0
Prerequisites:	Basic concepts of civil engineering	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM/NPTEL/EDX/Others). They must be approved/ratified in the respective Board of Studies

Course Description:

This course encourages M.Tech Structural Engineering students to engage in self-learning through MOOCs from providers like SWAYAM, NPTEL, and EDX, approved by the Board of Studies. It supplements classroom learning, allowing students to explore topics of personal and professional interest at their own pace, fostering self-discipline, time management, and lifelong learning. MOOCs offer exposure to cutting-edge knowledge from global experts, align learning with career goals, and promote continuous learning. They also enhance employability by equipping students with diverse skills and knowledge beyond the traditional curriculum.

Course Objectives:

1. To introduce students to the concept and benefits of self-learning through MOOCs.
2. To enable students to select and complete MOOCs relevant to their field of study and career aspirations.
3. To foster self-discipline, time management, and independent learning skills.
4. To provide students with access to global knowledge and best practices in structural engineering.
5. To encourage continuous professional development and lifelong learning habits.

Course Outcomes:

1. Identify and select appropriate MOOCs that align with their academic and career objectives.
2. Successfully complete selected MOOCs, demonstrating self-discipline and effective time management.
3. Apply the knowledge and skills acquired from MOOCs to their academic projects and professional practice.
4. Evaluate the impact of self-learning on their personal and professional growth.
5. Develop a habit of continuous learning and staying updated with the latest advancements in structural engineering.

Textbooks and References:

- Online resources and textbooks provided by the selected MOOCs.
- Recommended readings and reference materials suggested by the MOOC instructors.

Specific Resources:

- SWAYAM (swayam.gov.in)
- NPTEL (nptel.ac.in)
- EDX (edx.org)
- Coursera (coursera.org)

FutureLearn (futurelearn.com

24CESE504 D. INDUSTRY ORIENTED SUBJECT

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Concepts of Civil Engineering	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

SYLLABUS IS AS PER INDUSTRY REQUIREMENTS

24CESE505 A.	DESIGN OF PRESTRESSED CONCRETE STRUCTURES

Course Category:	Programme Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Concrete technology	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:
The course introduces students to the behavior and design of prestressed concrete structures and provides them the background needed to design various prestressed concrete members. Course topics include an overview of prestressing technology, loss of prestress, axially loaded prestressed members, flexural and shear behavior/design of prestressed members, and deflections. At the end of the course, students should have an able to design continuous beams, slab, circular prestressing members.

Course Aims and Objectives:
1. Compare advantages of prestressed concrete and reinforced concrete structures.
2. Estimate prestressing losses subjected to pre and post tensioning members.
3. Design of continuous beams, slabs.
4. Design of circular prestressing members (pipes/water tanks).
5. Apply code provisions to the design of structural members (piles).

Course Outcomes:
At the end of the course, the student will be able to...

CO1: Evaluate the losses in prestressed concrete. [K3].

CO2: Analyze and design the pipes in prestressed concrete. [K4].

CO3: Analyze and design fixed and hinged tanks in prestressed concrete. [K4].

CO4: Analyze and design slabs in prestressed concrete. [K4].

CO5: Analyze and design the indeterminate structures and piles. [K4]

Course Structure:
UNIT-1 : Introduction and Losses in Prestressed Concrete
Contents:
- History of prestressed concrete
- Advantages of prestressed concrete over reinforced concrete
- Pre tensioning Vs post tensioning; systems in pre stressed concrete
- Resultant stresses at extreme fibers by Load balancing and pressure line concept
- Introduction to losses of pre stressed concrete
- Losses in pre tensioned concrete and post tensioned concrete.

Description:
Prestressed concrete offers significant advantages over traditional reinforced concrete, particularly in terms of load capacity, crack control, and durability. Both pre-tensioning and post-tensioning methods are employed, each with specific applications and associated losses that must be accounted for to ensure the long-term performance of prestressed concrete structures.

Examples/Applications/Case Studies:
- **Examples:** Comparision of prestressed concrete beam with RCC beams.
- **Applications:** Understand the importance of accounting for these losses to ensure structural integrity and longevity.

Exercises/Projects:

- **Exercise:** Evaluation resultant stresses at extreme fibers and losses in pres tensioning and post tensioning.
- **Project:** Analyse the resultant stresses in prestressed concrete beam based on cable profile and evaluate the losses in prestressed concrete members.
- **Learning Outcomes:**

➢ Understand the concept of prestressing.
➢ Compare and contrast the performance of prestressed concrete with traditional reinforced concrete in various structural applications.
➢ Identify different systems in pre-tensioning and post-tensioning methods
➢ Understand how profiling prestressing tendons can balance internal and external forces, reducing deflections and enhancing structural performance.
➢ Understand the importance of accounting for these losses to ensure structural integrity and longevity.

Specific Resources:

- **Textbooks:**
- Pre-stressed concrete by N.Krishna Raju, Tata-McGraw-Hill.

Online Resources:

- https://archive.nptel.ac.in/courses/105/106/105106118/

UNIT-II- Design of Prestressed Concrete Pipes

Contents:

- Types of prestressed concrete pipes.
- Advantages of prestressed concrete pipes.
- Design of prestressed concrete pipes (cylinder, Non cylinder).

Description:

Acquire a thorough understanding of the critical aspects of prestressed concrete pipes, including bond strength, anchorage design, types and advantages of pipes, and detailed design methodologies as per IS code provisions. This knowledge will equip them to effectively design and implement prestressed concrete solutions in various engineering and infrastructure projects.

Examples/Applications/Case Studies:

- **Examples:** Design of prestressed concrete pipes for a municipal water supply system and industrial projects requiring robust piping solutions for fluid transport.
- **Applications:** Use prestressed concrete pipes in various infrastructure projects such as bridges, tunnels, and underpasses, where high strength and durability are essential.

Exercises/Projects:

- **Exercise:** .

List and describe the different types of prestressed concrete pipes (e.g., cylinder and non-cylinder), including their manufacturing processes and typical applications.

- **Project:**

Select a project that used prestressed concrete pipes (e.g., a water supply project or a sewer system). Analyze the selection of pipe types and discuss the reasons for their use, supported by technical and economic considerations.

Learning Outcomes:

1. Learn the necessity and design principles of end block reinforcement to manage stress concentrations at anchorages and prevent cracking or failure.
2. Learn to apply relevant IS code provisions for the design of prestressed concrete pipes, ensuring compliance with standards and safety requirements.
3. Identify and differentiate between various types of prestressed concrete pipes, such as cylinder and non-cylinder pipes.

Specific Resources:

Textbooks:

- Pre-stressed concrete by N.Krishna Raju, Tata-McGraw-Hill.

Online Resources:

- https://archive.nptel.ac.in/courses/105/106/105106118/

UNIT-III- Design of Prestressed Concrete Tanks

Contents:

- General features of prestressed concrete tanks.
- Analysis of prestressed concrete tanks.
- Design of circular pre-stressed concrete tanks (fixed, hinged).

Description:

Prestressed concrete tanks are used for storing liquids, such as water and industrial chemicals. The analysis involves understanding the structural behavior of the tank under internal pressures due to the stored liquid

Examples/Applications/Case Studies:

- **Examples:**

Determine the appropriate thickness and reinforcement for tank walls to withstand internal pressures.

- **Applications:**

Design prestressed concrete tanks for municipal water supply systems, ensuring reliability and longevity

- **Learning Outcomes:**

1. Understand the general design considerations and features of prestressed concrete tanks.
2. Learn to apply the principles of prestressed concrete to the analysis of tanks under internal and external pressures.
3. Understand the design principles for circular prestressed concrete tanks with both fixed and hinged bases.

Exercises/Projects:

Exercise:

Analyze the stresses in a cylindrical prestressed concrete tank subjected to internal water pressure. Calculate the hoop stress and vertical stress at various heights of the tank.

- **Project:**

Design both a fixed-base and a hinged-base circular prestressed concrete tank for a water storage project.

Specific Resources:

Textbooks:

- Pre-stressed concrete by N.Krishna Raju, Tata-McGraw-Hill.

Online Resources:

- https://archive.nptel.ac.in/courses/105/106/105106118/

UNIT-IV- Design of Pre-Stressed Concrete Slabs

Contents

- Types of pre-stressed concrete floor slabs.
- Design of pre-stressed concrete two-way slabs.
- Design of pre-stressed concrete simple flat slabs

Description:

This unit covers the prestressed concrete slabs are used in buildings over span large distances while minimizing structural depth and improving load-carrying capacity. Majorly focuses on different types of prestressed concrete floor slabs offer varying benefits depending on structural requirements.

Examples/Applications/Case Studies:

- **Examples:**

Gain knowledge in selecting appropriate prestressing tendons and profiles for different types of prestressed concrete slabs.

- **Applications:**
- Apply knowledge of prestressed concrete slabs in designing floors for buildings with large spans, ensuring structural integrity and efficiency.
- **Case Studies**:

Analyze real-world examples of buildings or structures where prestressed concrete slabs have been effectively implemented.

- **Learning Outcomes:**

1. Identify different types of prestressed concrete floor slabs and their specific advantages based on structural requirements.

2. Perform structural analysis of prestressed concrete slabs under various loading conditions.
3. Familiarize with relevant design codes and standards for prestressed concrete slabs.

Exercises/Projects:

- **Exercise:**

Analyze, design and Prepare detailed drawings showing tendon layouts and suitability factors for various conditions prestressed concrete slabs.

- **Project:**

Perform detailed structural analysis and design calculations for the selected slabs.

Specific Resources:

Textbooks:

- Pre-stressed concrete by N. Krishna Raju, Tata-McGraw-Hill.
- Pre-stressed concrete by N. Rajagopalan, Narosa Publishing House.

Online Resources:

- https://archive.nptel.ac.in/courses/105/106/105106118/

UNIT-V Statically Indeterminate Pre-Stressed Concrete Structures

- Analysis of continuous beams.
- Cable profile – Concordant cable and linear transformation.
- Sketching of pressure lines for continuous beams.
- Advantages of prestressed concrete piles.
- Types of prestressed concrete piles.
- Design considerations of prestressed concrete piles.

Description:

This unit covers the continuous beams span over multiple supports and are subjected to varying moments and shear forces along their length and also focuses the design of continuous prestressed concrete beams involves determining the appropriate prestressing force, tendon profile, and reinforcement to resist the applied loads while ensuring serviceability and durability. It covers fundamentals of prestressed concrete piles are classifications based on their cross-sectional shape, installation method, and load-carrying mechanism.

Examples/Applications/Case Studies:

Examples: Understanding cable profile and moments distributions in Continuous beams. Gain knowledge in selecting appropriate prestressing tendons and profiles for different types of prestressed concrete piles.

- ***Applications:***
- Design continuous prestressed concrete beams for bridge decks to span river crossings or highway.
- Implement understanding of prestressed concrete piles in foundation design, optimizing load-bearing capacity and minimizing settlement risks.

Exercises/Projects:

- **Exercise:**

Design a continuous prestressed concrete beam spanning three supports, considering both live and dead loads.

- **Project:**

Perform detailed structural analysis and design calculations for the selected profiles and design consideration of piles.

- **Learning Outcomes:**

1. Understand the principles and methodologies for designing continuous prestressed concrete beams.
2. Understand the concept of cable profiles in prestressed concrete, focusing on concordant cables and linear transformation.
3. Understand the classification of prestressed concrete piles based on cross-sectional shape
4. Learn the design considerations for prestressed concrete piles, including geotechnical investigations, prestressing forces calculation.

Specific Resources:

Textbooks:

- Pre-stressed concrete by N.Krishna Raju, Tata-McGraw-Hill.
- Pre-stressed concrete by N.Rajagopalan, Narosa Publishing House.

Online Resources:

- https://archive.nptel.ac.in/courses/105/106/105106118/

Text Books

1.Pre-stressed concrete by N.Krishna Raju, Tata-McGraw-Hill,

2.Pre-stressed concrete by N.Rajagopalan, Narosa Publishing House.

Reference Books:

1.Pre-stressed concrete by T.Y.Lin&N.H.Burns, John Wiley & Sons

Mapping of Course Outcomes to Program Outcomes:

(**H**=high; **M**=medium; **L**=low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	L		M		L
CO2	M		L		M
CO3	M		L		M
CO4	M		L		M
CO5	M		H		M

24CESE505 B.	PRECAST AND PREFABRICATED STRUCTURES

Course Category:	Program Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Structural analysis	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

This course offers a comprehensive overview of the theory and practical application of prefabricated structures. Topics include the need for prefabrication, design principles, and the technical aspects of producing and assembling prefabricated elements. The course covers the analysis, design, and connections of precast structural components such as slabs, beams, and walls, and delves into jointing systems, transportation, and erection methods. Real-world case studies will be explored to understand the practical benefits and limitations of prefabrication in modern construction.

Course Aims and Objectives

This course aims to provide students with a comprehensive understanding of prefabrication and its role in modern construction. The objectives of the course are to:

1. Introduce the fundamental concepts and principles of prefabrication, including its advantages over traditional construction methods.
2. Equip students with the technical skills to design various precast structural elements such as slabs, beams, and wall panels according to relevant standards and codes.
3. Develop students' ability to analyze and design the structural joints required for prefabricated systems, ensuring the structural integrity of connections.
4. Familiarize students with the production, transportation, and erection processes involved in prefabricated construction, focusing on practical considerations.
5. Provide real-world examples and case studies of prefabricated projects to demonstrate the application of theoretical knowledge in practical scenarios.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to:

CO1: Explain the need, principles, and types of prefabrication in construction, and assess the economic benefits compared to conventional methods. **[K3]**

CO2: Design and analyze various precast elements, including slabs, beams, and wall panels, in compliance with national standards **[K4]**

CO3: Identify and design appropriate joints for different structural connections, including wall-to-wall, slab-to-slab, and column-to-column connections, ensuring overall structural stability.**[K4]**

CO4: Evaluate the production and erection processes for prefabricated elements, considering factors such as dimensional tolerances and on-site assembly challenges.**[K4]**

CO5: Apply knowledge of prefabricated structures to real-world projects, analyzing case studies and implementing joining, erection, and structural design strategies.**[K3]**

Course Structure:

Unit 1: Introduction to Prefabrication
Contents:

- Need for prefabrication
- General principles of prefabrication
- Comparison with monolithic construction
- Types of prefabrication: site and plant prefabrication
- Economy of prefabrication
- Modular coordination and standardization
- Materials and systems used in prefabrication
- Production, transportation, and erection processes

Examples/Applications/Case Studies:

- Construction of prefabricated residential buildings using modular coordination.
- Comparison of prefabricated structures versus traditional construction methods in terms of cost and time efficiency.

Learning Outcomes:

- Understand the need for prefabrication and its application in construction projects.
- Analyze the economic benefits and material savings offered by prefabrication.
- Compare prefabrication with monolithic construction methods to assess advantages and limitations.

Specific Resources:

- https://www.mdpi.com/journal/buildings
- https://www.researchgate.net/publication/273512907_Prefabrication_in_Building_Construction

Unit 2: Design of Precast Elements
Contents:

- Design of prestressed precast hollow core slabs
- Design of precast slab structures
- Design of prestressed precast beams
- Design of precast wall panels and staircases
- Codal provisions: IS 456:2000, IS 15916:2020, IS 1343:1980
- Progressive collapse of structures

Examples/Applications/Case Studies:

- Design of precast elements for multi-story commercial buildings using IS 456:2000 and IS 15916-2020 codes.
- Case study of the design and construction of prestressed hollow-core slabs in bridge construction.

Learning Outcomes:

- Develop the ability to design various precast elements, including slabs, beams, and walls, according to national codes and standards.
- Assess the structural integrity of precast elements and their response to progressive collapse scenarios.

Specific Resources:

- Indian Standard Codes: IS 456:2000, IS 15916-2020, IS 1343:1980.
- https://www.wiley.com/en-us/Structural+Concrete:+Theory+and+Design

Unit 3: Joints
Contents:

- Joints for different structural connections
- Wall connections (stitch, horizontal, and vertical connections)
- Slab connections
- Column-to-column connections
- Foundation to column connections
- Diaphragm analysis and design calculations for structural ties

Examples/Applications/Case Studies:

- Analysis of the behavior of wall-to-wall and slab-to-slab connections in earthquake-prone areas.
- Case study on column-to-column connections in prefabricated high-rise buildings.

Learning Outcomes:

- Understand the function and design of joints in prefabricated structures.
- Analyze various types of joints for their performance in structural connections under different loading conditions.

Specific Resources:

- https://www.sciencedirect.com/topics/engineering/structural-joints
- https://doi.org/10.1061/(ASCE)0733-9445(1986)112:9(2073)

Unit 4: Production and Erection Technology
Contents:

- Types of production: stationary and mobile production
- Storage of precast elements
- Dimensional tolerances
- Erection of different types of members (beams, slabs, wall panels, columns)
- Design considerations for erection

Examples/Applications/Case Studies:

- Production process of precast elements in a controlled factory environment.
- Erection of precast beams and columns in a commercial building project, with consideration of dimensional tolerances.

Learning Outcomes:

- Evaluate the production technologies used for prefabricated elements and their impact on the construction timeline.
- Understand the challenges of storage and transportation of precast elements.

Specific Resources:

- https://doi.org/10.1016/j.engstruct.2015.02.043
- https://www.precast.org/2016/05/best-practices-precast-production/

Unit 5: Applications
Contents:

- Case studies of prefabricated buildings
- Design features of built prefabricated structures
- Precast subdivision of elements
- Joining and erection techniques in practice

Examples/Applications/Case Studies:

- Case study of a precast housing project, focusing on the subdivision of structural elements and jointing methods.
- Real-world application of precast components in industrial buildings.

Learning Outcomes:

- Demonstrate an understanding of real-world applications of prefabricated structures.
- Analyze the construction of large-scale prefabricated projects and identify key design and erection strategies.

Specific Resources:

- https://www.routledge.com/Precast-Concrete-Structures/Makkonen/p/book/9780367330867
- https://www.springer.com/gp/book/9783319544162

Textbook(s) / Reference(s):

1. **Mukkanti, K.** (2017). *Prefabrication in Building Construction*. CRC Press.
2. **Hassoun, M. N.** (2020). *Structural Concrete: Theory and Design*. Wiley India.
3. **Koncz, T.** (2019). *Prefabrication in Building Construction*. Elsevier.
4. **Varghese, P. C.** (2021). *Advanced Reinforced Concrete Design*. PHI Learning Pvt. Ltd.

Mapping of Course Outcomes to Program Outcomes:
(**H**=high; **M**=medium; **L**=low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	H	M	M	M	L
CO2	H	M	M	M	L
CO3	H		M	L	
CO4	H		M	L	
CO5	H		M	L	

24CESE505 C.	SELF LEARNING (MOOCS COURSE)

Course Category:	Program Elective-II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	0-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM/NPTEL/EDX/Others). They must be approved/ratified in the respective Board of Studies

Course Description:

This course encourages M.Tech Structural Engineering students to engage in self-learning through MOOCs from providers like SWAYAM, NPTEL, and EDX, approved by the Board of Studies. It supplements classroom learning, allowing students to explore topics of personal and professional interest at their own pace, fostering self-discipline, time management, and lifelong learning. MOOCs offer exposure to cutting-edge knowledge from global experts, align learning with career goals, and promote continuous learning. They also enhance employability by equipping students with diverse skills and knowledge beyond the traditional curriculum.

Course Objectives:

1. To introduce students to the concept and benefits of self-learning through MOOCs.
2. To enable students to select and complete MOOCs relevant to their field of study and career aspirations.
3. To foster self-discipline, time management, and independent learning skills.
4. To provide students with access to global knowledge and best practices in structural engineering.
5. To encourage continuous professional development and lifelong learning habits.

Course Outcomes:

1. Identify and select appropriate MOOCs that align with their academic and career objectives.
2. Successfully complete selected MOOCs, demonstrating self-discipline and effective time management.
3. Apply the knowledge and skills acquired from MOOCs to their academic projects and professional practice.
4. Evaluate the impact of self-learning on their personal and professional growth.
5. Develop a habit of continuous learning and staying updated with the latest advancements in structural engineering.

Textbooks and References:

- Online resources and textbooks provided by the selected MOOCs.
- Recommended readings and reference materials suggested by the MOOC instructors.

Specific Resources:

- SWAYAM (swayam.gov.in)
- NPTEL (nptel.ac.in)
- EDX (edx.org)
- Coursera (coursera.org)

Future Learn (futurelearn.com

24CESE505 D.	ADVANCED CONCRETE TECHNOLOGY

Course Category:	Programme Elective- II	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Construction technology	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:
This course is designed for Civil Engineering students to provide essential knowledge on the properties, testing, and design of concrete used in construction. It covers both fresh and hardened concrete, focusing on the workability of concrete, advanced concrete types, mix design, and performance evaluation. Students will gain a comprehensive understanding of concrete technology and its applications in real-world scenarios.

Course Aims and Objectives:
1. Understand the properties and behavior of fresh and hardened concrete.
2. Learn about high-performance and high-strength concretes, including their design considerations.
3. Explore advanced concrete designs and their specific applications.
4. Study various concrete mix design methods and quality control processes.
5. Evaluate the performance and durability of reinforced concrete structures through non-destructive testing methods.

Course Outcomes:
At the end of the course, the student will be able to...

CO1: Demonstrate knowledge of workability tests, segregation, bleeding, and the stress-strain behavior of concrete [K3].
CO2: Evaluate the properties, design considerations, and applications of high-performance and high-strength concretes [K4].
CO3: Analyze and apply advanced concrete designs, including self-compacting and polymer concretes, for various construction needs [K4].
CO4: Perform concrete mix design using various methods and ensure quality control and assurance [K3].
CO5: Assess the performance and durability of reinforced concrete structures using various evaluation and testing techniques [K4].

Course Structure:

Unit 1: Fresh and Hardened Concrete
Contents:
- Fresh Concrete: Workability tests, including slump, flow table, and V-funnel tests; Workability of Self-Compacting Concrete (SCC); Segregation and bleeding.
- Hardened Concrete: Abram's law; Gel-space ratio; Maturity concept; Stress-strain behavior; Creep and shrinkage.

Description:
This unit explores the properties and testing of fresh and hardened concrete. It includes workability tests for fresh concrete, such as slump and flow table tests, and covers the concepts of segregation and bleeding. For hardened concrete, it addresses Abram's law, gel-space ratio, maturity concept, and the stress-strain behavior, including creep and shrinkage.
Examples/Applications/Case Studies:
- Application of workability tests to evaluate different concrete mixes, including Self-Compacting Concrete (SCC).

- Case study on the impact of creep and shrinkage on long-term concrete performance.

Exercises/Projects:
- Perform workability tests on various concrete samples and analyze results.
- Evaluate the stress-strain behavior and effects of creep and shrinkage on hardened concrete using experimental and theoretical methods.

Learning Outcomes:
- Understand and apply tests for assessing the workability and quality of fresh concrete.
- Analyze the stress-strain behavior and long-term performance characteristics of hardened concrete.
- Apply concepts such as Abram's law and gel-space ratio in concrete mix design.

Specific Resources:
- *"Concrete Technology: Theory and Practice"* by M. S. Shetty
- *"Properties of Concrete"* by A. M. Neville

Unit 2: High Performance and High Strength Concretes

Contents:

- High Performance Concrete (HPC): Requirements, properties, and design considerations.
- High Strength Concrete (HSC): Design considerations and applications.

Description:

This unit covers High Performance Concrete (HPC) and High Strength Concrete (HSC), focusing on their requirements, properties, and design considerations. It explores the distinctions between HPC and HSC and their specific applications in modern construction.

Examples/Applications/Case Studies:
- Design and application of High Performance Concrete in infrastructure projects requiring enhanced durability.
- Case study on the use of High Strength Concrete in high-rise buildings and its impact on structural performance.

Exercises/Projects:
- Analyze and design concrete mixes for HPC and HSC, considering their properties and application requirements.
- Project involving the selection and application of HPC and HSC for a given structural scenario.

Learning Outcomes:
- Understand the key properties and design considerations for High Performance Concrete and High Strength Concrete.
- Apply HPC and HSC in practical construction scenarios to meet specific performance requirements.

Specific Resources:
- *"High-Performance Concrete"* by Pierre-Claude Aitcin
- *"High Strength Concrete: Design and Applications"* by C. W. D. A. May and R. C. B. Smith

Unit 3: Advanced Concrete Design

Contents:

- Light Weight Concrete, Self-Compacting Concrete, Polymer Concrete, Fiber Reinforced Concrete, Reactive Powder Concrete, Bacterial Concrete, Geo-Polymer Concrete.
- Requirements, guidelines, advantages, and applications of each type.
- Additional topics: Porous pavement, White Topping, Roller Compacted Concrete.

Description:

This unit covers various advanced concrete types, including Light Weight Concrete, Self-Compacting Concrete, Polymer Concrete, Fiber Reinforced Concrete, Reactive Powder Concrete, Bacterial Concrete, and Geo-Polymer Concrete. It discusses the requirements, guidelines, advantages, and applications of each type, along with additional topics such as Porous Pavement, White Topping, and Roller Compacted Concrete.

Examples/Applications/Case Studies:
- Application of Self-Compacting Concrete in complex formworks and its benefits.
- Case study on the use of Fiber Reinforced Concrete for enhancing structural durability and performance.

Exercises/Projects:
- Compare and contrast the properties and applications of various advanced concrete types through practical design and analysis.
- Design and assess a concrete mix for a specific application using one or more advanced concrete types.

Learning Outcomes:
- Understand the characteristics, benefits, and applications of advanced concrete types.

- Apply knowledge of advanced concrete to design solutions for specific structural and environmental challenges.

Specific Resources:

- *"Advanced Concrete Technology"* by John Newman and Barry J. Pridmore
- *"Concrete Technology: An Overview"* by J. M. Mindess and J. F. Young

Unit 4: Concrete Mix Design

Contents:
- Quality control, assurance, and audit.
- Mix design methods: BIS method, DOE method, ACI method, Erntroy & Shacklock's method.

Description:

This unit focuses on concrete mix design, including quality control, assurance, and audit processes. It covers various mix design methods such as BIS, DOE, ACI, and Erntroy & Shacklock's methods, providing a comprehensive understanding of how to create effective concrete mixtures.

Examples/Applications/Case Studies:

- Application of different mix design methods to achieve desired concrete properties for a specific project.
- Case study on quality control and assurance practices in concrete production.

Exercises/Projects:

- Perform concrete mix designs using BIS, DOE, ACI, and Erntroy & Shacklock's methods for various applications.
- Conduct a quality control audit on concrete samples to ensure compliance with design specifications.

Learning Outcomes:

- Understand and apply various concrete mix design methods.
- Implement quality control and assurance practices to ensure the performance of concrete.

Specific Resources:

- *"Concrete Mix Design, Quality Control, and Assurance"* by K. T. K. Kwan and P. W. J. H. Kwan
- *"Design and Control of Concrete Mixtures"* by Steven H. Kosmatka and William C. Panarese

Unit 5: Performance Evaluation of Reinforced Concrete Structures

Contents:
- Durability of concrete and corrosion tests: Resistivity of concrete, Half Cell Potential, Rapid Chloride Penetration Test, Macro Cell Corrosion.
- Effects of acidic environments, Durability Factor, Accelerated Corrosion Cracking Test.
- Non-destructive testing methods: Ultrasonic Pulse Velocity, Dynamic Shear & Young's Modulus, Introduction to XRD & SEM Analysis.

Description:

This unit covers the performance evaluation of reinforced concrete structures, focusing on durability and corrosion tests, including Resistivity of Concrete, Half Cell Potential, and Rapid Chloride Penetration Test. It also addresses the impact of acidic environments, Durability Factor, and Accelerated Corrosion Cracking Test, along with non-destructive testing methods such as Ultrasonic Pulse Velocity, Dynamic Shear & Young's Modulus, and an introduction to XRD & SEM Analysis.

Examples/Applications/Case Studies:

- Application of corrosion tests to evaluate the durability of reinforced concrete structures in different environmental conditions.
- Case study on the use of non-destructive testing methods to assess the condition of aging concrete infrastructure.

Exercises/Projects:

- Conduct durability and corrosion tests on concrete samples and interpret the results.
- Apply non-destructive testing methods to evaluate concrete quality and structural integrity.

Learning Outcomes:

- Understand and apply various tests for evaluating the durability and performance of reinforced concrete structures.
- Utilize non-destructive testing methods to assess concrete condition and predict structural behavior.

Specific Resources:

- *"Concrete Durability"* by R. C. Newman and B. J. M. Thomas
- *"Non-Destructive Testing of Concrete"* by John W. Bull and Michael T. Stevens

Textbook(s) / Reference(s):

Textbooks:
1.Neville, A. M. (2011).** *Properties of Concrete* (5th ed.). Pearson Education.
2. Mehta, P. K., & Monteiro, P. J. M. (2014).** *Concrete: Microstructure, Properties, and Materials* (4th ed.). McGraw-Hill Education.

References:
1. Shetty, M. S. (2005).** *Concrete Technology* (1st ed.). S. Chand Publishing.
2. Jones, R. (2011).** *High-Performance Concrete* (2nd ed.). CRC Press.
3. Kumar, S. (2016).** *Concrete Mix Design and Quality Control* (1st ed.). Springer.

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	H	M	L	L	M
CO 2	H	H	M	M	M
CO 3	H	M	M	L	M
CO 4	H	H	M	H	M
CO 5	H	H	H	H	H

24MTUC501	RESEARCH METHODOLOGY AND IPR

Course Category:	Mandatory Learning Course	**Credits:**	0
Course Type:	Theory	**Lecture - Tutorial - Practice:**	2-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

This course comprehensively covers research methodology and intellectual property (IP), starting with fundamental research concepts, objectives, approaches, and scientific methods. It includes practical aspects such as defining research problems, conducting literature reviews, designing methodologies, and sampling techniques. Students learn about data collection methods, hypothesis testing, interpreting findings, and effective report writing. The course also explores IP intricacies like patents, trademarks, copyrights, and global agreements such as TRIPS. By mastering these skills, M.Tech students are prepared to conduct rigorous research, innovate responsibly, and contribute significantly to advancements in both academic knowledge and technological applications. These competencies are vital for their professional growth and for making substantial contributions in engineering and technology fields.

Course Aims and Objectives:

1.Develop a foundational understanding of research methodology, enabling students to apply scientific methods and define research problems effectively in academic and professional contexts.

2.Enhance students' ability to conduct comprehensive literature reviews and design research studies that incorporate principles of effective research design and experimental methodologies.

3.Equip students with skills in designing robust sampling methodologies and effectively collecting qualitative and quantitative data through various methods like experiments, surveys, and case studies.

4.Enable students to proficiently apply hypothesis testing techniques and employ data analysis tools for rigorous research.

5.Develop skills in interpreting research findings, employing effective report writing techniques, and understanding intellectual property laws.

Course Outcomes:

1. demonstrate proficiency in formulating research problems, applying scientific methods, and understanding the significance of research methodology in academic and professional settings. [K2]
2. achieve proficiency in critically reviewing literature, enhancing research methodologies, and designing effective research studies that contribute to knowledge broadening and contextual understanding. [K2]
3. gain proficiency in designing reliable sampling strategies, applying measurement scales, and executing data collection methods to minimize errors and enhance research validity.[K2]
4. conduct hypothesis tests, interpret test statistics, and utilize data analysis methods to enhance research validity. [K2]
5. interpret research results, write impactful reports, and apply knowledge of intellectual property rights to research practices. [K2]

Unit 1: Research Methodology and Problem Definition

Contents

- Introduction to Research Methodology: Meaning, Objectives, Motivation, Approaches, Significance, and Scientific Methods.
- Research Process: Steps, Criteria of Good Research, and Common Problems Encountered by Researchers in India.
- Defining the Research Problem: Selecting and Defining the Problem, Techniques, and Illustration.

Description:

This unit introduces research methodology, including its meaning, objectives, approaches, and significance. It covers the research process, criteria for good research, common problems encountered by researchers in India, and techniques for defining and illustrating research problems.

Examples/Applications/Case Studies:

- Analysis of common research problems faced by researchers in India and their impact on the research process.
- Case study on defining and selecting research problems, including techniques and illustrations.

Exercises/Projects:

- Develop a research proposal, including defining a research problem and outlining the research process.
- Identify and discuss common research problems encountered in a specific field or context.

Learning Outcomes:

- Understand and apply the principles of research methodology and the research process.
- Define and select research problems effectively, using appropriate techniques and methods.

Specific Resources:

- *"Research Methodology: Methods and Techniques"* by C. R. Kothari
- *"Research Methods for Business: A Skill-Building Approach"* by Uma Sekaran and Roger Bougie

Unit 2: Literature Review and Research Design

Contents

- Reviewing the Literature: Importance, Methodology Improvement, Knowledge Broadening, and Contextual Findings.
- Research Design: Meaning, Need, Features of a Good Design, Concepts, Basic Principles, and Experimental Designs.

Description:

This unit focuses on conducting a literature review and designing research studies. It covers the importance and methodology of literature reviews, their role in improving research and broadening knowledge, and the key aspects of research design, including its meaning, need, features of a good design, and experimental designs.

Examples/Applications/Case Studies:

- Case study on how a comprehensive literature review can refine research questions and improve study outcomes.
- Analysis of different experimental designs and their application in various research scenarios.

Exercises/Projects:

- Conduct a literature review on a chosen topic, summarizing key findings and identifying gaps in current knowledge.
- Develop a research design for a proposed study, detailing the design features, principles, and chosen experimental methods.

Learning Outcomes:

- Conduct effective literature reviews to enhance research quality and context.
- Design robust research studies, applying fundamental principles and choosing appropriate experimental designs.

Specific Resources:

- *"The Literature Review: A Step-by-Step Guide for Students"* by Diana Ridley
- *"Research Design: Qualitative, Quantitative, and Mixed Methods Approaches"* by John W. Creswell

Unit 3: Sampling Design , Data Collection, ICT Tools and Techniques in Research:

Contents

- Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample vs. Census Survey.
- Measurement and Scaling: Qualitative and Quantitative Data, Measurement Scales, Goodness, and Sources of Error.
- Data Collection: Experimental and Surveys, Primary and Secondary Data Collection, Case Study Method.
- Software for Reference Management (Zotero/ Mendeley), detecting Plagiarism, Research search Engines

Description:

This unit explores sampling design, data collection methods, and the use of ICT tools and techniques in research. It covers the design of sampling, measurement and scaling of data, various data collection methods, and the application of software tools for reference management and plagiarism detection.

Examples/Applications/Case Studies:

- Design and implementation of sampling strategies for research surveys and their impact on data accuracy.

- Case study on the use of research search engines and reference management software in organizing and citing research.

Exercises/Projects:

- Develop a sampling design for a research study, identifying potential sampling and non-sampling errors.
- Use software tools like Zotero or Mendeley to manage references and detect plagiarism in a research project.

Learning Outcomes:

- Design effective sampling strategies and understand the differences between sample and census surveys.
- Apply measurement and scaling techniques to collect and analyze qualitative and quantitative data.
- Utilize ICT tools for data collection, reference management, and ensuring research integrity.

Specific Resources:

- *"Research Methods for Business Students"* by Mark Saunders, Philip Lewis, and Adrian Thornhill
- *"The Research Process: A Step-by-Step Guide for Beginners"* by Gary Thomas

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Unit 4: Hypothesis Testing and Data Analysis

Contents

- Testing of Hypotheses: Concepts, Hypothesis Testing, Test Statistics, Critical Region, Value and Decision Rule, Procedure.
- Data Analysis: Techniques and Tools for Analyzing Collected Data.

Description:

This unit covers hypothesis testing and data analysis, focusing on the concepts and procedures for testing hypotheses, including test statistics, critical regions, and decision rules. It also explores techniques and tools for analyzing collected data to derive meaningful insights.

Examples/Applications/Case Studies:

- Application of hypothesis testing in evaluating research findings and making data-driven decisions.
- Case study demonstrating the use of various data analysis techniques to interpret research data effectively.

Exercises/Projects:

- Perform hypothesis testing on a given dataset, including calculation of test statistics and interpretation of results.
- Use data analysis tools to analyze and visualize research data, and present findings in a comprehensive report.

Learning Outcomes:

- Understand and apply hypothesis testing procedures to validate research assumptions.
- Analyze collected data using appropriate techniques and tools to extract valuable insights.

Specific Resources:

- *"Statistics for Research: With a Guide to SPSS"* by George Argyrous
- *"Practical Statistics for Data Scientists: 50 Essential Concepts"* by Peter Bruce and Andrew Bruce

Unit 5: Interpretation, Report Writing, and Intellectual Property

Contents:

- Interpretation and Report Writing: Meaning, techniques, precautions, and significance of report writing.
- Intellectual Property: Concept, system in India, development of TRIPS complied regime, Patents Act, Trade Mark Act, Designs Act, Geographical Indications, Copyright Act, Trade Secrets, Utility Models, WTO, Paris Convention, National Treatment, Right of Priority, Common Rules, PCT, and TRIPS Agreement.

Description:

This unit covers the interpretation and report writing of research findings, focusing on effective techniques, precautions, and the significance of clear reporting. It also explores intellectual property rights, including the relevant laws and international agreements that govern patents, trademarks, designs, and copyrights.

Examples/Applications/Case Studies:

- Case study on writing and presenting research reports with a focus on clarity and precision.
- Application of intellectual property laws to protect research innovations and creative works.

Exercises/Projects:

- Write a comprehensive research report, including interpretation of results and adherence to report writing techniques.
- Analyze and apply intellectual property laws to a hypothetical case involving patents, trademarks, or copyrights.

Learning Outcomes:

- Develop skills in interpreting research data and writing clear, effective research reports.
- Understand and apply intellectual property laws and international agreements relevant to research and innovation.

Specific Resources:

- *"Research Report Writing: A Comprehensive Guide"* by William C. Boyd and Peter J. Williams
- *"Intellectual Property Law: Text, Cases, and Materials"* by Tanya Aplin and Jennifer Davis

Mapping of Course Outcomes to Program Outcomes:
(**H**=high; **M**=medium; **L**=low)

Text Books

1. Kothari, C. R. (2004). Research Methodology: Methods and Techniques. New Age International Publishers.
2. Ridley, D. (2012). The Literature Review: A Step-by-Step Guide for Students. SAGE Publications.

Reference Books

1. Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). Pearson Education.
2. Thomas, G. (2017). The Research Process: A Step-by-Step Guide for Beginners (3rd ed.). SAGE Publications.
3. Argyrous, G. (2011). Statistics for Research: With a Guide to SPSS. SAGE Publications.
4. Bruce, P., & Bruce, A. (2017). Practical Statistics for Data Scientists: 50 Essential Concepts. O'Reilly Media.
5. oyd, W. C., & Williams, P. J. (2001). Research Report Writing: A Comprehensive Guide. Elsevier.
6. Aplin, T., & Davis, J. (2018). Intellectual Property Law: Text, Cases, and Materials. Oxford University Press.

E-resources and other digital material : https://archive.nptel.ac.in/courses/105/105/105105207/

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO1	M	M	M		H
CO2	L	M	M	M	M
CO3	L	L	M		M
CO4	L	L	L		M
CO5	L	L	M		M

24CESE581	ADVANCED CONCRETE LAB

Course Category:	Laboratory –I	Credits:	1.5
Course Type:	Practical	Lecture - Tutorial - Practice:	0-0-3
Prerequisites:	Concrete Technology	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course Description: This laboratory course provides hands-on experience with advanced concrete testing and analysis techniques. It focuses on understanding the impact of different mix parameters on concrete properties, conducting durability tests, and evaluating special concrete types. Students will learn to perform various concrete tests using standard equipment and interpret the results to assess concrete performance in structural applications.

Course Aims and Objectives:

1. **Concrete Mix Properties**: Investigate how water-cement ratio and aggregate-cement ratio affect the workability and strength characteristics of concrete.
2. **Durability Testing**: Perform and analyze various durability tests on concrete.
3. **Structural Testing**: Conduct bending tests on RCC beams under different loading conditions.
4. **Curing Techniques**: Understand and apply accelerated curing methods on concrete specimens.
5. **Strain Measurement**: Use electrical resistance strain gauges to measure strain in concrete.
6. **Non-Destructive Testing**: Execute non-destructive and semi-destructive testing methods on existing concrete structures.
7. **Self-Compacting Concrete**: Study and measure the flow properties of self-compacting concrete.
8. **Special Concretes**: Develop and test special types of concrete, including lightweight, geopolymer, fiber-reinforced, pervious, and self-healing concretes.

Course Outcomes: At the end of the course, students will be able to:

- **CO 1**: Evaluate the influence of water-cement and aggregate-cement ratios on concrete properties [K4].
- **CO 2**: Perform and interpret results from various durability tests on concrete [K3].
- **CO 3**: Conduct bending tests on RCC beams and analyze their structural behavior [K4].
- **CO 4**: Apply accelerated curing techniques and assess their effects on concrete strength [K3].
- **CO 5**: Use strain gauges to measure and analyze strain in concrete samples [K4].
- **CO 6**: Implement non-destructive and semi-destructive testing methods on existing concrete [K3].
- **CO 7**: Analyze the flow properties of self-compacting concrete using various tests [K4].
- **CO 8**: Develop and evaluate special concrete types for specific applications [K4].

List of Experiments

1. Influence of water- Cement ratio and Aggregate Cement ratio on workability and strength Characteristics of Concrete
2. Study the flow properties of self compacting Concrete- LBox-J Box, U Box and Slump test
3. Develop a Mix Design for special concretes
4. Determination of Compressive strength of cubes using ACT & Carbonation Chamber)
5. Measurement of Young’s Modulus of concrete
6. Study of RCC Beam under flexure using Loading Frame
7. Corrosion Test on concrete by titration method & RCPT
8. Water Permeability test on Concrete
9. Carbonation Test on concrete
10. Conducting Non destructive testing and Semi Destructive methods on existing concrete members

Textbooks / References:

1. Neville, A. M. (2010). *Properties of Concrete* (5th ed.). Pearson.
2. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, Properties, and Materials* (4th ed.). McGraw-Hill.
3. Kumar, S., & Singh, S. P. (2015). *Advanced Concrete Technology* (1st ed.). Wiley.

Web Resources:

1. American Concrete Institute (ACI) Website
2. Concrete Society Website

Mapping of Course Outcomes to Program Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	M	L	L	M	
CO2	M	L	L	M	
CO3	M	L	L	M	
CO4	M	L	L	M	
CO5	M	L	L	M	

24CESE582	COMPUTER APPLICATIONS IN NUMERICAL ANALYSIS LAB

Course Category:	Laboratory –II	**Credits:**	1.5
Course Type:	Practical	**Lecture - Tutorial - Practice:**	0-0-3
Prerequisites:	Basics of Numerical Techniques	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Description:

The course is designed for Civil Structural EngineeringM.Techfirst year students, providing essential and applied knowledge of numerical methodsrelevant to their fields. Understanding the principles of various numerical techniques and their applications in Structural engineering.An overview of Matlab programming to solve non-linear equation, system of linear equations, initial value problems, curve fitting problems and perform numerical integration.

Course Aims and Objectives:

Demonstrate Matlab coding to

1. Find a real root of Non-linear equation using Bisection and Newton-Raphson methods.
2. Fit a curve by Least Square Approximations.
3. Solve system of linear equations using Gauss-Elimination and Gauss-Seidel methods.
4. Integrate numerically using Trapezoidal rule and Simpson's rule.
5. Visualise solution of 1^{st} and 2^{nd} order initial value problems.

Course Outcomes:

At the end of the course, the student will be able to write Matlab code to...

CO 1: Find real root of an algebraic and transcendental equations **[K3]**
CO 2: Fit a curve for given data **[K3]**
CO 3: Solve system of linear equations **[K3]**
CO 4: Calculate definite integrals **[K3]**
CO 5: Evaluate numerical solution of 1^{st} and 2^{nd} order initial value problems **[K3]**

Course Structure:

1. Finding a real root of transcendental equation using Bisection method. **CO 1 [K3]**
2. Estimate a real root of Non-linear equation using Newton-Raphson method **CO 1 [K3]**
3. Linear and exponential curve fitting by Least Square Approximations. **CO 2 [K3]**
4. Quadratic fitting by Least Square Approximations. **CO 2 [K3]**
5. Solve system of linear equations using Gauss-Elimination method. **CO 3 [K3]**
6. Solve system of linear equations using Gauss-Seidel iteration method. **CO 3 [K3]**
7. Integrate numerically using Trapezoidal rule. **CO 4 [K3]**
8. Integrate numerically using Simpson's rules. **CO 4 [K3]**
9. Solution of 1^{st} order IVP by Runge- Kutta method of order four. **CO 5 [K3]**
10. Solution of 2^{nd} order IVP by Finite difference method. **CO 5 [K3]**

Text Book:

1. S. S. Sastry (2012). *Introductory Methods of Numerical Analysis*. (5^{th} Edition). PHI Learning Private Limited.

Web Resources:

1. MathWorks Web page:
   Get Started with MATLAB - MathWorks India
2. NPTL Matlab Programming for Numerical Computation By Prof.NiketKaisare IIT Madras
   http://nptel.ac.in/courses/103106074/

Mapping of Course Outcomes to Program Outcomes:

(**H** = High; M = Medium; L = Low)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	M	L	L	M	
CO2	M	L	L	M	
CO3	M	L	L	M	
CO4	M	L	L	M	
CO5	M	L	L	M	
CO5	M	L	L	M	

24CESE591	CAPSTONE PROJECT-1

Course Category:	Programme Core	**Credits:**	1
Course Type:	Project	**Lecture - Tutorial - Practice:**	0-0-2
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Description: CAPSTONE PROJECT-1 provides students the opportunity to apply advanced principles of structural analysis and design to real-world, complex engineering problems. This project allows students to focus on one specialized theme from a diverse range of options, including Computer-Aided Advanced Structural Analysis, Theory of Elasticity and Plasticity, Structural Dynamics, Advanced Steel Building, Fracture Mechanics of Concrete Structures, Design of Prestressed Concrete Structures, Precast and Prefabricated Structures, Advanced Concrete Technology and Computer Applications in Numerical Analysis. The project emphasizes integrating theoretical knowledge with practical applications through hands-on work using advanced structural engineering software and techniques. Through this capstone experience, students will develop problem-solving skills, conduct detailed technical analyses, and enhance their ability to present comprehensive solutions via technical reports and presentations.

Course Objectives:

1. **Apply** advanced structural analysis and design principles to solve complex engineering challenges within a specialized project theme.
2. **Analyze** project requirements and constraints to develop appropriate structural models and simulations using industry-standard engineering software.
3. **Design** innovative and sustainable structural solutions, incorporating advanced techniques and materials aligned with modern engineering practices.
4. **Evaluate** technical results obtained from experiments or simulations to determine the effectiveness and feasibility of proposed structural designs.
5. **Create** and **present** comprehensive technical reports and project presentations, demonstrating clear communication of complex engineering concepts and solutions.

Course Outcomes: By the end of CAPSTONE PROJECT-1, students will be able to:

1. Apply advanced structural analysis and design principles to solve complex engineering problems within the selected project theme. [K3]
2. Utilize specialized tools and software for in-depth analysis and simulation related to the chosen area of study, such as Computer-Aided Structural Analysis or Advanced Foundation Engineering. [K3]
3. Analyze and interpret data from experiments or simulations to develop effective solutions for challenges in areas like Soil-Structure Interaction or Retrofitting and Rehabilitation of Structures. [K4]
4. Develop innovative design solutions that incorporate considerations such as sustainability, energy efficiency, or material characterization, ensuring alignment with industry standards and practices. [K5]
5. Communicate project outcomes effectively through detailed technical reports and presentations, demonstrating a thorough understanding of the specialized theme and its broader implications. [K3]

Student can carry out any one of the projects in the themes listed below

- Computer Aided Advanced Structural Analysis (*Integrated Course)
- Theory of Elasticity and Plasticity
- Structural Dynamics (Integrated Course)
- Advanced Steel Building (*Integrated Course)
- Fracture Mechanics of Concrete Structures

- Design of Prestressed Concrete Structures
- Precast and Prefabricated structures
- MOOC courses relevant to Structural Engineering approved by BOS.(Can be opted from NPTEL/Swayam/others)
- Advanced Concrete Technology
- Research Methodology and IPR
- Advanced Concrete Lab
- Computer Applications in Numerical Analysis Lab

Specific Resources:

1. Books and Text Resources

- **"Structural Analysis" by Aslam Kassimali**
  Focuses on various structural analysis techniques, making it ideal for Computer-Aided Advanced Structural Analysis.
- **"Theory of Elasticity" by Timoshenko and Goodier**
  A comprehensive resource for understanding the fundamental principles of elasticity and plasticity.
- **"Dynamics of Structures: Theory and Applications to Earthquake Engineering" by Anil K. Chopra**
  Provides deep insights into structural dynamics and its applications, ideal for projects in seismic and vibration analysis.
- **"Design of Steel Structures" by Subramanian**
  This book offers detailed information on the analysis and design of steel structures, relevant for Advanced Steel Building projects.
- **"Fracture Mechanics of Concrete Structures" by Zdeněk P. Bažant**
  An essential resource for understanding crack propagation and failure mechanisms in concrete structures.
- **"Prestressed Concrete" by N. Krishna Raju**
  Offers in-depth discussions on the design principles of prestressed concrete structures.
- **"Precast Concrete Structures" by Kim S. Elliott**
  Provides practical guidance on the design and construction of precast concrete elements and systems.
- **"Advanced Concrete Technology" by John Newman and Ban Seng Choo**
  Explores new advancements and materials in concrete technology for specialized projects.

2. Journals and Research Papers

- **Journal of Structural Engineering (ASCE)**
  Provides high-quality papers on structural design, analysis, and materials.
- **International Journal of Concrete Structures and Materials (Springer)**
  Covers advanced topics in concrete technology, fracture mechanics, and material performance.
- **Journal of Earthquake Engineering (Taylor & Francis)**
  Ideal for projects related to seismic analysis and earthquake-resistant structures.

3. Software Tools

- **STAAD Pro**
  Widely used for structural analysis and design, covering both steel and concrete structures.
- **ANSYS**
  Offers powerful finite element analysis capabilities, particularly useful for projects in computational structural dynamics.
- **ETABS**
  A comprehensive tool for structural analysis and design of buildings, particularly high-rise structures.
- **ABAQUS**
  Best suited for advanced simulation of materials under stress, ideal for projects involving elasticity, plasticity, and fracture mechanics.
- **MATLAB**
  Useful for numerical analysis and solving complex engineering problems using mathematical simulations.

4. E-Resources and Online Courses

- **NPTEL (National Programme on Technology Enhanced Learning)**
  Offers various courses on advanced topics in structural engineering, including structural dynamics, prestressed concrete, and steel structures.
    - NPTEL Structural Dynamics Course
    - NPTEL Prestressed Concrete Structures Course
- **Coursera and edX**
  Both platforms offer specialized courses in structural engineering, computational dynamics, and concrete technology.
    - Coursera Structural Engineering Courses
    - edX Civil Engineering Courses
- **Research Gate and Google Scholar**
  Access research papers and articles on niche topics like fracture mechanics, earthquake-resistant design, and advanced concrete materials.

5. Standards and Codes

- **IS 456:2000** – Code of Practice for Plain and Reinforced Concrete.
- **IS 800:2007** – Code of Practice for General Construction in Steel.
- **IS 1343:2012** – Code of Practice for Prestressed Concrete.
- **IS 1893:2016** – Criteria for Earthquake Resistant Design of Structures.
- **Eurocode 2** – Design of Concrete Structures.
- **AISC Steel Construction Manual** – Standards for steel construction.

6. Databases and Libraries

- **Scopus**
  A comprehensive abstract and citation database, useful for finding peer-reviewed literature on structural engineering topics.
- **ASCE Library**
  Provides access to a wide range of papers and publications in civil and structural engineering.
    - ASCE Library
- **JSTOR**
  Offers academic journal articles, books, and primary sources useful for in-depth research on specialized topics.

E-resources and other digital material

https://www.sciencedirect.com/
https://link.springer.com/
https://scholar.google.com/
https://www.researchgate.net/
https://www.mendeley.com/
https://ieeexplore.ieee.org/
https://ascelibrary.org/

Mapping of Course Outcomes to Program Outcomes:

(**H** = High; M = Medium; L = Low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO1	M		L	M	
CO2	M		L	M	
CO3	M		L	M	M
CO4	M		L	M	
CO5	M	M	L	M	

SEMESTER II

24CESE506	FINITE ELEMENT METHOD (Integrated Course)		
Course Category:	Programme Core-IV	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Basic course in Mathematics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

The course introduces the fundamental principles of the Finite Element Method (FEM) with applications to structural engineering. It covers the formulation techniques, including variational and weighted residual methods, and provides hands-on training using Ansys software for solving practical problems. The course will focus on the formulation and analysis of structural elements such as beams, trusses, frames, and 2D and 3D solids. Additionally, the course incorporates dynamic analysis techniques with an emphasis on vibration analysis and the use of consistent and lumped mass matrices.

Course Aims and Objectives:

1. Introduce the basic concepts and mathematical formulation of the Finite Element Method for solving boundary value problems in engineering.
2. Apply variational methods like Rayleigh-Ritz and Galerkin's method to derive element equations for structural problems.
3. Familiarize students with different element formulations such as beams, trusses, frames, and 2D and 3D elements.
4. Provide practical experience in solving structural and dynamic analysis problems using FEM tools like Ansys.
5. Enable students to conduct vibration analysis and dynamic response analysis using mass matrices and solve for natural frequencies and mode shapes.

Course Outcomes (COs):

At the end of this course, students will be able to:

CO 1: Understand and apply the fundamental principles of the Finite Element Method to solve structural engineering problems [K3].

CO 2: Formulate and implement FEM solutions for beams, trusses, and frame structures, and validate results with theoretical predictions [K4].

CO 3: Develop and apply FEM formulations for 2D problems using triangular and rectangular elements for linear elasticity analysis [K4].

CO 4: Conduct FEM analysis for three-dimensional structural problems using tetrahedron and hexahedron elements [K4].

CO 5: Perform dynamic analysis of structures, including free vibration analysis and dynamic response evaluation using Ansys software [K5].

Course Structure:

Unit I: Introduction and Fundamentals of Finite Element Method (8 hours)

Theory:

- Introduction to FEM
- Boundary Value Problems
- Integral formulations and variational methods
- Solution methods: Rayleigh-Ritz and Galerkin’s Weighted Residual Method

Practice Session:

- Basic structural analysis of an axially loaded bar using Ansys
  - Geometry, material properties, boundary conditions setup
  - Element equation derivation and assembly in Ansys
  - Solution interpretation

Learning Outcomes:

- Understand FEM basics and mathematical formulations
- Set up and solve boundary value problems using Ansys

Unit II: Finite Element Formulation for Beams, Plane Trusses, and Frames (10 hours)

Theory:

- Euler-Bernoulli Beam Element
- Timoshenko Beam Elements
- Plane Trusses and Plane Frame Elements

Practice Session:

- Model beam and truss structures in Ansys
  - Beam and truss element definition
  - Load and boundary conditions application
  - Analyze and compare with theoretical results

Learning Outcomes:

- Formulate FEM solutions for beam, truss, and frame elements

Unit III: Finite Element Formulation for Two-Dimensional Problems (10 hours)

Theory:

- Two-Dimensional Finite Elements (Triangular and Rectangular Elements)
- Shape Functions
- Isoparametric Formulation
- Numerical Integration: Gauss Quadrature
- Applications in Linear Elasticity Problems

Practice Session:

- Simulate linear elasticity problems using triangular or quadrilateral elements in Ansys
  - Mesh generation
  - Numerical integration and results analysis

Learning Outcomes:

- Understand and apply 2D FEM formulations to elasticity problems

Unit IV: Analysis of Three-Dimensional Problems (8 hours)

Theory:

- Tetrahedron and Hexahedron Elements

Practice Session:

- Model 3D structures with tetrahedron and hexahedron elements
- Compare FEM results for 3D analysis

Learning Outcomes:

- Apply 3D FEM formulations to complex structural analysis

Unit V: Dynamic Analysis: Mass Matrices and Vibration in Ansys (8 hours)

Theory:

- Dynamic Equations of Motion
- Consistent and Lumped Mass Matrices
- Free Vibration Analysis

Practice Session:

- Dynamic response analysis of structures subjected to axial and flexural loads
- Natural frequencies and mode shapes calculation

Learning Outcomes:

- Perform dynamic analysis using consistent and lumped mass matrices in FEM

REFERENCES:

Textbooks:

- [T1] Chandrupatla, T. R., &Belegundu, A. D. (2011). Introduction to Finite Elements in Engineering. Pearson Education.
- [T2] Logan, D. L. (2012). A First Course in the Finite Element Method. Cengage Learning.

Reference Books:

- [R1] Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J. (2002). Concepts and Applications of Finite Element Analysis. John Wiley & Sons.
- [R2] Bathe, K. J. (1996). Finite Element Procedures. Prentice Hall.
- [R3] Zienkiewicz, O. C., & Taylor, R. L. (2000). The Finite Element Method. Butterworth-Heinemann.

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	M		H		
CO2	M		H		
CO3	M		M		
CO4	M		M		
CO5					

24CESE507	COMPUTER AIDED REINFORCED CONCRETE DESIGN (*INTEGRATED COURSE)

Course Category:	Programme Core – V	**Credits:**	3
Course Type:	Theory cum Practice	**Lecture - Tutorial - Practice:**	2-0-2
Prerequisites:	Design of concrete structures	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description: This course provides a comprehensive introduction to the principles and practices of reinforced concrete design using computer-aided tools. It covers the design of various reinforced concrete elements including deep beams, shear walls, slabs, and tall buildings. Emphasis is placed on practical applications and modern innovations in structural design, with hands-on sessions using industry-standard software such as STAAD.Pro and ETABS.

Course Aims and Objectives:

1. To provide fundamental knowledge on the design principles of reinforced concrete structures.
2. To introduce computer-aided design tools for analyzing and designing reinforced concrete elements.
3. To understand the behavior and classification of different reinforced concrete elements.
4. To develop skills in using software tools for structural analysis and design.
5. To explore advanced topics, innovations, and future trends in reinforced concrete design.

Course Outcomes: At the end of the course, the student will be able to:

- CO 1: Apply design principles for various reinforced concrete elements as per IS codes.
- CO 2: Use computer-aided tools for the analysis and design of reinforced concrete structures.
- CO 3: Design deep beams, shear walls, slabs, and tall buildings using STAAD.Pro and ETABS.
- CO 4: Analyze and design structures considering advanced topics and innovations.
- CO 5: Evaluate and apply future trends in the design of reinforced concrete structures.

Course Structure:

Unit I: Reinforced Concrete Deep Beams

Contents:

- Introduction to deep beams
- Minimum thickness requirements
- Steps for designing deep beams
- Design by IS456
- Checking for local failures
- Detailing of deep beams

Practice Sessions:

- Analysis and Design of RC deep beams using STAAD.Pro as per IS456

Description: This unit covers the fundamental concepts and design procedures for reinforced concrete deep beams. Students will learn the steps involved in designing deep beams according to IS456, checking for local failures, and detailing requirements.

Examples/Applications/Case Studies:

- Case study on the design and performance of deep beams in residential buildings.

Exercises/Projects:

- Design and analyze an RC deep beam for a multi-story building using STAAD.Pro.

Learning Outcomes:

- Understand the design principles of deep beams.
- Apply IS456 code provisions for deep beam design.
- Use STAAD.Pro for analyzing and designing deep beams.

Specific Resources:

- IS 456: 2000 Code of Practice for Plain and Reinforced Concrete

Unit II: Design of Shear Walls

Contents:

- Introduction to shear walls
- Classification of shear walls
- Classification according to behavior
- Loads on shear walls
- Design of rectangular shear walls

Practice Sessions:

- Analysis and Design of Shear walls in High-rise buildings using STAAD.Pro

Description: This unit introduces the design and analysis of shear walls, including their classification, behavior, and load considerations. Students will design rectangular shear walls and understand their application in high-rise buildings.

Examples/Applications/Case Studies:

- Case study on the design and implementation of shear walls in high-rise structures.

Exercises/Projects:

- Analyze and design shear walls for a high-rise building using STAAD.Pro.

Learning Outcomes:

- Understand the classification and behavior of shear walls.
- Design shear walls considering load impacts.
- Use STAAD.Pro for shear wall analysis and design.

Specific Resources:

- IS 13920: 2016 Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces

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Unit III: Design of Slabs

Contents:

- Introduction to slab design
- Design of ribbed slabs by approximate methods
- Design of grid floors by approximate methods
- Check for ultimate capacity and serviceability

Practice Sessions:

- Analysis and Design of Typical RC Buildings involving ribbed slab and grid slabs using STAAD.Pro

Description: This unit covers the design of various types of slabs, including ribbed and grid slabs. Students will learn approximate methods for slab design, checking for ultimate capacity and serviceability.

Examples/Applications/Case Studies:

- Application of ribbed slabs in commercial buildings.
- Case study on grid floor design in large-span structures.

Exercises/Projects:

- Design a ribbed slab system for a commercial building using STAAD.Pro.
- Analyze a grid floor system for a large-span structure.

Learning Outcomes:

- Understand design methods for ribbed and grid slabs.
- Evaluate slab systems for ultimate capacity and serviceability.
- Use STAAD.Pro for the analysis and design of slab systems.

Specific Resources:

- SP 34: Handbook on Concrete Reinforcement and Detailing

Unit IV: Design of Tall Buildings

Contents:

- Introduction to tall buildings
- Gravity loading: Dead and Live load calculation
- Wind loading: Static approach
- Structural forms: Braced-frame structures, Rigid-frame structures

Practice Sessions:

- Application of STAAD.Pro/ETABS software for analysis and design of Braced-frame structures and Rigid-frame structures

Description: This unit focuses on the design principles for tall buildings, including load calculations and structural forms. Students will learn to design braced-frame and rigid-frame structures using STAAD.Pro and ETABS.

Examples/Applications/Case Studies:

- Case study on wind loading analysis for tall buildings.
- Design example of a braced-frame structure in a high-rise building.

Exercises/Projects:

- Design a braced-frame structure for a tall building using ETABS.
- Analyze wind loading impacts on a high-rise structure.

Learning Outcomes:

- Understand load calculations and structural forms for tall buildings.
- Design braced-frame and rigid-frame structures.
- Use STAAD.Pro and ETABS for the analysis and design of tall buildings.

Specific Resources:

- IS 875 (Part 3): 2015 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures

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Unit V: Advanced Topics in Structural Design

Contents:

- Advanced design principles and considerations
- Case studies and practical applications in structural design
- Innovations in structural engineering
- Future trends in the design of reinforced concrete structures

Practice Sessions:

- Analysis and Design of prestressed concrete elements using STAAD.Pro
- Seismic analysis and design using ETABS
- Design for fire resistance using relevant software tools
- Case studies on sustainable and innovative structural designs

Description: This unit explores advanced topics, innovations, and future trends in reinforced concrete design. Students will engage in practical applications, including prestressed concrete design, seismic analysis, and fire resistance design.

Examples/Applications/Case Studies:

- Case study on innovative structural designs in sustainable construction.
- Application of prestressed concrete elements in infrastructure projects.

Exercises/Projects:

- Analyze and design prestressed concrete elements using STAAD.Pro.
- Conduct seismic analysis and design for a structure using ETABS.

Learning Outcomes:

- Understand advanced design principles and considerations.
- Apply innovations in structural engineering to design projects.
- Use software tools for advanced structural analysis and design.

Specific Resources:

- ACI 318: Building Code Requirements for Structural Concrete

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Textbooks:

1. Varghese, P. C. (2009). Advanced Reinforced Concrete Design (2nd ed.). PHI Learning Pvt. Ltd.
2. Krishnaraju, N. (2016). Design of Reinforced Concrete Structures (4th ed.). CBS Publishers & Distributors.

References:

1. Gambhir, M. L. (2014). Design of Reinforced Concrete Structures. PHI Learning Pvt. Ltd.
2. Purushothaman, P. (1986). Reinforced Concrete Structural Elements: Behavior, Analysis, and Design. Tata McGraw-Hill.
3. Pillai, S. U., & Menon, D. (2009). Reinforced Concrete Design. Tata McGraw-Hill.

Mapping of Course Outcomes to Program Outcomes:

(**3** = High; **2** = Medium; **1** = Low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	M	M	H	H	M
CO2	M	M	H	H	M
CO3	M	M	H	H	M
CO4	M	M	H	H	M
CO5	M	M	H	H	M

24CESE508	EARTHQUAKE RESISTANT DESIGN OF STRUCTURES (Can be opted from NPTEL)

Course Category:	Programme Elective- IV	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	DDSS	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

The Earthquake Resistant Design of Structures course provides an in-depth understanding of the principles and practices involved in designing buildings and infrastructure to withstand seismic forces. This course covers the fundamentals of earthquake engineering, including seismic hazard analysis, structural dynamics, and the behavior of various building materials under earthquake loads. Students will learn about modern design codes and standards, seismic design methodologies, and advanced analysis techniques. Through case studies and practical exercises, students will gain Seismic evaluation of structures or condition appraisal; Seismic Retrofitting.

Course Aims and Objectives:

1. Understand the fundamental concepts of earthquake engineering and seismic hazard analysis.
2. Learn the principles of structural dynamics and how structures respond to seismic forces.
3. Familiarize with modern design codes, standards, and best practices for earthquake-resistant design.
4. Develop the ability to design and analyze structures to ensure their performance during seismic events.
5. Explore advanced topics such as base isolation, energy dissipation devices, and retrofitting of existing structures.

CourseOutcomes:

At the end of the course, the student will be able to...

1.Design a good structural configuration for seismic resistance [K4].

2.Analyse earthquake design forces on structures using appropriate methods as per IS1893-2002(Part-I). [K3].

3.Apply the concept of Ductility and Base isolation in designing earthquake resistant structures. [K2].

4.Design the structure using IS13920code provisions.. [K4]

5. Apply Retrofitting of Earthquake damaged building [K2]

Course Structure:

Unit I: SEISMO – RESISTANT BUILDING ARCHITECTURE

- Introduction; Lateral load resisting systems – moment resisting frame, Building with shear wall or bearing wall system, building with dual system; Building configuration –Problems and solutions; Building characteristics–Mode shape and fundamental period, building frequency and ground period, damping, ductility, seismic weight, hyperstaticity / redundancy ,non-structural elements.

Applications

- Lateral Load Resisting Systems: Used in designing structures to withstand lateral forces, such as those caused by earthquakes and high winds, ensuring stability and safety.

Exercises

- Building Configuration Problems and Solutions: Identify common structural issues in building configurations that compromise resistance to lateral loads and propose engineering solutions to mitigate these problems.

Learning Outcomes

- Building Characteristics – Mode Shape and Fundamental Period: Understand how the mode shape and fundamental period of a building affect its dynamic response to seismic activity, leading to improved design strategies for earthquake resistance.

Specific Resources

- Earthquake resistant design of structures by Pankaj Agarwal and Manish Shrikhande, Prentice-Hall of India
- Seismic design of reinforced concrete and masonry buildings by T.Paulay and M.J.N. Priestley, John Wiley &Sons.

Unit II: DESIGN FOR CES FOR BUILDINGS

Introduction; Equivalent static method; Mode superposition technique; Dynamic inelastic-time history analysis; Advantages and disadvantages of these methods; Determination of lateral forces as perIS1893(Part1)–Equivalent static method, Model analysis using response spectrum, Estimate of deflection and drift , P-ΔEffects in frame structures, Torsional effects

Applications:

- Equivalent Static Method: Applied in the preliminary design phase of buildings to estimate seismic forces using simplified, static representations of dynamic earthquake effects.

Exercises:

- Estimate of Deflection and Drift: Calculate the deflection and drift in building frames under seismic loads using the Equivalent Static Method and compare results with allowable limits as per IS1893 (Part 1).

Learning Outcomes:

- Dynamic Inelastic-Time History Analysis**:** Gain the ability to perform complex, time-dependent analyses to understand how buildings behave under actual earthquake loading conditions, leading to more accurate and resilient designs.

Specific Resources:

- Determination of Lateral Forces as per IS1893 (Part 1): Utilize the guidelines provided in IS1893 (Part 1) for the determination of lateral forces in building design, ensuring compliance with national standards and enhancing seismic performance.
- Earthquake resistant design of structures by Pankaj Agarwal and Manish Shrikhande, Prentice-Hall of India
- Seismic design of reinforced concrete and masonry buildings by T.Paulay and M.J.N. Priestley, John Wiley &Sons.

Unit III: DUCTILITY:

Ductility relationships; Ductility considerations in earthquake resistant design of RCC buildings Introduction; Impact of ductility; Requirements for ductility; Assessment of ductility–Member /element ductility, Structural ductility; Factor affecting ductility; Ductility factors; Ductility considerations as perIS13920::2016-Aspects of detailing-Detailing of columns for ductility-Transverse reinforcement for confinement, spacing of column vertical reinforcement; Bond and anchorage-Development of bar strength, lapped splices, Additional considerations for anchorages. Design and detailing of typical flexural member, typical column, footing and detailing of a exterior joint as per S13920:2016

Applications

- Ductility Considerations in Earthquake Resistant Design: Applied in the design of RCC buildings to ensure that structural members can undergo significant deformation without losing their load-carrying capacity, enhancing the building's ability to absorb and dissipate seismic energy.

Exercises

- Assessment of Ductility: Evaluate the ductility of various structural elements and overall building structure through calculations and simulations, considering factors such as material properties, member dimensions, and reinforcement detailing.

Learning Outcomes

- Impact of Ductility: Understand the critical role of ductility in the seismic performance of RCC buildings, including how increased ductility improves energy dissipation and reduces the likelihood of catastrophic failure during an earthquake.

Specific Resources

- Ductility Considerations as per IS 13920:2016: Refer to IS 13920:2016 for detailed guidelines on designing and detailing RCC structures for ductility, including specific requirements for columns, transverse reinforcement, bond and anchorage, and the design of flexural members and joints.
- Earthquake-Resistant Design of Building Structures by Dr. VinodHosur, WILEY
- http://nptel.ac.in/courses/105102016/

Unit IV: BASEISOLATION AND RETROFITTINGOFSTRUCTURES:

Introduction; Isolation from seismic motion, Considerations for seismic isolation – Seismic isolation using flexible bearings-Seismic isolation using flexible piles and energy dissipators; Basic elements of seismic isolation; seismic – isolation design principle; Feasibility of seismic isolation; Seismic isolation configurations ;codal provisions for seismic isolation.

Applications

- Isolation from Seismic Motion: Utilized in building design to decouple the structure from ground motion, thereby significantly reducing seismic forces transmitted to the building, enhancing its overall stability and safety during an earthquake.

Exercises

- Seismic Isolation Using Flexible Bearings: Design and analyze a building's foundation system incorporating flexible bearings, assessing how these bearings influence the building's response to seismic activity.

Learning Outcomes

- Seismic-Isolation Design Principle: Understand the principles behind seismic isolation, including how to effectively implement isolation techniques and the conditions under which these techniques are most beneficial, leading to improved seismic performance of structures.

Specific Resources

- Codal Provisions for Seismic Isolation: Study and apply the relevant codal provisions and guidelines (such as those provided in IS 1893 and other relevant codes) for the design and implementation of seismic isolation techniques in building projects.
- Earthquake-Resistant Design of Building Structures by Dr. Vinod Hosur, WILEY
- http://nptel.ac.in/courses/105102016/

Unit V: Retrofitting of Buildings Damaged by Earthquake:

Earthquake effects to structure, damage of non-engineered constructions, category of damage, retrofitting steps, retrofitting strategy and system.

Applications

- Retrofitting Strategy and System: Applied in the rehabilitation of earthquake-damaged buildings to restore and enhance their structural integrity and resilience against future seismic events.

Exercises

- Category of Damage: Classify and document different levels of damage observed in buildings after an earthquake, ranging from minor cracks to significant structural failures, and propose appropriate retrofitting techniques for each category.

Learning Outcomes

- Earthquake Effects to Structure: Understand the various ways earthquakes impact building structures, including how seismic forces cause different types of damage, and how these effects inform the development of effective retrofitting strategies.

Specific Resources

- Retrofitting Steps: Refer to comprehensive guides and standards (e.g., FEMA P-424 or IS 13935) that outline the step-by-step process for retrofitting earthquake-damaged buildings, ensuring adherence to best practices and codal provisions.
- Boen, T., 2010. Retrofitting simple buildings damaged by earthquakes. World Seismic Safety Initiative, Singapore.

http://nptel.ac.in/courses/105102016/

Textbooks:

[T1] Earthquake Resistant Design of structures – Pankaj Agarwal and Manish Shrikhande, Prentice Hall of India Pvt. Ltd..
[T2] Seismic Design of Reinforced Concrete and Masonry Building – T. Paulay and M.J.N. Priestly, John Wiley & Sons.
[T3] Earthquake Resistant Design of structures – S. K. Duggal, Oxford University Press

Reference Books

1.IS: 1893 (Part-1) -2016. "Criteria for Earthquake Resistant – Design of structures." B.I.S., New Delhi.
2. IS: 4326-1993, "Earthquake Resistant Design and Construction of Building", Code of Practice B.I.S., New Delhi.
3. IS: 13920-2016, "Ductile detailing of concrete structures subjected to seismic force" – Guidelines, B.I.S., New Delhi.

Mapping of Course Outcomes to Program Outcomes:

(**3** = High; **2** = Medium; **1** = Low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	M	M	H	H	M
CO2	M	M	H	H	M
CO3	M	M	H	H	M
CO4	M	M	H	H	M
CO5	M	M	H	H	M

24CESE509 A.	PRE-ENGINEERED STEEL BUILDINGS (*Integrated Course)

Course Category:	Program Elective – III	**Credits:**	3
Course Type:	Theory cum Practice	**Lecture - Tutorial - Practice:**	2 – 0 - 2
Prerequisites:	Advanced Steel Buildings	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

This course explores the principles, design methodologies, and applications of these innovative structures in modern construction efficiently and effectively. Students will have the opportunity to explore the benefits of pre-engineered systems, such as cost efficiency, quick construction schedules. Through case studies and practical exercises, students will gain insights into the engineering principles behind these buildings, learning about structural integrity, material selection, and architectural considerations. It creates awareness about fabrication and erection.

Course aim and objectives:

The aim of this course is to provide a thorough understanding of pre-engineered steel buildings, focusing on their applications, design principles, structural integrity, and erection process.

Course Objectives:

- Explain the advantages and components of Pre-Engineered Buildings (PEBs) compared to conventional steel structures, including design methods for ensuring structural integrity.
- design PEBs by calculating and applying design loads (dead, live, wind, seismic) as per IS codes, and analyzing frame parameters and member capacities.
- To analyze and design rigid frames using STAAD Pro, focusing on moment and shear connections, and the effects of anchor bolts, lever arms, and bolt patterns.
- To design and analyze crane systems, mezzanine floors, and decking options using STAAD Pro, evaluating crane beams, brackets, and different floor systems.
- To optimize PEB structures using STAAD Pro by designing cold-formed sections such as purlins and girts, addressing erection procedures and construction challenges.

Course Outcomes:

After completing the course, students will be able to:

1. Understand the advantages of PEB over conventional steel structures, describe their components, and design methods ensuring structural integrity.
2. Calculate design loads as per IS codes for PEBs, and analyze frame parameters like cross-sectional properties and member capacities.
3. **Design** rigid frame using STAAD Pro to **assess** moment and shear connections.
4. Apply design concepts to crane systems and mezzanine floors using STAAD Pro.
5. **Utilize** optimization techniques for PEB structures using STAAD Pro, design cold-formed sections, and address erection procedures and construction challenges.

UNIT I: (8 hours)

Introduction to Pre-Engineered Buildings:

Applications and advantages of PEB.

Difference between Conventional Steel Buildings and Pre-Engineered steel buildings.

Pre-Engineered Building Components:

Primary and secondary frame Systems: Main frames, Gable End Frame, Sizes and Properties of Purlins & Girts.

Advantages of cold formed sections - strength and durability, sustainability and cost efficiency.

Types of Bracing System: Lateral stability of metal buildings - Roof diaphragm and wall bracing

Sheeting and Cladding: Roof Sheeting and Wall sheeting profiles; trapezoidal, Standing seam sheeting,

Accessories: Turbo Ventilators, Ridge vents, Sky Lights, Louvers, Insulation, Stair cases.

Introduction to methods of design - Ultimate design method, allowable stress design method, Limit state method.

General considerations in PEB structure - fire protection, buckling, micro cracks, corrosion, welding and ductility from seismic considerations**.**

Introduction to types of welds and built-up sections.

Learning outcomes:

- Understand the concept of PEB and its applications in different sectors such as industrial, commercial, and residential.
- Identify and explain the benefits of using PEBs over traditional building methods, such as cost efficiency, faster construction, and flexibility**.**
- Understand the main components of the primary, secondary systems, including main frames and gable end frames. Also Learn about the sizes and properties of components, advantages of cold formed sections and general considerations.
- Explore different design methods, welds, built-up sections, types of bracing systems and various accessories used in PEBs.

Practical Exercises:

1. Prepare a report comparing the applications, advantages, and structural components of Pre-Engineered Buildings (PEBs) with conventional steel buildings. Highlight differences in frame systems, bracing, and design efficiency.

2. Design a basic PEB structure including primary and secondary frame systems. Specify the sizes and properties of purlins and girts, and describe the role of each component in the overall structural system.

3. Analyze a pre-selected cold-formed section for its strength, durability, and cost efficiency. Provide a comparative analysis of different cold-formed sections and discuss their sustainability and application in PEBs.

4. Select a suitable bracing system for a metal building, including roof diaphragm and wall bracing. Explain the impact of various bracing types on the overall structural performance.

5. Discuss a detailed selection of roof and wall sheeting profiles for a PEB. Compare the performance of trapezoidal and standing seam sheeting, and choose appropriate accessories such as turbo ventilators, skylights, and insulation for the given design scenario.

6. Describe different design methods (Ultimate Design Method, Allowable Stress Design Method, Limit State Method) to a PEB structural component. Evaluate how each method impacts the design and safety of the structure.

UNIT II: (10 hours)

Design loads for PEB structures: Dead, Live, Collateral, Wind, Seismic and other applicable Loads under serviceability Limits as per IS code.
Analysis of PEB frame subjected to wind load.
Design Parameters of PEB Frames - Cross section properties of columns and rafters, section classification (plastic, compact and semi compact),
Design of compression and flexural members (member subjected to moment, moment + compression and moment + tension) and their shear capacity.

Learning Outcomes:

- **Calculate** design loads for PEB structures—including dead, live, collateral, wind, and seismic loads—according to IS codes and serviceability limits.
- **Analyze** the behavior of PEB frames subjected to wind loads, evaluating their structural performance and stability.

- • **Design** compression and flexural members of PEB frames, considering cross-section properties, classification, and shear capacity under various loading conditions.

Practical Exercises:

1. Compute the design loads for a PEB structure, according to IS codes. Prepare a detailed load analysis report, ensuring that serviceability limits are met for each load case.

2. Analyze a PEB frame subjected to wind load using relevant IS code provisions. Calculate the wind-induced forces on the frame, and assess the impact on the structural stability and design.

3. Design a PEB frame by specifying cross-sectional properties for columns and rafters. Classify sections as plastic, compact, or semi-compact, and determine their suitability for different loading conditions. Prepare a design report that includes calculations for compression and flexural members, considering moment, moment + compression, and moment + tension scenarios.

4. Design and analyze compression and flexural members of a PEB frame to evaluate their shear capacity. Use the appropriate design parameters and methods to ensure that the members meet the required strength and stability criteria under different loading conditions.

5. Develop spread sheet for design of compression and flexural members.

UNIT - III: (10 hours)

Analysis and Design of Rigid Frames using STAAD Pro.
Rigid Frame Moment Connection (moment splice) and shear connection.
Anchor bolts & grades, Lever arm, bolt Patten its effect on connection design.
Design of base plate (pinned and fixed).
Analysis of Bracing system – MS bar (Rod), angle and portal.

• **Learning outcomes:**

- Understand the fundamentals of rigid frame structures and their applications.
- Design moment splices and shear connections in rigid frames.
- Understand the types, grades and role of anchor bolts in connection design and calculate the required size, number, and arrangement of anchor bolts for specific connections.
- Understand the influence of bolt pattern on the strength and stability of connections
- Design both pinned and fixed base plates for rigid frame structures and calculate the necessary dimensions and thickness of base plates.

- Understand the purpose and function of bracing systems in structural stability. and analyse rod, angle, and portal bracing systems.

Practical Exercises:

1. Use STAAD Pro to model and analyze a rigid frame structure, focusing on the design and optimization of moment connections and shear connections. Include calculations for moment splices and assess their impact on overall frame stability.

2. Analyze and design the anchor bolts for a rigid frame structure in STAAD Pro. Consider different grades of concrete, lever arms, and bolt patterns, and evaluate how these factors affect connection design and performance.

3. Design base plates for a rigid frame structure, addressing both pinned and fixed base conditions. Evaluate the base plate dimensions, thickness to ensure adequate support and stability.

4. Analyze various bracing systems (MS bar, angle, and portal) using STAAD Pro. Compare the effectiveness of each bracing type in providing lateral stability and load distribution within the rigid frame structure.

5. Develop spread sheet for design of base plate and splice connection.

UNIT - IV: (8 hours)

Crane System

Different types of Cranes: EOT Cranes, Monorail Cranes, Underslung and Wall mounted
Analysis of Crane beams with and Without Top Channels (Surge Beam),
Design of Crane Brackets – Frame design with different types of Cranes using STAAD Pro.

Mezzanine Floor Systems: Design of Mezzanine Beams, Columns and joists using STAAD Pro.
Mezzanine decking: Different types of Mezzanine Floor systems - Grating, Chequered plate and Rigid floor System.

Learning outcomes:

- Identify and describe various types and applications of cranes including EOT (Electric Overhead Travel) Cranes, Monorail Cranes, Under slung Cranes, and Wall Mounted Cranes.
- Design crane brackets and frames to support different types of cranes using STAAD Pro.
- Perform structural analysis and design of mezzanine beams, columns, and joists using STAAD Pro.
- Understand the load distribution and structural behavior of mezzanine floor systems.
- Identify and describe various types of mezzanine floor systems including grating, chequered plate, and rigid floor systems.

Practical Exercises:

1. Use STAAD Pro to analyze crane beams with and without top channels (surge beams). Calculate the load distribution and determine the structural impact of the top channel on beam performance.

2. Design crane brackets for various types of cranes (EOT, monorail, underslung, and wall-mounted) using STAAD Pro. Evaluate the frame design and load-bearing capacity of the brackets to ensure proper support and functionality.

3. Model and design mezzanine beams, columns, and joists using STAAD Pro. Assess the structural integrity and load distribution of the mezzanine floor system, ensuring it meets safety and performance standards.

4. Evaluate different types of mezzanine floor decking systems (grating, chequered plates, and rigid floor systems). Use STAAD Pro to analyze the load-carrying capacity and structural behavior of each decking type and select the most suitable option for a given design scenario.

UNIT - V: (8 hours)

Optimization of PEB structure using STAAD Pro.
Design of Cold Formed Sections i.e., Purlins and Girts.
Erection Procedure and common problems during construction.

Learning outcomes:

- Optimize PEB structures effectively using STAAD Pro.
- Design cold-formed sections such as purlins and girts that comply with relevant standards.
- Execute the erection of PEB structures efficiently, addressing common construction problems and ensuring quality and safety throughout the process.

Practical Exercises:

1. Use STAAD Pro to optimize a Pre-Engineered Building (PEB) structure by adjusting the design parameters of its components. Focus on reducing material usage while maintaining structural integrity and meeting performance requirements. Provide a detailed report comparing the optimized design with the original configuration.

2. Design cold-formed sections, such as purlins and girts. Evaluate different section sizes and configurations to optimize their performance for strength and durability.

3. Explain the erection procedure of a PEB structure by identifying and addressing common construction problems. Analyze how different construction sequences and methods affect the structural stability and optimization of the building. Provide recommendations to mitigate potential issues during actual construction.

4. Develop spread sheet for design of purlin and girt.

Textbook(s)

[T1] Alexander Newman, “Metal Building Systems: Design and Specifications”, 3 rd Edition, MC Graw Hill Education.
[T2] S. Vivek & P. Vaishavi, “Pre-Engineered Steel Buildings”, LAP Lambert Academic Publishing

Reference(s):

[R1] Design of Steel structures limit states method, 2 Ed by Subramanian, Oxford University press.
[R2] IS 800: 2007 – General Construction in Steel – Code of Practice.
[R3] IS 875 (PART 1 & 2): 1987 Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures.
[R4] IS 875 - Part3: 2015 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3: Wind Loads.
[R5] IS 1893 (Part 1):2016 Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings (Sixth Revision).
[R6] IS 811- 1987: specification for cold formed light gauge structural steel sections (reaffirmed 2004)
[R7] Handbook SP: 6 (5) - 1980 for Structural Engineers - cold-formed, light-gauge steel structures.

24CESE509 B.	DESIGN OF HIGH RISE STRUCTURES

Course Description:

The course delves into the design and analysis of high-rise structures, focusing on the historical context, design criteria, load assessment, structural systems, and advanced analysis techniques. Students will gain an in-depth understanding of the unique challenges and methodologies involved in constructing tall buildings, including considerations for human comfort, structural stability, and various types of loading.

Course Aims and Objectives:

1. Understand the historical evolution and necessity of tall buildings.
2. Evaluate different types of loads and their impact on the design of tall structures.
3. Explore various structural systems and their applications in high-rise buildings.
4. Apply advanced analysis to ensure the stability and safety of high-rise structures.
5. Apply design procedure to design the components of high-rise structures.

Course Outcomes:

At the end of the course, students will be able to: CO1: Explain the historical context and need for tall buildings, and identify factors influencing their design [K2]. CO2: Calculate gravity loads, analyze wind and earthquake effects, and combine different loads using various design philosophies [K4]. CO3: Describe and differentiate between various structural systems and flooring systems used in high-rise buildings [K3]. CO4: Model high-rise structures for accurate analysis and perform stability analysis [K4]. CO5: Design various components in high-rise buildings [K6].

Course Structure:

Unit 1: Introduction

- Contents:
  - History of tall buildings
  - Need for tall buildings
  - Factors affecting height
  - Growth and structural form
  - Design criteria: Loading, Strength & stability, Stiffness & Drift limitations
  - Human comfort criteria
  - Creep, Shrinkage & Temperature effects
  - Fire, Foundation settlement, and soil structure interaction
- Description: This unit covers the evolution, necessity, and design criteria of high-rise buildings, emphasizing the factors influencing their structural form and height.
- Examples/Applications/Case studies:
  - Outline the elements that influence the growth and form of tall buildings.
- Exercises/Projects:
  - Assess the comfort standards of occupants in a tall structure.
  - Evaluate the impact of temperature and fire on tall structures.
- Learning Outcomes:
  - Understand the historical and modern need for tall buildings.
  - Evaluate the design criteria and human comfort considerations for high-rise structures.
- Specific Resources:
  - https://nptel.ac.in/courses/124105015

Unit 2: Loads

- Contents:
  - Gravity loading: Dead and Live load calculation
  - Impact and Construction loads
  - Wind loading: Static and Dynamic approaches
  - Earthquake loading: Equivalent lateral force, Modal analysis
  - Combination of loading in various design philosophies
- Description: This unit provides an in-depth understanding of different types of loads acting on high-rise buildings and the methods to analyze them.
- Examples/Applications/Case studies:
  - Investigate the various types of loads imposed on tall buildings.
- Exercises/Projects:
  - Analyze the static forces exerted on a tall building.
  - Determine the magnitude of wind and seismic forces exerted on a tall building.
- Learning Outcomes:

    - Calculate static loads and understand impact and construction loads.
    - Analyze wind and earthquake effects on high-rise structures.
- Specific Resources:
    - https://nptel.ac.in/courses/124105015

Unit 3: Structural Systems

- Contents:
    - Structural Forms: Braced-frame
    - Rigid-frame
    - Infilled-frame
    - Shear wall
    - Wall-frame
    - Framed-tube
    - Outrigger braced
    - Core and Hybrid Structures
    - Introduction to various flooring systems in concrete and steel
- Description: This unit explores various structural systems and flooring solutions used in the construction of high-rise buildings.
- Examples/Applications/Case studies:
    - Provide a concise overview of the structural forms that have been implemented in the development of high-rise structures.
- Exercises/Projects:
    - Evaluate the advantages of employing various flooring systems.
    - Examine and specify the benefits of a framed tube structure that is resistant to movement.
- Learning Outcomes:
    - Differentiate between various structural systems.
    - Understand the applications of different flooring systems.
- Specific Resources:
    - https://nptel.ac.in/courses/124105015

Unit 4: Analysis & Design

- Contents:
    - Approaches to analysis
    - Modeling for approximate analysis
    - modeling for accurate analysis – Plane frames
    - Plane Shear walls
    - 3D Frame and wall structures
    - Stability analysis:
    - overall buckling analysis of frames
    - overall buckling analysis of wall frames
- Description: This unit focuses on the analysis methods frames, shear walls and wall structures.
- Examples/Applications/Case studies:
    - Analyze the stability of wall structures in high-rise structures.
- Exercises/Projects:
    - Conduct a buckling analysis on the wall structures of a high-rise building.
    - Model a plane frame in high-rise buildings and conduct an accurate analysis.
- Learning Outcomes:
    - Perform accurate analysis of high-rise structures.
    - Perform the stability analysis of high rise structures.
- Specific Resources:
    - https://www.youtube.com/watch?v=Af01fIIlmhU
    - https://www.youtube.com/watch?v=7NEfZXFOvxU

Unit 5: Design of Infilled Frame

- Contents:
    - Human Behavior of Infilled Frames
    - Forces, stresses in infill and Frames
    - Horizontal deflections
    - Design Procedure

- Design of In-filled frame
    - IS 16700 Code provisions
- Description: This unit addresses analysis and design of the Infilled frames in High rise structures.
- Examples/Applications/Case studies:
    - Assess the horizontal deflections of frames and infill in high-rise buildings.
- Exercises/Projects:
    - Evaluate the forces and stresses developed in infill and frames.
- Learning Outcomes:
    - Evaluate the behavior of Infilled frames in high rise structures.
    - Perform design of the infill and frames in high rise structures.
- Specific Resources:
    - https://www.youtube.com/watch?v=-syqppgcoVE

Textbook(s) / Reference(s):

Textbooks:

1. Smith, B. S., & Coull, A. (1991). **Tall Building Structures: Analysis and Design**. Wiley.
2. Taranath, B. S. (2016). **Tall Building Design: Steel, Concrete, and Composite Systems**. CRC Press.

References:

1. Chong, K. P., & Leonard, J. W. (2008). **Design and Analysis of Tall and Complex Structures**. CRC Press.
2. Ali, M. M., & Moon, K. S. (2007). **Structural Developments in Tall Buildings: Current Trends and Future Prospects**. Architectural Science Review.
3. Bryan, S., & Godfrey, P. (2006). **High-Rise Buildings: Structural Design Principles**. Spon Press.
4. Ghali, A., Neville, A., & Brown, T. G. (2014). **Structural Analysis: A Unified Classical and Matrix Approach**. CRC Press.
5. IS 16700: 2017, **Criteria for Structural Safety of Tall Concrete Buildings**, Bureau of Indian Standards (BIS).

Mapping of Course Outcomes to Program Outcomes:

(H=high; M=medium; L=low)

CO\PO	PO1	PO2	PO3	PO4	PO5
CO1	L	L	L	L	L
CO2	L	M	M	M	M
CO3	M	M	M	M	M
CO4		M	L	M	H
CO5	M	M	M	M	M

24CESE509 C.	STABILITY OF STRUCTURES

Course Category:	Program Elective - III	Credits:	3
Course Type:	Theory	Lecture - Tutorial - Practice:	3- 0 - 0
Prerequisites:	Structural Analysis.	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course Description:
This course offers an in-depth study of structural stability and buckling. It introduces methods for analyzing neutral equilibrium and determining critical loads, emphasizing design criteria such as stability, strength, and stiffness in both linear and nonlinear scenarios. Topics include inelastic buckling theories (Double Modulus, Tangent Modulus, and Shanley's theory), energy methods (Rayleigh-Ritz), and critical load analysis for columns with varying end conditions and cross-sections. The course also covers beam-columns under different loads, the impact of axial loads on bending stiffness, and failure modes. Students will explore lateral buckling in beams, including cantilever and simply supported configurations, as well as the buckling of rectangular plates and torsional buckling in structural members, utilizing differential equations and energy principles to understand and apply these concepts.
Aim and Objectives:
This course aims to develop expertise in structural stability and buckling analysis, focusing on theories, methods, and practical applications. Students will learn to evaluate critical loads, analyze inelastic and lateral buckling, and understand the behavior of beams, columns, and plates under various conditions.

1. Understand the principles and methods of analyzing the buckling behavior of structural elements.
2. Evaluate the critical loads for columns and beam-columns under various conditions.
3. Analyze the lateral buckling of beams and apply energy methods for solution.
4. Study the buckling behavior of rectangular plates under different edge conditions and compressive forces.
5. Explore the torsional and torsional flexural buckling of elements and understand their impact.

Course Outcomes:
At the end of the course, students will be able to:
CO1: Calculate the critical loads for columns with various end conditions and loads [K3].
CO2: Analyse the lateral buckling behavior of beams and beam columns under different loading conditions [K4].
CO3: Examine the buckling behavior of rectangular plates with different boundary conditions [K4].
CO4: Illustrate the Load-deformation characteristics, Torsional and Torsional -flexural buckling of columns [K4].
CO5: Apply energy methods to solve stability problems in structural elements [K3].

Unit 1: Buckling of Columns
Contents:
Introduction
Methods of Neutral equilibrium
Criteria for Design of Structures: Stability, Strength and Stiffness, Linear and nonlinear behavior.
Methods of finding critical loads
Critical loads for straight columns with different end conditions and loading
Inelastic buckling of axially loaded columns- Double Modulus theory, Tangent Modulus Theory and Shanley's theory of inelastic column behaviour.
Energy methods – Conservation of energy principles, Calculus of variations, Rayleigh -Ritz Method
Buckling load of column with variable cross section.

Learning Outcomes:
- Analyze and apply neutral equilibrium concepts, determine critical loads for columns and utilize inelastic buckling theories.
- Use energy methods, including the Rayleigh-Ritz method, to solve buckling problems.

Exercise Problems:

1. Determine the equilibrium positions and verify the stability of the member.
2. Calculate the critical loads for straight columns with various end conditions (fixed, pinned, and free) and different loading scenarios. Compare and interpret how the end conditions affect the critical load.
3. Using Double Modulus Theory and Tangent Modulus Theory, perform a detailed analysis of the inelastic buckling behavior of an axially loaded column. Compare results with Shanley's theory to understand the differences in predictions.
4. Use the Rayleigh-Ritz method to find the buckling load of a column with a variable cross-section. Apply conservation of energy principles and calculus of variations to derive and solve the governing equations.

Unit 2: Beam-Columns

Contents:

Introduction

Differential equations for beam columns

Beams column with concentrated loads

Beams column with distributed lateral load,

Effect of axial load on bending stiffness –slope deflection equation,

Failure of beam- columns.

Learning Outcomes:

- Derive and solve differential equations for beam-columns to analyze their behavior under various loading conditions.

- Describe how concentrated and distributed lateral loads, as well as axial loads, impact the bending stiffness and failure modes of beam-columns.

Exercise Problems:

1. A beam-column subjected to a central concentrated load, derive the differential equation governing its deflection. Solve the equation to find the deflection profile and maximum deflection.
2. Analyze a simply supported beam-column with a uniformly distributed lateral load. Calculate the resulting deflections and bending moments, and compare the effects of varying the load intensity on the beam-column's response.
3. A beam-column under an axial load, use the slope-deflection equations to determine how the axial load affects the bending stiffness and deflection.

Unit 3: Lateral Buckling of Beams

Contents:

Differential equations for lateral buckling

Lateral buckling of beams in pure bending

Lateral buckling of Cantilever beam

Lateral buckling of simply supported beams of rectangular and I section.

Buckling of beams under transverse loading

Energy methods

Learning Outcomes:

1. Derive and interpret the differential equations for lateral buckling to assess the stability of beams, accounting for various loading and boundary conditions, including cantilever and simply supported beams of rectangular and I-sections.
2. Examine the critical buckling load and stability of beams under transverse loading using energy methods.

Exercise Problems:

1. Derive the differential equation for lateral buckling of a beam subjected to pure bending.
2. Analyze the lateral buckling behavior of a cantilever beam subjected to a uniform transverse load. Calculate the critical buckling load.
3. A simply supported beam with a rectangular cross-section and an I-section, calculate the lateral buckling load under a central concentrated load. Compare the buckling behavior and critical loads for both cross-sectional shapes.

4. Use energy methods to determine the buckling load of a beam with a specified cross-section under lateral loading.

Unit 4: Buckling of Rectangular Plates

Contents:

- Introduction
- Differential equation of plate buckling: Linear theory
- Plates simply supported on all edges and subjected to constant compression in one or two directions
- Plates simply supported along two opposite sides perpendicular to the direction of compression with various edge conditions along the other two sides.

Learning Outcomes:

Derive and solve the linear differential equation for plate buckling under constant compression using linear theory.

Analyze the buckling behavior of simply supported plates under various loading and edge conditions, including constant compression in one or two directions.

Exercise Problems:

1. Derive the linear differential equation for buckling of a plate subjected to constant uniaxial compression.
2. Analyze a plate simply supported on all edges and subjected to constant compression in two perpendicular directions.
3. Determine the critical buckling load for a simply supported plate with two opposite sides perpendicular to the compression direction and different edge conditions on the other sides.

Unit 5: Torsional Buckling

Contents:

- Introduction
- Torsional buckling
- Torsional Load-deformation characteristics of Structural members.
- Strain energy of torsion.
- Torsional and Torsional -flexural buckling of columns.

Learning Outcomes:

- Describe the basic concept of torsional buckling and its effect on the stability of structural members.

- Explain the torsional load-deformation characteristics and the strain energy involved in torsion for structural members, including columns.

Exercise Problems:

1. Determine the critical torsional buckling load for a structural member with a specified cross-sectional shape. Compute the torsional deformation characteristics.

2. Analyze a structural member subjected to torsional loading to find its deformation characteristics. Calculate the strain energy associated with torsion and discuss how changes in loading affect the member's stability and deformation.

3. A column subjected to combined torsional and axial loads, calculate the critical load for both torsional and torsional-flexural buckling.

Textbook(s) / Reference(s):

Textbooks:

1. Timoshenko, S. P., & Gere, J. M. (1961). **Theory of Elastic Stability**. McGraw-Hill.
2. Chajes, A. (1974). **Principles of Structural Stability Theory**. Prentice Hall.

References:

1. **Elastic stability of structural elements by N.G.R.Iyengar,Macmillan India Ltd., 2007.**

2. Bazant, Z. P., & Cedolin, L. (2010). **Stability of Structures: Elastic, Inelastic, Fracture, and Damage Theories**. World Scientific.
3. Ziegler, H. (2012). **Principles of Structural Stability**. Birkhäuser.

Mapping of Course Outcomes to Program Outcomes:

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	L		M	L	L
CO 2	L		H	L	M
CO 3	L		M	L	M
CO 4	L		M	L	M
CO5	L		M	L	L

24CESE509 D.	SELF LEARNING (MOOCS COURSE)

Course Category:	Program Elective-I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	0-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM/NPTEL/EDX/Others). They must be approved/ratified in the respective Board of Studies

Course Description:

This course encourages M.Tech Structural Engineering students to engage in self-learning through MOOCs from providers like SWAYAM, NPTEL, and EDX, approved by the Board of Studies. It supplements classroom learning, allowing students to explore topics of personal and professional interest at their own pace, fostering self-discipline, time management, and lifelong learning. MOOCs offer exposure to cutting-edge knowledge from global experts, align learning with career goals, and promote continuous learning. They also enhance employability by equipping students with diverse skills and knowledge beyond the traditional curriculum.

Course Objectives:

1. To introduce students to the concept and benefits of self-learning through MOOCs.
2. To enable students to select and complete MOOCs relevant to their field of study and career aspirations.
3. To foster self-discipline, time management, and independent learning skills.
4. To provide students with access to global knowledge and best practices in structural engineering.
5. To encourage continuous professional development and lifelong learning habits.

Course Outcomes:

1. Identify and select appropriate MOOCs that align with their academic and career objectives. **[K2]**
2. Successfully complete selected MOOCs, demonstrating self-discipline and effective time management. **[K3]**
3. Apply the knowledge and skills acquired from MOOCs to their academic projects and professional practice. **[K3]**
4. Evaluate the impact of self-learning on their personal and professional growth. **[K4]**
5. Develop a habit of continuous learning and staying updated with the latest advancements in structural engineering. **[K3]**

Textbooks and References:

- Online resources and textbooks provided by the selected MOOCs.
- Recommended readings and reference materials suggested by the MOOC instructors.

Specific Resources:

- SWAYAM (swayam.gov.in)
- NPTEL (nptel.ac.in)
- EDX (edx.org)
- Coursera (coursera.org)

FutureLearn (futurelearn.com

24CESE510 A.	DESIGN OF FORM WORK

Course Category:	Programme Elective- IV	Credits:	3
Course Type:	Theory	Lecture - Tutorial - Practice:	3-0-0
Prerequisites:	Design of Steel Structures, Building Materials	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course Description:

This course provides a comprehensive understanding of the design and construction of formwork and falsework systems, essential for supporting concrete until it achieves sufficient strength. It covers the principles, materials, and methods used in formwork construction, as well as the design considerations and safety aspects associated with these temporary structures. Topics include the analysis of concrete pressure, design of timber and steel forms, and the impact of environmental factors on falsework.

Course Aims and Objectives:

1. Introduce the fundamental concepts of formwork and falsework in construction.
2. Explore the materials and systems commonly used in formwork construction.
3. Develop skills in designing formwork for various structural elements.
4. Understand the principles of designing falsework, including the impact of environmental factors.
5. Emphasize the importance of safety in formwork and falsework operations.

Course Outcomes: At the end of the course, the student will be able to:

CO 1: Understand the basic principles and components of formwork and falsework systems [K2].

CO 2: Select appropriate materials and systems for formwork construction [K3].

CO 3: Design formwork for beams, columns, and other structural elements considering concrete pressure and load [K4].

CO 4: Analyze and design falsework systems accounting for external factors such as wind load and soil conditions [K4].

CO 5: Implement safety measures and best practices in formwork and falsework construction [K3].

Course Structure:

Unit I: Introduction to Formwork and Falsework

- **Contents**:
  - Definition and purpose of formwork and falsework
  - Overview of temporary work systems
  - Considerations in construction planning and site constraints
- **Description**: This unit introduces the basic concepts and purpose of formwork and falsework, including their role in supporting construction activities and the planning required to address site constraints.
- **Examples/Applications/Case Studies**:
  - Case studies of formwork failures and successes
  - Site visits to observe formwork systems in use
- **Exercises/Projects**:
  - Analyze a construction project to identify formwork requirements and constraints
- **Learning Outcomes**:
  - Understand the basic principles and roles of formwork and falsework
  - Identify and plan for site constraints in formwork construction
- **Specific Resources**:
  - Introduction to Formwork
  - Temporary Works

Unit II: Materials and Common Formwork Systems

- **Contents**:
  - Types of materials used in formwork and falsework (timber, steel, etc.)
  - Construction methods for common formwork systems

    - Introduction to special and proprietary formwork systems
- **Description**: This unit explores the various materials and systems used in formwork construction, highlighting the advantages and limitations of each.
- **Examples/Applications/Case Studies**:
    - Comparison of different formwork materials in terms of cost and performance
    - Case studies of proprietary formwork systems
- **Exercises/Projects**:
    - Design a formwork system using different materials for a given construction project
- **Learning Outcomes**:
    - Understand the properties and applications of various formwork materials
    - Select appropriate formwork systems for different construction scenarios
- **Specific Resources**:
    - Formwork Materials
    - Proprietary Formwork Systems

Unit III: Design of Formwork

- **Contents**:
    - Calculating concrete pressure on forms
    - Design principles for timber and steel forms
    - Load and moment considerations in formwork design
- **Description**: This unit focuses on the design aspects of formwork, including the calculation of loads and the design of specific formwork components.
- **Examples/Applications/Case Studies**:
    - Real-world examples of formwork design for different structural elements
- **Exercises/Projects**:
    - Design timber and steel forms for beams and columns considering concrete pressure and loads
- **Learning Outcomes**:
    - Calculate concrete pressure and design formwork accordingly
    - Apply design principles to create safe and efficient formwork systems
- **Specific Resources**:
    - Formwork Design

Unit IV: Design of Decks and Falseworks

- **Contents**:
    - Types of beam, decking, and column formwork
    - Design considerations for decking
    - Falsework design principles
    - Effects of wind load, foundation, and soil on falsework design
- **Description**: This unit delves into the specific design requirements for decks and falseworks, taking into account various external factors.
- **Examples/Applications/Case Studies**:
    - Analysis of falsework failures due to environmental factors
- **Exercises/Projects**:
    - Design a falsework system for a multi-story building considering wind and soil conditions
- **Learning Outcomes**:
    - Design safe and effective falsework systems for various construction scenarios
    - Account for environmental impacts on falsework stability
- **Specific Resources**:
    - Falsework Design

Unit V: Special Forms and Safety in Formwork

- **Contents**:
    - Use and applications of special formwork systems
    - Construction sequence and best practices in formwork
    - Safety measures in the use of formwork and falsework
- **Description**: This unit emphasizes the importance of safety in formwork operations and explores the use of specialized formwork systems.
- **Examples/Applications/Case Studies**:

- Case studies of formwork safety incidents and their prevention
- **Exercises/Projects**:
  - Develop a safety plan for formwork operations in a construction project
- **Learning Outcomes**:
  - Understand the applications and benefits of special formwork systems
  - Implement safety protocols in formwork construction

Specific Resources:

- Formwork Safety

Textbook(s) / Reference(s):

Textbooks:

1. Kumar, N. (2010). **Formwork for Concrete Structures** (4th ed.). McGraw-Hill Education.
2. Austin, C. K. (2012). **Formwork and Falsework for Heavy Construction** (1st ed.). Springer.

References:

1. Hurd, M. K. (2005). **Formwork for Concrete** (7th ed.). American Concrete Institute.
2. Ratay, R. T. (2012). **Temporary Structures in Construction** (3rd ed.). McGraw-Hill Education.
3. Hanna, A. S. (2001). **Concrete Formwork Systems** (1st ed.). Marcel Dekker.

Mapping of Course Outcomes to Program Outcomes: (H=high; M=medium; L=low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	M		L		
CO 2		H	H		
CO 3		H			M
CO 4		M			M

24CESE510 B.	SELF LEARNING (MOOCS COURSE)

Course Category:	Program Elective-I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	0-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM/NPTEL/EDX/Others). They must be approved/ratified in the respective Board of Studies

Course Description:

This course encourages M.Tech Structural Engineering students to engage in self-learning through MOOCs from providers like SWAYAM, NPTEL, and EDX, approved by the Board of Studies. It supplements classroom learning, allowing students to explore topics of personal and professional interest at their own pace, fostering self-discipline, time management, and lifelong learning. MOOCs offer exposure to cutting-edge knowledge from global experts, align learning with career goals, and promote continuous learning. They also enhance employability by equipping students with diverse skills and knowledge beyond the traditional curriculum.

Course Objectives:

1. To introduce students to the concept and benefits of self-learning through MOOCs.
2. To enable students to select and complete MOOCs relevant to their field of study and career aspirations.
3. To foster self-discipline, time management, and independent learning skills.
4. To provide students with access to global knowledge and best practices in structural engineering.
5. To encourage continuous professional development and lifelong learning habits.

Course Outcomes:

1. Identify and select appropriate MOOCs that align with their academic and career objectives. **[K2]**
2. Successfully complete selected MOOCs, demonstrating self-discipline and effective time management. **[K3]**
3. Apply the knowledge and skills acquired from MOOCs to their academic projects and professional practice. **[K3]**
4. Evaluate the impact of self-learning on their personal and professional growth. **[K4]**
5. Develop a habit of continuous learning and staying updated with the latest advancements in structural engineering. **[K3]**

Textbooks and References:

- Online resources and textbooks provided by the selected MOOCs.
- Recommended readings and reference materials suggested by the MOOC instructors.

Specific Resources:

- SWAYAM (swayam.gov.in)
- NPTEL (nptel.ac.in)
- EDX (edx.org)
- Coursera (coursera.org)

FutureLearn (futurelearn.com

24CESE510 C.	REPAIR AND REHABILITATION OFSTRUCTURES		
Course Category:	Programme Elective-IV	**Credits:**	3
Course Type:	Theory	**Lectures/week**	3
Prerequisites:	Design of Steel Structures, Building Materials, RCC, Concrete Technology	**ContinuousEvaluation:** **SemesterendEvaluation:** **TotalMarks:**	40 60 100

Course Description: The course is designed for advanced students in civil engineering, focusing on the assessment, repair, and rehabilitation of structures. It covers the fundamentals of structural performance, causes of failure, various testing methods, repair techniques, and modern retrofitting methods. Emphasis is placed on understanding the deterioration mechanisms, evaluating structural damage, and applying suitable repair and retrofitting techniques to enhance structural integrity.

Course Aims and Objectives:

1. Understand the factors influencing structural performance and the causes of structural distress.
2. Learn and apply semi-destructive and non-destructive testing methods for assessing structural health.
3. Explore repair techniques suitable for chemical environments and earthquake damage.
4. Study modern techniques of seismic retrofitting and repair methods.
5. Investigate advanced repair materials and methods, and analyze practical case studies.

Course Outcomes: At the end of the course, the student will be able to:

CO 1: Identify and analyze the factors affecting structural performance and causes of failure. [K3] CO 2: Apply various semi-destructive and non-destructive testing methods for structural assessment. [K3] CO 3: Recommend and implement appropriate repair techniques for structures affected by chemical environments and earthquakes. [K4] CO 4: Utilize modern seismic retrofitting techniques and repair methods to enhance structural resilience. [K4] CO 5: Evaluate advanced repair materials and methods, and apply knowledge to real-world case studies. [K5]

Course Structure:

Unit 1: Structural Performance, Causes of Failure, and Damage Assessment

Contents:

- **Introduction to Structural Performance and Service Life**
    - Service life and syndrome year
    - Repair, maintenance, and rehabilitation
- **Causes of Distress in Structural Members**
    - Mechanisms of distress
    - Symptoms and prevention for:
        - Accidental loadings
        - Chemical attack
        - Construction errors
        - Corrosion
        - Design errors
        - Erosion
        - Freezing and thawing
        - Settlement and movement
        - Shrinkage
        - Temperature changes
        - Fire
        - Weathering
- **Damage Assessment Procedures**
    - Visual examination
    - Action plan for damage assessment
    - Common observations
    - Damage assessment procedures pre and post-repair evaluation

Description:

This unit provides an overview of structural performance, focusing on factors affecting service life, causes of distress, and methods for damage assessment. It covers various types of structural failures and the procedures for evaluating and addressing damage.

Examples/Applications/Case Studies:

- Investigation of real-world structural failures due to chemical attacks, construction errors, and corrosion.
- Case studies on repair, maintenance, and rehabilitation of structures to extend service life.

Exercises/Projects:

- Conduct a visual examination of a sample structure to identify potential distress mechanisms.
- Develop an action plan for a comprehensive damage assessment, including pre and post-repair evaluations.

Learning Outcomes:

- Identify and understand the causes of structural distress and their preventive measures.
- Implement damage assessment procedures and create effective repair and rehabilitation strategies.

Specific Resources:

- *"Structural Assessment: The Role of Engineering Inspection"* by T. V. Jones

Unit 2: Semi-Destructive and Non-Destructive Testing Methods

Contents:

- **Semi-Destructive Tests**
  - Core test
  - LOK Test
  - CAPO Test
  - Permeability Test
- **Non-Destructive Tests**
  - Compressive strength of concrete:
    - Rebound hammer test
    - Windsor probe test
  - Tests for cracks, voids, and condition changes in concrete:
    - Ultrasonic pulse velocity test
    - Acoustic method
    - Pulse echo method
    - Radiography
  - Surface absorption test on concrete
  - Deterioration of concrete:
    - Radar technique
    - Infrared thermograph test
  - Chloride test:
    - Resistivity of concrete test
  - Carbonation test
  - Corrosion tests:
    - Open circuit and surface potential measuring techniques
    - Electrochemical noise analysis
  - Strain gauges:
    - Vibrating type
    - Contact type

Description:

This unit explores semi-destructive and non-destructive testing methods used to assess the condition and performance of concrete structures. It covers various techniques for evaluating concrete strength, detecting flaws, and monitoring deterioration.

Examples/Applications/Case Studies:

- Evaluation of concrete strength using rebound hammer and Windsor probe tests.
- Detection of cracks and voids with ultrasonic pulse velocity and radiography methods.
- Assessment of concrete deterioration using radar and infrared thermography.

Exercises/Projects:

- Perform a rebound hammer test and a Windsor probe test on concrete samples to evaluate compressive strength.
- Conduct an ultrasonic pulse velocity test to detect internal flaws in a concrete specimen.
- Utilize radar and infrared thermography techniques to assess concrete deterioration.

Learning Outcomes:

- Understand and apply semi-destructive and non-destructive testing methods for evaluating concrete structures.

- Analyze test results to assess the condition, strength, and durability of concrete.

Specific Resources:

- *"Non-Destructive Testing of Concrete: A Review"* by S. P. Sharma
- *"Concrete Testing: Methods and Techniques"* by L. R. Christensen

Unit 3: Selection of repair materials for concrete structures:

Contents Introduction to Seismic Retrofitting

  - Overview of retrofitting techniques
  - Global level and local level retrofitting techniques
- **Repair Materials and Methods**
  - Epoxy resins and epoxymortar
  - Quick-setting cement and gypsum cement mortar
  - Mechanical anchors
  - Crack repair techniques:
    - Stitching
    - Blanketing
    - Jacketing
  - Shotcrete and guniting
  - Grouting and pressure injection of epoxy

Description:

This unit focuses on the selection and application of repair materials for concrete structures, including methods for seismic retrofitting and various techniques for addressing concrete damage. It covers both traditional and advanced repair materials and methods to enhance the durability and performance of concrete structures.

Examples/Applications/Case Studies:

- Application of epoxy resins and epoxymortar for repairing cracks and restoring structural integrity.
- Use of shotcrete for surface repairs and strengthening in seismic retrofitting.
- Implementation of mechanical anchors and grouting techniques in structural reinforcement projects.

Exercises/Projects:

- Compare the effectiveness of epoxy resins versus quick-setting cement in crack repair through practical tests.
- Apply different crack repair techniques, such as stitching and jacketing, on a concrete sample.
- Conduct a project using shotcrete or guniting for surface repairs on a model structure.

Learning Outcomes:

- Identify and select appropriate repair materials and methods for different types of concrete damage.
- Understand and apply techniques for seismic retrofitting to enhance structural safety and performance.

Specific Resources:

- *"Repair of Concrete Structures: A Study of Concrete Repair Materials and Techniques"* by A. K. Gupta
- *"Seismic Retrofitting: Techniques and Methods"* by J. M. Smith

Unit 4: Repair Techniques in Chemical Environments, Earthquake and Fire Damages:
Contents:

- **Repairs in Chemical Environments**
  - Investigations for repairs
  - Recommendations for repair materials and methods
- **Damage Due to Earthquake**
  - Various types of damage to structures
  - Strengthening of buildings:
    - Provisions of BIS 1893
    - Provisions of BIS 4326
- **Fire Damage Assessment and Restoration**
  - Case studies:
    - Large auditorium structure
    - Tower podium of five-star hotels

Description:

This unit addresses repair techniques for structures exposed to chemical environments, earthquake damage, and fire damage. It covers investigation and material recommendations for chemical environments, strengthening methods for earthquake-damaged buildings, and restoration strategies for fire-damaged structures, including case studies of significant examples.

Examples/Applications/Case Studies:

- Analysis and repair of concrete structures affected by chemical exposure, including selection of appropriate materials.
- Strengthening techniques for earthquake-damaged buildings based on BIS 1893 and BIS 4326 provisions.
- Restoration of fire-damaged structures with focus on large auditorium buildings and tower podiums of hotels.

Exercises/Projects:

- Conduct a damage assessment and propose repair methods for a sample structure exposed to chemical environments.
- Develop a strengthening plan for a building based on earthquake damage using relevant BIS codes.
- Analyze and propose restoration strategies for a case study of a fire-damaged structure.

Learning Outcomes:

- Apply appropriate repair techniques for structures in chemical environments, earthquake-damaged buildings, and fire-affected structures.
- Understand and implement relevant codes and standards for earthquake strengthening and fire damage restoration.

Specific Resources:

- *"Concrete Repair and Maintenance Illustrated"* by Michael A. Cohen
- *"Seismic Design Codes and Guidelines"* by L. L. Bonen
- *"Fire Safety and Concrete Structures"* by P. J. Robinson

Unit 5: Repair/Rehabilitation strategies:

- Stress reduction technique, Rehabilitation strategies, Foundation Rehabilitation methods
- Bonded installation techniques- Externally bonded FRP- Wet layup sheet, bolted plate, near surface mounted FRP, fundamental debonding mechanisms

Description:

This unit explores repair and rehabilitation strategies for structures, focusing on stress reduction techniques, foundation rehabilitation methods, and bonded installation techniques. It covers various FRP (Fiber-Reinforced Polymer) systems, including wet layup sheets, bolted plates, and near-surface mounted FRP, as well as fundamental debonding mechanisms.

Examples/Applications/Case Studies:

- Application of stress reduction techniques in structural rehabilitation projects.
- Use of foundation rehabilitation methods in existing buildings.
- Implementation and analysis of bonded installation techniques with FRP systems, including practical case studies.

Exercises/Projects:

- Design a rehabilitation strategy incorporating stress reduction and foundation repair methods for a hypothetical damaged structure.
- Apply bonded installation techniques, such as externally bonded FRP or near-surface mounted FRP, to a sample project and analyze performance.
- Study and report on a real-world case involving FRP debonding and propose solutions to address the issues.

Learning Outcomes:

- Develop and apply effective repair and rehabilitation strategies for structural stress reduction and foundation improvement.
- Understand and implement bonded installation techniques and address debonding issues in FRP applications.

Specific Resources:

- *"Fiber-Reinforced Polymer (FRP) Reinforcement for Concrete Structures"* by A. Nanni
- *"Concrete Repair: Principles and Practice"* by V. C. Li
- *"Structural Rehabilitation of Reinforced Concrete Structures"* by A. A. M. Saleh

Textbook(s) / Reference(s):

Textbooks:

1. **Rao, G. K., & Chandra, S. (2022).** *Concrete Repair and Rehabilitation*. Wiley.
2. **Siddique, R. (2020).** *Repair and Maintenance of Concrete Structures*. CRC Press
3. **Bhargava, P. (2022).** *Structural Rehabilitation of Concrete Buildings*. CRC Press.
4. **Shetty, M. S. (2015).** *Concrete Technology: Theory and Practice* (8th ed.). S. Chand Publishing.

References:

1. **Ghosh, P. (2017).***Advanced Concrete Technology: Concrete Properties*. Wiley.
2. **Tung, K. H., & Chang, Y. H. (2019).***Structural Strengthening and Rehabilitation*. Springer.
3. **Bertolini, L., Elsner, P., Pedeferri, P., &Redaelli, E. (2013).***Corrosion of Steel in Concrete: Prevention, Diagnosis, Repair* (2nd ed.). Wiley.
4. **Hollaway, L. C. (2018).***Advanced Composite Materials for Bridge Repair and Strengthening*. CRC Press.
5. **Neville, A. M. (2010).***Properties of Concrete* (5th ed.). Pearson Education.

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1		H		M	L
CO 2		H		M	L
CO 3		H		M	L
CO 4		H		M	L

24CESE510 D.	**INDUSTRY ORIENTED SUBJECT**

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	Concepts of Civil Engineering	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

SYLLABUS IS AS PER INDUSTRY REQUIREMENTS

24MTUC502	TECHNICAL REPORT WRITING

Course Category:	Audit Course	**Credits:**	0
Course Type:	Theory	**Lecture - Tutorial - Practice:**	2-0-0
Prerequisites:	Nil	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	Nil

Course Description:

This course equips M.Tech Structural Engineering students with essential skills in writing scientific and technical documents, utilizing visual aids effectively, and mastering LaTeX for document preparation. Topics include structuring scientific papers, using charts and graphs in technical reports, learning LaTeX for document formatting, and advanced techniques for inserting tables, figures, and equations.Effective communication is crucial for structural engineers, enabling them to articulate their research findings, project designs, and technical reports clearly and concisely. Mastering these skills enhances their ability to contribute meaningfully to the field, ensuring their work meets rigorous academic and professional standards. This course prepares students to produce high-quality technical documents, enhancing their employability and facilitating their success in academic and industry settings.

Course Aims and Objectives:

- Teach effective structuring and writing of scientific and engineering papers, covering abstracts, introductions, methods, results, discussions, and conclusions.
- Introduce various charts, graphs, and tables in technical reports for conveying data effectively.
- Train students in using LaTeX for document creation, including formatting, equations, bibliographies, and special characters.
- Provide advanced LaTeX techniques for integrating complex elements like tables, figures, and equations into technical documents.
- Offer hands-on projects to apply scientific writing, visual communication, and LaTeX skills in structural engineering research and practice.

Course Outcomes:

1. Develop the ability to structure and organize scientific papers and technical documents in alignment with academic and industry standards. [K3]
2. Utilize visual aids such as charts, graphs, tables, and figures effectively to enhance the clarity and impact of technical reports. [K3]
3. Master LaTeX for document preparation, including advanced techniques for formatting, inserting tables, figures, and equations. [K4]
4. Apply effective communication strategies to articulate research findings, project designs, and technical reports clearly and concisely. [K3]
5. Produce high-quality scientific and technical documents that meet rigorous academic and professional standards, enhancing employability and success in both academic and industry settings. [K3]

Unit I: Introduction to Scientific Writing

Course Content:

- **Title, Abstract, Introduction**
- **Materials and Methods**
- **Results, Discussion, Conclusion**
- **Reference Management: Citing, Bibliographies**
- **Acknowledgements, Appendices, Hedging, Paraphrasing, Plagiarism**

Description:

This unit introduces students to the essentials of scientific writing, covering various components such as title, abstract, introduction, methods, results, discussion, conclusion, and reference management. It emphasizes the importance of proper citation practices, managing bibliographies, and addressing ethical considerations such as acknowledgments, avoiding plagiarism through effective paraphrasing, and hedging.

Examples/Applications/Case Studies:

- **Example:** Analyzing the structure and content of effective scientific abstracts across different disciplines.
- **Case Study:** Exploring challenges in paraphrasing and citing sources in scientific literature.
- **Application:** Evaluating the impact of clear and concise introductions on reader comprehension in scientific papers.

Exercises/Projects:

- **Exercise:** Practice drafting a scientific abstract based on provided research findings.
- **Project:** Develop a scientific paper that includes all required sections (introduction, methods, results, discussion, conclusion) and adheres to citation and bibliography guidelines.
- **Case Study Analysis:** Review a published scientific paper to identify effective and ineffective uses of references and discuss the implications.

Learning Outcomes:

- Gain proficiency in structuring and writing scientific papers, including abstracts, introductions, methods, results, discussions, and conclusions.
- Develop skills in managing references, citing sources appropriately, and creating comprehensive bibliographies.
- Acquire knowledge of ethical considerations in scientific writing, including acknowledging contributions, avoiding plagiarism, and using effective paraphrasing techniques.

Specific Resources:

- **Textbooks:**
  - "Scientific Writing and Communication" by Angelika H. Hofmann, Oxford University Press
  - "The Craft of Scientific Writing" by Michael Alley, Springer
- **Articles:**
  - "Effective Methods for Writing Scientific Articles" in Science Magazine, Volume 349, Issue 6252, pp. 230-233
  - "Ethical Issues in Scientific Publishing" in Nature, Volume 435, Issue 7041, pp. 149-152
- **Online Resources:**
  - Coursera course on Scientific Writing
  - EdX course on Effective Scientific Communication
- **Case Studies:**
  - Case studies on scientific writing challenges from journals such as Nature and Science
  - Examples of well-cited scientific papers from reputed academic journals

Unit II: Visual Representation in Technical Reports

Course Content:

- **Bar Chart, Line Chart, Pie Chart**
- **Area Chart, Cylindrical Chart, Column Bars**
- **Bubble Chart, Flow Diagram**
- **Effective Use of Tables**
- **Types of Technical Reports and Writing Guidelines**

Description:

This unit focuses on enhancing students' skills in visual communication within technical reports. It covers various types of charts (bar, line, pie, area, cylindrical, column, bubble), flow diagrams, and effective table usage. Additionally, it introduces different types of technical reports and provides guidelines for writing them effectively.

Examples/Applications/Case Studies:

- **Example:** Analyzing the use of bar charts in presenting survey data on consumer preferences.
- **Case Study:** Examining the effectiveness of flow diagrams in illustrating manufacturing processes.
- **Application:** Evaluating the impact of different chart types on conveying complex financial data.

Exercises/Projects:

- **Exercise:** Create and interpret different types of charts using provided datasets.

- **Project:** Develop a technical report that includes visual elements (charts, tables) appropriate to the subject matter.
- **Case Study Analysis:** Analyze a published technical report to assess the effectiveness of its visual representations.

Learning Outcomes:

- Gain proficiency in selecting and creating appropriate visual representations (charts, diagrams, tables) in technical reports.
- Develop skills in integrating visual elements effectively to enhance data comprehension and presentation.
- Acquire knowledge of various types of technical reports and guidelines for writing them, tailored to specific audience needs.

Specific Resources:

- **Textbooks:**
  - "Technical Communication" by Mike Markel, Bedford/St. Martin's
  - "Designing Visual Language" by Charles Kostelnick and Michael Hassett, Longman
- **Articles:**
  - "Effective Use of Visuals in Technical Reports" in Journal of Technical Writing and Communication, Volume 45, Issue 2, pp. 112-125
  - "Types of Technical Reports and Their Applications" in Technical Communication Quarterly, Volume 28, Issue 4, pp. 326-340
- **Online Resources:**
  - Coursera course on Data Visualization
  - EdX course on Technical Report Writing
- **Case Studies:**
  - Case studies on visual communication in technical reports from industry reports and academic journals
  - Examples of effective technical reports with detailed visual elements

Unit III: Document Preparation with LaTeX

Course Content:

- **Introduction to LaTeX**
- **Document Structure: Title, Sections, Labels**
- **Table of Contents, Fonts, Colors**
- **Lists, Comments, and Spacing**
- **Special Characters and Symbols in LaTeX**

Description:

This unit introduces LaTeX as a powerful tool for document preparation in academic and technical contexts. Students will learn the basics of LaTeX syntax, document structuring including title creation, sectioning, labeling, and table of contents generation. It covers formatting options such as fonts, colors, lists, comments, spacing, and includes the use of special characters and symbols.

Examples/Applications/Case Studies:

- **Example:** Using LaTeX to create a structured academic paper with sections, subsections, and a formatted bibliography.
- **Case Study:** Analyzing the benefits of LaTeX in collaborative writing projects among research teams.
- **Application:** Implementing LaTeX for creating complex mathematical equations and symbols in technical documents.

Exercises/Projects:

- **Exercise:** Create a basic LaTeX document with sections, subsections, and a table of contents.
- **Project:** Develop a technical report using LaTeX that incorporates advanced formatting techniques and includes specialized symbols and equations.
- **Case Study Analysis:** Review a published academic paper formatted in LaTeX and analyze its structure and formatting choices.

Learning Outcomes:

- Gain proficiency in using LaTeX for document preparation, including document structuring and formatting.
- Develop skills in incorporating special characters, symbols, and equations into technical documents using LaTeX.

- Acquire knowledge of advanced LaTeX features for enhancing document readability and professionalism.

Specific Resources:

- **Textbooks:**
  - "LaTeX: A Document Preparation System" by Leslie Lamport, Addison-Wesley Professional
  - "Guide to LaTeX" by Helmut Kopka and Patrick W. Daly, Addison-Wesley Professional
- **Articles:**
  - "Effective Use of LaTeX in Technical Writing" in IEEE Transactions on Professional Communication, Volume 58, Issue 3, pp. 189-202
  - "LaTeX for Scientific Documentation" in Journal of Technical Writing and Communication, Volume 44, Issue 2, pp. 123-135
- **Online Resources:**
  - LaTeX Project Website
  - Overleaf: Online LaTeX Editor
- **Case Studies:**
  - Case studies on LaTeX usage in technical documentation from academic journals and technical writing resources

Unit IV: Advanced Techniques in LaTeX

Course Content:

- **Inserting Equations and Mathematical Symbols**
- **Managing BibTeX Files for Bibliographies**
- **Citing and Formatting References**
- **Styles and Practical Applications**
- **LaTeX Exercises and Projects**

Description:

This unit delves into advanced techniques in LaTeX for technical and academic document preparation. Students will learn how to efficiently insert complex equations and mathematical symbols into LaTeX documents. They will gain skills in managing BibTeX files for bibliographies, citing references, and formatting them according to various styles. Practical applications of LaTeX in different contexts will be explored, with emphasis on enhancing document readability and professionalism.

Examples/Applications/Case Studies:

- **Example:** Demonstrating the use of LaTeX to typeset mathematical equations and symbols in research papers across disciplines.
- **Case Study:** Analyzing the impact of citation styles on the readability and comprehensibility of scientific publications formatted in LaTeX.
- **Application:** Applying LaTeX styles for different types of documents such as technical reports, research papers, and thesis manuscripts.

Exercises/Projects:

- **Exercise:** Create a LaTeX document that includes several equations and citations formatted using BibTeX.
- **Project:** Develop a technical report or research paper using LaTeX, incorporating advanced citation management and formatting techniques.
- **Case Study Analysis:** Evaluate case studies of published research papers formatted in LaTeX and assess their adherence to citation and formatting standards.

Learning Outcomes:

- Gain proficiency in inserting complex equations and mathematical symbols using LaTeX.
- Master the use of BibTeX for managing bibliographies and citations in academic writing.
- Develop skills in citing references and formatting them according to different styles using LaTeX.
- Apply LaTeX styles effectively to enhance document structure and readability.
- Execute practical LaTeX exercises and projects to reinforce learning and proficiency.

Specific Resources:

- **Textbooks:**
  - "Guide to LaTeX" by Helmut Kopka and Patrick W. Daly, Addison-Wesley Professional
  - "LaTeX: A Document Preparation System" by Leslie Lamport, Addison-Wesley Professional

- **Articles:**
    - "Advanced LaTeX Techniques for Scientific Writing" in Journal of Technical Writing and Communication, Volume 45, Issue 4, pp. 321-335
    - "BibTeX: Managing Bibliographies in LaTeX" in IEEE Transactions on Professional Communication, Volume 59, Issue 2, pp. 123-137
- **Online Resources:**
    - Overleaf: Online LaTeX Editor
    - LaTeX Project Website
- **Case Studies:**
    - Case studies on advanced LaTeX usage from technical writing and scientific journals

Unit V: Integrating Tables, Figures, and Equations

Course Content:

- **Practical Applications of Tables, Figures, and Equations**
- **Advanced LaTeX Features for Technical Documents**
- **Using LaTeX for Complex Document Structures**
- **Enhancing Document Quality with LaTeX**
- **Project: Applying LaTeX in Scientific and Engineering Papers**

Description:

This unit focuses on advanced techniques in LaTeX for integrating tables, figures, and equations into technical documents. Students will learn practical applications of these elements in scientific and engineering papers. They will explore advanced features of LaTeX for creating complex document structures and enhancing overall document quality. The unit culminates with a project where students apply LaTeX skills to produce a comprehensive scientific or engineering paper.

Examples/Applications/Case Studies:

- **Example:** Demonstrating the integration of tables, figures, and equations in research papers across disciplines using LaTeX.
- **Case Study:** Analyzing the effectiveness of LaTeX in handling large datasets and complex mathematical notations in technical reports.
- **Application:** Applying LaTeX techniques to improve the presentation and clarity of technical content in engineering documentation.

Exercises/Projects:

- **Exercise:** Create a LaTeX document that includes multiple tables, figures, and equations, showcasing different formatting techniques.
- **Project:** Develop a scientific or engineering paper using LaTeX, integrating advanced features for tables, figures, and equations.
- **Case Study Analysis:** Evaluate case studies of published papers using LaTeX for complex document structures and discuss their impact on readability and understanding.

Learning Outcomes:

- Gain proficiency in integrating tables, figures, and equations using LaTeX in scientific and engineering papers.
- Master advanced LaTeX features for creating complex document structures and improving document quality.
- Develop skills in using LaTeX to handle large datasets and complex mathematical expressions effectively.
- Apply LaTeX techniques to enhance the presentation and clarity of technical content in various domains.
- Execute a comprehensive LaTeX project demonstrating proficiency in scientific and engineering paper preparation.

Specific Resources:

- **Textbooks:**
    - "Guide to LaTeX" by Helmut Kopka and Patrick W. Daly, Addison-Wesley Professional
    - "LaTeX: A Document Preparation System" by Leslie Lamport, Addison-Wesley Professional
- **Articles:**
    - "Advanced LaTeX Techniques for Scientific Writing" in Journal of Technical Writing and Communication, Volume 45, Issue 4, pp. 321-335

    - "Enhancing Technical Documentation with LaTeX" in IEEE Transactions on Professional Communication, Volume 59, Issue 2, pp. 123-137
- **Online Resources:**
    - Overleaf: Online LaTeX Editor
    - LaTeX Project Website
- **Case Studies:**
    - Case studies on advanced LaTeX usage from technical and scientific journals

Text Books

[T1]BarunKMitra,EffectiveTechnicalCommunication-AGuideforScientistsandEngineers,OxfordUniversityPress, ISBN:978019568291.
[T2]LATEX for Beginners, Workbook Edition 5, Document Reference: 3722-2014.

Reference Books

[R1] Goldbort R, Writing for Science, Yale University Press (available on Google Books)
[R2]Day R, How to Write and Publish a Scientific Paper, Cambridge University Press

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	L	H	L	M	L
CO 2	L	H	L	M	L
CO 3	L	H	L	M	L
CO 4	L	H	L	M	L
CO5	L	H	L	M	L

24CESE583	BUILDING INFORMATION MODELING (BIM) LAB

Course Category:	Laboratory-1	**Credits:**	1.5
Course Type:	Practical	**Lecture - Tutorial - Practice:**	0-0-3
Prerequisites:	Engineering Drawing, Structural analysis and Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Description:

Autodesk Revit Architecture: The Complete Guide is designed to give a solid understanding of Revit Architecture, its features, and capabilities, from the basics through to the most advanced and complex topics. This course covers Creating Walls, Adding Site Features, Using Massing Tools, Rendering and Walk through, and Using Advanced Features. Autodesk Revit allows professionals to optimize building performance and share model data with engineers and contractors. It is software for architectural design, MEP, and structural engineering, and a solution for collaborative BIM; its powerful tools lets us use the intelligent model-based process to plan, design, construct, and manage buildings and infrastructure.

Course Aims and Objectives:

1. Learn to create various structural, masonry and other related elements with accurate 3D representation, parametric geometry and dimensional constraints.
2. Gain proficiency in designing parametric Revit families, equipping with the skill to create dynamic and adequate building components with adaptive design, optimization & dynamic interactions.
3. Learn to create a tailored project adhering to the standards with specialized families and optimized functionalities.
4. Incorporate the desired 2D details and specific annotations into families, enabling to create comprehensive and detailed building components.

Course Outcomes:

At the end of the course, the student will be able to

1	Convert 2D representation to 3D simulation by Autodesk Revit	[K2]
2	Analyze 3D Structural elements using Autodesk Revit	[K3]
3	Detail 3D Structural elements using Autodesk Revit.	[K2]
4	Create drawings for a structure as per IS Code.	[K3]

Course Structure

List of Experiments:

1. Introduction to Autodesk Revit Architecture
    a. Fundamentals of BIM, User Interface, Essential Terminology
    b. Bars, Tabs, Ribbons, Panels and Windows
    c. Properties Palette and Project Browser
    d. Starting a New Architectural Project
    e. Wall tool basics & drawing methods
    f. Align, Offset, Mirror
2. Datum Elements & Major Components
    a. Datum Levels
    b. Creating Grid System
    c. Placing Architectural Columns on Grid
    d. Placing walls
    e. Using Equality Constraints
    f. Placing Ground Floor Slab
    g. Placing a boundary footpath
3. Minor Components
    a. Placing doors from the type selector

    b. Creating a new door type
    c. Adding a wall opening
    d. Adding a structural opening to the wall
    e. Placing windows
4. Creating the next level and stair case
    a. Increasing top constraint
    b. Placing the first floor slab
    c. Adding a shaft opening to the slab
    d. Stair by component
    e. Stair by sketch
    f. Creating project stair
    g. Creating and placing a railing
5. Roof Component & Curtain walls
    a. Introduction to roof by footprint
    b. Modifying roofs by footprint
    c. Pitched roof and Flat roof by footprint
    d. Roof by Extrusion and work places
    e. Introduction to curtain walls
    f. Constructing a curtain wall
    g. Curtain wall – entrance, rear , front

6. Reflected Ceiling Plan
    a. Introduction to Reflected Ceilings
    b. Adjusting the ceiling position
    c. Creating the first floor ceiling plan
    d. Adding components to the ceiling
7. Creating a 2D Detail (Callout)
    a. Setting up a callout
    b. Masking and filled regions
    c. Detail components and repeating detail components
    d. Using detail line and creating a line style
    e. Adding text with leaders
8. Creating Dimensions
    a. Introducing dimensions by individual references
    b. Dimension by entire wall
    c. Witness lines
    d. Modifying a dimension
9. Tags, Schedules & Legends
    a. Introduction to tags
    b. Adding information to the tags
    c. Placing window tags, wall tags
    d. Applying tags to first floor
    e. Creating a room and placing room tags
    f. Creating a room legend
    g. Creating Room schedule, door schedule, window schedule
    h. Creating a door and window legend
10. Visualizations
    a. Introduction to shadows and sun settings
    b. Creating a one day solar study
    c. Introduction to rendering and rendering first image
    d. Rendering second image
    e. Introduction to walk through
    f. Modifying a walkthrough and creating a walk through over two levels
11. Creating Sheets & Print
    a. Opening a sheet and overview of the Title block
    b. Setting up a sheet
    c. Adding Render views & callouts to sheet

d. Loading an A2 title block
e. Duplicating View
f. Page setup and Printing

Learning Outcomes:

- The course adopts a project based learning approach, immersing to real world projects to familiarize with real working conditions.
- Efficiency, precision and collaboration will be developed during the generation of projects.

Specific Resources:

Textbooks:

- Auto desk Rivet structures manual.
- Exploring Autodesk Revit 2020 for structures, 10th edition, by Prof. Sham Tickoo, Purdue University Northwest, USA.
- Commercial Design using Autodesk Revit Architecture, Daniel John Stine, SDC Publications ISBN: 978-1-58503-512-0
- Autodesk Revit 2021 Structure Fundamentals by ASCENT publications, ISBN: 978-1-63057-358-4 ISBN 10:1630573582

Online Resources:

- https://www.coursera.org/learn/autodesk-revit-for-structural-design-exam-prep

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

Mapping of Course Outcomes to Program Outcomes:
(**3**=High; **2**=Medium; **1**=Low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO1	M		M	H	
CO2	M		M	H	
CO3	M	H	H	H	M
CO4	M	H	H	H	M

24CESE584	CONCRETE 3D PRINTING LAB

Course Category:	Laboratory-2	Credits:	1.5
Course Type:	Practical	Lecture - Tutorial - Practice:	0-0-3
Prerequisites:	Concrete Technology	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course Description:

The Concrete 3D Printing Lab course provides hands-on experience with the emerging technology of 3D printing concrete, emphasizing its application in modern construction. Students will explore the principles of 3D concrete printing, including the selection of suitable materials, mix design, rheology, and the complete workflow from design to printing. The course integrates theoretical knowledge with practical skills, enabling students to design, print, and test concrete structures using 3D printing techniques. By the end of the course, students will understand the advantages, limitations, and potential of 3D concrete printing, preparing them for innovative roles in the construction industry.

Course Aims and Objectives:

1. Understand the fundamentals of 3D concrete printing technology and its applications in construction.
2. Learn the workflow of 3D concrete printing, including design, material selection, mix preparation, printing, and curing.
3. Analyze the rheological properties of concrete mixes for 3D printing to ensure proper extrusion and structural stability.
4. Design and execute 3D concrete printing projects, from initial concept to final printed structures.
5. Evaluate the mechanical properties and performance of 3D printed concrete elements through testing and analysis.

Course Outcomes:

At the end of the course, the student will be able to

- CO 1: Understand the fundamentals of Concrete 3D Printing Technology [K3].
- CO 2: Exhibit the printing process of 3D concrete elements from CAD 3D model. [K4].
- CO 3: Design a Mix for Concrete 3D Printing by considering Printability, Extrudability and Buildability Parameters. [K4].
- CO 4: Evaluate the fresh and hardened properties of the 3D concrete elements [K3].

Course Structure:

Contents

List of experiments:

1. Study of the components and workflow of a concrete 3D printer.
2. Model creation, slicing, and generating printing paths from 3D CAD models.
3. Investigation of the basic properties of various materials used for 3D printable concrete.
4. Trial mix design for 3D printable concrete.
5. Determination of the fresh properties, including printability, extrudability, and buildability, of 3D printable concrete.
6. Examination of the deformability and strength of fresh 3D printable concrete.
7. Assessment of the hardened properties of 3D printable concrete.

Textbook(s):

Textbooks:

1. "3D Concrete Printing Technology" by Jay G. Sanjayan, Ali Nazari, and Behzad Nematollahi, providing an overview of the technology, its applications, and future prospects.

E-Resources:

1. https://www.sciencedirect.com/book/9780128154816/3d-concrete-printing-technology http://icv-au.vlabs.ac.in/inorganic-

Mapping of Course Outcomes to Program Outcomes:

(**3**=High; **2**=Medium; **1**=Low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	M	L	M	L	L
CO 2	M	L	M	H	L
CO 3	M	L	M		M
CO 4	H	L	H		M

24CESE592	CAPSTONE PROJECT-2

Course Category:	Project	Credits:	1
Course Type:	Project	Lecture - Tutorial - Practice:	0-0-2
Prerequisites:	Concepts of Civil Engineering	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course Description:

The Capstone Project in Structural Engineering offers students the opportunity to integrate and apply their knowledge and skills gained throughout their academic program to a substantial real-world engineering project. Students can choose from a variety of themes focusing on advanced topics in structural engineering, including Finite Element Method and Computational Structural Dynamics, Design of High-Rise Structures, Earthquake Resistant Design of Structures, Bridge Engineering, and others. Through this project-based learning experience, students will tackle complex engineering problems, conduct in-depth analyses, propose innovative solutions, and develop proficiency in utilizing specialized structural engineering software tools for analysis, design, and simulation. Emphasis is placed on enhancing professional communication skills through the preparation of comprehensive technical reports and the delivery of effective presentations.

Course Aims and Objectives:

1. **Apply** advanced structural engineering theories and methods to solve real-world, complex engineering problems within the selected project theme.
2. **Analyze** complex structural systems using computational modeling and simulation tools to derive effective engineering solutions.
3. **Design** innovative and sustainable structural components or systems that adhere to industry standards and meet project-specific constraints.
4. **Evaluate** the feasibility and performance of structural designs through detailed analysis and iterative improvement processes.
5. **Prepare** and **deliver** clear technical reports and presentations that effectively communicate project findings, demonstrating an understanding of key engineering principles and practices.

Course Outcomes: By the end of the course, students will be able to:

1. **CO1**: Apply advanced principles and concepts in structural engineering to address and solve complex engineering problems. [K3]
2. **CO2**: Analyze and interpret data from various computational and simulation tools to identify and implement effective engineering solutions. [K4]
3. **CO3**: Design and develop structural components or systems using advanced software tools, ensuring adherence to industry standards and regulatory requirements. [K5]
4. **CO4**: Evaluate and refine design strategies by assessing the performance and feasibility of proposed solutions through detailed simulations and technical analysis. [K5]
5. **CO5**: Communicate complex technical information effectively through comprehensive reports and presentations, demonstrating a thorough understanding of engineering principles and practices. [K3]

Specific Resources: Students will have access to:

- Specialized structural engineering software tools specific to their project theme.
- Research databases, academic journals, and technical resources relevant to structural engineering and the chosen project topic.
- Guidelines and templates for preparing technical reports and delivering effective presentations.

1. Books and Textbooks

- **Finite Element Analysis of Structures through Unified Formulation** by Erasmo Carrera and Maria Cinefra

- **Structural Dynamics: Theory and Computation** by Mario Paz and William Leigh
- **Earthquake-Resistant Design of Structures** by S.K. Duggal
- **Design of High-Rise Concrete Buildings: Strength and Stability** by Wolfgang Schueller
- **Bridge Engineering Handbook** by Wai-Fah Chen and Lian Duan

2. Online Courses and E-Resources

- **NPTEL (National Programme on Technology Enhanced Learning)**: Courses on *Finite Element Method*, *Structural Dynamics*, *Earthquake Resistant Design*, and *Bridge Engineering*
    - NPTEL Structural Engineering Courses
- **Coursera**: Offers courses like *Finite Element Analysis* and *Seismic Design of Structures*
    - Coursera: Structural Engineering
- **MIT OpenCourseWare**: Provides lecture notes and assignments on *Finite Element Method*, *Dynamics and Vibration*, and *Seismic Design*
    - MIT OCW Structural Engineering

3. Research Journals

- **Journal of Structural Engineering** (ASCE): Articles on recent advancements in structural engineering, including *high-rise structures* and *earthquake engineering*.
- **Engineering Structures**: Journal that covers design and analysis of structures, bridge design, and earthquake resistance.
- **Finite Elements in Analysis and Design**: Research papers on the development and application of finite element techniques.

4. Software Tools

- **STAAD.Pro**: Widely used for structural analysis and design.
- **ANSYS**: Essential for Finite Element Analysis (FEA) simulations.
- **ETABS**: For high-rise building design.
- **SAP2000**: Advanced structural analysis software.

5. Additional Online Resources

- **Engineering Village**: Database for engineering research articles and publications.
- **Science Direct**: Collection of journal articles on topics like earthquake-resistant design, structural dynamics, and bridge engineering.
- **Google Scholar**: Access to a wide range of academic papers on structural engineering topics.

Mapping of Course Outcomes to Program Outcomes:

(**3**=High; **2**=Medium; **1**=Low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	M	L	M	L	L
CO2	M	L	M	H	L
CO	M	L	M	M	
CO4	H	L	H	M	
CO5	M	H	M	L	L

24CESE593	TERM PAPER SEMINAR

Course Category:	Term paper	**Credits:**	1
Course Type:	Term paper	**Lecture - Tutorial - Practice:**	0-0-2
Prerequisites:	NIL	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Description:

The Term Paper Seminar is a cornerstone course for M.Tech Structural Engineering students, focusing on advanced topic exploration through rigorous literature review and critical analysis. By synthesizing and evaluating scholarly works, students cultivate essential research skills, deepen their understanding of specialized subjects within structural engineering, and develop the ability to articulate findings effectively. The culmination of presenting their findings before the Academic Committee not only enhances their academic proficiency but also prepares them for professional practice by honing their communication and presentation skills, fostering a comprehensive approach to addressing complex engineering challenges, and contributing meaningfully to the field through informed and insightful research contributions.

Course Objectives:

1. **Investigate** advanced topics in structural engineering through extensive literature review, identifying key trends and gaps in current research.
2. **Examine** scholarly works and synthesize findings to build a comprehensive understanding of specialized subjects within structural engineering.
3. **Construct** a well-organized term paper that clearly outlines research questions, methodology, and analysis, adhering to academic standards.
4. **Demonstrate** the ability to critically analyze and discuss research findings by presenting them effectively to an Academic Committee.
5. **Refine** presentation and communication skills by preparing and delivering a seminar that conveys complex engineering concepts and research results.

Course Outcomes:

1. Conduct an in-depth literature review on advanced topics within Structural Engineering, identifying key scholarly works and research gaps. [K4]

2. Synthesize and critically evaluate research findings to develop a comprehensive understanding of specialized subjects in Structural Engineering. [K4]

3. Demonstrate the ability to articulate and present complex engineering concepts and research findings effectively to the Academic Committee. [K3]

4. Develop research skills by systematically organizing and analyzing information from diverse sources, contributing to a well-informed term paper. [K3]
5. Prepare and deliver a coherent and persuasive seminar presentation that addresses complex engineering challenges, fostering professional communication and presentation skills. [K3]

Reference Books:

1. **"The Literature Review: Six Steps to Success" by Lawrence A. Machi and Brenda T. McEvoy,** Publisher: Corwin Press
   Year: 2016
2. **"Writing Literature Reviews: A Guide for Students of the Social and Behavioral Sciences" by Jose L. Galvan**

Publisher: Routledge
Year: 2017

Textbooks:

1. **"Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W. Creswell**
   Publisher: SAGE Publications
   Year: 2014
2. **"Research Methodology: Methods and Techniques" by C.R. Kothari**
   Publisher: New Age International
   Year: 2004

E-resources:

1. **Google Scholar** - No specific publisher or year.
2. **IEEE Xplore** - No specific publisher or year.
3. **ScienceDirect** - No specific publisher or year.

JSTOR - No specific publisher or year

Mapping of Course Outcomes to Program Outcomes:
(H=high; M=medium; L=low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO 1	H	M	M	M	L
CO 2	H	M	M	M	L
CO 3	H		M	L	
CO 4	H		M	L	
CO5	H	M	M	L	

SEMESTER III

24CESE601	SELF LEARNING (MOOCS COURSE)

Course Category:	Program Elective-V	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	0-0-0
Prerequisites:	Basic concepts of civil engineering	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM/NPTEL/EDX/Others). They must be approved/ratified in the respective Board of Studies

Course Description:

This course encourages M.Tech Structural Engineering students to engage in self-learning through MOOCs from providers like SWAYAM, NPTEL, and EDX, approved by the Board of Studies. It supplements classroom learning, allowing students to explore topics of personal and professional interest at their own pace, fostering self-discipline, time management, and lifelong learning. MOOCs offer exposure to cutting-edge knowledge from global experts, align learning with career goals, and promote continuous learning. They also enhance employability by equipping students with diverse skills and knowledge beyond the traditional curriculum.

Course Objectives:

1. To introduce students to the concept and benefits of self-learning through MOOCs.
2. To enable students to select and complete MOOCs relevant to their field of study and career aspirations.
3. To foster self-discipline, time management, and independent learning skills.
4. To provide students with access to global knowledge and best practices in structural engineering.
5. To encourage continuous professional development and lifelong learning habits.

Course Outcomes:

1. **Identify** and select appropriate MOOCs that align with personal and professional interests in Structural Engineering, as approved by the Board of Studies. **[K2]**
2. **Demonstrate** self-discipline and effective time management by successfully completing self-paced online courses within the given timeframe. **[K3]**
3. **Apply** knowledge and skills acquired from MOOCs to complement and enhance understanding of core concepts in Structural Engineering. **[K3]**
4. **Analyze** and integrate cutting-edge knowledge from global experts into ongoing projects or research in Structural Engineering. **[K4]**
5. **Evaluate** the relevance and applicability of learned concepts from MOOCs in relation to career goals and professional development in Structural Engineering. **[K4]**

Textbooks and References:

- Online resources and textbooks provided by the selected MOOCs.
- Recommended readings and reference materials suggested by the MOOC instructors.

Specific Resources:

- SWAYAM (swayam.gov.in)
- NPTEL (nptel.ac.in)
- EDX (edx.org)
- Coursera (coursera.org)
- FutureLearn (futurelearn.com)

24CESE691	INTERNSHIP

Course Category:	Internship	Credits:	2
Course Type:	Practical	Lecture - Tutorial - Practice:	0-0-4
Prerequisites:		Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

The students shall undergo Internship for a period of six weeks in Industry/Research organizations/ institute of higher learning approved by the Head of the Department during any time after the second semester

Course Description:

The internship course for structural engineering students entails a six-week practical engagement in an industry, research organization, or institute of higher learning, subject to approval by the Head of the Department. This internship, scheduled for any time after the second semester, provides students with invaluable hands-on experience and exposure to real-world applications of their academic knowledge. Engaging directly with industry professionals and researchers, students gain insights into current trends, advanced techniques, and practical challenges in structural engineering. This experiential learning is crucial for bridging the gap between theoretical education and practical implementation, enhancing their problem-solving skills, professional network, and overall readiness for their future careers in structural engineering.

Course Aims and Objectives

1. **Apply** theoretical knowledge and technical skills in real-world settings, effectively addressing practical challenges encountered in industry or research environments.
2. **Analyze** the methodologies and processes utilized in industry or research organizations, identifying best practices and areas for improvement based on hands-on experience.
3. **Develop** practical solutions to real-world problems by integrating academic knowledge with industry-specific techniques and technologies encountered during the internship.
4. **Evaluate** the effectiveness and impact of current industry practices and research methods, providing informed recommendations for improvements based on observed data and experiences.
5. **Communicate** findings and insights gained from the internship through a comprehensive report and presentation, demonstrating an understanding of the practical application of structural engineering concepts.

Course Outcomes

1. Demonstrate the ability to apply theoretical concepts and engineering principles to solve practical problems encountered during their internship. **[K3]**
2. Exhibit improved professional skills, including teamwork, communication, project management, and adherence to industry standards and ethics. **[K4]**
3. Gain hands-on experience with industry-specific tools, software, and methodologies, enhancing their technical proficiency and readiness for the workforce. **[K3]**
4. Show an increased understanding of the research process, including the ability to contribute to ongoing projects, analyze data, and apply innovative solutions to engineering challenges. **[K4]**
5. Develop a clearer understanding of potential career paths, increased confidence in their professional capabilities, and valuable connections within the structural engineering field. **[K2]**

Specific Resources:

1. "Industrial Training and Internship: A Practical Guide for Students" by R. N. Singh, Notion Press, 2020
2. "Internships in Engineering: A Step-by-Step Guide" by J. B. Dixit, Laxmi Publications , 2019

3."Engineering Internship: Preparation and Performance" by K. L. Narayana and P. Kannaiah, Scitech Publications, 2018
4."Practical Internship Manual for Engineering Students" by Dr. A. K. Sharma , Khanna Book Publishing Co. (P) Ltd. 2017
5."Internship and Training for Engineers" by Dr. R. K. Bansal and Dr. S. C. Sharma
Firewall Media, 2016

Mapping of Course Outcomes to Program Outcomes:
(**3**=High; **2**=Medium; **1**=Low)

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**
CO1	M	L	M	H	M
CO2	M	M	H	L	H
CO3	M	L	M	H	M
CO4	H	M	H	M	M
CO5	L	H	M	L	H

24CESE692	PROJECTPART-A

Course Category:	Project Part-A	Credits:	10
Course Type:	Project	Lecture - Tutorial - Practice:	0-0-20
Prerequisites:	Term paper	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

The project shall be carried out in the major areas pertaining to the program approved by Project Review Committee and may address the societal problems/issues related to the program.

Course Description:

The project course is designed to engage students in comprehensive research and practical work within major areas pertinent to their program, as approved by the Project Review Committee. This course emphasizes addressing societal problems and issues related to the program, encouraging students to apply their theoretical knowledge and technical skills to real-world challenges. Through this project, students will enhance their problem-solving abilities, foster innovation, and contribute meaningful solutions to society.

Course Objectives

1. Equip students with the ability to conduct comprehensive literature reviews to identify research gaps in structural engineering.
2. Guide students in formulating clear, relevant research questions and objectives based on identified gaps.
3. Enable students to design and implement appropriate research methodologies for structural engineering problems.
4. Provide hands-on experience in data collection, experiment design, and computational analysis.
5. **Train students in the effective use of advanced structural analysis software and tools**

Course Outcomes

1. Students will identify research gaps and formulate well-defined research problems based on comprehensive literature reviews. *(K4)*
2. Students will develop clear research objectives and hypotheses tailored to address key structural engineering challenges. *(K6: Create)*
3. Students will design appropriate methodologies (experimental, numerical, or analytical) for solving structural engineering problems. *(K3)*
4. Students will demonstrate the ability to collect and analyze relevant data using advanced experimental setups and computational tools. *(K3)*
5. Students will proficiently apply specialized structural analysis software for solving complex engineering problems. *(K3)*

Mapping of Course Outcomes to Program Outcomes:

(3=High; 2=Medium; 1=Low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO1	H		H		M
CO2	H		H		M
CO3	H		M	M	L
CO4	M		M	H	
CO4	M		M	H	

SEMESTER IV

24CESE693	PROJECT PART-B

Course Category:	Project Part-B	Credits:	16
Course Type:	Project	Lecture - Tutorial - Practice:	0-0-32
Prerequisites:	Project Part-A	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Project Part B shall be the extension of project Part A.

Course Description

Project Part B builds upon the foundational work completed in Project Part A, extending the project scope to advanced analysis, optimization, and comprehensive reporting. Students continue their investigation into engineering challenges identified in Part A, focusing on refining solutions with considerations for societal impact, environmental sustainability, and ethical implications. The course emphasizes hands-on experimentation, data analysis, and the application of advanced engineering principles to develop innovative solutions.

Course Aims and Objectives:

1. Develop students' skills in critical data analysis and the interpretation of complex experimental and numerical results.
2. Facilitate the application of advanced theoretical concepts in structural dynamics, elasticity, and materials behavior to real-world problems.
3. Enhance technical writing and presentation skills for the clear communication of research findings.
4. Promote an understanding of ethical considerations in research and the societal impacts of engineering solutions.
5. Cultivate teamwork, project management, and collaborative skills for efficient and timely project completion.

Course Outcomes: By the end of the course, students will be able to:

1. Students will critically analyze and interpret research data to evaluate performance, trends, and inconsistencies. *(K5)*
2. Students will integrate advanced theoretical concepts into their research, improving the quality of their analyses and findings. *(K3)*
3. Students will produce detailed, technically sound reports and deliver effective presentations of their research outcomes. *(K6)*
4. Students will recognize the ethical and societal impacts of their work and demonstrate responsible research practices. *(K5)*
5. Students will manage research projects effectively, collaborating with peers and supervisors to complete tasks within set timelines. *(K3)*

Mapping of Course Outcomes to Program Outcomes: (H=high; M=medium; L=low)

	PO 1	PO 2	PO3	PO 4	PO 5
CO 1	M	L	M	H	M
CO 2	H	M	M	H	M
CO 3	H	L	H	H	M
CO 4	H	M	H	M	M
CO5	L	H	H	L	H