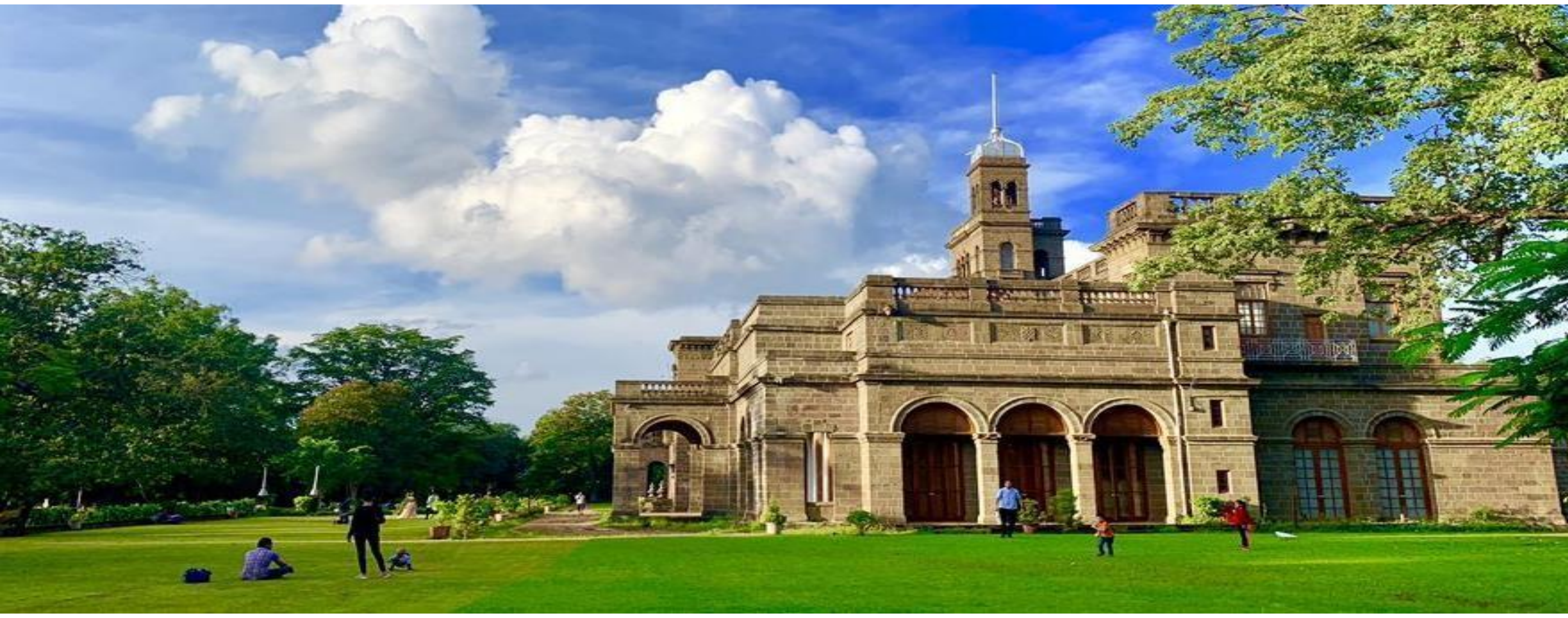
सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University

Pune, Maharashtra, India

FACULTY OF SCIENCE AND TECHNOLOGY



National Education Policy (NEP) 2020 Compliant Curriculum

Master of Engineering – Civil Engineering (2025 Pattern)

M.E. Civil (Structures)

(With effect from Academic Year 2025-26)

www.unipune.ac.in

Contents

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Civil Engineering, are very happy to present ME – Civil Engineering (2025 Pattern) Master of Engineering – Civil (Structures) (2025 Pattern) syllabus effective from the Academic Year 2025-26.

Civil Engineering is a dynamic discipline that lies at the intersection of engineering, design, and environmental stewardship. It provides the foundation for the planning, design, construction, and maintenance of infrastructure systems that support modern society. This curriculum is designed to provide students with a comprehensive understanding of the fundamental principles, theories, and practices of civil engineering, while also preparing them to address the challenges of an ever-evolving built environment and sustainable development.

The revised syllabus falls in line with the objectives of NEP-2020, Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

This curriculum is the result of extensive consultation with academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet the current industry standards but also to prepare students for higher studies and research in the field of Civil Engineering.

We hope that this curriculum will inspire students to become competent professionals, responsible citizens, and contributors to the technological advancement of society.

Dr. S. B. Thakare
Chairman
Board of Studies – Civil Engineering

Members of Board of Studies - Civil Engineering	
Dr. Ganesh A. Hinge	Dr. Pratibha M. Alandkar
Dr. Uttam R. Awari	Dr. Jyotiba B. Gurav
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Dr. Vinaykumar C. H.	Er. Ramesh D. Raskar

Program Specific Outcomes (PSO)

PSO1: Apply advanced concepts of structural analysis, design, and detailing in compliance with national and international codes to plan and execute safe and economical structural systems.

PSO2: Utilize modern computational tools, experimental methods, and emerging technologies to model, analyze, and evaluate the performance of civil engineering structures under various loading and environmental conditions.

PSO3: Demonstrate professional competence in addressing structural engineering challenges with due consideration to sustainability, durability, disaster resilience, and societal needs.

Program Educational Objectives (PEO)

Program Educational Objectives (PEOs): Program Educational Objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

PEO1: Core Competency and Professional Excellence

Graduates will establish themselves as competent Structural Engineering professionals by applying advanced knowledge of structural analysis, design, and construction practices to deliver safe, durable, and cost-effective structures that meet societal and industry requirements with professional integrity.

PEO2: Higher Education and Lifelong Learning

Graduates will engage in higher studies, research, and continuous professional development to stay updated with emerging technologies, advanced materials, computational tools, and evolving codes of practice in Structural Engineering and allied fields.

PEO3: Leadership and Social Responsibility

Graduates will demonstrate leadership, teamwork, and effective communication while contributing to innovative and sustainable structural solutions that enhance resilience, minimize environmental impact, and address the needs of society.

Program Outcomes (PO)

Graduate Attributes (GAs) are measurable outcomes that indicate the competencies a postgraduate student is expected to achieve. They represent the qualities and skills required for professional practice at the postgraduate level. The NBA defines the following Graduate Attributes for all PG programmes.

1. Scholarship of knowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

2. Critical thinking

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. Problem solving

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. Research skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

6. Collaborative and multidisciplinary work

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Project management and finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Life-long learning

Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Ethical practices and social responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Independent and reflective learning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

General Rules and Guidelines

- Course Outcomes (CO): Course Outcomes are narrower statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.
- Assessment: Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of Program Educational Objectives and Program Outcomes.
- Evaluation: Evaluation is one or more processes, done by the Evaluation Team, for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which Program Educational Objectives or Program Outcomes are being achieved, and results in decisions and actions to improve the program

Guidelines for Examination Scheme

Examination: The examination consists of two parts, (a) Comprehensive Continuous Evaluation (CCE) and (b) End-Semester Examination (ESE).

(a) Comprehensive Continuous Evaluation (CCE): CCE of 50 marks based on all units of course, to be scheduled and conducted at institute level. CCE consists of parameters and weightage as mentioned below:

Parameters	Marks	Coverage of Units
Written unit test	10	Units 1 and 2
Open book Test	10	Units 3 and 4
Assignments / Case study	10	Unit 5
Seminar presentation / Field visit	10	On any Unit
Mini-project	10	On any Unit
Term-paper	10	On any Unit
Project Based Learning (PBL)	10	On any Unit

The HoD / PG Coordinator may select any parameter from the above list. One unit test is mandatory. At the end of the semester, the final marks for CCE shall be awarded based on the student's performance and submitted to the University

Format and Implementation of Comprehensive Continuous Evaluation (CCE)

- **Unit Test**

Questions shall be designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, and Create)

- **Assignments / Case Study**

Each student shall submit one assignment or case study report. The assignment / report may include problem-solving tasks, theoretical questions, practical exercises, or case studies, and should reflect in-depth analysis as well as application of the concepts covered.

- **Seminar Presentation**

Students shall deliver a seminar presentation, followed by a Question and Answer session. Each student is required to prepare presentation slides and submit a seminar report. Evaluation shall be based on the quality of slides, the seminar report, and performance during the presentation. The seminar presentations shall be scheduled at the end of the course.

- **Open Book Test**

Students will be allowed to refer to textbooks, class notes, and other approved reference materials during the test. The questions will emphasize problem-solving, application of concepts, critical analysis, and logical reasoning rather than direct reproduction of information.

Each student shall submit detailed answers that demonstrate clarity of thought, depth of understanding, and appropriate application of theory to practical situations. Evaluation shall be based on the quality of analysis, correctness of solutions, organization of answers, and effective use of reference material

- **Mini Project**

Each student shall undertake an individual mini project that addresses a relevant problem, concept, or application within the scope of the course. A report shall be submitted highlighting the problem identified, objectives, methodology adopted, implementation process, results obtained, and conclusions drawn. The work should demonstrate originality, clarity in methodology, and effective presentation of outcomes

- **Project Based Learning (PBL)**

It shall be carried out in small groups of 2–3 students. Each group shall work on a realistic, open-ended problem relevant to the course, which may involve design, analysis, simulation, model development, field-based study, or innovative solutions to practical challenges. A report shall be submitted highlighting the problem identified, objectives, methodology adopted, results obtained, and conclusions drawn. The work should demonstrate originality, clarity in methodology, and effective presentation of outcomes.

Schedule for conducting CCE

- Weeks 1 - 5: Cover Units 1 and 2
- Week 6: Conduct Unit Test
- Weeks 7 - 9: Cover Units 3 and 4
- Week 10: Conduct open book test
- Weeks 11 - 12: Cover Units 5
- Week 13: Conduct seminar presentations / mini project / PBL.

(b) End-Semester Examination (ESE)

The End-Semester Examination (ESE) shall be a 50-mark theory examination covering all units of the course, as scheduled by the University. Question papers will be provided by the University through the Question Paper Delivery (QPD) system. The ESE shall be conducted by the University at the end of the semester.

The paper setting, conduct of examination, and assessment for the End-Semester Examination of Elective I, Elective II, and Elective III shall be carried out by the respective college, in accordance with the schedule prescribed by Savitribai Phule Pune University.

Format and Implementation of End-Semester Evaluation (ESE)

- **Question Paper Design**

The End-Semester Examination (ESE) for a theory subject of 50 marks shall cover all five units of the syllabus, with 10 marks allocated per unit. The question paper shall be designed in accordance with Bloom's Taxonomy guidelines to ensure balanced coverage of all units and assessment across different cognitive levels.

M.E. Civil (Structures) (2025 Pattern)

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Semester I

Course Code	Type of Course	Course Title	Teaching Scheme		Examination Scheme						Credits			
			L	P	CCE	ESE	TW	PR	OR	Total	L	T	P	Total
PCC-501-STR	Major Mandatory	Theory of Elasticity and Plasticity	4		50	50				100	4			4
PCC-502-STR	Major Mandatory	Structural Dynamics	4		50	50				100	4			4
PCC-503-STR	Major Mandatory	Structural Mechanics	4		50	50				100	4			4
PCC-504-STR	Major Mandatory	Design of Prestressed Concrete Structures	4		50	50				100	4			4
PCC-505-STR	Major Mandatory	Practical 1 (on Core Subjects)		4			25		25	50			2	2
PEC-506-STR	Major Elective - I	Elective Course 1	3		50	50				100	3			3
PEC-507-STR	Major Elective - I	Practical 2 (on Elective Subject)		2			25		25	50			1	1
		Total	**19**	**6**	**250**	**250**	**50**	**0**	**50**	**600**	**19**	**0**	**3**	**22**

Semester II

Course Code	Type of Course	Course Title	Teaching Scheme		Examination Scheme						Credits			
			L	P	CCE	ESE	TW	PR	OR	Total	L	T	P	Total
PCC-508-STR	Major Mandatory	Theory of Plates and Shells	4		50	50				100	4			4
PCC-509-STR	Major Mandatory	Finite Element Method	4		50	50				100	4			4
PCC-510-STR	Major Mandatory	Structural Design of Foundations	4		50	50				100	4			4
PCC-511-STR	Major Mandatory	Practical 3 (on Core Subjects)		4			25		25	50			2	2
PEC-512-STR	Major Elective - II	Elective Course 2	3		50	50				100	3			3
PEC-513-STR	Major Elective - III	Elective Course 3	3		50	50				100	3			3
SEM-514-STR	Seminar	Seminar I		4			25		25	50			2	2
		Total	**18**	**8**	**250**	**250**	**50**	**0**	**50**	**600**	**18**	**0**	**4**	**22**

Semester III

Course Code	Type of Course	Course Title	Teaching Scheme		Examination Scheme						Credits			
			L	P	CCE	ESE	TW	PR	OR	Total	L	T	P	Total
RM-601-STR	Research Methodology	Research Methodology	4		50	50				100	4			4
OJT-602-STR	On Job training / Internship	Internship		10			100			100			5	5
SEM-603-STR	Seminar	Seminar II		8			25		25	50			4	4
PRJ-604-STR	Research Project	Research Project Stage I		18			25		25	50			9	9
		Total	**4**	**36**	**50**	**50**	**150**	**0**	**50**	**300**	**4**	**0**	**18**	**22**

Semester IV

Course Code	Type of Course	Course Title	Teaching Scheme		Examination Scheme						Credits			
			L	P	CCE	ESE	TW	PR	OR	Total	L	T	P	Total
SEM-605-STR	Research Project	Seminar III		8			50		50	100			4	4
PRJ-606-STR	Research Project	Research Project - Stage II		36			150		50	200			18	18
		Total	**0**	**44**	**0**	**0**	**200**	**0**	**100**	**300**	**0**	**0**	**22**	**22**

Elective Courses

Elective Course 1 (SEM - I)	Elective Course 2 (SEM - II)	Elective Course 3 (SEM - II)
PEC-506-STR (a): Design of Industrial Steel Structures	PEC-512-STR (a): Smart Materials and Structures	PEC-513-STR (a): Stability of Structures
PEC-506-STR (b): Plastic Analysis of Steel Structures	PEC-512-STR (b): Advanced Construction Materials	PEC-513-STR (b): Structural Optimization
PEC-506-STR (c): Structural Design of Bridges	PEC-512-STR (c): Design of Earthquake Resistant Structures	PEC-513-STR (c): Intellectual Property Rights
PEC-506-STR (d): Design of Composite Construction	PEC-512-STR (d): Structural Audit and Retrofitting of Structures	PEC-513-STR (d): Structural Reliability

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Semester I

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PCC-501-STR

Course: THEORY OF ELASTICITY AND PLASTICITY

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of strength of materials.

Companion course, if any

Practical 1

Course objectives

This course provides a rigorous foundation in the mechanics of deformable solids, focusing on the principles of elasticity and plasticity. It aims to develop the ability to analyze and solve two- and three-dimensional stress and strain problems, understand material yielding and plastic flow, and apply the theories to structural engineering problems.

Course outcomes

CO1	Formulate and solve stress and strain problems in two and three dimensions.
CO2	Derive and apply constitutive relations for isotropic and anisotropic elastic materials.
CO3	Analyze torsion and bending of non-circular and unsymmetrical sections using elasticity theory.
CO4	Employ energy principles and approximate methods to obtain solutions for structural members.
CO5	Assess plastic deformation and collapse behavior of structural members and systems using yield criteria, flow rules, and limit analysis principles.

COURSE CONTENTS

Unit I	Analysis of Stress and Strain	(12 hours)

Definition and components of stress and strain tensors in 2D and 3D; transformation of stress and strain; principal stresses and invariants; octahedral stresses and strains; equilibrium equations, strain–displacement relations, compatibility conditions; Airy’s stress function.

Unit II	Constitutive Relations and Elasticity Solutions	(12 hours)

Generalized Hooke’s law for isotropic and anisotropic materials; plane stress and plane strain problems; two-dimensional problems in cartesian and polar coordinates; analysis of thick- and thin-walled cylinders, rotating discs; stress concentration around holes and inclusions

Unit III	Torsion and Bending in Elasticity	(12 hours)

Torsion of prismatic bars with non-circular sections; Prandtl’s stress function; warping and shear centre; bending of beams with unsymmetrical sections; effect of transverse shear; elasticity solutions compared to elementary theory results.

Unit IV	Energy Methods and Approximate Solutions	(12 hours)

Strain energy and complementary energy; variational principles (principle of virtual work, Rayleigh–Ritz method); approximate solutions for elasticity problems; introduction to finite difference method with applications to beams and plates.

Unit V	Plasticity and Collapse Mechanisms	(12 hours)

Introduction to plasticity and yield criteria (Tresca, von Mises, Drucker–Prager); flow rules, plastic potential, and hardening laws; stress–strain response in the plastic range; plastic bending of beams and plates, plastic torsion of structural members, collapse load analysis of framed systems, slip-line field theory, and principles of limit analysis for ultimate load evaluation.

LEARNING RESOURCES

Text books

1. Theory of Elasticity, S. P. Timoshenko, J. N. Goodier (McGraw Hill)
2. Theory of Plasticity, A. Chakaraborty (McGraw Hill)

Reference book

1. Theory of Elasticity and Plasticity, H.M. Westergaard (Harvard University Press)
2. Advanced Mechanics of Materials, Arthur P. Boresi and Richard J. Schmidt (John Wiley and Sons, Inc.)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PCC-502-STR

Course: STRUCTURAL DYNAMICS

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of engineering mechanics, structural analysis, and basics of differential equations and linear algebra.

Companion course, if any

Practical 1

Course objectives

This course introduces the fundamental principles of structural dynamics with emphasis on the vibration response of single- and multi-degree-of-freedom systems under various excitations. It develops the ability to analyze seismic and dynamic loads, apply vibration control strategies, and implement numerical techniques for practical structural engineering applications.

Course outcomes

CO1	Formulate and solve equations of motion for single-degree-of-freedom (SDOF) systems under free vibrations considering damping mechanisms.
CO2	Evaluate the response of SDOF systems subjected to various dynamic loadings using Duhamel's integral and apply response spectra concepts for seismic design.
CO3	Formulate equations of motion for multi-degree-of-freedom (MDOF) systems, compute natural frequencies and mode shapes, and apply modal superposition principles for vibration analysis.
CO4	Assess and design vibration control strategies such as tuned mass dampers, base isolation, and supplemental damping devices for structural applications.
CO5	Apply numerical integration methods for solving dynamic response problems of structures.

COURSE CONTENTS

Unit I	Single Degree of Freedom Systems	(12 hours)

Dynamic equilibrium, degrees of freedom, damping mechanisms and energy dissipation; mathematical modeling of SDOF systems; solution to free vibration problems (undamped and damped); forced vibration under harmonic excitation, resonance, dynamic amplification, transmissibility, and principles of vibration isolation.

Unit II	Response to General Dynamic Loading	(12 hours)

SDOF response to step, ramp, and pulse loads; formulation and evaluation of Duhamel's integral; impulse response function; response to base motion under dynamic excitation; response spectra concepts and applications in seismic design.

Unit III	Multi Degree of Freedom Systems	(12 hours)

Equations of motion for MDOF systems; determination of natural frequencies and mode shapes; orthogonality of modes and modal participation factors; modal superposition for free and forced response; applications to multi-storey frames and shear buildings.

Unit IV	Vibration Control in Structures	(12 hours)

Principles of vibration control; passive, active, and semi-active strategies; tuned mass dampers; base isolation systems; supplemental damping devices; performance evaluation and practical applications in buildings, bridges, and infrastructure.

Unit V	Numerical Methods in Structural Dynamics	(12 hours)

Time-integration methods for dynamic analysis: explicit and implicit schemes, stability and convergence; Newmark-β and Wilson-θ methods; average acceleration method; direct integration vs modal superposition; introduction to finite element method for dynamic problems; practical aspects of computational modeling.

LEARNING RESOURCES

Text books

1. Structural Dynamics: Theory and Computation, Mario Paz (Springer)
2. Dynamics of Structures: Theory and Applications to Earthquake Engineering, A.K. Chopra (Prentice Hall / Pearson)

Reference books

1. Dynamics of Structures, R. W. Clough, J. Penzin (McGraw Hill Publications)
2. Dynamics of Structures, J. L. Humar (CRC Press)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PCC-503-STR

Course: STRUCTURAL MECHANICS

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of solid and structural mechanics.

Companion course, if any

Practical 1

Course objectives

This course aims to develop advanced analytical skills for evaluating the behavior of structural elements and systems under complex loading, geometry, and material conditions. Students will gain the ability to analyze thin- and thick-walled members, unsymmetrical and curved beams, cables, and nonlinear responses for realistic structural engineering applications.

Course outcomes

CO1	Analyze stress distribution in thin and thick cylinders under internal and external pressures.
CO2	Evaluate unsymmetrical bending, locate shear centers in thin-walled sections, and analyze arches under various loads.
CO3	Construct and apply influence line diagrams for beams, trusses, arches, and cables to determine maximum internal forces under moving loads.
CO4	Analyze structural behavior of beams curved in plan and elevation, and determine stresses in curved members.
CO5	Understand geometric and material nonlinearities in structures and apply concepts of second-order effects, plastic hinges, and redistribution in analysis and design.

COURSE CONTENTS

Unit I	Thin and Thick Cylinders	(12 hours)

Thin cylinders: circumferential, longitudinal, and shear stresses and strains; volumetric strain; effect of compressibility of fluid.
Thick cylinders: Lame's equations; radial and circumferential stresses under internal and external pressures; compound cylinders; graphical representation of stress variation.

Unit II	Unsymmetrical Bending, Shear Center, and Arches	(12 hours)

Analysis of bending of beams with unsymmetrical cross sections; principal axes and neutral axis for asymmetric sections; shear center for open and closed thin-walled sections; torsion of thin-walled sections; applications in channels and angles.
Arches: analysis of two-hinged and three-hinged arches for horizontal thrust, bending moment, normal thrust, and radial shear under different loading conditions.

Unit III	Influence Line Diagrams and Moving Loads	(12 hours)

Influence line diagrams for beams (reactions, shear force, and bending moment in simply supported, continuous, and compound beams).
ILDs for trusses (reactions, member forces, bridge systems).
Moving loads: point loads, UDL, series of loads; absolute maximum moment; equivalent uniformly distributed load; application to beams, trusses, and arches.

Unit IV	Beams Curved in Plan and Elevation	(12 hours)

Beams curved in plan: circular beams on symmetrically placed supports, semi-circular and quarter-circle beams with fixed and free ends.
Beams curved in elevation: Winkler-Bach theory; stress distribution in curved beams with different cross sections; applications to hooks, rings, and frames.

Unit V	Nonlinear Structural Behavior	(12 hours)

Geometric nonlinearity: P–Δ and P–δ effects, second-order analysis of beams and frames, stability under large displacements.
Material nonlinearity: yield phenomena, plastic behavior at member level, plastic hinges and redistribution.
Applications in stability and limit state design of structural systems.

LEARNING RESOURCES

Text books

1. Structural Analysis, R. C. Hibbeler (Pearson)
2. Advanced Mechanics of Solids and Structures, O. P. Jain, B. K. Jain, K. Chopra (Nem Chand)
3. Advanced Mechanics of Materials, Boresi and Schmidt (Wiley)
4. Theory of Structures, Timoshenko and Young (McGraw Hill)

Reference book

1. Structural and Stress Analysis, T. H. G. Megson (Butterworth-Heinemann)
2. Intermediate Structural Analysis, C. K. Wang Paz (McGraw Hill)
3. Engineering Mechanics of Solids, Egor P. Popov (Pearson)
4. Fundamentals of Structural Analysis, K. M. Leet, Chia-Ming Uang, Joel Lanning (McGraw Hill)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PCC-504-STR

Course: DESIGN OF PRESTRESSED CONCRETE STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of reinforced concrete design and familiarity with structural analysis and material properties of concrete and steel.

Companion course, if any

Practical 2

Course objectives

This course aims to provide advanced knowledge in the analysis and design of prestressed concrete members and systems. It focuses on fundamental principles, design methodologies for beams, slabs, continuous systems, and bridge girders, while emphasizing serviceability, durability, and sustainability in modern structural engineering practice.

Course outcomes

CO1	Analyze prestressed concrete members considering elastic and time-dependent losses of prestress.
CO2	Design prestressed concrete flexural members, check ultimate and service load behaviour, and ensure compliance with codal provisions.
CO3	Analyze and design prestressed members subjected to shear, torsion, and anchorage forces.
CO4	Evaluate and design indeterminate prestressed concrete structures such as continuous beams and frames.
CO5	Design prestressed concrete slabs for various structural applications, considering serviceability and durability requirements.

COURSE CONTENTS

Unit I	Principles and Materials for Prestressing	(12 hours)

Prestressing systems, methods, and devices; materials for prestressing: high-strength concrete and steel; time-dependent losses due to creep, shrinkage, and relaxation; estimation of losses; partial prestressing and codal provisions.

Unit II	Analysis and Design for Flexure	(12 hours)

Elastic and ultimate strength methods; IS: 1343 provisions for flexure; limit states of collapse and serviceability; kern concepts, cable profiles, and pressure line; eccentric and concentric prestressing; design of simply supported beams and slabs.

Unit III	Design for Shear, Torsion and Anchorage	(12 hours)

Shear resistance of uncracked and cracked sections; design and detailing of anchorage zones and end blocks; codal design procedures for shear and torsion; combined stress conditions and strength considerations.

Unit IV	Indeterminate Prestressed Structures	(12 hours)

Analysis and design of continuous beams; concordant and non-concordant cable profiles; redistribution of moments; secondary and resultant moments; prestressing in frames and indeterminate systems; compatibility and detailing considerations.

Unit V	Prestressed Concrete Slabs and Flat Slabs	(12 hours)

Design of prestressed two-way slabs and flat slabs; codal provisions for span–depth ratios, reinforcement detailing, and load balancing; serviceability checks for deflection and cracking; long-term performance; case studies and introduction to software applications.

LEARNING RESOURCES

Text books

1. Prestressed Concrete, N. Krishna Raju (Tata McGraw Hill)
2. Prestressed Concrete, N. Rajagopalan (Narosa Publishing)

Reference books

1 Design of Prestressed Concrete Structures, T. Y. Lin (Wiley)
2. Prestressed Concrete: Analysis and Design Fundamentals, A.E. Naaman (Techno Press)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PCC-505-STR

Course: PRACTICAL 1

Teaching scheme	Credits	Examination	
Practical: 4 hours/week	02	TW OR	25 marks 25 marks

Course objectives

The objective of this course is to provide hands-on experience in applying advanced concepts of elasticity, plasticity, structural dynamics, structural mechanics, and prestressed concrete through assignments, computational tools, and experiments.

Course outcomes

CO1	Apply theoretical knowledge of elasticity, plasticity, structural dynamics, structural mechanics, and prestressed concrete to solve practical design and analysis problems through assignments and computational tools.
CO2	Develop technical proficiency in using computational tools and experimental methods, interpret results critically, and document analyses, design solutions, and experiments in a professional format.

COURSE CONTENTS

a) Theory of Elasticity and Plasticity

- One assignment from each unit.
- Use computational tools to calculate and plot the radial and circumferential stress distribution in a thick-walled cylinder subjected to internal and/or external pressure, or in a rotating disc.
- Use software to analyze torsion in a prismatic bar with a non-circular cross-section (e.g., rectangular or channel section), determine the shear stress distribution and warping displacement, and visualize results.

b) Structural Dynamics

- One assignment from each unit.
- Develop a spreadsheet or write a program to determine the Eigen values for a multi-degree of freedom system.
- Perform experiment on shake table and compare analytical results.

c) Structural Mechanics

- One assignment from each unit.
- Develop a spreadsheet or write a program to generate and plot influence line diagrams for a simply supported or continuous beam subjected to moving loads.
- Perform second-order analysis (P–Δ effect) of a beam-column or a simple portal frame and compare the results with first-order analysis.

d) Design of Prestressed Concrete Structures

- One assignment from each unit.
- Use software to design a flat slab and prepare detailed drawings.

- Use software to design a I-girder and prepare detailed drawings.

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PEC-506-STR (a)

Course: Elective Course 1 - DESIGN OF INDUSTRIAL STEEL STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of structural analysis and steel design

Companion course, if any

Practical 2

Course objectives

This course aims to equip students with the knowledge and skills to analyze, design, and detail specialized steel structures commonly used in industrial and infrastructural facilities. The course focuses on the application of limit state and working stress methods as per relevant IS codes.

Course outcomes

CO1	Analyze and design hoarding structures, castellated beams, and crane girders under various loading conditions.
CO2	Design microwave and transmission towers considering functional requirements, wind effects, slenderness, and stability criteria.
CO3	Evaluate and design industrial steel chimneys subjected to wind, seismic, and temperature effects.
CO4	Design pre-engineered buildings, pipe racks, mezzanine floors, and industrial platforms incorporating safety and serviceability requirements.
CO5	Design pipe racks and industrial platforms with emphasis on load combinations, detailing, and safety provisions.

COURSE CONTENTS

Unit I	Hoardings, Castellated Beams and Crane Girders	(8 hours)

Analysis and design of hoarding structures under dead, live, and wind loads using limit state method; concept and fabrication of castellated beams, their design for bending and shear; design of crane girders considering impact, lateral forces, and fatigue.

Unit II	Microwave and Transmission Towers	(8 hours)

Introduction to lattice and monopole towers; functional requirements and configurations; loads on towers including wind, antenna, and equipment loads; analysis and design of tower members as per IS code; slenderness and stability considerations; design of foundations for towers; case examples of failures and lessons learned.

Unit III	Industrial Steel Chimneys	(8 hours)

Types of steel chimneys – self-supported, guyed, and braced; functional and structural requirements; loads on chimneys – dead, wind, seismic, and temperature effects; design of chimneys as per IS code including stress checks and stability; design of base plates, anchor bolts, and foundation connections; detailing of expansion joints, ladders, and platforms.

Unit IV	Pre-Engineered Buildings	(8 hours)

Introduction to PEBs and their significance in industrial applications; types and components of PEBs; material specifications; detailing of main frames, roof, wall cladding, eave struts, and bracing systems; design of mezzanine floors; design considerations for connections, foundations, and secondary members.

Unit V	Pipe Racks and Industrial Platforms	(8 hours)

Purpose and functional requirements of pipe racks; structural configurations and design criteria; typical design steps for pipe racks in chemical, petrochemical, and power plants; design of industrial platforms, walkways, and stairways considering live loads, vibration, and safety requirements.

LEARNING RESOURCES

Text books

1. Design of Steel Structures, N. Subramanian (Oxford University Press)
2. Design of Steel Structures: Volume II — Special Structures, Ramachandra and Virendra Gehlot (Standard Publishers Distributors)
3. An Explanatory Handbook on Proposed IS 875 (Part 3) Wind Load on Buildings and Structures, IITK-GSDMA-Wind06 - V3.0, Final Report: B – Wind Loads, IITK-GSDMA Project on Building Codes.

Reference book

1. Analysis and Design Practice of Steel Structures, Karuna Moy Ghosh (PHI Learning)
2. Design of Steel Structures, P. Dayaratnam (S. Chand and Company Ltd.)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PEC-506-STR (b)

Course: Elective Course 1 - PLASTIC ANALYSIS OF STEEL STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of strength of materials and structural analysis

Companion course, if any

Practical 2

Course objectives

This course aims to develop an in-depth understanding of the principles and methods of plastic analysis applied to steel structures. Students will learn to determine collapse loads of statically indeterminate steel frames, beams, and other structural elements using plastic theory, and to apply these principles for efficient, safe, and economical structural design.

Course outcomes

CO1	Explain the fundamentals of plastic behaviour, ductility, and plastic hinge formation.
CO2	Compute the plastic moment capacity and shape factor of standard and built-up sections, considering the influence of axial force, shear, and buckling.
CO3	Perform plastic analysis of beams and steel frames under various loading conditions to determine collapse loads and mechanisms.
CO4	Apply the theorems of plasticity and moment redistribution to optimize structural design and evaluate the economy of steel structures.
CO5	Design steel frames for industrial and infrastructural applications under realistic load combinations, incorporating ductility, stability, and practical design considerations.

COURSE CONTENTS

Unit I	Fundamentals of Plastic Analysis	(8 hours)

Elastic vs. plastic behaviour; assumptions, ductility, and plastic hinge formation; collapse mechanisms and ultimate load; equilibrium, mechanism, and plastic moment conditions; advantages, limitations, and codal provisions for plastic design.

Unit II	Shape Factor and Plastic Moment Capacity	(8 hours)

Shape factors and plastic moments for standard and built-up sections; influence of axial force, shear, and local buckling; section classifications (plastic, compact, slender); efficiency of sections and comparison of elastic and plastic capacities.

Unit III	Plastic Analysis of Beams and Frames	(8 hours)

Collapse mechanisms and loads for simply supported, continuous, and fixed beams; plastic analysis of portal, gable, and pitched-roof frames under vertical, horizontal, and combined loads; use of interaction diagrams and practical considerations.

Unit IV	Theorems of Plasticity and Moment Redistribution	(8 hours)

Lower-bound, upper-bound, and uniqueness theorems with applications; moment redistribution in continuous beams and frames; optimal design and economy; case studies of industrial and infrastructural steel structures.

Unit V	Industrial Applications and Design Considerations	(8 hours)

Plastic design of portal, gable, and continuous frames under combined loads; lateral-torsional buckling; partial plastification; redundancy and ductility considerations; design of frames under realistic load combinations; case studies of industrial structures and lessons learned.

LEARNING RESOURCES

Text books

1. The Plastic Methods of Structural Analysis, B. G. Neal (Chapman and Hall / Wiley)
2. Design Of Steel Structures, A.S. Arya, J.L. Ajmani (Nem Chand and Bros)
3. Plastic Design of Steel Frames, L. S. Beedle (Wiley)
2. Design of Steel Structures, N. Subramanian (Oxford University Press)

Reference book

1. Plasticity for Structural Engineers, W. F. Chen, D. J. Han (Springer)
2. Steel Structures: Design and Behavior, Charles G. Salmon, John E. Johnson (Pearson)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PEC-506-STR (c)

Course: Elective Course 1 - STRUCTURAL DESIGN OF BRIDGES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any
Knowledge of RCC and prestressed concrete design

Companion course, if any
Practical 2

Course objectives
This course aims to impart advanced knowledge and design expertise for the structural design of various types of bridges. Students will learn the principles of analysis and detailed design of reinforced concrete, prestressed concrete, steel, and composite bridges under different loading and environmental conditions.

Course outcomes

CO1	Identify appropriate bridge types and materials based on site conditions, span, and functional requirements.
CO2	Design prestressed concrete I-girders and box girders for serviceability and ultimate limit states.
CO3	Analyze and design steel bridges, including truss and plate girder types, with emphasis on member design, connection detailing, fatigue, and erection methods.
CO4	Select and design bearings and expansion joints appropriate to span and superstructure type, considering load transfer, movement, and maintenance requirements.
CO5	Analyze and design substructure elements such as abutments and piers under earth pressure, live loads, and seismic effects, ensuring structural safety, serviceability, and durability.

COURSE CONTENTS

Unit I	Introduction and RC Bridge Design	(8 hours)

Bridge classification, IRC and railway loading standards, impact, wind, hydraulic, and seismic loads; design philosophy and limit state approach; design of RC bridges including slabs, beams, and box culverts; detailing and durability considerations.

Unit II	Prestressed Concrete Bridges	(8 hours)

Analysis and design of prestressed I-girders and box girders; prestressing systems, tendon layouts, and anchorages; design for serviceability and ultimate limit states; advanced construction methods including segmental construction, incremental launching, and balanced cantilever; inspection, maintenance, and durability.

Unit III	Steel Bridges	(8 hours)

Design of highway and railway steel bridges; classification and components; truss bridges – member design, connection detailing; plate girder bridges – web, flange, stiffeners, and shear buckling; bearings, expansion joints, erection methods, fatigue design, and maintenance strategies.

Unit IV	Bearings and Expansion Joints	(8 hours)

Types of bearings – elastomeric, pot, rocker, roller, and spherical; design principles for load transfer and rotation; selection criteria based on span and superstructure type; expansion joint types, design, detailing, and installation; performance considerations under thermal, creep, and shrinkage movements; maintenance and inspection practices.

Unit V	Substructure Design: Abutments and Piers	(8 hours)

Design of abutments – gravity, cantilever, and counterfort types; analysis for earth pressure, surcharge, and live loads; design of piers including slenderness, eccentricity, and bending; detailing for durability, serviceability, and constructability; consideration of seismic and wind effects.

LEARNING RESOURCES

Text books

1. Design of Bridge Structures, T. R Jagadeesh, M. A. Jayaram (PHI Learning)
2. Design of Bridges, N. Krishna Raju (Oxford and IBH)

Reference books

1. Bridge Analysis Simplified, B. Bakht, L. G. Jaeger (McGraw Hill Publications)
2. Bridge Deck Behaviour, E. C. Hambly (CRC Press)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PEC-506-STR (d)

Course: Elective Course 1 - DESIGN OF COMPOSITE CONSTRUCTION

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of structural analysis and design of steel and reinforced concrete structures

Companion course, if any

Practical 2

Course objectives

This course aims to provide students with comprehensive knowledge of the behavior, advantages, and design of composite construction systems, focusing on steel–concrete composites for buildings and bridges.

Course outcomes

CO1	Explain the fundamental behavior, interaction mechanisms, and codal provisions of different composite construction systems.
CO2	Analyze and design composite beams with appropriate shear connectors, ensuring strength, serviceability, and codal compliance.
CO3	Design composite slabs with profiled steel decking, addressing load capacity, deflection, vibration, and fire resistance.
CO4	Evaluate and design composite columns under axial and biaxial loading with stability and buckling considerations.
CO5	Apply practical aspects of construction, detailing, fire resistance, sustainability, and advanced practices in composite structures.

COURSE CONTENTS

Unit I — Introduction to Composite Construction — (8 hours)

Overview of composite construction; comparison with conventional systems; types of composite systems including steel–concrete, concrete–concrete, timber–concrete, and FRP–concrete; interaction and load transfer mechanisms; fundamental behavior of composite elements; introduction to design philosophy, codal provisions, and illustrative case studies.

Unit II — Design of Composite Beams and Shear Connectors — (8 hours)

Analysis and design of simply supported and continuous composite beams under sagging and hogging moments; concepts of full and partial shear connection; types, spacing, and design of shear connectors; flexural strength and serviceability checks; detailing for construction and fire performance; codal compliance.

Unit III — Design of Composite Slabs and Decking — (8 hours)

Behaviour and design of composite slabs with profiled steel decking; analysis of ultimate load capacity, deflection, vibration, and fire rating; propping during construction; transverse reinforcement; detailing for constructability and safety; codal guidelines.

Unit IV	Design of Composite Columns	(8 hours)

Types of composite columns: concrete-encased steel and concrete-filled steel tubes; axial and biaxial bending interaction; buckling and stability considerations; detailing and design as per codes; constructability and serviceability aspects; practical considerations for bridges and buildings.

Unit V	Construction, Detailing, and Modern Practices	(8 hours)

Practical aspects of composite construction including sequencing, temporary supports, and connections; effective shear transfer and continuity; detailing practices for joints, reinforcement, and slab–deck interface; fire resistance strategies and codal requirements; quality control, sustainability considerations, modular/prefabricated elements, and recent advances in composite construction.

LEARNING RESOURCES

Text books

1. Composite Structures of Steel and Concrete Beams, Slabs, Columns and Frames for Buildings, Roger P. Johnson (Wiley)
2. Composite Steel and Concrete Structural Members: Fundamental Behaviour, D. J. Oehlers, M. A. Bradford (Pergamon Press)

Reference books

1. Composites for Construction Structural Design with FRP Materials, Lawrence C. Bank (Wiley)
2. Elementary Behaviour of Composite Steel and Concrete Structural Members, D. J. Oehlers, M. A. Bradford (Butterworth-Heinemann)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: I

Course code: PEC-507-STR

Course: PRACTICAL 2

Teaching scheme	Credits	Examination	
Practical: 2 hours/week	01	TW OR	25 marks 25 marks

Course objectives

This course aims to provide students with an opportunity to independently conceptualize and design a civil engineering structure relevant to their chosen elective—such as a steel building, bridge, or composite system. It is designed to integrate theoretical knowledge with practical application by involving students in structural modeling, analysis, and design using appropriate software and relevant codes.

Course outcomes

CO1	Independently develop a conceptual layout and carry out structural modelling and design of a civil engineering project (steel structure, bridge, or composite system) using appropriate software and codes.
CO2	Prepare comprehensive technical documentation including general arrangement drawings, detailed structural drawings, and a report integrating design decisions, construction observations, and practical insights.

COURSE CONTENTS

a) Each student shall individually conceptualize and design a structure based on the elective course chosen—such as a steel building, a bridge, or a composite structural system. The project shall include the development of a conceptual layout, structural modelling and analysis using appropriate software, design of key structural components as per relevant codes, and preparation of general arrangement drawings (GAD) and detailed structural drawings.

b) A site visit relevant to the chosen elective course shall be undertaken to enhance practical understanding of real-world applications, construction techniques, and structural detailing. A report documenting observations from the site visit shall be submitted.

Savitribai Phule Pune University

Pune, Maharashtra, India

M.E. Civil (Structures) (2025 Pattern)

(With effect from Academic Year 2025-26)

Semester II

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PCC-508-STR

Course: THEORY OF PLATES AND SHELLS

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Fundamentals of solid mechanics and structural analysis.

Companion course, if any

Practical 3

Course objectives

This course aims to provide students with a thorough understanding of the behavior, analysis, and design of thin plates and shell structures. Students will learn classical and advanced plate theories, membrane and bending actions of shells, approximate and numerical solution methods, and codal provisions for practical design.

Course outcomes

CO1	Formulate and apply classical and advanced plate theories to derive governing equations, stress resultants, and boundary conditions for isotropic and anisotropic plates.
CO2	Analyze rectangular plates under various loading and boundary conditions using analytical and approximate methods.
CO3	Evaluate the behavior of circular and annular plates subjected to symmetric and asymmetric loads with different edge conditions.
CO4	Assess the buckling and stability of thin plates under in-plane forces, and determine critical loads for structural applications.
CO5	Apply membrane and bending theories of shells to analyze and evaluate design aspects of shell structures.

COURSE CONTENTS

Unit I — Fundamentals of Plate Theory — (12 hours)

Introduction to thin and thick plates; assumptions of classical plate theory; small and large deflection theories; moment–curvature relations; governing differential equations in Cartesian coordinates; stress resultants; boundary conditions; pure and simple bending; orthotropic and anisotropic plates.

Unit II — Analytical and Approximate Methods — (12 hours)

Navier and Levy solutions for simply supported and partially fixed rectangular plates under uniform, concentrated, and distributed loads; Rayleigh–Ritz method; first-order shear deformation theory (Reissner–Mindlin); moment–curvature relations for shear-deformable plates; approximate solutions for practical problems.

Unit III	Analysis of Circular Plates and Annular Plates	(12 hours)

Formulation and solutions for circular and annular plates under symmetric and asymmetric loads; boundary conditions (simply supported, clamped, free edges); plates with central openings.

Unit IV	Buckling and Stability of Plates	(12 hours)

Stability of thin plates under in-plane forces; governing equations for uniaxial, biaxial, and shear loading; critical buckling loads for simply supported and stiffened plates; applications to panels, stiffened plates, and industrial components; introduction to numerical methods for stability analysis.

Unit V	Membrane and Bending Theory of Shells	(12 hours)

Classification and geometry of shells; thin shell assumptions; derivation of membrane theory for shells of revolution (cylindrical, conical, spherical); bending theory of cylindrical and doubly curved shells; beam and arch analogies; hyperbolic paraboloid and folded plate structures; application to tanks, silos, and roofs; codal provisions and practical design considerations.

LEARNING RESOURCES

Text books

1. Theory of Plates and Shells, S. Timoshenko, S. Krieger (McGraw Hill)
2. Stresses in Plates and Shells, A. C. Ugural (McGraw Hill)

Reference books

1. Design and Construction of Concrete Shell Roofs, G. S. Ramaswamy (CBS Publishers)
2. Buckling of Bars, Plates, and Shells, Brush and Almroth (McGraw Hill)

Semester: II

Course code: PCC-509-STR

Course: FINITE ELEMENT METHOD

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Engineering Mathematics (linear algebra, differential equations, vector calculus)

Companion course, if any

Practical 3

Course objectives

The course aims to impart theoretical understanding and practical formulation techniques of the finite element method (FEM) for structural engineering problems.

Course outcomes

CO1	Understand and apply variational and weighted residual methods for FEM formulation.
CO2	Formulate stiffness matrices and load vectors for truss, beam, and plane stress/strain elements.
CO3	Develop and interpret shape functions for 1D, 2D, and 3D elements using cartesian and natural coordinates.
CO4	Apply isoparametric formulations and numerical integration for complex geometries.
CO5	Analyze thin and thick plates, shell, and curved structural elements using FEM.

COURSE CONTENTS

Unit I — Fundamentals of FEM and Variational Formulation — (12 hours)

Overview of finite element method; comparison with other numerical methods; review of variational calculus; weighted residual methods – Galerkin, collocation, least squares; variational principles – Rayleigh–Ritz method, principle of minimum potential energy; concept of polynomial displacement functions (introduction only); stiffness formulation for 1D bar, truss, and beam elements using variational methods.

Unit II — 2D FEM Formulation – Plane Stress and Plane Strain — (12 hours)

Basic 2D element types – CST, LST, rectangular; displacement functions using Pascal's triangle; geometric invariance and convergence criteria; stiffness matrix and load vector formulation using variational principles; treatment of boundary conditions; assembly of global matrices; aspect ratio effects and mesh refinement; static condensation and overall analysis procedure for 2D problems.

Unit III	Shape Functions and Higher Order Elements	(12 hours)
Shape functions in cartesian and natural coordinates; interpolation functions for 1D, 2D, and 3D elements; completeness and compatibility; derivation of shape functions for Lagrange and Serendipity elements; numerical integration (Gaussian quadrature); stiffness matrix formulation for higher-order elements.		
Unit IV	**Isoparametric Formulation**	**(12 hours)**
Isoparametric, sub-parametric, and super-parametric elements; coordinate mapping and Jacobian; 2D quadrilateral isoparametric elements in plane elasticity; introduction to 3D isoparametric solids.		
Unit V	**FEM for Plates and Shells**	**(12 hours)**
Analysis of thin and thick plates using triangular and rectangular elements (ACM, BFS); Mindlin's theory for thick plates; introduction to shell elements – flat and curved; conforming and non-conforming elements; Axisymmetric elements in axisymmetric problems, cylindrical shells.		

LEARNING RESOURCES

Text books

1. Introduction to Finite Elements in Engineering, T. R. Chandrupatla, A. D. Belegundu (Pearson Education)
2. An Introduction to the Finite Element Method, J. N. Reddy (Mc-Graw Hill)

Reference books

1. Finite Element Procedures, K. J. Bathe (Prentice Hall)
2. Concepts and Applications of Finite Element Analysis, R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt (Wiley)

Semester: II

Course code: PCC-510-STR

Course: STRUCTURAL DESIGN OF FOUNDATIONS

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of structural analysis, reinforced concrete design, soil mechanics, and basics of foundation engineering.

Companion course, if any

Practical 3

Course objectives

To introduce students to advanced concepts of structural design of foundations, including the behavior and design of shallow and deep foundations, retaining and supporting structures. The course also aims to develop understanding of soil-structure interaction, foundation performance under dynamic loads, and the application of modern design codes and techniques to real-world problems.

Course outcomes

CO1	Demonstrate understanding of advanced foundation concepts, soil–structure interaction, and design philosophies as per IS codes and international standards.
CO2	Analyze and design raft and combined foundations considering settlement, irregular load distribution, and structural constraints.
CO3	Design deep foundation systems including piles, pile caps, diaphragm walls, and pile-raft foundations under axial, lateral, and seismic loading.
CO4	Evaluate and design retaining and supporting structures such as retaining walls, basement walls, and deep excavation systems under earth, water, surcharge, and seismic effects.
CO5	Apply dynamic analysis to the design of machine foundations subjected to vibration and impact loads, and assess case studies of failures and best practices.

COURSE CONTENTS

Unit I	Concepts and Design Criteria	(12 hours)

Role of foundations in high-rise and special structures, advanced soil-structure interaction concepts, structural vs geotechnical failure modes, settlement tolerances for critical structures, overview of IS codes and international standards, design philosophy and detailing for constructability.

Unit II	Design of Rafts and Combined Foundations	(12 hours)

Structural design of mat foundations for buildings, tanks, and under differential settlement; analysis methods (rigid, flexible, and plate-on-elastic-foundation); mat foundations with basement walls; combined footings for irregular load distributions and space constraints.

Unit III	Deep Foundations	(12 hours)

Structural design of deep piles under heavy axial, lateral, and seismic loads; group pile behaviour and pile caps; large-diameter bored piles and diaphragm walls as deep foundations; introduction to pile-raft foundations and their design principles.

Unit IV	Retaining and Supporting Structures	(12 hours)

Structural design of retaining walls and basement walls under earth, water, surcharge, and seismic loads; design of diaphragm walls. Deep excavation support systems and advanced drainage / waterproofing considerations.

Unit V	Dynamic and Machine Foundations	(12 hours)

Introduction to dynamic loads on foundations, soil-structure interaction in dynamic problems, design of block and framed machine foundations considering resonance and isolation; design considerations for foundations subjected to reciprocating and impact machines; case studies of failures and best practices.

LEARNING RESOURCES

Text books

1. Foundation Engineering, P.C. Varghese (Prentice Hall India)
2. Design of Substructures, Swami Saran (Oxford and IBH)
3. Design of Foundations for Buildings, N.P. Kurian (Narosa Publishing House)

Reference books

1. Foundation Analysis and Design, Bowles, J.E. (McGraw Hill)
2. Handbook of Machine Foundations, Srinivasulu and Vaidyanathan (Tata McGraw Hill)

Semester: II

Course code: PCC-511-STR

Course: PRACTICAL 3

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	02	TW OR	25 marks 25 marks

Course objectives

The objective of this course is to provide practical exposure to advanced analysis and design concepts related to plate and shell structures, finite element methods, and advanced foundation systems.

Course outcomes

CO1	Apply advanced analysis techniques and design principles in plate and shell structures, finite element modelling, and foundation systems using relevant codes and software tools.
CO2	Prepare detailed technical documentation, drawings, and reports demonstrating clarity in design decisions, assumptions, and interpretations of structural behaviour.

COURSE CONTENTS

a) Theory of Plates and Shells
- One assignment from each unit.
- Use computational tools or software to analyze bending behaviour of rectangular plates under various boundary conditions using Navier or Levy methods.
- Model a shell structure (e.g., cylindrical or spherical dome) using membrane theory and compare results with bending theory.
- Analyze hyperbolic paraboloid or folded plate structures using appropriate methods or simplified shell models and interpret the response under various loading conditions.

b) Finite Element Method
- One assignment from each unit.
- Use FEM software or open-source tools to model a 2D plane stress/strain problem using CST or LST elements and compare convergence behavior.
- Write a simple program to generate shape functions and stiffness matrices for a 1D or 2D element using isoparametric formulation.
- Create an isoparametric 2D quadrilateral element model for a plate or foundation slab; evaluate bending and shear behavior under applied loads.

c) Structural Design of Foundations
- Use software to design a mat foundation for a multi-storey building under differential settlement conditions.
- Model and analyze a deep pile group using any software; interpret group efficiency and load sharing.
- Design a retaining structure with earth pressure and water pressure using limit state method and check against sliding, overturning, and bearing failure.
- Prepare detailed drawings and reinforcement details for a combined or pile-raft foundation system.

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PEC-512-STR (a)

Course: Elective Course 2 - SMART MATERIALS AND STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of structural analysis and basic structural dynamics.

Course objectives

This course aims to introduce students to the principles, types, and applications of smart materials and their integration into structural systems. It focuses on the behavior and characteristics of materials that respond to external stimuli and explores how these materials enhance the performance, monitoring, and control of structures. The course equips students with the knowledge to analyze, design, and evaluate smart structural systems incorporating sensing, actuation, and adaptive capabilities.

Course outcomes

CO1	Understand the fundamental principles, classification, and working mechanisms of smart materials and structures applied in civil engineering.
CO2	Analyze the behaviour and applications of piezoelectric materials, shape memory alloys, and fiber-optic sensors for structural health monitoring and vibration control in buildings and bridges.
CO3	Assess the performance of shape memory alloys and other active materials in adaptive structural systems, and apply design considerations for practical implementation in buildings and bridges.
CO4	Apply fiber optic sensing techniques and structural health monitoring concepts for real-time measurement, data acquisition, and performance evaluation of civil infrastructure.
CO5	Design and evaluate adaptive and intelligent civil structures incorporating active, semi-active, and passive control strategies, with emphasis on sustainability and real-world case studies.

COURSE CONTENTS

Unit I	Introduction to Smart Materials and Structures	(8 hours)

Introduction to smart materials and intelligent structures; comparison with conventional systems; classification and working principles of smart materials; sensing, actuation, and feedback mechanisms; basic concepts of structural health monitoring, adaptive control, and system intelligence; illustrative case studies from civil infrastructure applications.

Unit II	Piezoelectric and Shape Memory Materials	(8 hours)

Characteristics of piezoelectric materials: direct and inverse effects, constitutive models, and use in vibration control and energy harvesting; shape memory alloys (SMA): phase transformation, super-elasticity, hysteresis, and stress–strain behaviour; applications in structural damping, adaptive supports, and precision actuators; comparative performance and design considerations.

Unit III	Shape Memory Alloys and Other Active Materials	(8 hours)

Phase transformation, super-elasticity, and hysteresis in SMAs; use in adaptive supports, dampers, and actuators for civil structures; performance comparison with conventional materials; design and practical implementation considerations in buildings and bridges.

Unit IV	Fiber Optic Sensing and Structural Health Monitoring	(8 hours)

Fiber optic sensor principles: Bragg gratings, interferometers, distributed sensing; strain, displacement, and temperature measurement in concrete and steel structural elements; real-time data acquisition and signal processing; integration with civil infrastructure for monitoring structural performance, crack propagation, and early warning systems.

Unit V	Adaptive and Intelligent Civil Structures	(8 hours)

Active, semi-active, and passive control strategies for civil structures; design and evaluation of adaptive buildings and bridges; real-time feedback and actuation for vibration mitigation and damage prevention; case studies of smart bridges, high-rise buildings, and other civil infrastructure; emerging applications, challenges, and sustainability considerations.

LEARNING RESOURCES

Text books

1. Encyclopaedia of Structural Health Monitoring, C. Boller, F.-K. Chang and Y. Fujino (Wiley)
2. Smart Materials and Structures, M.V. Gandhi, Brian S. Thompson (Springer)

Reference books

1. Smart Structures and Materials, B. Culshaw (Artech House)
2. Smart Materials and Technologies for the Architecture and Design Professions, M. Addington and D. L. Schodek (Architectural Press)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PEC-512-STR (b)

Course: Elective Course 2 - ADVANCED CONSTRUCTION MATERIALS

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Basic knowledge of material science and engineering

Course objectives

This course introduces students to innovative, sustainable, and high-performance materials beyond conventional concrete and reinforcement. It covers advanced metallic, polymeric, ceramic, smart, nano-engineered, and hybrid materials for structural and architectural applications. The course emphasizes material selection for extreme environments, durability, sustainability, and emerging technologies to meet modern construction demands.

Course outcomes

CO1	Evaluate the properties, performance, and durability of advanced metallic alloys for structural applications.
CO2	Analyze the structural behavior, fabrication, and load performance of advanced polymers, composites, ceramics, and glazing systems in civil engineering.
CO3	Apply concepts of smart, nano, and functional materials to assess their role in adaptive, durable, and multifunctional construction systems.
CO4	Assess the mechanical and durability performance of sustainable and recycled materialsfor green construction and retrofitting applications.
CO5	Formulate design strategies using high-performance and specialized materials for structures exposed to extreme conditions.

COURSE CONTENTS

Unit I	Advanced Metallic and Alloy Materials	(8 hours)

High-strength, low-alloy steels (HSLA), weathering steel, stainless steels, and corrosion-resistant alloys; advanced aluminium alloys and their structural use; titanium and its applications in specialized structures; metallic foams and lightweight alloys; durability and fatigue behaviour of advanced metallic systems in construction.

Unit II	Polymers, Composites and Ceramics	(8 hours)

Advanced polymeric materials — thermosetting and thermoplastic resins; structural composites — fiber-reinforced polymers (FRP), laminated composites, sandwich panels, and hybrid composites; ceramics and glass in structural applications — laminated glass, structural glazing systems, advanced tiles, and fire-resistant panels; processing, fabrication, and performance under loads.

Unit III	Smart, Nano and Functional Materials	(8 hours)

Smart materials — shape memory alloys (SMA), piezoelectric and magnetostrictive materials, electrochromic and thermochromic materials; nano-engineered materials — CNTs, graphene-based materials, nano-clays, and coatings; multifunctional materials — self-cleaning, self-healing, energy-harvesting materials for structural and façade applications.

Unit IV	Sustainable and Recycled Materials	(8 hours)

Bio-based construction materials, recycled and reused aggregates, geopolymers, and carbon-sequestering materials; civil applications in low-carbon and green buildings; performance under service loads and durability aspects; case studies of sustainable bridges, pavements, and structural retrofits.

Unit V	Materials for Extreme and Specialized Environments	(8 hours)

High-performance materials for blast-, impact-, and fire-resistance; marine and cryogenic environments; high-temperature insulations and coatings; additive manufacturing and 3D printing applications for structural components; practical design considerations for buildings, bridges, and infrastructure in harsh or specialized conditions.

LEARNING RESOURCES

Text books

1. Materials for Civil and Construction Engineers, By Michael S. Mamlouk, John P. Zaniewski (Pearson)
2. Smart Materials and Structures, M.V. Gandhi, Brian S. Thompson (Springer)

Reference books

1. Construction Materials Their Nature and Behaviour, Marios Soutsos, Peter Domone (CRC Press)
2. Advanced Materials in Civil Engineering M. C. Limbachiya, H. Kew (Thomas Telford Publishing)

Semester: II

Course code: PEC-512-STR (c)

Course: Elective Course 2 - EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of structural analysis, reinforced concrete and steel design, basics of structural dynamics, and working knowledge of IS: 456, IS: 1893, and IS: 13920.

Course objectives

To develop the ability to analyze and design advanced earthquake-resistant RC and steel structures considering irregularities, inelastic behavior, and ductile detailing. The course emphasizes manual design of critical members and systems using codal provisions, performance-based concepts, and retrofitting strategies.

Course outcomes

CO1	Analyze seismic demand in regular and irregular buildings using codal provisions.
CO2	Evaluate inelastic response of structural members and apply capacity design principles to ensure ductility, hierarchy of strength, and prevention of brittle failures.
CO3	Design and detail ductile RC and steel components, hybrid systems, and dual systems using IS: 13920 and related codes.
CO4	Design and assess hybrid and dual structural systems combining frames, shear walls, and composite elements, ensuring seismic safety and drift control in complex buildings.
CO5	Assess seismic deficiencies in existing structures and propose retrofitting and mitigation strategies, including FRP strengthening, external bracing, base isolation, and supplemental damping devices.

COURSE CONTENTS

Unit I	Seismic Demand in Structures	(8 hours)

Seismic effects in plan and vertical irregularities; torsion, diaphragm flexibility, and P–Δ effects. Codal evaluation of base shear and force distribution in tall, hybrid, and podium/tower buildings. Seismic implications of transfer systems and setbacks.

Unit II	Inelastic Response and Capacity Design	(8 hours)

Inelastic response of RC and steel members; formation of plastic hinges, ductility demand, and over-strength. Capacity design principles: strong-column–weak-beam concept, hierarchy of strength, prevention of shear failures. Manual computation of ductility ratios, plastic rotations, and force redistribution in beams, columns, and frames.

Unit III	Ductile Detailing of RC and Steel Members	(8 hours)

Ductile detailing for RC members as per IS: 13920 — anchorage, confining reinforcement, boundary elements. Design of coupling beams, transfer girders, and hybrid RC–steel connections. Detailing of steel braced frames and dual systems incorporating shear walls and bracing for civil structures.

Unit IV	Hybrid and Dual Systems in Buildings	(8 hours)

Analysis and design of dual systems combining frames and shear walls; coupled wall behavior; design of composite RC–steel structural systems. Seismic performance evaluation of high-rise and irregular buildings. Simplified methods for drift, torsion, and inter-story forces in practical design.

Unit V	Retrofitting, Seismic Mitigation and Resilience	(8 hours)

Assessment of existing structures and identification of seismic deficiencies. Retrofitting techniques — jacketing, FRP strengthening, external bracing, and base isolation. Design of supplemental damping devices; evaluation of drift, acceleration, and uplift in civil structures. Case studies of retrofitting and performance during past earthquakes.

LEARNING RESOURCES

Text books

1. Dynamics of Structures: Theory and Applications to Earthquake Engineering, A. K. Chopra (Pearson Education India)
2. Earthquake Resistant Design of Structures, Pankaj Agarwal, Manish Shrikhande (PHI)

Reference books

1. Tall Building Design: Steel, Concrete, and Composite Systems, Bungale S. Taranath (CRC Press)
2. The Seismic Design Handbook, F. Naeim (Springer)

Semester: II

Course code: PEC-512-STR (d)

Course: Elective Course 2 – STRUCTURAL AUDIT AND RETROFITTING OF STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Knowledge of reinforced concrete and steel design, construction materials and practices.

Course objectives

This course aims to develop advanced knowledge and skills in evaluating the health of existing structures and designing effective retrofitting and rehabilitation strategies. Students will learn the principles, practices, and codal guidelines for structural audit, condition assessment, and damage diagnosis of buildings, bridges, and other structures.

Course outcomes

CO1	Understand the principles, need, scope, and professional responsibilities in structural audit of civil infrastructure.
CO2	Apply appropriate survey techniques and assessment methodologies to evaluate the condition of existing structures and document findings for engineering decision-making.
CO3	Select and interpret suitable Non-Destructive and Semi-Destructive Tests for diagnosing material and structural performance.
CO4	Evaluate and recommend repair materials and techniques ensuring durability, constructability, and compatibility with the parent structure.
CO5	Design retrofitting and strengthening solutions for RC, steel, and composite structures by considering codal provisions, cost-effectiveness, and sustainability, supported by lessons from case studies.

COURSE CONTENTS

Unit I — Introduction to Structural Audit and Damage Mechanisms — (8 hours)

Need and scope of structural audit, objectives, stages of audit, legal and professional obligations. Common causes of deterioration: material degradation, design and construction deficiencies, environmental effects, overloading and accidental events. Symptoms of distress: cracks, deflections, corrosion, and other visible indicators.

Unit II — Condition Assessment and Survey Techniques — (8 hours)

Planning and methodology of structural surveys; visual inspection techniques; load testing; long-term monitoring; use of condition assessment checklists. Interpretation and documentation of survey data for decision-making in civil engineering projects.

Unit III — Non-Destructive (NDT) and Semi-Destructive Testing (SDT) — (8 hours)

Overview and application of NDT and SDT: rebound hammer, ultrasonic pulse velocity (UPV), carbonation depth, core testing, half-cell potential, ground-penetrating radar, infrared thermography, and acoustic emission. Guidelines for selection, execution, and interpretation in real civil structures.

Unit IV	Repair Materials and Techniques	(8 hours)

Repair materials: polymers, micro-concretes, mortars, fiber-reinforced composites, grouts, coatings, and corrosion inhibitors. Repair techniques: crack injection, jacketing, shotcreting, epoxy bonding, grouting, surface treatment, and cathodic protection. Practical considerations for durability, constructability, and structural compatibility.

Unit V	Retrofitting, Strengthening and Case Studies	(8 hours)

Retrofitting strategies for RC, steel, and composite structures; section enlargement, post-tensioning, FRP strengthening, addition of members, bracing, shear walls, base isolation, and energy dissipation devices. Codal provisions, cost, sustainability, and durability considerations. Case studies highlighting civil engineering applications, lessons learned, and best practices in retrofitting.

LEARNING RESOURCES

Text books

1. Maintenance, Repair and Rehabilitation of Concrete Structures, P. C. Varghese (PHI Learning)
2. Testing of Concrete in Structures, J. Bungey, J., S. Millard, M. Grantham, M. (CRC Press)

Reference books

1. Concrete Structures Protection, Repair and Rehabilitation, R. Dodge Woodson (Butterworth-Heinemann)
2. RILEM Technical Recommendations on Repair Materials and Testing Methods.

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PEC-513-STR (a)

Course: Elective Course 3 – STABILITY OF STRUCTURES

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Advanced knowledge of solid mechanics and structural analysis.

Course objectives

This course aims to provide students with a deep understanding of the stability behavior of structural elements and systems under different loading conditions. It covers the fundamental concepts of elastic, inelastic, and dynamic stability, enabling students to predict critical loads, understand post-buckling behavior, and assess the safety of beams, columns, frames, and plates using analytical and energy-based methods.

Course outcomes

CO1	Explain the fundamental principles, types, and criteria of structural stability.
CO2	Apply energy methods to analyze buckling problems and compare approximate solutions with exact methods.
CO3	Analyze inelastic buckling of columns and lateral–torsional buckling of beams considering material nonlinearity, residual stresses, and codal provisions.
CO4	Evaluate the stability of beams under flexure by considering lateral–torsional effects, warping, and real-life boundary/loading conditions in steel and RC members.
CO5	Assess the stability of structural systems including frames, plates, and elements under conservative and non-conservative loading.

COURSE CONTENTS

Unit I	**Fundamentals of Stability and Elastic Buckling**	**(8 hours)**

Concept of equilibrium, stability, and imperfection sensitivity; classification of stability problems — elastic, inelastic, dynamic; critical load derivation for axially loaded ideal columns — Euler's theory for various end conditions; effects of shear, axial load eccentricity, and initial curvature; influence of boundary conditions on stability.

Unit II	**Energy Methods and Approximate Techniques**	**(8 hours)**

Energy principles in stability analysis; total potential energy and stability criterion; Rayleigh–Ritz and Galerkin methods for approximate solutions; buckling of columns with variable cross-sections; comparison of exact and approximate methods.

Unit III	**Inelastic and Lateral–Torsional Buckling**	**(8 hours)**

Inelastic buckling of columns — tangent modulus and reduced modulus concepts; buckling of beams under lateral–torsional instability; influence of slenderness ratio, residual stresses, and material non-linearity on buckling strength; codal provisions and design curves.

Unit IV	**Lateral–Torsional Buckling of Beams**	**(8 hours)**

Buckling of beams under flexure; influence of boundary conditions, loading type, and slenderness; lateral–torsional instability; effect of warping and residual stresses; codal provisions and practical applications in steel and RC members.

Unit V	**Stability of Structural Systems**	**(8 hours)**

Buckling of multi-storey frames and beams on elastic foundation; stability of plates under in-plane loads — uniaxial, biaxial, and shear; local and global buckling of stiffened and unstiffened elements; overview of dynamic stability and introduction to non-conservative loading (follower forces, flutter).

LEARNING RESOURCES

Text books

1. Theory of Elastic Stability, S. Timoshenko, J. M. Gere (McGraw Hill)
2. Principles of Structural Stability Theory, A. Chajes (Prentice Hall)

Reference books

1. Structural Stability of Columns and Plates, N. G. R. Iyenger (Wiley)
2. Stability Theory of Structures, Ashwini Kumar (Allied Publishers)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PEC-513-STR (b)

Course: Elective Course 3 – STRUCTURAL OPTIMIZATION

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Fundamentals of structural analysis and design.

Course objectives

This course aims to introduce students to the principles, methods, and applications of structural optimization in engineering. Students will learn to formulate optimization problems, select appropriate objective functions and constraints, and apply classical, numerical, and modern techniques to achieve efficient, economical, and innovative designs of structural systems.

Course outcomes

CO1	Formulate structural optimization problems mathematically, defining objectives and constraints clearly.
CO2	Apply classical and numerical optimization techniques to structural elements and systems.
CO3	Perform size, shape, and topology optimization of structures.
CO4	Evaluate advanced optimization approaches including multi-objective, reliability-based, and metaheuristic algorithms for practical structural applications.
CO5	Integrate sustainability concepts such as life-cycle cost, durability, resource efficiency, BIM, and digital twins into structural optimization frameworks.

COURSE CONTENTS

Unit I	Fundamentals of Structural Optimization	(8 hours)

Introduction to optimization in engineering; objective functions, constraints, and design variables; formulation of structural optimization problems; classical methods of optimization — linear, nonlinear, unconstrained, and constrained problems; Kuhn–Tucker conditions and Lagrange multipliers.

Unit II	Numerical Methods in Structural Optimization	(8 hours)

Numerical techniques — steepest descent, conjugate gradient, Newton–Raphson methods; linear programming using simplex and revised simplex methods; sensitivity analysis; penalty and barrier methods; introduction to stochastic optimization and global search techniques.

Unit III	Structural Applications of Optimization	(8 hours)

Size optimization of trusses, beams, and frames; shape optimization — methods and examples in continuous and discrete systems; topology optimization — basic principles and applications in continuum structures; optimization of tall buildings and bridges for weight, stiffness, and cost.

Unit IV	Optimization Strategies and Applications	(8 hours)

Multi-objective optimization and Pareto fronts; reliability-based and robust design optimization; genetic algorithms, particle swarm optimization, and other meta heuristics; use of software tools and case studies; practical challenges and current research trends in structural optimization.

Unit V	Sustainability and Emerging Applications in Structural Optimization	(8 hours)

Life-cycle cost optimization; material selection and resource minimization; optimization for durability, serviceability, and maintainability; integration of optimization with Building Information Modelling (BIM) and digital twins; applications in sustainable construction, retrofitting, and disaster-resilient structures.

LEARNING RESOURCES

Text books

1. Introduction to Optimum Design, J. S. Arora (Academic Press)
2. Optimization Concepts and Applications in Engineering, A. D. Belegundu, T. R. Chandrupatla, (Cambridge University Press)

Reference books

1. Structural Optimization: Fundamentals and Applications, U. Kirsch (Springer)
2. Design and Optimization of Laminated Composite Materials, R. T. Haftka, Z. Gürdal (Wiley)

Semester: II

Course code: PEC-513-STR (c)

Course: Elective Course 3 – INTELLECTUAL PROPERTY RIGHTS

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Basic understanding of law, contracts, and ethics.

Course objectives

This course introduces the fundamental principles, laws, and practices of intellectual property rights (IPR) with a focus on their significance in engineering, technology, and creative industries. Students will understand the various forms of IPR — patents, copyrights, trademarks, industrial designs, geographical indications, and trade secrets — and their protection mechanisms, applications, and limitations.

Course outcomes

CO1	Explain the concepts of Intellectual Property Rights and their significance in engineering research and practice.
CO2	Apply the principles of patentability and trade secret protection to engineering and technology innovations, particularly in civil engineering and software applications.
CO3	Analyze the role of copyrights, industrial designs, and trademarks in protecting engineering drawings, BIM/CAD models, software codes, and construction-related products.
CO4	Evaluate the significance of geographical indications and address emerging IPR issues in sustainable construction materials, BIM copyrights, open-source platforms, and digital technologies.
CO5	Demonstrate the ability to manage IPR through protection strategies, technology transfer, licensing, and by reviewing real-world case studies and patents in civil engineering.

COURSE CONTENTS

Unit I	Introduction to IPR and International Frameworks	(8 hours)

Overview and need for intellectual property (IPR); types of intellectual property — patents, copyrights, trademarks, industrial designs, geographical indications, trade secrets; innovation and its protection; IPR in India and worldwide; role of Indian patent offices; important IPR treaties — Paris Convention, Berne Convention, WIPO Convention, Patent Cooperation Treaty, TRIPS Agreement.

Unit II	Patents and Trade Secrets	(8 hours)

Concept of patents and their relevance to engineering and technology; criteria of patentability — novelty, inventive step, industrial applicability; non-patentable subject matter; process vs.

product patents; term, rights and obligations of patentees; restoration, revocation, and infringement; patents in civil engineering and software; introduction to trade secrets — definition, examples, protection, and role in business.

Unit III	Copyrights, Industrial Designs and Trademarks	(8 hours)

Protection of drawings, reports, BIM/CAD models, software codes; trademarks in construction firms and products; design rights in architectural/structural products (modular precast elements).

Unit IV	Geographical Indications and Emerging Issues	(8 hours)

Geographical Indications (GI) — definition, registration, GI in construction materials; IPR in sustainable and eco-friendly materials; emerging issues in BIM copyrights, open-source software, digital twins.

Unit V	IPR Management and Case Studies	(8 hours)

Protection of innovations in construction techniques, SHM, and retrofitting; technology transfer, licensing, and commercialization; review of patents filed in civil engineering.

LEARNING RESOURCES

Text books

1. Law Relating to Intellectual Property Rights, V. K. Ahuja (LexisNexis)
2. Intellectual Property Rights, Neeraj Pandey, Khushdeep Dharni (PHI Learning)

Reference books

1. Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications, B. L. Wadehra. (Universal Law Publishing)
2. Guide to Intellectual Property - World Intellectual Property Organization (WIPO)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: II

Course code: PEC-513-STR (d)

Course: Elective Course 3 – STRUCTURAL RELIABILITY

Teaching scheme	Credits	Examination	
Theory: 3 hours/week	03	CCE ESE	50 marks 50 marks

Prerequisites, if any

Basics of probability, statistics, and random variables.

Course objectives

This course introduces students to probabilistic approaches for assessing the safety, reliability, and performance of structures under uncertainty. It equips students with the tools to model uncertainties in loads, material properties, and geometry, evaluate failure probabilities, and apply reliability-based design principles.

Course outcomes

CO1	Explain the fundamentals of probability, statistics, and sources of uncertainties in structural engineering, and compute basic reliability indices.
CO2	Apply analytical reliability analysis methods to evaluate the safety and performance of structural systems.
CO3	Use simulation-based approaches to estimate failure probabilities of complex structures.
CO4	Integrate reliability-based design principles into structural engineering problems, compare with deterministic approaches, and evaluate life-cycle cost and risk.
CO5	Analyze system-level and time-dependent reliability of structures under natural hazards and demonstrate robust/resilient design through case studies.

COURSE CONTENTS

Unit I	Fundamentals of Reliability and Probability	(8 hours)

Introduction to structural safety and reliability; sources of uncertainty — loads, material properties, geometry; basic probability theory, random variables, probability distributions commonly used in engineering; statistical moments, correlation, and dependence; concept of reliability index and safety margin.

Unit II	Reliability Analysis Methods	(8 hours)

Definition of failure domain; first-order second-moment (FOSM) methods; first-order and second-order reliability methods (FORM and SORM); Hasofer-Lind reliability index; interpretation of results; sensitivity and importance factors; limitations of approximate methods.

Unit III	Simulation Methods in Structural Reliability	(8 hours)

Monte Carlo simulation and variance reduction techniques; importance sampling, subset simulation; response surface methods; stochastic finite element method (SFEM); application of simulation techniques to evaluate failure probabilities of complex structures.

Unit IV	Reliability-Based Design and Applications	(8 hours)

Reliability-based design principles and comparison with deterministic design; target reliability levels and codal provisions; calibration of partial safety factors; case studies — beams, frames, bridges under uncertain loads; life-cycle cost and risk assessment; introduction to robust and resilient design concepts.

Unit V	Applications of Structural Reliability	(8 hours)

Reliability of systems and structural components; system reliability and load-path interaction; time-dependent reliability and fatigue; robust and resilient design concepts; reliability under natural hazards (earthquake, wind, flood); case studies of practical structural engineering applications.

LEARNING RESOURCES

Text books

1. Probability Concepts in Engineering Planning and Design, A. H. S. Ang, W. H. Tang (Wiley)
2. Structural Reliability Analysis and Prediction, R. E. Melchers (Wiley)

Reference books

1. Risk Analysis in Engineering: Techniques, Tools and Trends, M. Modarres (CRC Press)
2. Structural Reliability Theory and Its Applications, P. Thoft-Christensen, M. J. Baker (Springer)

Semester: II

Course code: SEM-514-STR

Course: SEMINAR I

Teaching scheme	Credits	Examination	
Practical: 4 hours/week	02	TW OR	25 marks 25 marks

Course objectives

To enable students to explore and critically analyze an advanced or emerging topic from any subject in the Elective I list, and to effectively communicate the findings through a structured report and professional presentation.

Course outcomes

CO1	Select and critically evaluate a topic from any subject in the Elective I list, integrating literature findings to identify knowledge gaps or practical implications.
CO2	Prepare a concise seminar report and deliver a professional oral presentation demonstrating subject understanding, clarity, and effective engagement with the audience.

COURSE CONTENTS

The seminar shall focus on an advanced or emerging topic from any subject in the Elective I list. The topic shall be selected by the student in consultation with the faculty supervisor and may be based on recent research developments, innovative materials, advanced analysis/design methodologies, notable project case studies, or industry-relevant challenges within the selected elective domain.

The content should demonstrate a clear understanding of the subject, include a critical review of relevant literature, identify knowledge gaps or practical implications, and highlight future directions or applications. The seminar must reflect the student’s ability to synthesize technical information, present it logically, and engage the audience with meaningful discussion.

As part of the seminar, students shall prepare a well-structured report summarizing the literature review, identified research gap, rationale, objectives, and methodology or key findings related to the elective topic. They shall also deliver a professional oral presentation of their work, use appropriate visual aids, and respond confidently to questions and feedback.

Savitribai Phule Pune University
Pune, Maharashtra, India

M.E. Civil (Structures) (2025 Pattern)

(With effect from Academic Year 2025-26)

Semester III

Semester: III

Course code: RM-601-STR

Course: RESEARCH METHODOLOGY

Teaching scheme	Credits	Examination	
Theory: 4 hours/week	04	CCE ESE	50 marks 50 marks

Prerequisites, if any

Basic knowledge of mathematics and statistics.

Course objectives

This course equips students with the knowledge and skills required to conduct systematic research in engineering and science. It covers research design, data collection, statistical analysis, technical writing, and ethical practices. Students learn to formulate research problems, develop appropriate methodologies, and effectively communicate their findings.

Course outcomes

CO1	Demonstrate an understanding of research fundamentals, problem formulation, and the significance of literature review in identifying research gaps.
CO2	Design appropriate research methodologies by selecting suitable variables, sampling techniques, and experimental/non-experimental approaches.
CO3	Apply effective techniques for data collection, processing, and organization using surveys, experiments, and statistical software.
CO4	Analyze and interpret research data using descriptive and inferential statistics, hypothesis testing, regression, and multivariate methods.
CO5	Prepare and present high-quality technical reports, theses, and research papers while adhering to research ethics and professional standards.

COURSE CONTENTS

Unit I — Introduction to Research and Problem Formulation — (12 hours)

Definition, objectives, and significance of research; types of research — fundamental, applied, qualitative, quantitative, experimental, and analytical; identifying research topics and formulating research problems; research questions and hypotheses; characteristics of a good research problem; literature review — purpose, sources, and tools.

Unit II — Research Design and Planning — (12 hours)

Elements of research design — variables, population, and sampling techniques; experimental and non-experimental designs; validity and reliability; planning of experiments; pilot studies; budgeting and scheduling of research projects.

Unit III — Data Collection and Processing — (12 hours)

Types of data — primary and secondary; data collection methods — surveys, interviews, observations, experiments; questionnaire design; measurement scales; data coding, editing, and tabulation; handling missing data; introduction to statistical software.

Unit IV	**Data Analysis and Interpretation**	**(12 hours)**

Descriptive and inferential statistics; hypothesis testing — parametric and non-parametric tests; analysis of variance (ANOVA), regression and correlation analysis; multivariate analysis basics; interpretation of results and drawing conclusions.

Unit V	**Technical Communication, Reporting, and Research Ethics**	**(12 hours)**

Structure and components of research reports, theses, and journal papers; citation and referencing styles (APA, IEEE, etc.); use of reference management tools; preparing tables, figures, and appendices; oral and poster presentations; ethical principles — plagiarism, falsification, fabrication, authorship, intellectual property; guidelines for consent, approval, and responsible publishing.

LEARNING RESOURCES

Text books

1. Research Methodology: Methods and Techniques, C. R. Kothari, G. Garg (New Age International)
2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar (Sage Publications)

Reference books

1. Fundamentals of Research Methodology and Statistics, P Kumar (New Age International)
2. Research in Education, J. W. Best, J. V. Kahn (Pearson)

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: III

Course code: OJT-602-STR

Course: ON JOB TRAINING / INTERNSHIP

Teaching scheme	Credits	Examination	
Practical: 10 hours/week	05	TW	100 marks

Course objectives

This course aims to provide students with practical exposure to real-world structural engineering projects, enabling them to apply theoretical knowledge to professional practice. The internship helps students understand site operations, design office procedures, construction techniques, material testing, quality control, and project management aspects. It fosters an appreciation of professional responsibilities, teamwork, ethical practices, and effective communication within an organizational setup, bridging the gap between academic learning and industry expectations.

Course outcomes

CO1	Apply theoretical knowledge to real-world structural engineering problems by actively participating in design, construction, or testing activities within a professional environment.
CO2	Demonstrate professional behaviour, teamwork, communication skills, and the ability to document and present technical observations, learnings, and reflections effectively.

COURSE CONTENTS

The internship, of one semester duration, shall be undertaken at a construction site, structural design office, consultancy firm, infrastructure project, or an approved research/testing laboratory. The objective is to provide students with structured exposure to professional structural engineering practice.

During the internship, students are expected to gain hands-on experience and insight into various aspects of the profession, which may include:

- Site Operations and Supervision
  - Understanding project planning, scheduling, and site organization.
  - Observing and assisting in formwork, reinforcement placement, concreting, prestressing, and quality assurance procedures.
  - Familiarization with safety practices, codes, and regulatory compliance at construction sites.
- Design Office Procedures
  - Exposure to structural analysis, design calculations, and preparation of detailed drawings.
  - Understanding codal provisions, specifications, and design standards.
  - Use of relevant structural engineering software for modeling, detailing, and documentation.

- Material Testing and Quality Control
  - Hands-on experience with laboratory and field testing of construction materials.
  - Understanding quality assurance/quality control (QA/QC) processes.
  - Exposure to non-destructive testing (NDT) and modern testing technologies.
- Project Management and Professional Practice
  - Introduction to project monitoring, estimation, costing, and billing procedures.
  - Exposure to tendering, contracts, and documentation practices.
  - Observation of coordination among various stakeholders (engineers, contractors, architects, clients).
- Research and Innovation (if carried out in a laboratory/research center)
  - Participation in experimental work, data collection, and result interpretation.
  - Exposure to advanced instrumentation and testing protocols.
  - Critical review of technical literature and ongoing research work.

At the end of the internship, students are required to:
Prepare and submit a detailed report documenting the nature of the organization, type of work observed / undertaken, technical learnings, challenges, and reflections on professional practice.
Present their work through a presentation, demonstrating clarity in communication, technical documentation, and professional behavior.

Semester: III

Course code: SEM-603-STR

Course: SEMINAR II

Teaching scheme	Credits	Examination	
Practical: 8 hours/week	04	TW OR	25 marks 25 marks

Course objectives

To enable students to explore and critically analyze an advanced or emerging topic from any subject in the Elective II list, and to effectively communicate the findings through a structured report and professional presentation.

Course outcomes

CO1	Select and critically evaluate a topic from any subject in the Elective I list, integrating literature findings to identify knowledge gaps or practical implications.
CO2	Prepare a concise seminar report and deliver a professional oral presentation demonstrating subject understanding, clarity, and effective engagement with the audience.

COURSE CONTENTS

The seminar shall focus on an advanced or emerging topic from any subject in the Elective II list. The topic shall be selected by the student in consultation with the faculty supervisor and may be based on recent research developments, innovative materials, advanced analysis/design methodologies, notable project case studies, or industry-relevant challenges within the selected elective domain.

The content should demonstrate a clear understanding of the subject, include a critical review of relevant literature, identify knowledge gaps or practical implications, and highlight future directions or applications. The seminar must reflect the student's ability to synthesize technical information, present it logically, and engage the audience with meaningful discussion.

As part of the seminar, students shall prepare a well-structured report summarizing the literature review, identified research gap, rationale, objectives, and methodology or key findings related to the elective topic. They shall also deliver a professional oral presentation of their work, use appropriate visual aids, and respond confidently to questions and feedback.

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: III

Course code: PRJ-604-STR

Course: RESEARCH PROJECT STAGE I

Teaching scheme	Credits	Examination	
Practical: 18 hours/week	09	TW OR	25 marks 25 marks

Course objectives

The objective of Research Project Stage I is to enable students to identify and select a relevant, original, and feasible research topic in structural engineering, in consultation with a faculty supervisor. It aims to develop the student's ability to conduct a critical review of existing literature, identify research gaps, and formulate a clear problem statement with well-defined objectives and scope.

Course outcomes

CO1	Identify, justify, and define a relevant, original, and feasible research topic in structural engineering by conducting a critical literature review, identifying knowledge gaps, and formulating clear objectives, problem statement, and scope of work.
CO2	Develop and present a comprehensive research proposal document and oral presentation, outlining the rationale, methodology, plan of action, and resource requirements, while incorporating feedback from supervisors and reviewers to refine the research plan.

COURSE CONTENTS

In Research Project Stage 1, students initiate their dissertation work by identifying and finalizing a research topic of relevance and significance in structural engineering, in consultation with and approved by their faculty supervisor. Students are expected to conduct a thorough literature review to critically assess the current state of knowledge, identify research gaps, and clearly define the problem statement, objectives, and scope of the proposed research. They shall develop a detailed plan of work, outlining the methodology, experimental or analytical approaches, timelines, and required resources.

The students shall prepare a well-structured report that summarizes the literature review, identified research gap, rationale, objectives, and methodology or findings.

They shall also deliver a professional oral presentation of their work, using appropriate visual aids, effectively communicating complex ideas, and responding confidently to questions and feedback.

Savitribai Phule Pune University
Pune, Maharashtra, India

M.E. Civil (Structures) (2025 Pattern)

(With effect from Academic Year 2025-26)

Semester IV

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: IV

Course code: SEM-605-STR

Course: SEMINAR III

Teaching scheme	Credits	Examination	
Practical: 8 hours/week	04	TW OR	50 marks 50 marks

Course objectives

To develop the student's ability to independently investigate and critically analyze an advanced topic in structural engineering, and to effectively communicate the findings through a well-structured report and professional oral presentation.

Course outcomes

CO1	Select and critically evaluate an advanced topic in structural engineering, integrating literature findings to identify knowledge gaps or emerging opportunities.
CO2	Prepare a comprehensive seminar report and deliver a professional oral presentation demonstrating technical depth, clarity, and effective audience engagement.

COURSE CONTENTS

The seminar should be based on any advanced topic in structural engineering, selected by the student in consultation with the faculty supervisor.

The seminar should demonstrate a strong grasp of the subject, supported by critical evaluation of relevant literature, identification of knowledge gaps or emerging opportunities, and discussion of practical or research implications.

As part of the seminar, students shall prepare a structured report that includes the literature review, identified research gap, rationale, objectives, methodology or findings, conclusions, and future scope. They shall also deliver a professional oral presentation using appropriate visual aids, and respond confidently to questions and feedback

Savitribai Phule Pune University
M.E. Civil (Structures) (2025 Pattern)

Semester: IV

Course code: PRJ-606-STR

Course: RESEARCH PROJECT STAGE II

Teaching scheme	Credits	Examination	
Practical: 36 hours/week	18	TW OR	150 marks 50 marks

Course objectives

The objective of Research Project Stage II is to enable students to execute the research plan developed in Stage I, systematically carry out experimental, analytical, or computational work, and generate meaningful results. Students are expected to critically analyze and interpret the outcomes of their research, draw valid conclusions, and demonstrate originality, technical rigor, and ethical conduct throughout their work. The course aims to develop the ability to document the entire research process in a comprehensive dissertation conforming to academic standards and to defend the research confidently and professionally in an oral examination (viva voce).

Course outcomes

CO1	Execute the approved research plan with originality, technical competence, and ethical rigor, systematically generating, analyzing, and interpreting results to address the stated research problem effectively.
CO2	Document the entire research process in a comprehensive, well-structured dissertation adhering to academic standards, and confidently present and defend the findings in a formal viva voce, responding thoughtfully to critiques and highlighting contributions and future directions.

COURSE CONTENTS

In Research Project Stage II, students execute the research plan developed during Stage I, conducting the necessary experimental, analytical, computational, or field work under the guidance of their faculty supervisor. They are required to systematically document observations, analyze data, interpret results critically, and draw meaningful conclusions aligned with the objectives. The dissertation must include the full research process — literature review, problem formulation, methodology, results, discussions, conclusions, and future scope.

The dissertation shall be prepared in the prescribed format (as per institute/department guidelines), typed and properly bound. It must include a signed certificate from the supervisor, plagiarism check report (within permissible limits), and any necessary annexures such as raw data, drawings, or codes. Both hard and soft copies are to be submitted by the notified deadline.

The report should typically contain: Title Page, Certificate, Declaration, Acknowledgements, Abstract, Table of Contents, List of Figures, List of Tables, List of Symbols/Abbreviations/Notations, Introduction, Literature Review, Methodology, Results, Discussion, Conclusions and Future Scope, References, and Appendices/Annexures with supporting data and documents.

The stage culminates in the submission of the dissertation and a formal oral defense (viva voce) before a panel of examiners, where students demonstrate their ability to communicate and justify their research outcomes effectively.

As part of this stage, each student is required to prepare a research paper based on their project work, suitable for submission to and/or presentation at a peer-reviewed conference, PG CON, or academic journal.