# COURSE OUTLINE DESCRIPTION

| SECTION 1: General Information about the Course | |
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| Course Title | **ADVANCED STRUCTURAL ANALYSIS** |
| Course Code | BSTE01 |
| Course Start | First Semester |
| Course Type | Core |
| Regulation | IARE - MT 25 |
| Prerequisite Courses | Structural Analysis (ACED14) |
| Department | Civil Engineering |
| Number of Credits | 3 Credit hours |
| Academic Year | 2025-26 |
| Method(s) of Instruction | Theory |
| Course Administrator | **Dr. Venu M,** Professor of Civil Engineering<br>IARE10607<br>**venu@iare.ac.in** |
| Course Coordinator's Name | **Dr. Venu M,** Professor of Civil Engineering<br>IARE10607<br>**venu@iare.ac.in** |
| Prior Learning Assessment and Recognition (PLAR) | Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance. |
| Open Learning Faculty Member Information | Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course. |
| Course Webpage | https://akanksha.iare.ac.in/index?route=course/details&course_id=665 |
| Course Description | This course focuses on advanced methods of analyzing structural members and systems, extending beyond classical approaches. Students will explore unsymmetrical bending, curved beam behavior, beams on elastic foundations, and stability problems in columns. The course also emphasizes modern computational techniques such as stiffness and flexibility formulations, matrix methods, and the direct stiffness method for analyzing trusses, beams, and frames. It equips students with theoretical understanding and analytical tools essential for tackling complex structural engineering problems in practice and research. |
| Course Objectives | **The students will try to learn:**<br>a. The analysis of curved beams and beams supported on elastic foundations under different loading conditions.<br>b. The theories of column buckling with various end conditions, local effects, and inelastic behavior.<br>c. The fundamentals of stiffness and flexibility approaches in matrix methods of structural analysis.<br>d. The formulation of stiffness matrices, load vectors, and coordinate transformations for structural members. |
| Text and Reference Books | **Text Books**<br>1. C.S. Reddy, "Basic Structural Analysis", Tata McGraw-Hill, 3rd Edition, 2010.<br>2. R. Vaidyanathan & P. Perumal, "Comprehensive Structural Analysis – Vol. I & II", Laxmi Publications, 2005. |

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| | 3. A. Ghose, "Matrix Methods of Structural Analysis", Prentice Hall of India, 1996.<br>4. W. Weaver & J.M. Gere, "Matrix Analysis of Framed Structures", CBS Publishers, 3rd Edition, 1990.<br>**Reference Books**<br>1. R.C. Hibbeler, "Structural Analysis", Pearson, 10th Edition, 2017.<br>2. Aslam Kassimali, "Matrix Analysis of Structures", Cengage Learning, 2nd Edition, 2011.<br>3. Devdas Menon, "Advanced Structural Analysis", Narosa Publishing, 2009.<br>4. M.L. Gambhir, "Fundamentals of Structural Mechanics and Analysis", PHI Learning, 2011.<br>5. B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain, "Structural Analysis", Laxmi Publications, 16th Edition, 2017 |
| Learning Resources | **Course full stack** is made available in IARE learning management portal – Akansha, which includes lecture notes, tutorial question bank, definition and terminology, tech-talk topics, assignments, Model question papers (2 sets), complex engineering problem solving statements, power point presentations (PPTs) and ELRV lecture recordings at: |
| Supplemental Materials | **Readings, Videos, and Links**<br>1. https://nptel.ac.in/courses/105105690 |
| Learning and Teaching Strategies | Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course.<br><br>There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks. |

**SECTION 2: Teaching Learning Scheme**

At least 48 lecture hours of scheduled teaching and learning activities (TLA) will be delivered in person, with the remaining hours for scheduled and self-scheduled teaching and learning activities delivered either in person or online.

Notional Study Time: 90 Hours (Lecture hours: 48, Tutorial hours: 8, Guided independent study hours: 10, Homework / Programming assignment hours: 9, Course project / Preparation for complex problem solving hours: 15)

| TLA Code | Teaching and Learning Activities | Number | Duration (Hours) | Total Workload |
|---|---|---|---|---|
| TLA 1 | Lectures | 48 | 01 | 48 |
| TLA 2 | Tutorials | 08 | 01 | 08 |
| TLA 3 | Case Study | | | |
| TLA 4 | Problem Solving | | | |
| TLA 5 | Demonstration | | | |
| TLA 6 | Scheduled revision sessions | | | |
| TLA 7 | Guided independent study: Directed viewing of video materials / PPTs | | | 10 |
| TLA 8 | Independent private study | | | |
| TLA 9 | Laboratory Exercises | | | |
| TLA 10 | Homework assignments / Programming assignments | | | 9 |
| TLA 11 | Placement / work based learning or Specific practical training | | | |

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| TLA 12 | Presentation / Seminar Preparation | | | |
| TLA 13 | Course Project / Preparation for Complex Problem Solving | | | 15 |
| TLA 14 | Technical visit | | | |
| TLA 15 | Field activities | | | |
| | | | **Total study hours** | **90** |
| | | | **Expected total study hours** | **90** |

| **SECTION 3A: Course Outcomes** | | |
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| After successfully completing this course, the student will be able to: | | |
| **Outcome Number** | **Course Outcomes** | **Learning Domain** |
| CO1 | **Explain** the concept of shear centre and analyze stresses and deflections in beams subjected to unsymmetrical bending for design purpose. | Understand |
| CO2 | **Examine** circumferential and radial stresses in curved beams for analysis and response of beams resting on elastic foundations. | Understand |
| CO3 | **Analyze** the buckling behavior of columns under elastic, inelastic, and local instability conditions for the stability requirements of columns. | Analyse |
| CO4 | **Formulate** stiffness and flexibility matrices for different structural elements and transform them between local and global coordinates. | Apply |
| CO5 | **Assemble** global stiffness matrices and solve for structural responses using matrix methods of analysis. | Apply |
| CO6 | **Apply** direct stiffness method for analyzing trusses, beams, and frames in practical structural systems. | Apply |

| **SECTION 3B: Cognitive Levels** | |
|---|---|
| **Blooms Taxonomy Level** | **Cognitive Level in Percentage (%)** |
| Remember | 0 |
| Understand | 30 |
| Apply | 50 |
| Analyse | 20 |
| Evaluate | 0 |
| Create | 0 |

| **SECTION 4: Content and Context of Design of Steel Structures** | |
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| **CO1** | **Explain the concept of shear centre and analyze stresses and deflections in beams subjected to unsymmetrical bending for design purpose.** |
| | Understanding the concept of shear centre and the behavior of beams under unsymmetrical bending is essential for designing safe and efficient structural members.<br>1. **Shear Centre Concept and Significance:** The shear centre is the point through which the load must pass to produce bending without twisting. Recognizing its location helps prevent undesirable torsional effects in asymmetric sections such as angles, channels, and T-beams.<br>2. **Unsymmetrical Bending Behavior:** Beams with unsymmetrical cross-sections or loading experience bending about non-principal axes, causing combined bending and twisting. Analyzing stresses and deflections under these conditions ensures the beam's performance and serviceability.<br>3. **Stress Distribution and Deflection Analysis:** Understanding how normal and shear stresses are distributed across complex cross-sections allows accurate prediction of deflection patterns and identification of critical regions for failure prevention. |

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| | 4. **Design Implications:** Applying these concepts in design enables engineers to ensure that members subjected to eccentric or lateral loads maintain stability, stiffness, and strength within permissible limits.<br>By this, students can develop the ability to analyze and design structural members subjected to unsymmetrical bending with due consideration to torsional effects, ensuring safe and reliable performance in steel and composite structures. |
| **CO2** | **Examine circumferential and radial stresses in curved beams for analysis and response of beams resting on elastic foundations.** |
| | Understanding the behavior of curved beams and beams on elastic foundations is vital for accurate stress analysis and structural performance evaluation.<br>1. **Curved Beam Behavior:** Unlike straight beams, curved beams experience a non-linear stress distribution across their depth due to curvature effects. Recognizing this difference is essential for determining true bending stresses and ensuring structural integrity in arches, hooks, and crane frames.<br>2. **Circumferential and Radial Stresses:** The presence of both circumferential and radial stresses in curved members influences their design strength and deformation characteristics. Proper evaluation of these stresses helps prevent cracking, yielding, and failure under complex loading.<br>3. **Beams on Elastic Foundations:** Beams supported on elastic media, such as soil or flexible materials, require analysis of interaction between the beam and the foundation. Understanding this response helps in designing pavements, pipelines, and structural supports with realistic deflection and stress predictions.<br>4. **Analytical and Design Relevance:** Integrating the study of curved beam theory and beam-foundation interaction enables students to perform precise structural analysis and select suitable cross-sections and materials for varying boundary and loading conditions.<br>With this, students gain the ability to evaluate and design curved beams and beams on elastic foundations with a comprehensive understanding of stress behavior and structural response, ensuring efficiency and safety in engineering applications. |
| **CO3** | **Analyze the buckling behavior of columns under elastic, inelastic, and local instability conditions for the stability requirements of columns.** |
| | Understanding the buckling behavior of columns is fundamental to ensuring stability and preventing sudden failure in structural systems.<br>1. **Elastic and Inelastic Buckling:** Columns may fail by elastic buckling at lower loads or by inelastic buckling when material yielding precedes instability. Recognizing these modes enables accurate prediction of critical loads and safe design of slender and stocky columns.<br>2. **Local Instability:** Thin-walled and built-up sections are prone to local buckling of individual plate elements, affecting the overall capacity and stiffness. Evaluating these local effects ensures that design assumptions remain valid under real loading conditions.<br>3. **Critical Load Determination:** Application of Euler's theory and empirical design formulas helps determine the critical buckling load for different end conditions, supporting rational design decisions aligned with structural codes.<br>4. **Stability Requirements:** Assessing slenderness ratios, effective lengths, and boundary conditions ensures that columns meet the required stability limits under axial and combined loading.<br>Students can analyze and design columns with a comprehensive understanding of elastic, inelastic, and local instability behavior, ensuring structural safety, stability, and code compliance under diverse loading conditions. |
| **CO4** | **Formulate stiffness and flexibility matrices for different structural elements and transform them between local and global coordinates.** |
| | Understanding the stiffness and flexibility characteristics of structural elements forms the foundation for modern structural analysis using the matrix method.<br>1. **Matrix Representation of Structural Behavior:** Stiffness and flexibility matrices describe the relationship between forces and displacements in structural members. Developing these matrices enables precise modelling of element behavior under different loading conditions.<br>2. **Element-Level Formulation:** Beams, trusses, and frames possess unique stiffness and flexibility relationships depending on their geometry and boundary conditions. Deriving these expressions ensures accurate structural representation for both determinate and indeterminate systems.<br>3. **Coordinate Transformation:** Converting matrices from local to global coordinate systems allows the integration of individual element behavior into the overall structure. This transformation ensures compatibility and equilibrium across the entire framework. |

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| | 4. **Analytical Relevance:** Mastery of matrix formulation enhances computational efficiency and accuracy in modern structural analysis software, bridging theoretical understanding with practical applications.<br>By this, students gain the ability to construct and transform stiffness and flexibility matrices for various elements, enabling systematic and precise structural analysis of complex systems. |
| **CO5** | **Assemble global stiffness matrices and solve for structural responses using matrix methods of analysis.** |
| | Developing the ability to assemble and solve global stiffness matrices is essential for analyzing complex structural systems using the matrix method.<br>1. **Global Matrix Assembly:** The global stiffness matrix represents the collective behavior of all structural elements within a system. Assembling it from individual element matrices ensures compatibility of displacements and equilibrium of internal forces throughout the structure.<br>2. **Boundary Conditions and Load Application:** Incorporating supports, restraints, and external loads into the global matrix framework ensures realistic modelling of structural behavior under actual loading scenarios.<br>3. **Solution for Structural Responses:** Solving the global system of equations provides key responses such as nodal displacements, internal forces, and reactions, which form the basis for performance evaluation and design verification.<br>4. **Computational Implementation:** Understanding the matrix assembly process lays the groundwork for computer-based structural analysis tools, enhancing accuracy and efficiency in real-world design applications.<br>By this, students can confidently assemble and solve global stiffness matrices, enabling them to determine structural responses for trusses, beams, and frames through systematic matrix analysis methods. |
| **CO6** | **Apply direct stiffness method for analyzing trusses, beams, and frames in practical structural systems.** |
| | The direct stiffness method is a fundamental computational approach for analyzing complex structural systems efficiently and accurately.<br>1. **Principle of Direct Stiffness Method:** This method is based on formulating and assembling element stiffness matrices directly in the global coordinate system, enabling systematic evaluation of structural behavior under various loading conditions.<br>2. **Application to Structural Elements:** The method can be effectively applied to trusses, beams, and frames, allowing determination of nodal displacements, member forces, and support reactions for different boundary and loading configurations.<br>3. **Systematic Computational Process:** The step-by-step procedure ranging from element formulation to global assembly and solution, provides a clear, organized framework suitable for manual calculations and computer-based analysis.<br>4. **Practical Relevance:** Understanding and applying the direct stiffness method equips students to analyze real-world structures using modern analysis tools and ensures reliability, safety, and structural efficiency in design.<br>with this, students develop the capability to model, analyze, and interpret the behavior of truss, beam, and frame systems using the direct stiffness method, bridging theoretical understanding with practical engineering applications. |

## SECTION 5: Complex Engineering Problem Solving

**Complex engineering problem solving projects**

There is one piece of assessed coursework, involving a mixture of theoretical work and practical work. We encourage to use the laboratory for practical purpose. For the calculation part in the project, they have to develop the programme code in java or python.

Programming part is mandatory for this course. Homework assignments will concentrate on theoretical concepts and techniques. Projects will be full scale to calculate the slopes and deflections of the various structural members discussed in class. All projects are individual assignments. Student are required to complete the tasks during the class period with no assistance.

**Design of industrial structures:** The entire course is dealt with analysis and design of various elements in the structures. Design of industrial structures will be combination of all the structural elements with joints, so introduction to design of industrial structures will be discussed in the class.

| SECTION 6A: Assessment Methods – Direct | | | |
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| **Item** | **Evaluation Components** | **Week in / out** | **Marks** |
| AAT: 1 - 1 | Tech-Talk | Week – 2 / 5 | 05 |
| AAT: 1 - 2 | Assignments | Week – 4 / 7 | 05 |
| AAT: 2 - 1 | Complex Engineering Problem Solving | Week – 9 / 12 | 05 |
| AAT: 2 - 2 | Definitions and Terminology | Week – 12 / 15 | 05 |
| CIE - 1 | 2 hours - Answer 4 out of 5 questions | Week - 9 | 10 |
| CIE - 2 | 2 hours - Answer 4 out of 5 questions | Week - 17 | 10 |
| SEE | 3 hours - Answer 1 from each module | Week - 18 | 60 |
| | | **Total Marks** | **100** |
| **Department's Late Submission Policy:**<br>1. 1 – 24 hours: 25% of the mark will be deducted<br>2. > 24 hours: Not accepted | | | |
| **SECTION 6B: Assessment Methods –Indirect** | | | |
| Course End Survey (End Semester OBE Feedback) | | | ✓ |

| **SECTION 7: Engineering Competencies (ECs) Focused**<br>Please tick (✓) relevant engineering competency profile covered | | | |
|---|---|---|---|
| **EC Number** | **Attributes** | **Profiles** | **(✓)** |
| EC1 | Depth of knowledge required (CP) | Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline | ✓ |
| EC2 | Depth of analysis required (CP) | Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models. | ✓ |
| EC3 | Design and development of solutions (CA) | Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness. | ✓ |
| EC4 | Range of conflicting requirements (CP) | Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues. | - |
| EC5 | Infrequently encountered issues (CP) | Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. | - |
| EC6 | Protection of society (CA) | Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline. | - |
| EC7 | Range of resources (CA) | Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes | - |
| EC8 | Extent of stakeholder involvement (CP) | Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs. | - |

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| EC9 | Extent of applicable codes, legal and regulatory (CP) | Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities. | ✓ |
| EC10 | Interdependence (CP) | High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration. | ✓ |
| EC11 | Continuing professional development (CPD) and lifelong learning (CA) | Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. | - |
| EC12 | Judgement (CA) | Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities. | - |

## SECTION 8: Employability Skills

**Example: Communication skills / Programming skills / Project based skills**

Studying advanced structural analysis equips students with a variety of employability skills that are highly valued in civil and structural engineering industries.

**Employability Skills:**

- Competency in analyzing indeterminate structures using classical and matrix methods, ensuring accurate prediction of displacements, internal forces, and reactions.
- Proficiency in evaluating structural responses of trusses, beams, frames, and multi-storey systems under complex loading conditions, including axial, bending, torsion, and combined loads.
- Expertise in using computational tools and software (e.g., STAAD Pro, ETABS, SAP2000, ANSYS) for modelling, analyzing, and interpreting results for 2D and 3D structural systems.
- Ability to formulate and solve stiffness and flexibility matrices, and apply direct and slope-deflection methods for practical structural analysis problems.
- Knowledge of stability analysis, including column buckling, frame sway, and lateral-torsional behavior, essential for safe and code-compliant design.
- Capability to prepare clear analytical reports, diagrams, and interpretation of results to support engineering decisions and project documentation.

**Project Management:**

- Ability to plan and execute structural analysis projects, including defining objectives, selecting suitable analysis methods, and meeting project timelines.
- Experience in collaborative team work to solve complex structural problems, perform case studies, and validate analysis results for multi-member systems.
- Decision-making skills in selecting modeling assumptions, boundary conditions, and load combinations based on project requirements and safety considerations.
- Risk identification and mitigation through stability checks, sensitivity analysis, and verification of critical load paths and member capacities.
- Technical documentation and presentation skills, including writing detailed analysis reports, preparing result summaries, and communicating findings to stakeholders effectively.

| SECTION 9: Relevance to Sustainability goals<br>Brief description about the course and its correlation with Sustainability Development Goal (SDGs). | |
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| **SDG Goals** | **Correlation with SDG** |
| 4 | **Quality Education:** The course develops critical thinking, problem-solving, and computational skills essential for engineering professionals. Enhances learning outcomes in structural mechanics, matrix methods, and computational analysis, preparing students for global engineering challenges. |
| 9 | **Industry, Innovation, and Infrastructure:** By mastering advanced structural analysis, students contribute to the design and construction of safe, resilient, and sustainable infrastructure. Skills in modeling, stability assessment, and structural optimization support innovation in bridges, buildings, and industrial structures. |
| 11 | **Sustainable Cities and Communities:** Analyzing complex structural systems ensures the safety and durability of urban infrastructure, supporting sustainable and resilient communities. Students learn to evaluate structures under diverse loadings, natural forces, and environmental conditions, promoting long-term urban resilience. |
| 12 | **Responsible Consumption and Production:** By understanding load paths, structural efficiency, and optimization, students can design resource-efficient structures. Promotes minimal material waste and sustainable use of construction resources. |
| 13 | **Climate Action:** Students gain knowledge to analyze structures for extreme loading scenarios (wind, seismic), supporting climate-resilient design. Encourages integration of safety and sustainability principles in civil engineering projects. |

| SECTION 10A: Mapping between COs and POs / PSOs | | | | | | |
|---|---|---|---|---|---|---|
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| CO1 | ✓ | | ✓ | | | |
| CO2 | ✓ | | ✓ | ✓ | ✓ | |
| CO3 | ✓ | | ✓ | ✓ | ✓ | |
| CO4 | ✓ | | ✓ | ✓ | ✓ | |
| CO5 | ✓ | | ✓ | ✓ | ✓ | |
| CO6 | ✓ | | ✓ | ✓ | ✓ | |

| Outcomes | | WKS and Indicators of attainment and Justification for mapping (students will be able to) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | IAs Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | POs | WK 1 | WK 2 | | | | | | | | WK 3 | | | WK 4 | | | WK 5 | | | | | | WK 6 | | | WK 7 | | | | WK 8 | | | | | | | WK 9 | | | | | | |
| | | a | a | b | c | d | e | f | g | h | a | b | c | a | b | c | a | b | c | d | e | f | a | b | c | a | b | c | d | a | b | c | d | e | f | g | a | b | c | d | e | f | |
| CO 1 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| CO 2 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 3 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 4 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 5 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 6 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |

| SECTION 10B: Indicators of Attainment with COs to POs and PSOs | | | | | | |
|---|---|---|---|---|---|---|
| Course Outcomes | Percentage of Indicators of Attainments (IA) with POs | | | | | |
| | PO | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| CO1 | 73 | - | 78 | - | - | - |
| CO2 | 73 | - | 78 | 73 | 72 | - |
| CO3 | 73 | - | 78 | 73 | 72 | - |
| CO4 | 73 | - | 78 | 73 | 72 | - |
| CO5 | 73 | - | 78 | 73 | 72 | - |
| CO6 | 73 | - | 78 | 73 | 72 | - |

| SECTION 10C: Course Articulation Matrix of COs to POs | | | | | | |
|---|---|---|---|---|---|---|
| **0** No Contribution (0-5%) | | **1** Low (≥5 - <40%) | | **2** Moderate (≥40 - <60%) | | **3** High (≥60%) |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| CO1 | 3 | - | 3 | - | - | - |
| CO2 | 3 | - | 3 | 3 | 3 | - |
| CO3 | 3 | - | 3 | 3 | 3 | - |
| CO4 | 3 | - | 3 | 3 | 3 | - |
| CO5 | 3 | - | 3 | 3 | 3 | - |
| CO6 | 3 | - | 3 | 3 | 3 | - |
| **Total** | 18 | - | 18 | 15 | 15 | - |
| **Average** | 3 | - | 3 | 3 | 3 | - |

| SECTION 10D: Level of Contribution of the COs to POs | | | |
|---|---|---|---|
| **Number** | **Programme Outcomes** | **Proficiency Assessed by** | **Contribution Level (from 1 to 3)** |
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. | CIE / SEE / AAT:1 – 2 Assignments / Open-ended problems | **3** |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | CIE / SEE / AAT:1 – 2 | **3** |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | CIE / SEE / AAT:2 – 1 Complex Engineering Problem Solving | **3** |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | CIE / SEE / AAT:2 – 2 | **3** |

| SECTION 11: Course Content | |
|---|---|
| **MODULE - I** | **UNSYMMETRICAL BENDING** |
| | Definition of Shear Center in Bending - Symmetrical and Non-symmetrical Bending - Bending Stresses in Beams Subjected to Non-symmetrical Bending - Deflections of Straight Beams Subjected to Non-symmetrical Bending. |
| **MODULE - II** | **ADVANCED ANALYSIS OF BEAMS** |
| | Curved Beams: Circumferential Stresses in a Curved Beam - Radial Stresses in Curved Beams - Correction of Circumferential Stresses in Curved Beams Having I-, T-, or Similar Cross Sections - Deflections of Curved Beams, Beams on Elastic Foundations - Infinite Beam Subjected to a Concentrated Load: Boundary Conditions - Infinite Beam Subjected to a Distributed Load Segment. |
| **MODULE - III** | **COLUMN BUCKLING** |

| | |
|---|---|
| | Concept of Column Buckling - Deflection Response of Columns to Compressive Loads<br><br>Euler Buckling of Columns with General End Constraints - Local Buckling of Columns - Inelastic Buckling of Columns |
| **MODULE - IV** | **INTRODUCTION TO MATRIX METHODS OF ANALYSIS** |
| | Static indeterminacy and kinematic indeterminacy - degree of freedom - coordinate system - structure idealization stiffness and flexibility matrices - suitability element stiffness equations - elements flexibility equations - mixed force – displacement equations-Transformation of coordinates - element stiffness matrix - and load vector - local and global coordinates - Assembly of stiffness matrix from element stiffness matrix – Analysis of trusses, beams and frames by stiffness matrix methods. |
| **MODULE - V** | **DIRECT STIFFNESS METHOD** |
| | General procedure - banded matrix - semi bandwidth - assembly by direct stiffness matrix method -Application of direct stiffness method to trusses, simple and continuous beams and frames. |

| **SECTION 12: Tentative Schedule of Instructions** | | |
|---|---|---|
| **Week Number** | **Topics** | **Duration (Hours)** |
| 1 | 1.1 Definition of shear centre in bending<br>1.2 Symmetrical bending<br>1.3 Non-symmetrical bending | 3 |
| 2 | 2.1 Bending stresses in beams subjected to symmetrical bending<br>2.2 Bending stresses in beams subjected to non-symmetrical bending<br>2.3 Deflections of straight beams subjected to symmetrical bending | 3 |
| 3 | 3.1 Deflections of straight beams subjected to symmetrical bending<br>3.2 Curved beams: circumferential stresses in a curved beam<br>3.3 Radial stresses in curved Beams | 3 |
| 4 | 4.1 Correction of circumferential stresses in I – curved beams<br>4.2 Correction of circumferential stresses in T – curved beams<br>4.3 Correction of circumferential stresses in curved beams of other cross sections | 3 |
| 5 | 5.1 Deflections of curved beams<br>5.2 Beams on elastic foundations<br>5.3 Infinite beam subjected to a concentrated load | 3 |
| 6 | 6.1 Boundary conditions<br>6.2 Infinite beam subjected to a distributed load segment<br>6.3 Infinite beam subjected to a other loads | 3 |
| 7 | 7.1 Concept of column buckling<br>7.2 Single angle strut<br>7.3 Built up compression members | 3 |
| 8 | 8.1 Bending strength laterally supported beams<br>8.2 Shear strength laterally supported beams<br>8.3 Deflection response of columns to compressive loads | 3 |
| **CONTINIUOUS INTERNAL EXAMINATION (CIE- I)** | | |
| 9 | 9.1 Euler buckling of columns<br>9.2 Euler buckling of columns with general end constraints<br>9.3 Local buckling of columns | 3 |
| 10 | 10.1 Inelastic Buckling of Columns<br>10.2 Static indeterminacy<br>10.3 Kinematic indeterminacy | 3 |
| 11 | 11.1 Degree of freedom<br>11.2 Coordinate system<br>11.3 Structure idealization | 3 |
| 12 | 12.1 Stiffness matrices<br>12.2 Flexibility matrices | 3 |

| | | |
|---|---|---|
| | 12.3 Suitability element stiffness equations | |
| 13 | 13.1 Elements flexibility equations<br>13.2 Mixed force – displacement equations<br>13.3 Transformation of coordinates | 3 |
| 14 | 14.1 Element stiffness matrix<br>14.2 Load vector - local and global coordinates<br>14.3 Assembly of stiffness matrix from element stiffness matrix | 3 |
| 15 | 15.1 Analysis of trusses, beams and frames by stiffness matrix methods<br>15.2 General procedure - banded matrix<br>15.3 Semi bandwidth | 3 |
| 16 | 16.1 Assembly by direct stiffness matrix method<br>16.2 Application of direct stiffness method to trusses<br>16.3 Simple and continuous beams and frames | 3 |
| | **Total** | **48** |

| **SECTION 13: Specific Goals for the Course** | |
|---|---|
| **The following table shows the knowledge and skills covered by the unit outcomes:** | |
| **Knowledge** | **Skills** |
| • Concept of unsymmetrical bending and the role of the shear centre in determining bending stresses and deflections<br>• Behavior of beams under non-symmetrical bending and derivation of related stress and deflection equations<br>• Fundamental principles governing curved beam analysis including circumferential and radial stresses<br>• Correction factors for non-uniform cross-sections (I, T, or similar) in curved beams<br>• Behavior and analysis of beams on elastic foundations, including boundary conditions for concentrated and distributed loads<br>• Concepts of column buckling, critical load, and the influence of boundary conditions<br>• Types of buckling: elastic, inelastic, and local buckling and their implications on column design<br>• Fundamentals of matrix methods of structural analysis and distinction between stiffness and flexibility formulations<br>• Concepts of degrees of freedom, coordinate transformation, and assembly of global stiffness matrices<br>• Principles of structure idealization, element formulation, and load vector generation<br>• Application of Direct Stiffness Method (DSM) in computer-based structural analysis<br>• Integration of advanced analysis techniques into design and evaluation of real-world structural systems | • Identify and locate the shear center for various cross-sections subjected to unsymmetrical bending<br>• Analyze and compute bending stresses and deflections in beams subjected to unsymmetrical bending<br>• Calculate circumferential and radial stresses in curved beams with various cross-sections<br>• Apply correction factors to determine accurate stress distribution in curved beams<br>• Formulate and solve problems involving beams on elastic foundations under different loading conditions<br>• Determine critical buckling loads for columns with various end constraints using Euler's theory<br>• Evaluate buckling behavior of columns and assess stability limits for different materials and geometries<br>• Formulate and solve indeterminate structures using stiffness and flexibility methods<br>• Develop element stiffness matrices, perform coordinate transformations, and assemble the global stiffness matrix<br>• Idealize real structures into analytical models and generate appropriate load vectors and boundary conditions<br>• Perform matrix-based analysis of trusses, beams, and frames using the direct stiffness method both manually and through computational tools<br>• Construct and manage banded matrix formulations for efficient numerical analysis of complex structures<br>• Interpret and validate analysis results for design applications, ensuring stability, safety, and accuracy in practical structures |

## Administrative Information

| SECTION 15: History of changes | | |
|---|---|---|
| **Regulations** | **Description of change** | **BOS Date** |
| R 18 | Changes from R16 to R18 regulation<br>• New course introduced in this regulation | 10.07.2018 |
| PG 21 | Changes from R18 to PG 21 regulation<br>• No change | 02.11.2021 |
| MT 23 | Incorporated the following additions in MT 23 regulations<br>• Stiffness and flexibility methods are made as two different modules<br>• Approximate methods analysis are introduced as fifth module | 18.08.2023 |
| MT 25 | Incorporated the following additions in MT 25 regulations<br>• Unsymmetrical bending, analysis of curved beams and column buckling are introduced in three modules and remaining two modules are related to matrix methods of structural analysis | 01.09.2025 |

| **Course Outline Approvals** | |
|---|---|
| **Course Coordinator**<br>Name:<br>Signature:<br>Date: | **Head of the Department**<br>Name:<br>Signature:<br>Date: |
| **Course Outline Approvals: The course outline description approved by Outcome Based Teaching Learning (OBTL) committee on *date* in meetings *IARE - OBTL – COD /104/25*** | |
| **Dean of Outcome Based Teaching and Learning**<br>Name:<br>Signature:<br>Date: | **Dean of Academics**<br>Name:<br>Signature:<br>Date: |

| Check List | | |
|---|---|---|
| **Section** | **Description** | **Please tick (✓)** |
| 1 | General Information about the Course | |
| 2 | Notional Study Time | |
| 3 | A. Course Outcomes | |
| | B. Cognitive Levels | |
| 4 | Content and Context of the Course | |
| 5 | Complex Engineering Problem Solving | |
| 6 | A. Assessment Methods – Direct | |
| | B. Assessment Methods – Indirect | |
| 7 | Content Delivery / Instructional Methodologies | |
| 8 | Engineering Competencies (ECs) Focused | |
| 9 | Employability Skills | |
| 10 | Relevance to Sustainability goals | |
| 11 | A. Mapping between COs and POs / PSOs | |
| | B. Indicators of Attainment with COs to POs and PSOs | |
| | C. Course Articulation Matrix of COs to POs | |
| | D. Level of Contribution of the COs to POs and PSOs | |
| 12 | Syllabus | |
| 13 | Tentative Schedule of Instructions | |
| 14 | Specific Goals for the Course | |
| 15 | History of Changes | |

# INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

## COURSE DESCRIPTION

| | | | | | |
|---|---|---|---|---|---|
| Department | **CIVIL ENGINEERING (STRUCTURAL ENGINEERING)** | | | | |
| Course Title | **THEORY OF ELASTICITY AND PLASTICITY** | | | | |
| Course Code | BSTE02 | | | | |
| Program | M. Tech (STE) | | | | |
| Semester | I | | | | |
| Course Type | CORE | | | | |
| Regulation | MT25 | | | | |
| Course Structure | Theory | | | Practical | |
| | Lecture | Tutorials | Credits | Laboratory | Credits |
| | 3 | - | 3 | - | - |
| Course Coordinator | Dr.M.Maheswara Rao, Assistant Professor | | | | |

## I COURSE PRE-REQUISITES:

| **Level** | **Course Code** | **Semester** | **Prerequisites** |
|---|---|---|---|
| | | | |
| | | | |

## II COURSE OVERVIEW:

This course introduces the principles of elasticity, components of stresses and strains, differential equations of equilibrium, boundary conditions, compatibility conditions and stress function. This course also covers the two dimensional problems in rectangular coordinates and polar coordinates, Fourier series for two dimensional problems stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, analysis of stress strain in three dimensions, torsion of prismatical bars and plasticity.

## III MARKS DISTRIBUTION:

| **Subject** | **SEE Examination** | **CIE Examination** | **Total Marks** |
|---|---|---|---|
| THEORY OF ELASTICITY AND PLASTICITY | 60 Marks | 40 Marks | 100 |

## IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Power Point Presentations | ✓ | Chalk & Talk | ✓ | Assignments | x | MOOC |
| x | Open Ended Experiments | x | Seminars | x | Mini Project | x | Videos |
| x | Others | | | | | | |

## V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

**Semester End Examination (SEE):** The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question. The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

| | |
|---|---|
| 50% | To test the objectiveness of the concept |
| 30 % | To test the analytical skill of the concept |
| 20% | To test the application skill of the concept |

**Continuous Internal Assessment (CIA):**
CIA is conducted for a total of 40 marks, with 20 marks for continuous internal examination (CIE) and 10 marks for Definitions and Terminology / Quiz and 10 marks for Tech Talk / Assignment.

| **Component** | | Marks | Total Marks |
|---|---|---|---|
| **CIA** | Continuous Internal Examination – 1 (Mid-term) | 10 | 40 |
| | Continuous Internal Examination – 2 (End-term) | 10 | |
| | AAT-1 | 10 | |
| | AAT-2 | 10 | |
| **SEE** | Semester End Examination (SEE) | 60 | 60 |
| **Total Marks** | | | 100 |

**Continuous Internal Examination (CIE):**
Two CIE exams shall be conducted at the end of the 9th and 17th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

**Assignment:** To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

**Alternative Assessment Tool (AAT):** In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. **The AAT may includes**, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

| Concept Video | Tech-talk | Complex Problem Solving |
|---|---|---|
| 40% | 40% | 20% |

## VI COURSE OBJECTIVES:

**The students will try to learn:**

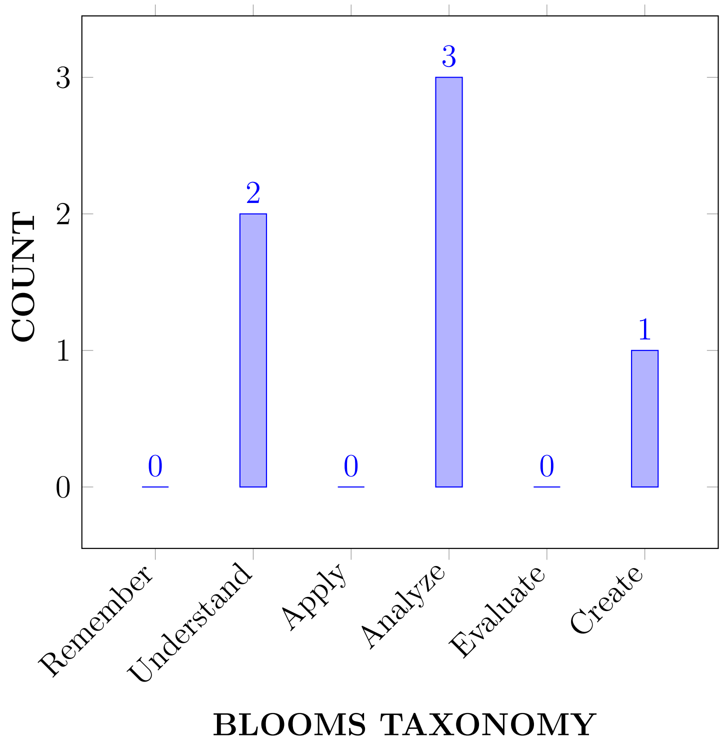
| | |
|---|---|
| I | The transformation of stresses and strains in two and three Dimensional problems related to structural elements. |
| II | The Engineering properties of materials, force-deformation and stress-strain relationships. |
| III | The plastic behaviour of deformable bodies in Cartesian coordinates and polar coordinates. |

## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** theory of elasticity including strain/displacement and Hooke's law relationships for analysing the structures with in elastic range. | Understand |
| CO 2 | **Develop** constitutive relationships between stress and strain in linearly elastic solid for analysing the stresses in the field. | Create |
| CO 3 | **Analyse** the Stresses and Strains, Strain Displacement and Compatibility Relations for Boundary Value Problems in the Principal Directions. | Analyse |
| CO 4 | **Explain** the Plane Stress and Plane Strain Problems using Airy's stress Function and Two-Dimensional Problems in Polar Coordinates. | Understand |
| CO 5 | **Analyze** boundary value problems using Modified Galerkin Method. | Analyse |
| CO 6 | **Examine** the properties of ideally plastic solids using different yield criterion. | Analyse |

## COURSE KNOWLEDGE COMPETENCY LEVEL




## VIII PROGRAM OUTCOMES:

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. | 1 | CIE, SEE |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 1 | CIE, SEE |

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 2 | CIE, SEE |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 3 | CIE, SEE |

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

## X MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | ✓ | ✓ | - | - |
| CO 2 | ✓ | - | - | ✓ | ✓ | - |
| CO 3 | - | - | ✓ | ✓ | ✓ | - |
| CO 4 | ✓ | - | - | ✓ | ✓ | - |
| CO 5 | - | - | - | ✓ | ✓ | - |
| CO 6 | - | - | ✓ | ✓ | - | - |

## XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO 1 | PO3 | Analyze the given **problem statement** and find the static and kinematic inderteminacy of structures to establish innovative solutions in structural system and **Interpret the result** on various applications. | 2 |
| | PO4 | Demonstrate the importance of structural analysis of new innovative structures for solving society relevant problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |
| CO2 | PO1 | Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure using matrix methods. | 2 |
| | PO4 | Select the appropriate method for the analysis of different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO3 | PO3 | Analyze the given **problem statement** and find the member forces for different loads to establish innovative solutions in structural system and **Interpret the results.** | 2 |
| | PO 4 | Analyse the member forces due to loads and lack of fit by Selecting the appropriate method for different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO4 | PO1 | Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure in terms of stiffness matrix in global coordinate system. | 2 |
| | PO4 | Apply the knowldege of stiffness matrix in global level by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.** | 2 |
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO5 | PO4 | Demonstrate the importance of shape functions in analysing the one and two dimensional elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.** | 2 |
| | PO5 | Utilize the concepts of shape functions for the analysis and design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO6 | PO3 | Analyze the given **problem statement** and find the solution of one dimensional boundary value problem using different methods for innovative solutions in structural system and **Interpret the result** on various applications. | 2 |
| | PO4 | Select the appropriate method for the analysis of one dimensional boundary value problem by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |

## XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | 2 | 4 | - | - |
| CO 2 | 2 | - | - | 4 | 4 | - |
| CO 3 | - | - | 2 | 4 | 4 | - |
| CO 4 | 2 | - | - | 2 | 4 | - |
| CO 5 | - | - | - | 2 | 4 | - |
| CO 6 | - | - | 2 | 4 | - | - |

## XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 28.5 | 50.0 | 0.0 | 0.0 |
| CO 2 | 28.5 | 0.0 | 0.0 | 50.0 | 80.0 | 0.0 |
| CO 3 | 0.0 | 0.0 | 28.5 | 50.0 | 80.0 | 0.0 |
| CO 4 | 28.5 | 0.0 | 0.0 | 25.0 | 80.0 | 0.0 |
| CO 5 | 0.0 | 0.0 | 0.0 | 25.0 | 80.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 28.5 | 50.0 | 0.0 | 0.0 |

## XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq C \leq 5\%$ – No correlation
***1*** -$5 < C \leq 40\%$ – Low/ Slight
***2*** - $40\ \% < C < 60\%$ –Moderate
***3*** - $60\% \leq C < 100\%$ – Substantial /High

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 |
| CO 2 | 1.0 | 0.0 | 0.0 | 2.0 | 3.0 | 0.0 |
| CO 3 | 0.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 |
| CO 4 | 1.0 | 0.0 | 0.0 | 1.0 | 3.0 | 0.0 |
| CO 5 | 0.0 | 0.0 | 0.0 | 1.0 | 3.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 |
| **Total** | 2.0 | 0.0 | 3.0 | 10.0 | 12.0 | 0.0 |
| **Average** | 1 | 0 | 1 | 2 | 3 | 0 |

## XV ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | - | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## XVI ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## XVII SYLLABUS:

| | |
|---|---|
| MODULE I | **INTRODUCTION** |
| | Introduction: Elasticity, notation for forces and stresses, components of stresses, components of strain, Hooks law. Plane stress and plane strain analysis, plane stress, plane strain, differential equations of equilibrium, boundary conditions, compatibility equations, stress function, boundary condition. |
| MODULE II | **TWO DIMENSIONAL PROBLEMS IN RECTANGULAR COORDINATES** |
| | Two dimensional problems in rectangular coordinates, solution by polynomials, St. Venant's principle, determination of displacements, bending of simple beams, application of Fourier series for two dimensional problems, gravity loading. Two dimensional problems in polar coordinates, stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, general solution of two dimensional problems in polar coordinates, application of general solution in polar coordinates. |
| MODULE III | **STIFFNESS MATRIX ASSEMBLY OF STRUCTURES AND APPLICATIONS TO SIMPLE PROBLEMS** |

| | |
|---|---|
| | Analysis of stress and strain in three dimensions, principal stresses, stress ellipsoid, director surface, determination of principal stresses, max shear stresses, homogeneous deformation, and principal axes of strain rotation.<br><br>General theorems: Differential equations of equilibrium, conditions of compatibility, determination of displacement, equations of equilibrium in terms of displacements, principle of super position, uniqueness of solution, the reciprocal theorem. |
| MODULE IV | **TORSION OF PRISMATICAL BARS** |
| | Torsion of prismatic bars, bars with elliptical cross sections, other elementary solution, membrane analogy, torsion of rectangular bars, solution of torsion problems by energy method, use of soap films 19 in solving torsion problems, hydro dynamical analogies, torsion of shafts, tubes, bars etc. Bending of prismatic bars: Stress function, bending of cantilever, circular cross section, elliptical cross section, rectangular cross section, bending problems by soap film method, displacements. |
| MODULE V | **THEORY OF PLASTICITY** |
| | Theory of Plasticity: Introduction, concepts and assumptions, idealized stress train behavior, Elastic perfectly plastic material, Perfectly plastic material, Linearly strain hardening material, power law stress train model, strain hardening, nominal and true stress strain, yield criterions. |

## TEXTBOOKS

1. 1. Timoshenko, "Theory of Elasticity", McGraw-Hill Publications, 3rd edition, 1970.
2. Atkin, Raymond John, and Norman Fox. An introduction to the theory of elasticity. Courier Corporation, 2005.
3. J. Chakarbarthy, "Theory of Plasticity, McGraw-Hill Publications.

## REFERENCE BOOKS:

1. Y. C. Fung, "Theory of Elasticity.
2. Mendelson, A, "Plasticity: Theory and Applications", Mac Millan and Company, New York.
3. Gurucharan Singh, "Theory of Elasticity".

## WEB REFERENCES:

1. http://nptel.ac.in/courses/105106049/77
2. https://lecturenotes.in/subject/162/advanced-mechanics-of-solids-amos
3. http://nptel.ac.in/courses/105106049/pdf-assignments/main.pdf

## XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's | Reference T1: R1: |
|---|---|---|---|
| | **OBE DISCUSSION** | | |
| 1 | Discussion on OBE, POs and COs of Advanced Structural Analysis | | |
| | **CONTENT DELIVERY (THEORY)** | | |
| 1 | Introduction | CO1 | T1,T2 |
| 2 | Introduction to Elasticity . | CO1 | T1,T2 |
| 3 | Notation for forces and stresses. | CO1 | T1,T2 |
| 4 | Components of stresses . | CO1 | T1,T2 |
| 5 | Components of strain . | CO1 | T1,T2 |
| 6 | Hooks law. | CO1 | T1,T2 |
| 7 | Plane stress and plane strain analysis. | CO1 | T1,T2 |
| 8 | Plane stress, plane strain. | CO1 | T1,T2 |
| 9 | Differential equations of equilibrium. | CO1 | T1,T2 |
| 10 | Boundary conditions. | CO1 | T1,T2 |
| 11 | Compatibility equations, stress function, boundary condition. | CO1 | T1,T2 |
| 12 | Two dimensional problems in rectangular coordinates. | CO1,CO2 | T1,T2 |
| 13 | Solution by polynomials | CO1,CO2 | T1,T2 |
| 14 | St. Venant's principle | CO2 | T1,T2 |
| 15 | Determination of displacements. | CO2 | T1,T2 |

| | | | |
|---|---|---|---|
| 16 | Bending of simple beams | CO2 | T1,T2 |
| 17 | Application of Fourier series for two dimensional problems | CO2 | T1,T2 |
| 18 | Gravity loading. Two dimensional problems in polar coordinates. | CO2 | T1,T2 |
| 19 | Stress distribution symmetrical about an axis. | CO2 | T1,T2 |
| 20 | Pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions. | CO2 | T1,T2 |
| 21 | Simple symmetric and asymmetric problems, general solution of two dimensional problems in polar coordinates. | CO2 | T1,T2 |
| 22 | Application of general solution in polar coordinates. | CO2 | T1,T2 |
| 23 | Analysis of stress and strain in three dimensions. | CO3 | T1,T2 |
| 24 | Principal stresses. | CO3 | T1,T2 |
| 25 | Stress ellipsoid. | CO3 | T1,T2 |
| 26 | Director surface. | CO3 | T1,T2 |
| 27 | Determination of principal stresses. | CO3 | T1,T2 |
| 28 | Max shear stresses, homogeneous deformation. | CO3 | T1,T2 |
| 29 | principal axes of strain rotation | CO3 | T1,T2 |
| 30 | Differential equations of equilibrium, conditions of compatibility. | CO4 | T1,T2 |
| 31 | Determination of displacement, equations of equilibrium in terms of displacements. | CO4 | T1,T2 |
| 32 | Principle of super position, uniqueness of solution, the reciprocal theorem. | CO4 | T1,T2 |
| 33 | Torsion of prismatic bars, bars with elliptical cross sections, other elementary solution. | CO4 | T1,T2 |
| 34 | Membrane analogy, torsion of rectangular bars, solution of torsion problems by energy method. | CO4 | T1,T2 |
| 35 | Use of soap films 19 in solving torsion problems, hydro dynamical analogies. | CO4 | T1,T2 |
| 36 | Torsion of shafts, tubes, bars etc. | CO4 | T1,T2 |
| 37 | Bending of prismatic bars: Stress function. | CO4 | T1,T2 |
| 38 | Bending of cantilever, circular cross section. | CO4 | T1,T2 |
| 39 | Elliptical, rectangular cross section, bending problems by soap film method, displacements | CO4 | T1,T2 |
| 40 | Introduction TO Theory of Plasticity. | CO5 | T1,T2 |
| 41 | Concepts and assumptions, idealized stress train behavior. | CO5 | T1,T2 |
| 42 | Elastic perfectly plastic material. | CO5 | T1,T2 |
| 43 | Perfectly plastic material, Linearly strain hardening material. | CO5 | T1,T2 |
| 44 | Power law stress train model, strain hardening. | CO4,CO5 | T1,T2 |
| 45 | Nominal and true stress strain, yield criterions. | CO5 | T1,T2 |
| **PROBLEM SOLVING/ CASE STUDIES** | | | |
| 1 | Problems on Two dimensional in rectangular coordinatess | CO 1 | T1,T2 |
| 2 | Determination of displacements | CO 2 | T1,T2 |
| 3 | Problems onTwo dimensional in polar coordinates | CO 2 | T1,T2 |

| | | | |
|---|---|---|---|
| 4 | Problems on simple symmetric and asymmetric | CO 3 | T1,T2 |
| 5 | Problems two dimensional in polar coordinates. | CO 4 | T1,T2 |
| 6 | Problems on Analysis of stress and strain in three dimensions | CO 4 | T1,T2 |
| 7 | Problems on torsion | CO 5 | T1,T2 |
| 8 | Problems on bending by soap film method | CO 6 | T1,T2 |
| 9 | Problems on bending of cantilever. | CO 6 | T1,T2 |
| 10 | Problems onelliptical cross section | CO 6 | T1,T2 |
| **DISCUSSION OF DEFINITION AND TERMINOLOGY** | | | |
| 1 | Elasticity | CO 1 | T1,T2 |
| 2 | Plane stress and plane strain | CO2 | T1,T2 |
| 3 | pure bending | CO3 | T1,T2 |
| 4 | principal stresses | CO4 | T1,T2 |
| 5 | Conditions of compatibility | CO5 | T1,T2 |
| **DISCUSSION OF QUESTION BANK** | | | |
| 1 | What are displacements for symmetrical stress distributions . | CO1 | T1,T2 |
| 2 | What are application of general solution in polar coordinates. | CO2 | T1,T2 |
| 3 | Determination of principal stresses | CO3, | T1,T2 |
| 4 | Hydro dynamical analogies | CO4 | T1,T2 |
| 5 | Solution forprinciple of super position | CO6 | T1,T2 |

**Signature of Course Coordinator** **HOD,CE**
**Dr.M.Maheswara Rao**

# COURSE OUTLINE DESCRIPTION

| SECTION 1: General Information about the Course | |
|---|---|
| Course Title | **SPECIAL CONCRETES** |
| Course Code | BSTE04 |
| Course Start | First Semester |
| Course Type | Core |
| Regulation | IARE - MT 25 |
| Prerequisite Courses | Concrete materials (ACED10) |
| Department | Civil Engineering |
| Number of Credits | 3 Credit hours |
| Academic Year | 2025-26 |
| Method(s) of Instruction | Theory |
| Course Administrator | **Dr. R Ramya swetha,** Associate Professor of Civil Engineering<br>IARE11031<br>**r.ramyaswetha@iare.ac.in** |
| Course Coordinator's Name | **Dr. R Ramya swetha,** Associate Professor of Civil Engineering<br>IARE11031<br>**r.ramyaswetha@iare.ac.in** |
| Prior Learning Assessment and Recognition (PLAR) | Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance. |
| Open Learning Faculty Member Information | Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course. |
| Course Webpage | https://akanksha.iare.ac.in/index?route=course/details&course_id=1339 |
| Course Description | Special Concretes course provides an in-depth understanding of advanced concrete types and their applications beyond conventional mixes. It covers various specialized concretes, including high-strength, self-compacting, fiber-reinforced, lightweight, mass, shotcrete, preplaced aggregate, underwater anti-washout, and micro-concretes. The course emphasizes the properties, mix design, construction techniques, and quality control measures required for these concretes under diverse environmental and structural conditions. It also highlights practical applications in high-rise buildings, massive infrastructure, underwater structures, and extreme weather conditions, equipping students and professionals with the knowledge to select and apply suitable concrete types for complex engineering projects. |
| Course Objectives | **The students will try to learn:**<br>a. Explore the design, manufacturing, and applications of high-strength, high-performance, and special concretes.<br>b. Develop skills to design concrete mixes using BIS and international methods for different construction needs.<br>c. Understand formwork materials, design requirements, erection, maintenance, and failure prevention techniques. |
| Text and Reference Books | **TEXTBOOKS:**<br>1. Properties of Concrete by A. M. Neville, ELBS publications Oct 1996.<br>2. Concrete: Micro Structure, Properties and Materials by P.K.Mehta and P.J.Monteiro,. McGraw-Hill Publishing Company Ltd. New Delhi. |

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|---|---|
| | **Reference Books**<br>1. Concrete Technology by M.S.Shetty, S.Chand & Co 2009.<br>2. Concrete Technology by A.R. Santhakumar, 2nd Edition, Oxford University Press.<br>3. Design of Concrete Mixes by N.Krishna Raju, CBS Publications, 2000.<br>4. Special Structural concretes by Rafat Siddique, Galgotia Publications 2000. |
| Learning Resources | **Course full stack** is made available in IARE learning management portal – Akansha, which includes lecture notes, tutorial question bank, definition and terminology, tech-talk topics, assignments, Model question papers (2 sets), complex engineering problem solving statements, power point presentations (PPTs) and ELRV lecture recordings at: |
| Supplemental Materials | **Readings, Videos, and Links**<br>**1.** https://nptel.ac.in/courses/105104206 |
| Learning and Teaching Strategies | Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course.<br><br>There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks. |

**SECTION 2: Teaching Learning Scheme**

At least 48 lecture hours of scheduled teaching and learning activities (TLA) will be delivered in person, with the remaining hours for scheduled and self-scheduled teaching and learning activities delivered either in person or online.

Notional Study Time: 90 Hours (Lecture hours: 48, Tutorial hours: 8, Guided independent study hours: 10, Homework / Programming assignment hours: 9, Course project / Preparation for complex problem solving hours: 15)

| TLA Code | Teaching and Learning Activities | Number | Duration (Hours) | Total Workload |
|---|---|---|---|---|
| TLA 1 | Lectures | 48 | 01 | 48 |
| TLA 2 | Tutorials | 08 | 01 | 08 |
| TLA 3 | Case Study | | | |
| TLA 4 | Problem Solving | | | |
| TLA 5 | Demonstration | | | |
| TLA 6 | Scheduled revision sessions | | | |
| TLA 7 | Guided independent study: Directed viewing of video materials / PPTs | | | 10 |
| TLA 8 | Independent private study | | | |
| TLA 9 | Laboratory Exercises | | | |
| TLA 10 | Homework assignments / Programming assignments | | | 9 |
| TLA 11 | Placement / work based learning or Specific practical training | | | |
| TLA 12 | Presentation / Seminar Preparation | | | |
| TLA 13 | Course Project / Preparation for Complex Problem Solving | | | 15 |
| TLA 14 | Technical visit | | | |
| TLA 15 | Field activities | | | |
| | | | **Total study hours** | **90** |

| | Expected total study hours | 90 |
|---|---|---|

| SECTION 3A: Course Outcomes | | |
|---|---|---|
| After successfully completing this course, the student will be able to: | | |
| **Outcome Number** | **Course Outcomes** | **Learning Domain** |
| CO1 | **Explain** the properties and functions of various concrete-making materials such as cement, aggregates, and admixtures, and interpret relevant BIS provisions for material selection and quality control. | Understand |
| CO2 | **Interpret** the behavior of fresh and hardened concrete through laboratory testing, and interpret results for workability, strength, and durability based on BIS standards. | Understand |
| CO3 | **Examine** the production techniques, microstructure, and mechanical properties of high-strength and high-performance concretes to understand their behavior using established analytical methods. | Analyse |
| CO4 | **Apply** concepts of hydration, material composition, and mix proportioning to develop high-strength and high-performance concretes for advanced structural applications. | Apply |
| CO5 | **Assess** various types of special concretes such as self-compacting, polymer, fiber-reinforced, and reactive powder concretes for their composition, behavior, and suitability w.r.t mix proportioning methods and BIS guidelines. | Evaluate |
| CO6 | **Apply** design principles and safety considerations for formwork systems, materials, and removal procedures for ensuring quality and structural stability in concrete construction. | Apply |

| SECTION 3B: Cognitive Levels | |
|---|---|
| **Blooms Taxonomy Level** | **Cognitive Level in Percentage (%)** |
| Remember | 0 |
| Understand | 30 |
| Apply | 30 |
| Analyse | 20 |
| Evaluate | 20 |
| Create | 0 |

| SECTION 4: Content and Context of Design of Steel Structures | |
|---|---|
| **CO1** | **Explain the properties and functions of various concrete-making materials such as cement, aggregates, and admixtures, and interpret relevant BIS provisions for material selection and quality control.** |
| | **Understanding the behavior and application of special concretes is essential for achieving high-performance, durable, and sustainable structural members.**<br>1. **Types and Characteristics of Special Concretes:** Special concretes include self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, reactive powder concrete (RPC), high-performance concrete (HPC), and geopolymer concrete. Understanding their composition, microstructure, and mechanical properties is crucial for selecting the right concrete type for specific structural requirements.<br>2. **Material Behavior and Performance:** Special concretes exhibit unique fresh and hardened behavior such as improved workability, enhanced strength, reduced permeability, and controlled shrinkage. Analyzing these properties ensures that the concrete meets functional, durability, and sustainability objectives.<br>3. **Mix Proportioning and Standards:** Knowledge of mix design principles, mineral and chemical admixtures, and BIS/ASTM guidelines enables proper proportioning of concrete mixes to achieve desired performance characteristics under different environmental and loading conditions. |

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| | 4. **Applications and Structural Implications:** Applying these concretes in structural elements such as beams, slabs, and columns allows engineers to optimize strength, durability, and serviceability. It also facilitates innovation in construction practices like rapid construction, corrosion resistance, and lightweight structures.<br>By this, students develop the ability to select, analyze, and apply special concretes **for** advanced structural and environmental applications, ensuring safety, durability, and sustainable performance in modern construction. |
| **CO2** | **Interpret the behavior of fresh and hardened concrete through laboratory testing, and interpret results for workability, strength, and durability based on BIS standards.** |
| | Understanding the behavior of special concretes is vital for achieving high-performance, durable, and sustainable structural elements.<br>1. **Types and Characteristics of Special Concretes**: Special concretes include self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, reactive powder concrete (RPC), high-performance concrete (HPC), and geopolymer concrete. Each type exhibits unique material properties and microstructural behavior that influence strength, durability, and workability.<br>2. **Fresh and Hardened Concrete Behavior**: Special concretes demonstrate distinctive fresh properties such as flowability, segregation resistance, and setting characteristics, as well as hardened properties like compressive and tensile strength, creep, shrinkage, and durability. Understanding these behaviors ensures the concrete meets structural performance requirements under varying environmental and loading conditions.<br>3. **Mix Proportioning and Material Interactions**: The inclusion of mineral and chemical admixtures, fibers, polymers, and supplementary cementitious materials affects the microstructure and mechanical properties of concrete. Correct mix proportioning following BIS or international guidelines ensures optimized performance for specific applications.<br>4. **Applications and Structural Implications**: Special concretes are used in advanced structural applications such as high-rise buildings, bridges, industrial floors, and marine structures. Integrating knowledge of their properties allows engineers to select the right concrete type for durability, strength, and sustainability while minimizing maintenance and enhancing service life.<br>By this, students gain the ability to analyze, select, and apply special concretes for diverse structural applications, ensuring safety, durability, and high-performance in modern engineering projects. |
| **CO3** | **Examine the production techniques, microstructure, and mechanical properties of high-strength and high-performance concretes to understand their behavior using established analytical methods.** |
| | Understanding the performance and durability of special concretes is fundamental to achieving safe, efficient, and long-lasting structural elements.<br>1. **Mechanical and Durability Characteristics:** Special concretes, including high-performance concrete (HPC), self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, and reactive powder concrete (RPC), exhibit enhanced compressive and tensile strengths, improved creep and shrinkage behavior, and superior resistance to environmental degradation. Recognizing these properties enables optimized structural performance under varied service conditions.<br>2. **Microstructural Behavior:** The inclusion of admixtures, fibers, and supplementary cementitious materials modifies the concrete's microstructure, influencing workability, bonding, and crack resistance. Understanding these effects ensures concrete meets intended mechanical and durability requirements.<br>3. **Mix Proportioning and Quality Control:** Proper mix proportioning based on BIS or international guidelines, along with monitoring fresh and hardened properties, ensures the concrete achieves the desired strength, durability, and performance for specific applications.<br>4. **Structural Applications and Implications:** Application of special concretes in structural elements such as beams, slabs, columns, and pavements allows engineers to address challenges like high load demands, aggressive environments, and serviceability requirements, ensuring safety, efficiency, and sustainability.<br>By this, students gain the ability to analyze, select, and apply special concretes for advanced structural applications, ensuring enhanced performance, durability, and compliance with engineering standards. |

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| **CO4** | **Apply concepts of hydration, material composition, and mix proportioning to develop high-strength and high-performance concretes for advanced structural applications.** |
| | Understanding the mechanical behavior and mix performance of special concretes forms the foundation for high-performance and durable structural applications.<br>1. **Material Behavior Representation:** The mechanical properties of special concretes—such as high-performance concrete (HPC), self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, and reactive powder concrete (RPC)—define their response to loads, environmental conditions, and long-term service. Representing these behaviors accurately helps in predicting structural performance.<br>2. **Microstructure-Property Relationship:** The inclusion of admixtures, fibers, and supplementary cementitious materials alters the microstructure, affecting strength, durability, shrinkage, and creep characteristics. Understanding these relationships ensures the concrete performs as intended under design loads.<br>3. **Mix Design and Optimization:** Developing appropriate mix proportions using BIS or international guidelines integrates material properties with performance requirements. Proper mix design ensures workability, strength, durability, and sustainability of special concretes.<br>4. **Analytical and Practical Relevance:** Knowledge of the behavior and properties of special concretes supports structural analysis, selection of suitable concrete types, and optimization of construction techniques for advanced applications.<br>By this, students gain the ability to analyze, select, and apply special concretes for various structural elements, ensuring precise performance prediction, durability, and compliance with modern construction standards. |
| **CO5** | **Assess various types of special concretes such as self-compacting, polymer, fiber-reinforced, and reactive powder concretes for their composition, behavior, and suitability w.r.t mix proportioning methods and BIS guidelines.** |
| | Developing the ability to integrate material behavior and mix design principles is essential for optimizing the performance of special concretes in structural applications.<br>1. **Integration of Material Properties:** Combining the mechanical, durability, and workability characteristics of special concretes—such as high-performance concrete (HPC), self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, and reactive powder concrete (RPC)—provides a comprehensive understanding of how these materials behave under various structural and environmental conditions.<br>2. **Mix Design and Proportioning:** Applying appropriate mix proportioning methods according to BIS or international guidelines ensures that all performance requirements, including strength, durability, and workability, are met for specific structural applications.<br>3. **Performance Prediction and Evaluation:** Assessing the expected behavior of the concrete under load, creep, shrinkage, and environmental exposure allows engineers to predict long-term performance, serviceability, and durability of structural elements.<br>4. **Practical and Computational Relevance:** Understanding how material properties, mix design, and performance interrelate supports the effective use of advanced analysis and design tools for structural applications, enabling efficient and safe implementation in real-world projects.<br>By this, students gain the ability to integrate material characteristics and mix design principles for special concretes, enabling them to predict performance, ensure durability, and apply these concretes effectively in advanced structural applications. |
| **CO6** | **Apply design principles and safety considerations for formwork systems, materials, and removal procedures for ensuring quality and structural stability in concrete construction.** |
| | The systematic understanding of material behavior and mix design principles is fundamental for the efficient application of special concretes in advanced structural systems.<br>1. **Principles of Special Concrete Behavior:** Knowledge of mechanical properties, durability, and workability of special concretes—such as high-performance concrete (HPC), self-compacting concrete (SCC), fiber-reinforced concrete (FRC), polymer concrete, and reactive powder concrete (RPC)—forms the foundation for predicting structural performance under diverse loading and environmental conditions.<br>2. **Application to Structural Elements:** These concretes can be applied in beams, slabs, columns, pavements, and other structural components to meet specific performance requirements, including strength, serviceability, and durability.<br>3. **Systematic Material and Mix Design:** A structured approach to mix proportioning, selection of admixtures, and incorporation of supplementary cementitious materials ensures |

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| | the concrete achieves the desired mechanical and durability properties for particular applications.<br>4. **Practical Relevance:** Understanding the behavior and proper application of special concretes enables engineers to implement advanced construction techniques, optimize material performance, and ensure safe, durable, and sustainable structures in real-world projects.<br>By this, students develop the capability to analyze, select, and implement special concretes for diverse structural applications, bridging theoretical understanding with practical engineering and construction practices. |

| **SECTION 5: Complex Engineering Problem Solving** |
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| **Complex engineering problem solving projects**<br>There is one piece of assessed coursework, involving a mixture of theoretical work and practical work. We encourage to use the laboratory for practical purpose. For the calculation part in the project, they have to develop the programme code in java or python.<br><br>Programming part is mandatory for this course. Homework assignments will concentrate on theoretical concepts and techniques. Projects will be full scale to calculate the slopes and deflections of the various structural members discussed in class. All projects are individual assignments. Student are required to complete the tasks during the class period with no assistance.<br><br>**Design of industrial structures:** The course focuses on the properties, mix design, and performance of special concretes such as HPC, SCC, FRC, polymer, and reactive powder concretes.<br>It emphasizes their use in structural elements like beams, slabs, and columns to achieve strength, durability, and sustainability. Introduction to their application in advanced and industrial structural systems, including joints and construction considerations, will also be discussed. |

| **SECTION 6A: Assessment Methods – Direct** | | | |
|---|---|---|---|
| **Item** | **Evaluation Components** | **Week in / out** | **Marks** |
| AAT: 1 - 1 | Tech-Talk | Week – 2 / 5 | 05 |
| AAT: 1 - 2 | Assignments | Week – 4 / 7 | 05 |
| AAT: 2 - 1 | Complex Engineering Problem Solving | Week – 9 / 12 | 05 |
| AAT: 2 - 2 | Definitions and Terminology | Week – 12 / 15 | 05 |
| CIE - 1 | 2 hours - Answer 4 out of 5 questions | Week - 9 | 10 |
| CIE - 2 | 2 hours - Answer 4 out of 5 questions | Week - 17 | 10 |
| SEE | 3 hours - Answer 1 from each module | Week - 18 | 60 |
| | | **Total Marks** | **100** |

**Department's Late Submission Policy:**

1. 1 – 24 hours: 25% of the mark will be deducted
2. > 24 hours: Not accepted

| **SECTION 6B: Assessment Methods –Indirect** | |
|---|---|
| Course End Survey (End Semester OBE Feedback) | ✓ |

**SECTION 7: Engineering Competencies (ECs) Focused**
Please tick (✓) relevant engineering competency profile covered

| EC Number | Attributes | Profiles | (✓) |
|---|---|---|---|
| EC1 | Depth of knowledge required (CP) | Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, | ✓ |

| | | | |
|---|---|---|---|
| | | processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline | |
| EC2 | Depth of analysis required (CP) | Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models. | ✓ |
| EC3 | Design and development of solutions (CA) | Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness. | ✓ |
| EC4 | Range of conflicting requirements (CP) | Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues. | - |
| EC5 | Infrequently encountered issues (CP) | Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. | - |
| EC6 | Protection of society (CA) | Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline. | - |
| EC7 | Range of resources (CA) | Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes | - |
| EC8 | Extent of stakeholder involvement (CP) | Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs. | - |
| EC9 | Extent of applicable codes, legal and regulatory (CP) | Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities. | ✓ |
| EC10 | Interdependence (CP) | High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration. | ✓ |
| EC11 | Continuing professional development (CPD) and lifelong learning (CA) | Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. | - |
| EC12 | Judgement (CA) | Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities. | - |

**SECTION 8: Employability Skills**

**Example: Communication skills / Programming skills / Project based skills**

**Studying Special Concretes equips students with employability skills highly valued in civil and structural engineering industries.**
**Employability Skills:**

- Competency in selecting and applying different types of special concretes (HPC, SCC, FRC, polymer, RPC) for structural elements based on performance, durability, and environmental requirements.
- Proficiency in understanding fresh and hardened properties, microstructure, and mechanical behavior of special concretes for predicting long-term performance under service loads.
- Expertise in designing and proportioning concrete mixes following BIS or international standards to achieve desired workability, strength, and durability.

- Ability to evaluate the performance of special concretes in beams, slabs, columns, pavements, and industrial structures under different environmental and loading conditions.
- Knowledge of sustainability and durability considerations, including admixtures, supplementary cementitious materials, and fibers, essential for modern construction projects.
- Capability to prepare clear laboratory and project reports, document mix designs, and interpret test results for informed engineering decisions.

**Project Management:**

- Ability to plan and execute projects involving the application of special concretes, including defining performance objectives, selecting suitable concrete types, and ensuring compliance with quality standards.
- Experience in collaborative teamwork for testing, analyzing, and validating concrete mixes and structural elements in laboratory and field conditions.
- Decision-making skills in selecting appropriate admixtures, mix proportions, and curing methods for project-specific requirements.
- Risk identification and mitigation through assessment of durability, shrinkage, creep, and environmental exposure effects on structural elements.
- Technical documentation and presentation skills, including writing detailed mix design reports, summarizing laboratory test results, and communicating findings to stakeholders effectively.

**SECTION 9: Relevance to Sustainability goals**

Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

| SDG Goals | | Correlation with SDG |
|---|---|---|
| 4 | QUALITY EDUCATION | **Quality Education:** The course develops critical thinking, problem-solving, and practical skills essential for advanced construction materials.It enhances understanding of special concretes, including mix design, material behavior, and performance evaluation, preparing students for modern and sustainable structural applications. |
| 9 | INDUSTRY, INNOVATION AND INFRASTRUCTURE | **Industry, Innovation, and Infrastructure:** By mastering special concretes, students contribute to the design and construction of durable, high-performance, and sustainable structures.Skills in material selection, mix design, and performance evaluation support innovation in buildings, pavements, bridges, and industrial structures. |
| 11 | SUSTAINABLE CITIES AND COMMUNITIES | **Sustainable Cities and Communities:** Understanding and applying special concretes ensures the durability, performance, and sustainability of urban infrastructure, supporting resilient and long-lasting structures.Students learn to evaluate concrete behavior under diverse loads, environmental conditions, and service requirements, promoting safe and sustainable construction practices. |
| 12 | RESPONSIBLE CONSUMPTION AND PRODUCTION | **Responsible Consumption and Production:** By understanding material behavior, mix optimization, and performance characteristics, students can apply special concretes to achieve resource-efficient and sustainable structures.Promotes minimal material waste, enhanced durability, and efficient use of construction resources. |
| 13 | 13 CLIMATE ACTION | **Climate Action:** Students gain knowledge to apply special concretes in structures exposed to extreme environmental conditions, supporting climate-resilient and durable design. Encourages integration of safety, sustainability, and long-term performance principles in civil engineering projects. |

| SECTION 10A: Mapping between COs and POs / PSOs | | | | | | |
|---|---|---|---|---|---|---|
| Course Outcomes | Program Outcomes (POs) | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| CO1 | ✓ | | ✓ | | | |
| CO2 | ✓ | | ✓ | ✓ | ✓ | |
| CO3 | ✓ | | ✓ | ✓ | ✓ | |
| CO4 | ✓ | | ✓ | ✓ | ✓ | |
| CO5 | ✓ | | ✓ | ✓ | ✓ | |
| CO6 | ✓ | | ✓ | ✓ | ✓ | |

| Outcomes | | WKS and Indicators of attainment and Justification for mapping (students will be able to) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | IAs Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | POs | WK 1 | WK 2 | | | | | | | | WK 3 | | | WK 4 | | | WK 5 | | | | | | WK 6 | | | WK 7 | | | | WK 8 | | | | | | | WK 9 | | | | | | |
| | | a | a | b | c | d | e | f | g | h | a | b | c | a | b | c | a | b | c | d | e | f | a | b | c | a | b | c | d | a | b | c | d | e | f | g | a | b | c | d | e | f | |
| CO 1 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| CO 2 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 3 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 4 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 5 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |
| CO 6 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | | | • | • | • | • | • | | | | | | | | 8 |

| SECTION 10B: Indicators of Attainment with COs to POs and PSOs | | | | | | |
|---|---|---|---|---|---|---|
| **Course Outcomes** | **Percentage of Indicators of Attainments (IA) with POs** | | | | | |
| | **PO** | | | | | |
| | **1** | **2** | **3** | **4** | **5** | **6** |
| CO1 | 73 | - | 78 | - | - | - |
| CO2 | 73 | - | 78 | 73 | 72 | - |
| CO3 | 73 | - | 78 | 73 | 72 | - |
| CO4 | 73 | - | 78 | 73 | 72 | - |
| CO5 | 73 | - | 78 | 73 | 72 | - |
| CO6 | 73 | - | 78 | 73 | 72 | - |

| SECTION 10C: Course Articulation Matrix of COs to POs | | | |
|---|---|---|---|
| **0**<br>No Contribution (0-5%) | **1**<br>Low (≥5 - <40%) | **2**<br>Moderate (≥40 - <60%) | **3**<br>High (≥60%) |

| **Course Outcomes** | **Program Outcomes (POs)** | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| CO1 | 3 | - | 3 | - | - | - |
| CO2 | 3 | - | 3 | 3 | 3 | - |
| CO3 | 3 | - | 3 | 3 | 3 | - |
| CO4 | 3 | - | 3 | 3 | 3 | - |
| CO5 | 3 | - | 3 | 3 | 3 | - |
| CO6 | 3 | - | 3 | 3 | 3 | - |
| **Total** | 18 | - | 18 | 15 | 15 | - |
| **Average** | 3 | - | 3 | 3 | 3 | - |

| SECTION 10D: Level of Contribution of the COs to POs | | | |
|---|---|---|---|
| **Number** | **Programme Outcomes** | **Proficiency Assessed by** | **Contribution Level (from 1 to 3)** |
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. | CIE / SEE / AAT:1 – 2 Assignments / Open-ended problems | **3** |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | CIE / SEE / AAT:1 – 2 | **3** |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | CIE / SEE / AAT:2 – 1 Complex Engineering Problem Solving | **3** |

| | | | |
|---|---|---|---|
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | CIE / SEE / AAT:2 – 2 | **3** |

| **SECTION 11: Course Content** | |
|---|---|
| **MODULE - I** | **CONCRETE MAKING MATERIALS** |
| | Cement – Bogus Compounds, Hydration Process, Types of Cement, Aggregates – Gradation Charts, Combined Aggregate, Alkali Silica Reaction, Admixtures - Chemical and Mineral Admixtures. Bureau of Indian Standards (BIS) Provisions. |
| **MODULE - II** | **FRESH AND HARDENED CONCRETE** |
| | Fresh Concrete – workability tests on Concrete, Setting Times of Fresh Concrete, Segregation and bleeding. Hardened Concrete: Abrams Law, Gel space ratios, Maturity concept, Stress strain Behaviour, Creep and Shrinkage, Durability Tests on Concrete, Non-Destructive Testing of Concrete. BIS Provisions. |
| **MODULE - III** | **HIGH STRENGTH CONCRETE AND HIGH-PERFORMANCE CONCRETE** |
| | High Strength Concrete – Microstructure, Manufacturing and Properties, Design of HSC Using Erintroy Shaklok method, Ultra High Strength Concrete.<br><br>High Performance Concrete –Requirements and Properties of High-Performance Concrete, Design Considerations. BIS Provisions |
| **MODULE - IV** | **SPECIAL CONCRETES AND MIX DESIGN** |
| | Special Concretes: Self Compacting concrete, Polymer Concrete, Fibre Reinforced Concrete, Reactive Powder Concrete, Requirements and Guidelines, Advantages and Applications.<br>Concrete Mix Design: Quality Control, Quality Assurance, Quality Audit, Mix Design Method, BIS Method IS.10262 – 2019 Concrete Mix proportion guidelines. DOE Method, Light Weight Concrete, Self-Compacting Concrete. |
| **MODULE - V** | **FORM WORK** |
| | Form work, materials, structural requests, form work systems, connections, specifications, design of form work, shores, removal for forms, shores, reshoring, failure of form work. |

| **SECTION 12: Tentative Schedule of Instructions** | | |
|---|---|---|
| **Week Number** | **Topics** | **Duration (Hours)** |
| 1 | 1.1 Definition and composition of cement<br>1.2 Bogus compounds in cement and hydration process<br>1.3 Types of cement and their properties | 3 |
| 2 | 2.1 Aggregates – classification and gradation charts<br>2.2 Combined aggregates and significance in concrete<br>2.3 Alkali-silica reaction and preventive measures | 3 |
| 3 | 3.1 Chemical and mineral admixtures – types and functions<br>3.2 BIS provisions related to concrete-making materials<br>3.3 Workability of fresh concrete and measurement methods | 3 |
| 4 | 4.1 Setting times of concrete and factors affecting setting<br>4.2 Segregation and bleeding in fresh concrete<br>4.3 Stress-strain behavior of hardened concrete | 3 |
| 5 | 5.1 Abrams law and gel-space ratio concept<br>5.2 Maturity concept and its application<br>5.3 Creep and shrinkage behavior | 3 |

| | | |
|---|---|---|
| 6 | 6.1 Durability tests and non-destructive testing of concrete<br>6.2 BIS provisions for fresh and hardened concrete<br>6.3 Microstructure and properties of high-strength concrete (HSC) | 3 |
| 7 | 7.1 Manufacturing methods of HSC<br>7.2 Design of HSC using Erintroy Shaklok method<br>7.3 Ultra-high-strength concrete – characteristics and applications | 3 |
| 8 | 8.1 Requirements of high-performance concrete (HPC)<br>8.2 Properties and performance evaluation of HPC<br>8.3 Design considerations and BIS provisions for HPC | 3 |
| **CONTINIUOUS INTERNAL EXAMINATION (CIE- I)** | | |
| 9 | 9.1 Self-compacting concrete – properties and applications<br>9.2 Polymer concrete – composition and uses<br>9.3 Fibre-reinforced concrete – types and performance characteristics | 3 |
| 10 | 10.1 Reactive powder concrete – guidelines and advantages<br>10.2 Mix design principles – quality control and quality assurance<br>10.3 Mix design methods: BIS Method IS 10262 – 2019 | 3 |
| 11 | 11.1 DOE method of mix proportioning<br>11.2 Light-weight concrete and self-compacting concrete mix design<br>11.3 Applications of special concretes in advanced structural systems | 3 |
| 12 | 12.1 Formwork materials and structural requirements<br>12.2 Types of formwork systems and connections<br>12.3 Specifications for formwork design and safety considerations | 3 |
| 13 | 13.1 Shoring, reshoring, and removal procedures<br>13.2 Failure mechanisms in formwork and preventive measures | 3 |
| 14 | 14.1 Revision of Modules I & II<br>14.2 Discussion on laboratory testing and mix trials<br>14.3 Case studies on HSC and HPC applications | 3 |
| 15 | 15.1 Revision of Modules III & IV<br>15.2 Analysis of special concrete properties for structural performance<br>15.3 Demonstration of mix design and quality control procedures | 3 |
| 16 | 16.1 Revision of Module V (Formwork)<br>16.2 Integration of special concretes in structural systems<br>16.3 Final discussion, Q&A, and pre-end term review | 3 |
| | **Total** | **48** |

| **SECTION 13: Specific Goals for the Course** | |
|---|---|
| **The following table shows the knowledge and skills covered by the unit outcomes:** | |
| **Knowledge** | **Skills** |
| • Understanding the composition and properties of cement, aggregates, and admixtures, and their influence on fresh and hardened concrete behavior.<br>• Evaluating the workability, setting, segregation, bleeding, stress-strain behavior, creep, shrinkage, and durability of concrete for performance assessment.<br>• Analyzing high-strength and high-performance concretes, including microstructure, mechanical properties, and advanced mix design methods.<br>• Assessing special concretes such as self-compacting, polymer, fiber-reinforced, and reactive powder concretes with reference to mix proportioning, performance, and BIS guidelines.<br>• Applying mix design principles, quality control, and quality assurance techniques to ensure | • Identify and select appropriate types of special concretes (HPC, SCC, FRC, polymer, RPC) for specific structural applications.<br>• Analyze fresh and hardened properties, including workability, strength, creep, shrinkage, and durability, for performance evaluation.<br>• Evaluate microstructure and mechanical behavior of high-strength and high-performance concretes.<br>• Apply mix proportioning methods, BIS guidelines, and quality control procedures to achieve desired concrete properties.<br>• Formulate and implement mix designs for light-weight, self-compacting, and fiber-reinforced concretes. |

| | |
|---|---|
| desired mechanical and durability properties in structural applications.<br>• Integrating special concretes into structural systems, considering formwork, construction practices, and practical applications in beams, slabs, columns, pavements, and industrial structures. | • Assess the performance of concrete under environmental exposure, service loads, and extreme conditions.<br>• Integrate special concretes into beams, slabs, columns, pavements, and industrial structures for optimized performance.<br>• Apply knowledge of formwork systems, shoring, and reshoring for safe construction of structures using special concretes.<br>• Conduct laboratory tests and interpret results for material characterization and validation of design assumptions.<br>• Interpret and validate design and mix performance data for practical, code-compliant, and sustainable construction projects. |

## Administrative Information

| **SECTION 15: History of changes** | | |
|---|---|---|
| **Regulations** | **Description of change** | **BOS Date** |
| R 18 | Changes from R16 to R18 regulation<br>• New course introduced in this regulation | 10.07.2018 |
| PG 21 | Changes from R18 to PG 21 regulation<br>• No change | 17.11.2020 |
| MT 23 | Changes from PG 21 to MT 23 regulation<br>• No change | 21.08.2023 |
| MT 25 | Incorporated the following additions in MT 25 regulations<br>• Form work, materials, structural requests, form work systems, connections, specifications, design of form work, shores, removal for forms, shores, reshoring, failure of form work. | 01.09.2025 |

| **Course Outline Approvals** | |
|---|---|
| **Course Coordinator**<br>Name:<br>Signature:<br>Date: | **Head of the Department**<br>Name:<br>Signature:<br>Date: |
| **Course Outline Approvals: The course outline description approved by Outcome Based Teaching Learning (OBTL) committee on *date* in meetings *IARE - OBTL – COD /17/25*** | |
| **Dean of Outcome Based Teaching and Learning**<br>Name:<br>Signature:<br>Date: | **Dean of Academics**<br>Name:<br>Signature:<br>Date: |

| Check List | | |
|---|---|---|
| **Section** | **Description** | **Please tick (✓)** |
| 1 | General Information about the Course | |
| 2 | Notional Study Time | |
| 3 | A. Course Outcomes | |
| | B. Cognitive Levels | |
| 4 | Content and Context of the Course | |
| 5 | Complex Engineering Problem Solving | |
| 6 | A. Assessment Methods – Direct | |
| | B. Assessment Methods – Indirect | |
| 7 | Content Delivery / Instructional Methodologies | |
| 8 | Engineering Competencies (ECs) Focused | |
| 9 | Employability Skills | |
| 10 | Relevance to Sustainability goals | |
| 11 | A. Mapping between COs and POs / PSOs | |
| | B. Indicators of Attainment with COs to POs and PSOs | |
| | C. Course Articulation Matrix of COs to POs | |
| | D. Level of Contribution of the COs to POs and PSOs | |
| 12 | Syllabus | |
| 13 | Tentative Schedule of Instructions | |
| 14 | Specific Goals for the Course | |
| 15 | History of Changes | |

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

# COURSE DESCRIPTION

| | | | | | |
|---|---|---|---|---|---|
| Department | **CIVIL ENGINEERING** | | | | |
| Course Title | **Theory of Plates and Shells** | | | | |
| Course Code | BSTE07 | | | | |
| Program | M. Tech (STE) | | | | |
| Semester | I | | | | |
| Course Type | Professional Core Elective | | | | |
| Regulation | MT 25 | | | | |
| Course Structure | Theory | | | Practical | |
| | Lecture | Tutorials | Credits | Laboratory | Credits |
| | 3 | - | 3 | - | - |
| Course Coordinator | Mr.Gude Ramakrishna, Assistant Professor | | | | |

## I COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites |
|---|---|---|---|
| M.Tech | - | - | - |

## II COURSE OVERVIEW:

Plates and shells exhibit two dimensional structural actions that result in stronger, thinner and lighter structures and therefore, have economic advantage. This has opened the scope for the wide use of such elements in all fields of engineering due to significant increase of strength/weight ratio. The exposure to this course and its completion are very essential in understanding the behaviour of thin structures for their applications in design.

## III MARKS DISTRIBUTION:

| Subject | SEE Examination | CIE Examination | Total Marks |
|---|---|---|---|
| Theory of Plates and Shells | 60 Marks | 40 Marks | 100 |

## IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Power Point Presentations | ✓ | Chalk & Talk | x | Assignments | x | MOOC |
| x | Open Ended Experiments | x | Seminars | x | Mini Project | ✓ | Videos |
| x | Others | | | | | | |

## V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

**Semester End Examination (SEE):** The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

| | |
|---|---|
| 50 % | To test the objectiveness of the concept |
| 30 % | To test the analytical skill of the concept |
| 20% | To test the application skill of the concept |

**Continuous Internal Assessment (CIA):**

For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course. The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty.

| **Activity** | **CIA-I** | **CIA-II** | **SEE** | **Total Marks** |
|---|---|---|---|---|
| Continuous Internal Examination (CIE) | 10 Marks | 10 Marks | - | 20 Marks |
| Definitions and Terminology / Quiz | 05 Marks | 05 Marks | - | 10 Marks |
| Tech Talk / Assignment | 05 Marks | 05 Marks | | 10 Marks |
| Semester End Examination (SEE) | - | - | 60 Marks | 60 Marks |
| Total | - | - | - | 100 Marks |

**Continuous Internal Examination (CIE):**

Two CIE exams shall be conducted at the end of the $8^{th}$ and $16^{th}$ week of the semester respectivelyy for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

**Assignment:**

To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

**Quiz:**

It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

**Alternative Assessment Tool (AAT):**

In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center. The AAT may include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

## VI COURSE OBJECTIVES:

**The students will try to learn:**

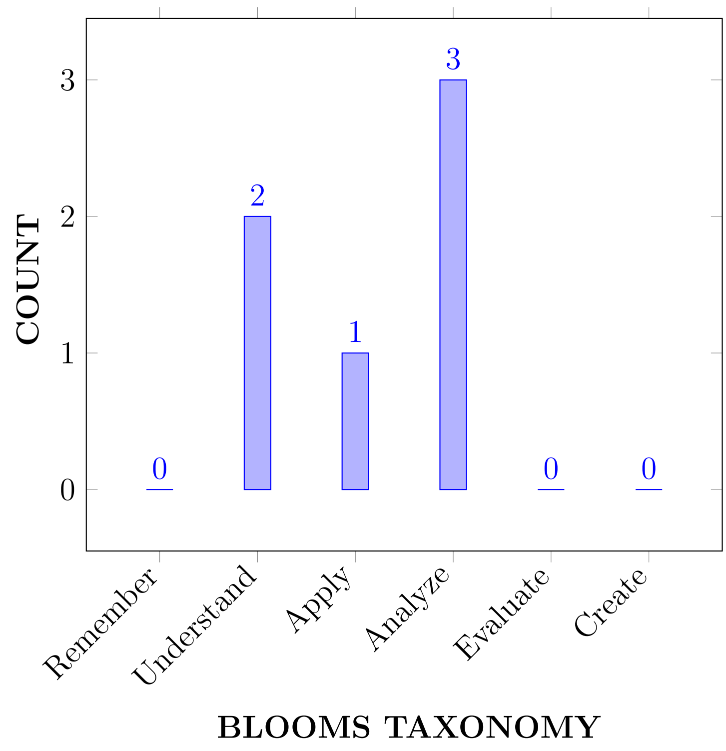
| | |
|---|---|
| I | The Formulation of differential equations for bending of thin rectangular and circular plates. |
| II | The theory of large deflection of plates for efficient and economical design. |
| III | The numerical techniques and tools for the complex problems in thin plates. |

## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** the Concept of of governing differential equation, and solution of Navier and Levy type, large plate loaded at equidistant points by concentrated forces. | Understand |
| CO 2 | **Explain** about annular plate, rotationally symmetric loading, eccentric concentrated load, simultaneous bending and stretching of circular plates. | Understand |
| CO 3 | **Solve** the governing differential equation for Plates on an elastic foundations. | Apply |
| CO 4 | **Understand** the general theory in bending of cylindrical shell, for simplified method of cylindrical shell. | Analyze |
| CO 5 | **Analysis** of governing equation for bending of plate under the action of lateral loads. | Analyze |
| CO 6 | **Examine** the buckling of rectangular plates by compressive forces acting in one and two directions in the middle plane of plate. | Analyze |

## COURSE KNOWLEDGE COMPETENCY LEVEL




## VIII PROGRAM OUTCOMES:

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research / investigation and development work to solve practical problems. |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | An ability to Independently carry out research / investigation and development work to solve practical problems. | 3 | CIE/ SEE |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 2 | CIE/SEE |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 3 | CIE/SEE |

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

## X MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | ✓ | - | - |
| CO 2 | ✓ | - | - | ✓ | ✓ | - |
| CO 3 | - | - | - | - | - | - |
| CO 4 | ✓ | - | - | ✓ | - | - |
| CO 5 | ✓ | - | - | - | ✓ | - |
| CO 6 | - | - | - | ✓ | ✓ | - |

## XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO 1 | PO 4 | Recall the concepts of the static and kinematic indeterminacy of structures (apply)for its behaviour by applying the principles of **mathematics and engineering fundamentals..** | 2 |
| CO2 | PO1 | Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.** | 2 |
| | PO4 | Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose. | 2 |
| | PO5 | select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose | 1 |
| CO3 | PO 1 | Understand indeterminate trusses and analyse the same for member forces due to applied loads, lack of fit and temperature change by using ther **mathematical principles** and **engineering fundamentals** | 2 |
| | PO4 | Use the **mathematical principles** and **engineering fundamentals** in identifying the determinate and indeterminate trusses. | 2 |
| CO4 | PO1 | Recall (knowledge) the continuous beam and portal frames and form the stiffness and flexibility matrices by applying the principles of**mathematics and engineering fundamental.** | 2 |
| | PO4 | Select the appropriate method for the analysis of structures using **mathematical principles and engineering knowledge** for different loads for the design purpose. | 2 |
| | PO5 | select the appropriate method for the analysis of structures using **mathematical principal** for desing purpose | 1 |

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO5 | PO1 | undderstand the **engineering** concepts of shapes functions to obtain stiffness matrix for two dimensional elements by using the **principles of mathematics and sciences.** | 3 |
| | PO4 | **Identify the problem, formulate** stiffness matrix for two dimensional elements **for solution development** in reaching substantiated conclusions by the **interpretation of results.** | 4 |
| CO6 | PO4 | Analyze the quantitative techniques for cost management of the engineering projects using **fundamental in mathematics and engineering fundamentals.** | 2 |
| | PO5 | Make use of galerkin method for solving one dimensional boundary value problmes by applying the principles of **engineering fundamentals.** | 1 |

## XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | 2 | - | - |
| CO 2 | 2 | - | - | 2 | 1 | - |
| CO 3 | 2 | - | - | 2 | - | - |
| CO 4 | 2 | - | - | 2 | 1 | - |
| CO 5 | 3 | - | - | 4 | - | - |
| CO 6 | - | - | - | 2 | 1 | - |

## XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 0.0 | 50 | 0.0 | 0.0 |
| CO 2 | 66.66 | 0.0 | 0.0 | 50 | 100 | 0.0 |
| CO 3 | 66.66 | 0.0 | 0.0 | 50 | 0.0 | 0.0 |
| CO 4 | 66.66 | 0.0 | 0.0 | 50 | 100 | 0.0 |
| CO 5 | 100 | 0.0 | 0.0 | 25 | 0.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 0.0 | 50 | 100 | 0.0 |

## XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq C \leq 5\%$ – No correlation
***1*** -$5 < C \leq 40\%$ – Low/ Slight
***2*** - $40\ \% < C < 60\%$ –Moderate
***3*** - $60\% \leq C < 100\%$ – Substantial /High

| **Course Outcomes** | **PROGRAM OUTCOMES** | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 0.0 | 2 | 0.0 | 0.0 |
| CO 2 | 3 | 0.0 | 0.0 | 2 | 3 | 0.0 |
| CO 3 | 3 | 0.0 | 0.0 | 2 | 0.0 | 0.0 |
| CO 4 | 3 | 0.0 | 0.0 | 2 | 3 | 0.0 |
| CO 5 | 3 | 0.0 | 0.0 | 1 | 0.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 0.0 | 2 | 3 | 0.0 |
| **Total** | 12 | 0.0 | 0.0 | 11 | 9 | 0.0 |
| **Average** | 3 | 0.0 | 0.0 | 2 | 3 | 0.0 |

## XV ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | - | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## XVI ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## XVII SYLLABUS:

| | |
|---|---|
| MODULE I | **THIN RECTANGULAR PLATES** |
| | Bending of thin plates, assumptions, governing differential equations in cartesian coordinate system, Boundary conditions, analytical solutions for rectangular plates by Navier and Levy s methods, distributed and concentrated loads. |
| MODULE II | **CIRCULAR PLATES** |
| | Circular plates: Governing differential equations in polar coordinate system, annular plate, rotationally symmetric loading, eccentric concentrated load, simultaneous bending and stretching of thin plates, introduction to large deflection theory of plates. |
| MODULE III | **PLATES ON ELASTIC FOUNDATIONS** |

| | |
|---|---|
| | Plates on elastic foundations, governing differential equation and deflection of uniformly loaded simply supported rectangular plate.<br>Navier and Levy type solutions, large plate loaded at equidistant points by concentrated forces. |
| MODULE IV | **SHELS** |
| | Shells: Shells, geometry and classifications, stress resultants, membrane theory and its applications to shells of surface of revolutions, membrane theory for cylindrical shell, general theory in bending of cylindrical shell, simplified method for cylindrical shell. |
| MODULE V | **BUCKLING OF THIN PLATES** |
| | Buckling of plates: Governing equation for bending of plate under the combined action of inplane loading and lateral loads, buckling of rectangular plates by compressive forces acting inone and two directions in the middle plane of plate. |

**TEXTBOOKS**


1. Timoshenko S. and Krieger, “Theory of Plates and Shells”, W. McGraw Hill, 1959.
2. Chandra shekhara. K, “Theory of Plates”, Universities Press, 2001.
3. Timoshenko ,”Theory of Plates and Shells” , Tata MC Graw Hill, 1959.


**REFERENCE BOOKS:**


1. UguralAnselC,”Stresses in Plates and Shells”, McGraw Hill, 2009.
2. Kraus.H, “Thin Elastic Shells”, John Wiley and Sons, 1998.
3. Rama swamy.G.S., “Design and Construction of Concrete Shells”, 2001.


**WEB REFERENCES:**

1. https://pdfs.semanticscholar.org/presentation/ce6d/b61238325d60d3f6dc0f1fbe7af33e3972c1.pdf

**COURSE WEB PAGE:**

## XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's | Reference T1: 4.1 |
|---|---|---|---|
| **OBE DISCUSSION** | | | |
| 1 | Discussion on OBE, CO's and CLO's of subject Theory of Plates and Shells | | |
| **CONTENT DELIVERY (THEORY)** | | | |
| 1 | Introduction | CO1 | T1,T2 |
| 2 | Assumptions, governing differential equations. | CO1 | T1,T2 |
| 3 | Strain displacement relatioin. | CO1 | T1,T2 |
| 4 | Governing differential equations in Cartesian coordinate system, Boundary conditions . | CO1 | T1,T2 |
| 5 | Analytical solutions for rectangular plates. | CO1 | T1,T2 |
| 6 | Strain Energy in Pure Bending of Plates. | CO1 | T1,T2 |
| 7 | Derivation for the relations between bending moments and curvature in pure bending of plates | CO1 | T1,T2 |
| 8 | Distinguish between thin plate with small deflection and thin plate with large deflection | CO1 | T1,T2 |
| 9 | Analytical solutions for rectangular plates by Navier method. | CO1 | T1,T2 |
| 10 | analytical solutions for rectangular plates by Levy's method. | CO1 | T1,T2 |
| 11 | Navier method for distributed and concentrated loads. | CO1 | W2:2 |
| 12 | Levy's methods, for distributed and concentrated loads. | CO1 | T1,T2 |
| 13 | Differential equations of cylindrical bending of uniformly loaded rectangular plates with simply supported edges. | CO1 | T1,T2 |
| 14 | Deflection and internal moments of simply supported rectangular support plate of size a x b. | CO1 | T1,T2 |
| 15 | General expressions for deflection and bending moment of a rectangular plate a x b simply supported at the edges is subjected to sinusoidal loading using the Navier solution. | CO1 | T1,T2 |
| 16 | Differential equation for plate subjected to cylindrical bending. | CO1 | T1,T2 |
| 17 | Derivation for differential equations of cylindrical bending of uniformly loaded rectangular plates will simply supported edges. | CO1,CO2 | T1,T2 |
| 18 | Maximum deflection for uniform loaded solid circular plate with radius 'a' has its edges simply supported. expressions for the | CO1,CO2 | T1,T2 |
| 19 | Governing differential equations in polar coordinate system | CO1,CO2 | T1,T2 |
| 20 | Deflection equation equation for a plate subjected to hydrostatic pressure use Levy's basic equation for calculating deflection | CO1,CO2 | T1,T2 |
| 21 | Differential equations in polar coordinate system, annular plate, rotationally symmetric loading | CO2 | T1,T2 |
| 22 | Differential equation for eccentric concentrated load | CO2 | T1,T2 |

| | | | |
|---|---|---|---|
| 16 | Circular Plate with a Circular Hole at the Center. | CO2 | T1,T2 |
| 23 | Differential equation simultaneous bending and stretching of thin plates | CO2 | T1,T2 |
| 24 | Differential equation simultaneous bending and stretching of thin plates | CO2 | T1,T2 |
| 25 | Introduction to large deflection theory of plates | CO2 | T1,T2 |
| 26 | Differential equations of cylindrical bending of uniformly loaded rectangular plates with built in edges. | CO2 | T1,T2 |
| 27 | Introduction to Plates on elastic foundations | CO3 | T1,T2 |
| 28 | Governing differential equation and deflection of uniformly loaded simply supported rectangular plate | CO3 | T1,T2 |
| 29 | Derivation for the moment curvature in the case of pure bending of plates. | CO3 | T1,T2 |
| 30 | Deflection equation equation for a plate subjected to hydrostatic pressure by Levy's solution. | CO3 | T1,T2 |
| 31 | Levy type solutions for plates on elastic foundation | CO3 | T1,T2 |
| 32 | Navier and Levy type solutions for large plate loads | CO3 | T1,T2 |
| 33 | Navier and Levy type solutions for plates on elastic foundation by concentrated forces | CO3 | T1,T2 |
| 34 | Plate with clamped edge under a uniform load Po. | CO3 | T1,T2 |
| 35 | Circular Plates on elastic foundation. | CO3 | T1,T2 |
| 36 | Derivation for the general equations for axisymmetric shells of revolution. | CO3 | T1,T2 |
| 37 | Shells, geometry and classifications | CO3 | T1,T2 |
| 38 | stress resultants, membrane theory and its applications to shells of surface of revolutions | CO4 | T1,T2 |
| 39 | Derive an expression for all round simply supported rectangular plate by Navier solution. | CO 6 | T1,T2 |
| 40 | Membrane theory for cylindrical shell. | CO4 | T1,T2 |
| 41 | Bending of Circular Plates by Moments Uniformly Distributed along the Edge | CO4 | T1,T2 |
| 42 | Axisymmetric Bending of Circular Plates | CO4 | T1,T2 |
| 43 | Maximum deflections and bending moment of a uniform loaded solid circular plate with radius 'a ' at its edges simply suppored. | CO4 | T1,T2 |
| 44 | General theory in bending of cylindrical shells shell | CO4 | T1,T2 |
| 45 | Theory of simplified method for cylindrical shell | CO4 | T1,T2 |
| 46 | Introduction to Buckling of plates | CO4 | T1,T2 |
| 47 | Introduction to Buckling of plates | CO4 | T1,T2 |
| 48 | Introduction to Buckling of plates | CO4 | T1,T2 |
| 49 | Governing equation for bending of plate under the action of in plane loading | CO5 | T1,T2 |
| 50 | Derivation of geometrical relations for shells of double curvature. | CO5 | T1,T2 |
| 51 | Governing equation for bending of plate under the action of lateral loads | CO5 | T1,T2 |

| | | | |
|---|---|---|---|
| 52 | Bending and membrane theories for analysis of shells. | CO5 | T1,T2 |
| 53 | Plate Bending by Approximate and Numerical Methods | CO5 | T1,T2 |
| 54 | buckling of rectangular plates | CO5 | T1,T2 |
| 55 | Modified galerkin method for one-dimensional | CO5 | T1,T2 |
| 56 | Buckling of plate by compressive forces acting in one and two directions | CO6 | T1,T2 |
| 57 | Buckling of sanewich plate . | CO6 | T1,T2 |
| 59 | Classical stability analysis of thin elastic plates. | CO6 | T1,T2 |
| 60 | Buckling of rectangular plates by compressive forces acting in one and two directions in the middle plane of plate | CO6 | T1,T2 |
| **DISCUSSION OF QUESTION BANK** | | | |
| 1 | What are the assumptions in pure bending. | CO1 | T1,T2 |
| 2 | Deflection and bending moments for circular plate loaded at center. | CO2 | T1,T2 |
| 3 | Expression for rigidity of corrugated sheet. | CO3, | T1,T2 |
| 4 | Explain about the advantages and disadvantages of the shells. | CO4 | T1,T2 |
| 5 | Buckling of rectangular plates by compressive force acting in two directions . | CO6 | T1,T2 |

**Signature of Course Coordinator** **HOD,CE**
**Mr.Gude Ramakrishna.**

# INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

## COURSE DESCRIPTION

| | | | | | |
|---|---|---|---|---|---|
| Department | **CIVIL ENGINEERING** | | | | |
| Course Title | **RESEARCH METHODOLOGY AND IPR** | | | | |
| Course Code | BHSE01 | | | | |
| Program | M.Tech(ST) | | | | |
| Semester | I Semester | | | | |
| Course Type | Core | | | | |
| Regulation | MT25 | | | | |
| Structure of the Course | Theory | | | Practical | |
| | Lecture | Tutorials | Credits | Laboratory | Credits |
| | 2 | 0 | 2 | - | - |
| Course Coordinator | Mr Gude Ramakrishna, Assistant Professor | | | | |

## I COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites |
|---|---|---|---|
| - | - | - | - |

## II COURSE OVERVIEW:

This course imparts research methodology and philosophy of intellectual property rights, including basic concepts employed in quantitative and qualitative research methods, Patents, Copyrights, and Trademarks. It provides the research framework, research methodology research design, and formulation hypothesis, sampling techniques, data analysis and report writing. It implies on research skills and intellectual property rights to encourage new creations, including technology, artwork, and inventions, that might increase economic growth.

## III MARKS DISTRIBUTION:

| Subject | SEE Examination | CIE Examination | Total Marks |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Design of Advanced Concrete Structures | 60 Marks | 40 Marks | 100 |

## IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | PPT | ✓ | Chalk & Talk | x | Assignments | x | MOOC |
| x | Open Ended Experiments | ✓ | Seminars | x | Mini Project | x | Videos |
| x | Others | | | | | | |

## V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

**Semester End Examination (SEE):** The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria .

| | |
|---|---|
| 50% | To test the objectiveness of the concept |
| 30 % | To test the analytical skill of the concept |
| 20 % | To test the application skill of the concept |

**Continuous Internal Assessment (CIA):**

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper Outline of the Continuous Internal Assessments (CIA– 1 and CIA– 2) and SEE

| Activities | CIA- I | CIA- II | SEE | Total Marks |
|---|---|---|---|---|
| Continuous Internal Examination( CIE) | 10 Marks | 10 Marks | - | 20 Marks |
| Assignment / Quiz | 05 Marks | 05 Marks | - | 10 Marks |
| Alternative Assessment Tool (AAT) | 05 Marks | 05 Marks | - | 10 Marks |
| Semester End Examination (SEE) | - | - | 60 Marks | 60 Marks |
| Total | - | - | - | 100 Marks |

**Continuous Internal Examination (CIE ):**
100 Marks CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.
**Technical Seminar and Term Paper:**
Twoseminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations. Page

## VI COURSE OBJECTIVES:

**The students will try to learn:**

| | |
|---|---|
| I | The Knowledge on formulate the research problem, characteristics of a good research and interpretation of collected data. |
| II | The importance of research ethics while preparing literature survey and writing thesis to achieve plagiarism free report. |
| III | The intellectual property rights such as patent, trademark, geographical indications and copyright for the protection of their invention done. |

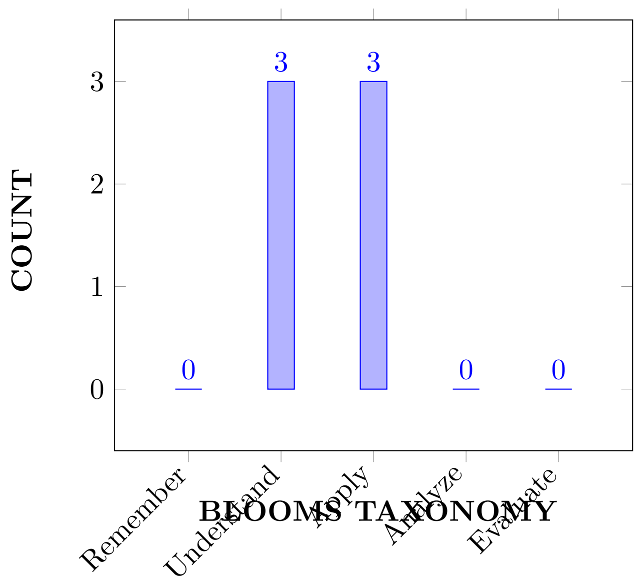
## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Interpret** the technique of determining a research problem for a crucial part of the research study. | Understand |
| CO 2 | **Examine** the way of methods for avoiding plagiarism in research. | Apply |

| | | |
|---|---|---|
| CO 3 | **Apply** the feasibility and practicality of research methodology for a proposed project. | Apply |
| CO 4 | **Make** use of the legal procedure and document for claiming patent of invention. | Understand |
| CO 5 | **Identify** different types of intellectual properties, the right of ownership and scope of protection to create and extract value from IP. | Apply |
| CO 6 | **Defend** the intellectual property rights throughout the world with the involvement of world intellectual property organization. | Remember |

## COURSE KNOWLEDGE COMPETENCY LEVEL




## VIII PROGRAM OUTCOMES:

| | **ProgramOutcomes** |
|---|---|
| PO 1 | Anability to Independently carry out research/investigation and developmen twork to solve practical problems. |
| PO 2 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 3 | An ability to Write and present a substantial technical report/document. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engagein life-long learning for continuing education in research-level studies and professiona ldevelopment. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. | 3 | CIE,SEE |
| PO 2 | Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. | 1 | CIE,SEE |
| PO 3 | Design/Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations | 1 | CIE,SEE |
| PO 5 | Modern Tool Usage: Create, select, 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 | 2 | CIE,SEE |

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

## X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

| Program | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PSO 1 | Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards | 3 | CIA,SEE |

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

## XI MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | ✓ | - | - | - | - | - |
| CO 2 | ✓ | ✓ | ✓ | - | ✓ | - |
| CO 3 | ✓ | ✓ | ✓ | - | - | - |
| CO 4 | ✓ | ✓ | ✓ | - | ✓ | - |
| CO 5 | ✓ | ✓ | ✓ | - | - | - |
| CO 6 | - | ✓ | - | - | - | - |

## XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

| COURSE OUTCOMES | PO'S PSO'S | Justification for mapping (Students will be able to) | No. of Key Competencies |
|---|---|---|---|
| CO 1 | PO 1 | Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesto classify various rocket propulsion systems and missiles | 3 |
| | PO 2 | Identify the problem statement (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement | 2 |
| CO 2 | PO 1 | Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesand derive the rocket thrust equation under different flight conditions | 3 |
| | PO 2 | Analyze the performance parameters of rocket and various forces acting on a rocket using first principles of Mathematics and engineering sciences. | 2 |
| CO 3 | PO 1 | Identify various chemical rocket propulsion systemsand its propellants using principles of mathematics, science, and engineering fundamentals. | 3 |
| CO 4 | PO 1 | Apply the knowledge of different forces (scientific Principles and mathematical principles) for chemical rocket engine and describe different performance parameters. | 3 |
| | PO 2 | Determine the grain parameters and rocket performance parameters using first principles and Mathematics and Engineering sciences. | 2 |

| | | | |
|---|---|---|---|
| | PO 5 | Illustrate Thrust vs time graph of solid rocket motor using modern Engineering and IT tools (Matlab) to solve complex engineering problems. | 1 |
| CO 5 | PO 1 | Understand the advantages of solid propellant, monopropellant and Bi-propellant to determine the desirable properties of oxidizer, Inert gas and fuel using the fundamentals of engineering and mathematical equations | 3 |
| CO 6 | PO 1 | Analyze different Engine cycles used for propulsion system of a chemical rocket engine using fundamentals of science &and engineering fundamentals. | 3 |
| | PO 2 | Categorize the concept of Pyrotechnics based on its physical state and its usage in complex engineering problems. | 3 |
| | PO 3 | Investigate and define a problem and identify constraints of Pyrotechnics including environmental and sustainability limitations, health and safety and risk assessment issues when dealing with performance of gaseous mixtures and their application on real world problems | 2 |
| CO 7 | PO 1 | Understand (knowledge) different combustion instabilities w.r.t time for various chemical rocket engines during flight by applying the knowledge of sciences and Engineering fundamentals principles | 3 |
| | PSO 1 | Synthesize and analyze different combustion systems for non-air breathing engines to provide thrust for the Rockets and missiles | 2 |
| CO 8 | PO 1 | Describe (Knowledge) different guidance phases and guidance systems for a cruise and ballistic missile using principles of mathematics, natural science, and engineering fundamentals. | 3 |
| | PSO 2 | Extend the focus to understand the innovative and dynamic challenges involve the guidance system of rocket and missiles for specific role. | 1 |
| CO 9 | PO 1 | Evaluate the performance characteristics of single stage and multistage rocket using the basic understanding of engineering science and mathematical equations | 3 |
| | PO 2 | Identify the problem statement (mission requirement), select the number of stages required for placing a payload into the orbit by reviewing the literature (information and data collection) suitable to mission requirement | 2 |
| CO 10 | PO 1 | Apply the knowledge of engineering fundamentals to test the prototype of rockets and various safety measures that should be taken while testing. | 3 |

| | | | |
|---|---|---|---|
| CO 11 | PO 1 | Apply the knowledge of Sciences and Engineering fundamentals for design and development of TVC mechanism and cooling systems for rocket propulsion system. | 3 |
| | PO 2 | Identify the proper cooling system and TVC mechanism for a chemical rocket engine (complex system) using first principle of natural sciences and Engineering sciences. | 2 |
| CO 12 | PO 1 | Apply the knowledge of sciences and Engineering fundamentals principles to design a prototype of different rocket components. | 3 |
| | PO 5 | Make use of computational/ Experimental tools to synthesize and analyze rocket aerodynamics by application of Modern tools. | 1 |
| | PO 12 | Make use of broad knowledge of propellant composition in innovative, dynamic challenging environment for design and development of new products. | 4 |

## XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| **Course Outcomes** | **PROGRAM OUTCOMES** | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 2 | - | - | - | - | - |
| CO 2 | 3 | 3 | 3 | - | 2 | - |
| CO 3 | 2 | 2 | 2 | - | - | - |
| CO 4 | 2 | 2 | 2 | - | 1 | - |
| CO 5 | 3 | 2 | 2 | - | - | - |
| CO 6 | - | - | 1 | - | 1 | - |

## XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| **Course Outcomes** | **PROGRAM OUTCOMES** | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 25 | - | - | - | - | - |
| CO 2 | 37.50 | 28.57 | 42.85 | - | 40 | - |
| CO 3 | 25 | 42.85 | 28.57 | - | - | - |
| CO 4 | 100 | 37.5 | 28.57 | - | 28.5 | - |
| CO 5 | 37.50 | 25 | 28.57 | - | - | - |
| CO 6 | - | - | 15 | - | 12.70 | - |

## XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq C \leq 5\%$ – No correlation
***1*** -$5 < C \leq 40\%$ – Low/ Slight
***2*** - $40\% < C < 60\%$ –Moderate
***3*** - $60\% \leq C < 100\%$ – Substantial /High

| **Course Outcomes** | **PROGRAM OUTCOMES** | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 2 | - | - | - | - | - |
| CO 2 | 3 | 2 | 3 | - | 3 | - |
| CO 3 | 2 | 3 | 3 | - | - | - |
| CO 4 | 2 | 2 | 3 | - | 3 | - |
| CO 5 | 3 | 3 | 2 | - | - | - |
| CO 6 | - | - | 1 | - | 3 | - |
| **Total** | 12 | 10 | 12 | - | 9 | - |
| **Average** | 2 | 2 | 3 | - | 3 | – |

## XVI ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | ✓ | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## XVII ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## XVIII SYLLABUS:

| | |
|---|---|
| MODULE I | **INTRODUCTION** |
| | Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. |
| MODULE II | **RESEARCH ETHICS** |
| | Effective literature studies approaches, analysis Plagiarism and Research ethics. |
| MODULE III | **RESEARCHPROPOSAL** |
| | Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. |
| MODULE IV | **PATENTING** |
| | Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. |
| MODULE V | **PATENT RIGHTS** |
| | Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. |

### TEXTBOOKS


1. Panneerselvam, Ramasamy. Research methodology. PHI Learning Pvt. Ltd., 2014.
2. Goddard, Wayne, and Stuart Melville. Research methodology: An introduction. Juta and Company Ltd, 2004.
3. Ranjit Kumar, "Research Methodology: A Step-by-Step Guide for beginners". 2nd edition, 2007


### REFERENCE BOOKS:


1. Halbert, "Resisting Intellectual Property", Taylor and Francis Ltd, 2007.
2. Correa, Carlos M. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed books, 2000.
3. Niebel, "Product Design", McGraw Hill, 1974.

## XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | **Topics to be covered** | **CO's** | **Reference T1: 4.1** |
|---|---|---|---|
| 1-2 | Explanation of research problem | CO 1 | T2: 1.1-1.5, |
| 3-4 | Sources of research problem | CO 1 | T2: 2.1-2.2, |
| 5-6 | Criteria Characteristics of a good research problem | CO 1 | T2: 2.3-2.4 |
| 7-8 | Errors in selecting a research problem | CO 2 | T2: 2.5-2.6, |
| 9-10 | Scope and objectives of research problem | CO 4 | T2: 3.3 |
| 11-12 | Approaches of investigation of solutions for research problem | CO 3 | T2: 3.4 |
| 13-14 | Data collection, analysis, interpretation, Necessary instrumentations. | CO 5 | T2: 3.3 |
| 15-18 | analysis Plagiarism and Research ethics. | CO 3 | R2: 4.2 |
| 19-20 | Effective technical writing. | CO 6 | T2: 5.2 |
| 21-24 | How to write report, Paper Developing a Research Proposal. | CO 3 | T2: 4.5 |
| 25-26 | , s, Format of research proposal, presentation and assessment. | CO 5 | T1: 4.2 |
| 27-28 | Patents, Designs, Trade and Copyright. | CO 4 | T1: 4.3 |
| 29-30 | Process of Patenting and development, technological research. | CO | T2: 5.2 |
| 31-32 | innovation, patenting, development. International Scenario. | CO 2 | T2: 5.2 |
| 33-34 | Scope of Patent Rights. Licensing and transfer of technology. | CO 6 | T2: 5.2 |
| 35-36 | Patent information and databases. Geographical Indications. | CO 5 | R3: 7.2 |
| 37 | Administration of Patent System. | CO 5 | T1: 7.5 |
| 38-39 | IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs. | CO 6 | R2:7.5 |

**Signature of Course Coordinator** **HOD,CE**

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

## ADVANCED CAD LABORATORY
## COURSE TEMPLATE

| | | | | | |
|---|---|---|---|---|---|
| 1 | Department | **CIVIL ENGINEERING** | | | |
| 2 | Course Title | **ADVANCED CAD LABORATORY** | | | |
| 3 | Course Code | BSTE11 | | | |
| 4 | Program | M.Tech | | | |
| 5 | Semester | I Semester | | | |
| 6 | Regulation | MT-25 | | | |
| 7 | Structure of the course | Practical | | | |
| | | Tutorial Hours | | | Practical Hours |
| | | 1 | | | 2 |
| 8 | Course Offered | Odd Semester ✓ | | Even Semester × | |
| 9 | Course Coordinator | Dr. M.Maheswara Rao | | | |
| 10 | Date Approved by BOS | 25/08/2023 | | | |
| 11 | Course Webpage | www.iare.ac.in/—-/—- | | | |
| 12 | Course Prerequistes | **Level** | **Course Code** | **Semester** | **Prerequisites** |
| | | - | - | - | - |
| | | - | - | - | - |

## 13. COURSE OVERVIEW

This course deals with the drawing of various structural elements related to reinforced concrete structures using software package. This will help the students to expose the new software and also minute detailing of the structures. This will also help how to study the existing drawing and incorporate the improvements in the drawings as and when required.

## 14. EMPLOYABILITY SKILLS

| |
|---|
| 1. **Technical Proficiency in Structural Design Software::** Students gain practical experience in designing structural elements such as slabs, beams, columns, footings, and staircases using Excel. This enhances their ability to work efficiently with spreadsheet tools for structural analysis and detailing. |
| 2. **Computer-Aided Design (CAD) and 3D Modeling Skills:** Through modules involving geometry creation, command input, and 3D model development, students learn to visualize and process structural designs using CAD tools. These skills are essential for roles in structural engineering and contribute to proficiency in modern design workflows. |

## 15.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

| | | |
|---|---|---|
| X | NO POVERTY | |
| X | ZERO HUNGER | |
| X | GOOD HEALTH AND WELL-BEING | |
| X | QUALITY EDUCATION | |
| X | GENDER EQUALITY | |
| X | CLEAN WATER AND SANITATION | |
| X | AFFORDABLE AND CLEAN ENERGY | |
| X | DECENT WORK AND ECONOMIC GROWTH | |

| | | |
|---|---|---|
| ✓ | INDUSTRY, INNOVATION AND INFRASTRUCTURE | **Industry, Innovation, and Infrastructure:** By teaching the use of modern tools like Excel, STAAD.Pro, and AutoCAD Civil 3D for structural design, the course fosters innovation in infrastructure development, promoting efficient, durable, and smart construction practices. |
| X | REDUCED INEQUALITIES | |
| ✓ | SUSTAINABLE CITIES AND COMMUNITIES | **Sustainable Cities and Communities:** Students learn to design safe and resilient structural components, essential for developing sustainable buildings and infrastructure in urban environments. |
| ✓ | RESPONSIBLE CONSUMPTION AND PRODUCTION | **Responsible Consumption and Production:** The software-based design and simulation approach minimizes material waste, supports optimized resource usage, and encourages life-cycle thinking in structural engineering. |
| ✓ | CLIMATE ACTION | **Climate Action:** The emphasis on energy-efficient and accurate design using digital tools reduces the environmental impact of construction processes, contributing to climate-resilient infrastructure planning. |
| X | LIFE BELOW WATER | |
| X | LIFE ON LAND | |
| X | PEACE, JUSTICE AND STRONG INSTITUTIONS | |

| | | | |
|---|---|---|---|
| X | PARTNERSHIPS FOR THE GOALS | | |

## 16. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Day to Day lab evaluation | ✓ | Demo Video | ✓ | Expected Viva Voce questions | ✓ | Open Ended Experiments |
| X | Competitions | X | hackathons | ✓ | Certifications | ✓ | Probing Further Questions |

## 17. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

**Continuous Internal Assessment (CIA):**
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 2: CIA marks distribution

| **Component** | | | | |
|---|---|---|---|---|
| Type of Assessment | Day to Day performance and viva voce examination | Final internal lab assessment | Laboratory Report / Project and Presentation | Total Marks |
| CIA marks | 20 | 10 | 10 | 40 |

**Continuous Internal Examination (CIE):** One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 3: Experiment based

| Objective | Analysis | Design | Conclusion | Viva voce | Total |
|---|---|---|---|---|---|
| | | | | | 20 |

Table 4: Programming based

| Objective | Analysis | Program | Results | Viva voce | Total |
|---|---|---|---|---|---|
| 4 | 4 | 6 | 4 | 2 | 20 |

**Semester End Examination:**
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

## 18. COURSE OBJECTIVES

**The students will try to learn:**

| | |
|---|---|
| I | The use of various software tools for drafting of typical structures. |
| II | The Design and drawings of the structural detailing of the RC elements. |
| III | The structural drawings of various elements in the structures for preparing quantities. |

## 19. COURSE OUTCOMES

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

| | |
|---|---|
| CO 1 | Design basic structural elements like slabs, beams, columns and stair cases etc. for construction purpose. |
| CO 2 | Analyze technical drawings using both CAD and basic manual tools. |
| CO 3 | Develop the drawings of structural elements for different applications. |
| CO 4 | Build the different stages of the structure from scratch using engineering graphics techniques such as sectional projections, dimensioning and computer-generated drawings. |
| CO 5 | Make use of software packages for creating different structural Geometry. |
| CO 6 | Apply principles of technical drawings for producing different 3D models. |

## 20. SYLLABUS

| | |
|---|---|
| CO 1 | **DESIGN OF BASIC STRUCTURAL ELEMENTS** |
| | 1. Program for design of slabs using Excel and detailing<br>2. Program for design of beams using Excel and detailing<br>3. Program for design of column using Excel and detailing<br>4. Program for design of footing using Excel and detailing<br>5. Program for design of footing using Excel and detailing |
| CO 2 | **STRUCTURAL SYSTEMS and COMMAND INPUTS** |
| | 1. General Description-Type of structure, Unit systems, structure geometry and Co-ordinate system.<br>2. Commands- Using Edit Input-Command Formats-Text Input. |
| CO 3 | **Developing Geometry and Dimensioning** |
| | 1. PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning |
| CO 4 | **Develop and build structure with drawings** |

| | |
|---|---|
| | 1. PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning<br>2. Commands- Using Edit Input-Command Formats-Text Input. |
| CO 5 | **Make use of software packages for structural geometry** |
| | 1. Introduction to analysis and design software's |
| CO 6 | **Apply principles for producing 3D models** |
| | 1. POST - Graphical Post Processing - Animation - Icons - Isometric View Zooming-Results of Analysis and Design – Query reports. |

Note: One Course Outcome may be mapped to multiple number of experiments.

## Text Books


1. Terence M. Shumaker, David A., Madsen AutoCAD and its Applications: Advanced AutoCAD, Good heart-Wilcox, 12th edition, 2005

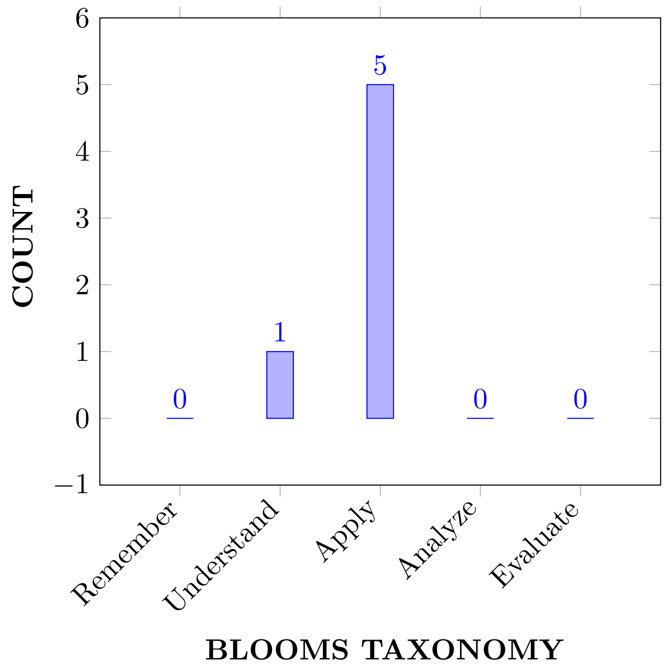

## Reference Books


1. Dr M.N. Sesha Prakash and Dr. G.S. Servesh, "Computer Aided Design Laboratory", Laxmi Publications, 1st edition, 2016.
2. Omura, George, and Brian C. Benton. Mastering AutoCAD 2018 and AutoCAD LT 2018. John Wiley & Sons, 2017.


## Materials Online

1. https://structuralbd.com/dwg-file-sample
2. https://dwgmodels.com/construction_details

## 21. COURSE KNOWLEDGE COMPETENCY LEVEL




## 22. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## 23. HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program Outcomes | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. problems. | 1 | LAB PROGRAMS/CIE/SEE |

| | | | |
|---|---|---|---|
| PO 2 | An ability to Write and present a substantial technical report/document. | | |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 3 | LAB PROGRAMS/CIE/SEE |

## 24. MAPPING OF EACH CO WITH PO(s):

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | ✓ | - | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - |
| CO 2 | ✓ | ✓ | - | ✓ | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | ✓ | - | ✓ | ✓ | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | ✓ | - | ✓ | ✓ | - | - | - | - | - | - | - | - | - |

## 25. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT:

| COURSE OUTCOMES | PO'S PSO'S | Justification for mapping (Students will be able to) | No. of Key Competencies |
|---|---|---|---|
| CO 1 | PO 1 | Apply knowledge of structural design (e.g., slabs, beams, staircases) by utilizing core engineering fundamentals to address real-world construction needs. | 3 |
| | PO 3 | Demonstrate mastery in basic structural element design above undergraduate level with deeper understanding of construction application. | 3 |
| | PO 4 | Apply multidisciplinary engineering knowledge to solve practical structural design challenges. | 3 |
| | PO 5 | Consider socio-economic and functional aspects while designing basic structures. | 3 |

| COURSE OUTCOMES | PO'S<br>PSO'S | Justification for mapping (Students will be able to) | No. of Key Competencies |
|---|---|---|---|
| CO 2 | PO 1 | Analyze and interpret construction drawings using both manual and CAD tools, applying core structural engineering knowledge. | 3 |
| | PO 2 | Prepare technical documents and detailed drawings for project communication. | 3 |
| | PO 4 | Use integrated engineering knowledge in understanding different drawing standards and conventions. | 3 |
| CO 3 | PO 3 | Demonstrate advanced skill in developing application-oriented drawings of structural elements using latest tools. | 3 |
| | PO 4 | Apply cross-functional knowledge for varied structural drawing needs in real-life applications. | 3 |
| | PO 5 | Conceptualize the design intent in drawing form for different civil engineering structures. | 3 |
| CO 4 | PO 2 | Communicate technical aspects of structure development using accurate drafting and documentation. — | 3 |
| | PO 3 | Apply advanced drawing techniques and representation strategies above undergraduate level. | 3 |
| | PO 4 | Understand, design and analyze computer programs in the areas related to Algorithms, System Software, Web design, Big data, Artificial Intelligence, Machine Learning and Networking. | 3 |
| CO 5 | PO 3 | Show competence in using structural design software for modeling and drawing generation. | 3 |
| | PO 5 | Create structural geometries that reflect practical considerations like space planning and economy. | 3 |
| | PO 6 | Engage with evolving tools and technologies for continuous professional growth in structural design. | 3 |
| CO 6 | PO 3 | Apply technical drawing principles for advanced 3D visualization and modeling of structures. | 3 |
| | PO 5 | Model structures based on realistic and sustainable civil engineering practices. | 3 |
| | PO 6 | Continue adapting to new 3D design tools for lifelong learning and improvement in professional capabilities. | 3 |

## 26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 3 | - | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 3 | 3 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - | - - |

## 27. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 25 | - | 25 | 25 | 25 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 33.3 | 33.3 | - | 33.3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | 33.3 | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | 33.3 | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | 33.3 | - | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | 33.3 | - | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - |

## 28. COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - 0≤ C≤ 5% – No correlation

***2*** - 40 % <C < 60% –Moderate

***1-5*** <C≤ 40% – Low/ Slight

***3*** - 60% ≤ C < 100% – Substantial /High

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 1 | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 1 | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | | - |
| CO 6 | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | - | - |
| **TOTAL** | 2 | 2 | 5 | 4 | 4 | 2 | - | - | - | - | - | - | - | - | - |
| **AVERAGE** | 1 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - |

## 29. ASSESSMENT METHODOLOGY DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Laboratory Practices | ✓ |
| Certification | - | Student Viva | ✓ | Open Ended Experiments | - |

## 30. ASSESSMENT METHODOLOGY INDIRECT:

| | | | |
|---|---|---|---|
| x | Assessment of Mini Projects by Experts | ✓ | End Semester OBE Feedback |

## 31. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's |
|---|---|---|
| 1 | Program for design of slabs using Excel and detailing | CO 1 |
| 2 | Program for design of beams using Excel and detailing | CO 1 |
| 3 | Program for design of column using Excel and detailing | CO 1 |
| 4 | Program for design of footing using Excel and detailing | CO 1 |
| 5 | Program for design of footing using Excel and detailing | CO 1 |
| 6 | Introduction to analysis and design software's | CO 5 |
| 7 | General Description-Type of structure, Unit systems, structure geometry and Co-ordinate system. | CO 2 |
| 8 | Commands- Using Edit Input-Command Formats-Text Input. | CO 2, CO4 |
| 9 | PRE- Graphical Input Generation-Library- Geometry Generation – Dimensioning | CO3, CO 4 |
| 10 | POST – Graphical Post Processing – Animation – Icons – Isometric View – Zooming-Results of Analysis AND Design – Query reports. | CO6 |

## Experiments for enhanced learning (EEL):

| S.No | Design Oriented Experiments |
|---|---|
| 1. | STAAD.Pro: Introduce students to structural analysis and design using STAAD.Pro for real-time modeling, analysis, and validation of concrete and steel structures. |
| 2. | AutoCAD Civil 3D: Train students in using Civil 3D for civil infrastructure design, focusing on transportation, land development, and water projects through dynamic modeling and documentation. |

**Approved by: Board of Studies in the meeting conducted on** ——————————.

**Signature of Course Coordinator** **HOD,CSE**
**Dr. M.Maheswara Rao, Assistant Professor**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

# COURSE OUTLINE DESCRIPTION

| SECTION 1: General Information about the Course | |
|---|---|
| Course Title | **ADVANCED CONCRETE LABORATORY** |
| Course Code | BSTE12 |
| Course Start | First Semester |
| Course Type | Core |
| Regulation | IARE - MT 25 |
| Prerequisite Courses | - |
| Department | Civil Engineering (Structural Engineering) |
| Number of Credits | 1.5 Credit hours |
| Academic Year | 2025-26 |
| Method(s) of Instruction | Laboratory |
| Course Coordinator's Name | **Mr. K. Anand Goud, Assistant,** Professor of Aeronautical Engineering<br>IARE10537<br>**k.anandgoud@iare.ac.in** |
| Prior Learning Assessment and Recognition (PLAR) | Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance. |
| Open Learning Faculty Member Information | Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course. |
| Course Webpage | https://akanksha.iare.ac.in/index?route=course/details&course_id=1242 |
| Course Description | Advanced concrete laboratory provides a comprehensive coverage of the theoretical and practical aspects of the subject and includes the latest developments in the field of concrete construction. It incorporates the latest Indian standard specifications and codes regulating concrete construction. The properties of concrete and it constituent materials and the role of various admixtures in modifying these properties to suit specific requirements, such as ready mix concrete, reinforcement detailing, disaster-resistant construction, and concrete machinery have been treated exhaustively the and also special concrete in addition to the durability maintenance and quality control of concrete structure. |
| Course Objectives | **The students will try to learn:**<br>a. The mechanical behavior of concrete under various loading conditions such as compression, tension, flexure, shear, and torsion.<br>b. How to establish correlations among different strength parameters such as cube strength, cylinder strength, split tensile strength, and modulus of rupture.<br>c. To assess the quality and durability of concrete using non-destructive testing methods and permeability tests, and interpret their relevance in structural evaluation.<br>d. The influence of material composition and mix parameters (such as water–cement ratio and workability) on the strength and performance of both conventional and self-compacting concrete. |
| Text and Reference Books | **Textbooks** |

| | |
|---|---|
| | 1. Hemanth Sood and L.N. Mittal, "Laboratory Manual on Concrete Technology," CBS Publishers Pvt. Ltd., New Delhi, 2nd Edition, 2013.<br>2. Khanna S.K. and Justo C.E.G., "Pavement Materials and Testing," Tata McGraw Hill Education, 2012.<br>**Reference Books**<br>1. Malik R.S. and Meo, G.S., "Laboratory Manual on Concrete Technology," Computech Publication Ltd New Asian, 2009.<br>2. Sikka, V.B., "Laboratory Manual on Concrete Technology," S. K. Kataria & Sons, 2013. |
| Learning and Teaching Strategies | Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course.<br>There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks. |

| **DELIVERY / INSTRUCTIONAL METHODOLOGIES:** | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Demo Video | ✓ | Lab Worksheets | ✓ | Viva Questions | ✓ | Probing further Questions |

| **SECTION 2: Teaching Learning Scheme** | | | | |
|---|---|---|---|---|
| At least 48 lecture hours of scheduled laboratories activities (TLA) will be delivered in person,<br>Notional Study Time: 48 Hours (Laboratory Exercises) | | | | |
| **TLA Code** | **Teaching and Learning Activities** | **Number** | **Duration (Hours)** | **Total Workload** |
| TLA 1 | Lectures | - | - | - |
| TLA 2 | Tutorials | - | - | - |
| TLA 3 | Case Study | - | - | - |
| TLA 4 | Problem Solving | - | - | - |
| TLA 5 | Demonstration | - | - | - |
| TLA 6 | Scheduled revision sessions | - | - | - |
| TLA 7 | Guided independent study: Directed viewing of video materials / PPTs | - | - | - |
| TLA 8 | Independent private study | - | - | - |
| TLA 9 | Laboratory Exercises | 48 | 01 | 48 |
| TLA 10 | Homework assignments / Programming assignments | - | - | - |
| TLA 11 | Placement / work based learning or Specific practical training | - | - | - |
| TLA 12 | Presentation / Seminar Preparation | - | - | - |
| TLA 13 | Course Project / Preparation for Complex Problem Solving | - | - | - |
| TLA 14 | Technical visit | - | - | - |
| TLA 15 | Field activities | - | - | - |
| | | | **Total study hours** | **48** |
| | | | **Expected total study hours** | **48** |

| SECTION 3A: Course Outcomes | | |
|---|---|---|
| After successfully completing this course, the student will be able to: | | |
| **Outcome Number** | **Course Outcomes** | **Learning Domain** |
| CO1 | Construct the stress–strain curve of high-strength concrete to analyze its mechanical behavior for use in RC design. | Analyze |
| CO2 | Develop the correlation between cube and cylinder strengths to interpret variations in strength parameters as per different code provisions. | Evaluate |
| CO3 | Determine the relationship between compressive and split tensile strengths to evaluate the tensile performance of concrete. | Analyze |
| CO4 | Identify the relationship between compressive strength and modulus of rupture to understand the flexural behavior of concrete members. | Analyze |
| CO5 | Perform non-destructive tests (Rebound Hammer and UPV) to assess the quality, uniformity, and integrity of concrete structures. | Evaluate |
| CO6 | Explain the behavior of beams under flexure, shear, and torsion to apply the concepts in the design of reinforced concrete elements. | Apply |

| SECTION 3B: Cognitive Levels | |
|---|---|
| **Blooms Taxonomy Level** | **Cognitive Level in Percentage (%)** |
| Remember | 0 |
| Understand | 0 |
| Apply | 17 |
| Analyse | 50 |
| Evaluate | 33 |
| Create | 0 |

| SECTION 4: Concrete Materials laboratory | |
|---|---|
| **CO1** | **Construct the stress–strain curve of high-strength concrete to analyze its mechanical behavior for use in RC design.** |
| | • Enables students to understand the fundamental properties of cement and aggregates.<br>• Builds skills to analyze different physical properties such as fineness, consistency, and specific gravity.<br>• Develops an understanding of how these properties affect the performance of concrete in construction.<br>• Prepares students to identify the suitability of materials for different concrete applications. |
| **CO2** | **Develop the correlation between cube and cylinder strengths to interpret variations in strength parameters as per different code provisions.** |
| | • Helps students understand how to assess the quality of cement.<br>• Builds skills in determining properties such as setting time, soundness, and compressive strength.<br>• Teaches how cement properties influence the strength and durability of concrete.<br>• Prepares students to select suitable cement types for various construction needs. |
| **CO3** | **Determine** the **relationship between compressive and split tensile strengths** to **evaluate the tensile performance of concrete**. |
| | • Helps students understand the importance of specific gravity in mix design.<br>• Builds skills in performing specific gravity tests for accurate material proportioning.<br>• Teaches how variations in cement composition affect mix design calculations.<br>• Prepares students to optimize concrete mixes for strength and durability. |
| **CO4** | **Identify the relationship between compressive strength and modulus of rupture to understand the flexural behavior of concrete members.** |
| | • Helps students understand the grading of fine and coarse aggregates. |

| | |
|---|---|
| | • Builds skills in determining the fineness modulus and bulking of sand.<br>• Teaches how aggregate properties impact concrete workability and strength.<br>• Prepares students to select appropriate aggregates for different construction projects. |
| **CO5** | **Perform non-destructive tests (Rebound Hammer and UPV) to assess the quality, uniformity, and integrity of concrete structures.** |
| | • Helps students understand the factors influencing workability.<br>• Builds skills in performing slump tests, compaction factor tests, and flow table tests.<br>• Teaches how workability affects placement, compaction, and finishing of concrete.<br>• Prepares students to modify mix proportions for improved concrete performance. |
| **CO6** | **Explain the behavior of beams under flexure, shear, and torsion to apply the concepts in the design of reinforced concrete elements.** |
| | • Perform compressive strength tests on concrete cubes/cylinders using a Compression Testing Machine (CTM) as per IS standards.<br>• Evaluate results against IS 456:2000 acceptance criteria to determine if the concrete mix meets required strength.<br>• Use test data for quality control, acceptance decisions, and mix adjustments in real-world construction practices. |

| **SECTION 5: Complex Engineering Problem Solving- NA** |
|---|
| . |

| **SECTION 6A: Assessment Methods – Direct** | | | |
|---|---|---|---|
| **Item** | **Evaluation Components** | **Week in / out** | **Marks** |
| 1 | Day to day evaluation | Every week | 20 |
| 2 | Internal examination and Viva-voce | 10 +10 | 20 |
| 3 | Semester end examination (External) | Week – 17 | 60 |
| | | **Total Marks** | **100** |

**Department's Late Submission Policy:**
1. 1 – 24 hours: 25% of the mark will be deducted
2. > 24 hours: Not accepted

| **SECTION 6B: Assessment Methods –Indirect** | |
|---|---|
| Course End Survey (End Semester OBE Feedback) | ✓ |

**SECTION 8: Engineering Competencies (ECs) Focused: NA**
Please tick (✓) relevant engineering competency profile covered

| **EC Number** | **Attributes** | **Profiles** | **(✓)** |
|---|---|---|---|
| EC1 | Depth of knowledge required (CP) | Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline | ✓ |
| EC2 | Depth of analysis required (CP) | Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models. | ✓ |
| EC3 | Design and development of solutions (CA) | Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and | - |

| | | | |
|---|---|---|---|
| | | optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness. | |
| EC4 | Range of conflicting requirements (CP) | Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues. | ✓ |
| EC5 | Infrequently encountered issues (CP) | Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. | ✓ |
| EC6 | Protection of society (CA) | Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline. | ✓ |
| EC7 | Range of resources (CA) | Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes | - |
| EC8 | Extent of stakeholder involvement (CP) | Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs. | - |
| EC9 | Extent of applicable codes, legal and regulatory (CP) | Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities. | ✓ |
| EC10 | Interdependence (CP) | High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration. | ✓ |
| EC11 | Continuing professional development (CPD) and lifelong learning (CA) | Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. | ✓ |
| EC12 | Judgement (CA) | Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities. | ✓ |

**SECTION 9: Employability Skills**

**Example: Communication skills / Programming skills / Project based skills**

The study of Aerodynamics and Propulsion Laboratory equips students with a range of practical, hands-on skills that are highly valued in the aerospace industry. These skills are particularly important in the design, testing, and optimization of aerodynamic systems and propulsion technologies.

**Employability Skills:**

- Problem-Solving Skills: Ability to analyze and solve real-world material quality and concrete mix design issues through experimentation and testing.
- Analytical and Critical Thinking: Expertise in interpreting laboratory test data, identifying trends, and making informed decisions to optimize material selection.
- Proficiency in Testing Equipment: Skilled in handling laboratory equipment such as vicat apparatus, slump cones, compression testing machines, and permeability testers.
- Optimization Skills: Ability to adjust concrete mix proportions to achieve desired workability, strength, and durability.
- Knowledge of Concrete Technology: Strong understanding of cement, aggregates, admixtures, and their role in concrete performance.
- Teamwork and Collaboration: Effective communication and teamwork in conducting experiments and analyzing results with peers.

- Adaptability: Ability to adapt to evolving construction material technologies and industry best practices.

**Project Management Skills:**

- Planning and Organizing: Ability to design and manage laboratory experiments efficiently.
- Resource Allocation: Proficiency in managing laboratory materials, equipment, and personnel.
- Collaboration and Communication: Clear communication of experimental goals, procedures, and results across various teams.
- Risk Identification and Mitigation: Identifying potential risks in material testing and taking proactive measures to ensure accuracy and safety.
- Testing and Validation: Conducting rigorous testing and validation of concrete materials to ensure compliance with industry standards.

**SECTION 10: Relevance to Sustainability goals**

Brief description about the course and its correlation with Sustainability Development Goal (SDGs).

| SDG Goals | | Correlation with SDG |
|---|---|---|
| 4 | QUALITY EDUCATION | **Quality Education:** This course prepares students for modern construction challenges by enhancing their understanding of concrete materials, ensuring high-quality infrastructure development. |
| 8 | DECENT WORK AND ECONOMIC GROWTH | **Decent Work and Economic Growth:** The course equips students with industry-relevant skills, increasing employability in the civil engineering and construction sectors. |
| 9 | INDUSTRY, INNOVATION AND INFRASTRUCTURE | **Industry, Innovation, and Infrastructure:** Supports innovation in concrete technology, promoting sustainable material selection and efficient construction techniques. |
| 11 | SUSTAINABLE CITIES AND COMMUNITIES | **Sustainable Cities and Communities:** Encourages the use of durable, high-performance concrete for sustainable urban infrastructure development. |
| 12 | RESPONSIBLE CONSUMPTION AND PRODUCTION | **Responsible Consumption and Production:** Enhances awareness about optimizing raw material use in concrete production to minimize waste and environmental impact. |

**SECTION 11A: Mapping between COs and POs / PSOs**

| Course Outcomes | Program Outcomes (POs) | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| CO1 | ✓ | | | - | - | |
| CO2 | ✓ | ✓ | | ✓ | | ✓ |
| CO3 | ✓ | ✓ | ✓ | | ✓ | - |
| CO4 | ✓ | | | ✓ | | - |
| CO5 | | ✓ | ✓ | | | ✓ |
| CO6 | | | | | ✓ | |

| Outcomes | WKS and Indicators of attainment and Justification for mapping (students will be able to) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | IAsCoUnt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | POs | WK 1 | WK 2 | | | | | | | | WK 3 | | | WK 4 | | | WK 5 | | | | | | WK 6 | | | WK 7 | | | | WK 8 | | | | | | | WK 9 | | | | | | |
| | | A | a | b | c | D | e | f | g | h | a | b | c | a | b | c | a | b | c | d | e | f | a | b | c | a | b | c | d | a | b | c | d | e | f | g | a | b | c | d | e | f | |
| CO 1 | PO 1 | • | • | • | • | • | • | • | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 2 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | • | • | • | • | • | • | • | | | | • | • | • | • | | • | • | • | • | | | • | • | • | | | | | | | | | | | | | | | | | | 7 |
| | PO 4 | • | • | • | • | • | • | • | | | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 6 | • | • | • | • | • | • | • | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO 3 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | • | • | | • | • | • | | | | | | | | 7 |
| | PO 3 | • | • | • | • | • | • | • | | | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | • | • | • | • | • | • | • | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CO 4 | PO 1 | • | • | • | • | • | • | • | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 4 | • | • | • | • | • | • | • | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 5 | PO 2 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | • | • | | | • | • | • | | | | | | | 11 |
| | PO 3 | | | | | | | | | | | | | | | | • | • | • | • | | | • | • | • | | | | | • | • | | | • | • | • | | | | | | | 7 |
| | PO 6 | • | • | • | | | • | • | | | • | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 6 | PO 1 | • | • | • | • | • | • | | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |

| SECTION 10B: Indicators of Attainment with COs to POs and PSOs | | | | | | |
|---|---|---|---|---|---|---|
| Course Outcomes | Percentage of Indicators of Attainments (IA) with POs | | | | | |
| | PO | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| CO1 | 78 | - | - | - | - | - |
| CO2 | 78 | 74 | - | 73 | - | 72 |
| CO3 | 73 | 73 | 78 | | 74 | - |
| CO4 | 73 | - | - | 73 | - | - |
| CO5 | - | 73 | 78 | - | - | 73 |
| CO6 | - | - | - | - | 72 | - |

| SECTION 11C: Course Articulation Matrix of COs to POs | | | | | |
|---|---|---|---|---|---|
| 0<br>No Contribution (0-5%) | | 1<br>Low (≥5 - <40%) | 2<br>Moderate (≥40 - <60%) | | 3<br>High (≥60%) |
| | | | | | |
| Course Outcomes | Program Outcomes (POs) | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CO1 | 3 | - | | | | - |
| CO2 | 3 | 3 | | 3 | | 3 |
| CO3 | 3 | 3 | 3 | | 3 | - |
| CO4 | 3 | - | | 3 | | - |
| CO5 | - | 3 | 3 | | | - |
| CO6 | - | - | | | 3 | 3 |
| **Total** | 12 | 9 | 6 | 6 | 6 | 6 |
| **Average** | 3 | 3 | 3 | 3 | 3 | 3 |

| **SECTION 11D: Level of Contribution of the COs to POs and PSOs** | | | |
|---|---|---|---|
| **Number** | **Programme Outcomes** | **Proficiency Assessed by** | **Contribution Level (from 1 to 3)** |
| PO 1 | Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in **WK1 to WK4** respectively to develop to the solution of **complex engineering problems**. | CIE / SEE | **3** |
| PO 2 | Identify, formulate, review research literature and analyse **complex engineering problems** reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4). | CIE / SEE | **3** |
| PO 3 | Design creative solutions for **complex engineering problems** and design / develop systems / components/ processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5) | CIE / SEE | **3** |
| PO 4 | Conduct investigations of **complex engineering problems** using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8) | CIE / SEE | **3** |
| PO 5 | Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve **complex engineering problems**. (WK2 and WK6). | CIE / SEE | **3** |
| PO 6 | Analyze and evaluate societal and environmental aspects while solving **complex engineering problems** for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7) | CIE / SEE | **3** |

| 2.1 SECTION 12: Course Content | |
|---|---|
| **WEEK- I** | **STRESS STRAIN CURVE FOR CONCRETE** |
| | Study of stress-strain curve of high strength concrete |
| **WEEK- 2** | **CORRELATION BETWEEN CUBE STRENGTH AND CYLINDER STRENGTH** |
| | Correlation between cube strength and cylinder strength |
| **WEEK- 3** | **DETERMINTION OF SPLIT TENSILE STRENGTH OF CONCRETE** |
| | Split tensile strength. |
| **WEEK- 4** | **DETERMINTION OF MODULUS OF RUPTURE OF CONCRETE** |
| | Modulus of rupture. |
| **WEEK- 5** | **RELATION BETWEEN COMPRESSIVE STRENGTH AND SPLIT TENSILE STRENGTH** |
| | Correlation between compressive strength and cylinder strength |
| **WEEK- 6** | **RELATION BETWEEN COMPRESSIVE STRENGTH AND MODULUS OF RUPTURE** |
| | Effect of cyclic loading on steel. |
| **WEEK- 7** | **NON – DESTRUCTIVE TEST (NDT)** |
| | Non-Destructive testing (rebound hammer) of existing concrete members. |
| **WEEK- 8** | **PERMEABILITY OF CONCRETE TEST** |
| | Permeability of concrete test. |
| **WEEK- 9** | **SHEAR STRENGTH TEST** |
| | Behavior of Beams under Shear. |
| **WEEK- 10** | **TORSION STRENGTH TEST** |
| | Behavior of steel under Torsion |
| **WEEK- 11** | **WORKABILITY TEST ON SELF COMPACTING CONCRETE** |
| | Determine the workability of self-compacting concrete by using L-box, U-box, V-Funnel and J-ring. |
| **WEEK- 12** | **QUALITY OF CONCRETE USING NDT** |
| | Determine the uniformity of concrete using Ultra sonic pulse velocity. |
| **WEEK-13** | **STRENGTH OF SCC WITH DIFFERENT W/C RATIOS** |
| | Determine the strength of Self compacting concrete with different W/C ratios. |
| **WEEK-14** | **DURABILITY OF CONCRETE** |
| | Determine the durability of concrete |

| SECTION 13: Tentative Schedule of Instructions | | |
|---|---|---|
| **Week Number** | **Topics** | **Duration (Hours)** |
| 1 | 1.1 Stress–strain curve of high-strength concrete | 3 |
| 2 | 2.1 Correlation between cube strength and cylinder strength | 3 |
| 3 | 3.1 Determination of split tensile strength of concrete | 3 |
| 4 | 4.1 Determination of modulus of rupture of concrete | 3 |

| | | |
|---|---|---|
| 5 | 5.1 Relation between compressive strength and split tensile strength | 3 |
| 6 | 6.1 Relation between compressive strength and modulus of rupture | 3 |
| 7 | 7.1 Non-destructive testing of concrete members using Rebound Hammer | 3 |
| 8 | 8.1 Permeability of concrete test | 3 |
| 9 | 9.1 Shear strength test of beams | 3 |
| 10 | 10.1 Torsion strength test of steel / concrete | 3 |
| 11 | 11.1 Workability tests on fresh self-compacting concrete (L-box, U-box, V-funnel, J-ring) | 3 |
| 12 | 12.1 Quality assessment of concrete using Ultrasonic Pulse Velocity (UPV) | 3 |
| 13 | 13.1 Strength of SCC with different W/C ratios | 3 |
| 14 | 14.1 Durability assessment of concrete | 3 |
| | **Total** | **48** |

| **SECTION 14: Specific Goals for the Course** | |
|---|---|
| **The following table shows the knowledge and skills covered by the unit outcomes:** | |
| **Knowledge** | **Skills** |
| **Learners should understand:** | **Learners can:** |
| • Fundamental properties of cement, aggregates, and admixtures used in concrete.<br>• Factors affecting workability and methods for measuring it in fresh concrete.<br>• The significance of the water/cement (W/C) ratio and its effect on concrete strength.<br>• Quality control measures in concrete mix design.<br>• Non-destructive and destructive testing methods for concrete durability assessment.<br>• The role of admixtures in modifying concrete properties.<br>• The environmental impact of concrete production and sustainability considerations.<br>• Advanced testing techniques for evaluating concrete performance.<br>• The importance of curing methods and their influence on concrete strength.<br>• The effects of aggregate properties on concrete performance. | • Conduct laboratory tests to assess material properties such as fineness, consistency, and setting time.<br>• Perform workability tests like slump test, compaction factor test, and flow table test.<br>• Analyze the impact of different W/C ratios on compressive strength through experimental data.<br>• Design concrete mixes using IS code methods for different applications.<br>• Perform permeability tests and non-destructive testing techniques like rebound hammer and ultrasonic pulse velocity.<br>• Evaluate the effects of chemical and mineral admixtures on workability, setting time, and strength.<br>• Implement sustainable practices in concrete mix designs by optimizing material proportions.<br>• Use laboratory equipment like compression testing machines, permeability meters, and air entrainment apparatus.<br>• Conduct curing techniques, including accelerated curing, to assess early strength development.<br>• Determine the fineness modulus of fine and coarse aggregates and assess bulking of sand. |

## EXPERIMENTS FOR ENHANCED LEARNING (EEL):

| S. No | Design Oriented Experiments |
|---|---|
| 1 | Simulation of workability and strength variations in concrete with different water-cement ratios. |
| 2 | Influence of admixtures on the setting time and strength development of concrete. |
| 3 | Optimization of aggregate grading for enhanced durability and performance in concrete mix design. |

| | |
|---|---|
| 4 | Non-destructive evaluation of hardened concrete using ultrasonic pulse velocity and rebound hammer tests. |

## Administrative Information

| SECTION 15: History of changes | | |
|---|---|---|
| **Regulations** | **Description of change** | **BOS Date** |
| PG 21 | **Changes from R16 to R18 regulation**<br>• **No change in syllabus** | 17.11.2020 |
| MT 23 | **Changes from R18 to UG 20 regulation**<br>**Incorporated the following additions in UG 20 regulations**<br>• Studies on Non-Destructive test on concrete | 21.08.2023 |
| MT 25 | **Incorporated the following additions in BT 23 regulations**<br>• Air entrainment test on fresh concrete<br>• Permeability of concrete<br>• Non-destructive testing of concrete<br>• Test for compressive strength of cement concrete<br>• Accelerated curing of concrete<br>• Influence of w/c ratio on strength and aggregate / cement ratio on workability and strength<br>• Marsh cone test<br>• Workability tests on fresh self-compacting concrete | 1.09.2025 |

| Course Outline Approvals | |
|---|---|
| **Course Coordinator**<br>Name: Mr. K. Anand Goud<br>Signature:<br>Date: | **Head of the Department**<br>Name: Dr. R. Ramya Swetha<br>Signature:<br>Date: |
| **Dean of Outcome Based Teaching and Learning**<br>Name: Dr. Srinivasulu<br>Signature:<br><br>Date: | **Dean of Academics**<br>Name: Dr. GVR. Sheshagiri Rao<br>Signature:<br><br>Date: |

| Check List | | |
|---|---|---|
| **Section** | **Description** | **Please tick (✓)** |
| 1 | General Information about the Course | |
| 2 | Notional Study Time | |
| 3 | A. Course Outcomes | |
| | B. Cognitive Levels | |
| 4 | Content and Context of the Course | |
| 5 | Complex Engineering Problem Solving | |
| 6 | A. Assessment Methods – Direct | |
| | B. Assessment Methods – Indirect | |
| 7 | Content Delivery / Instructional Methodologies | |
| 8 | Engineering Competencies (ECs) Focused | |
| 9 | Employability Skills | |
| 10 | Relevance to Sustainability goals | |
| 11 | A. Mapping between COs and POs / PSOs | |
| | B. Indicators of Attainment with COs to POs and PSOs | |
| | C. Course Articulation Matrix of COs to POs | |
| | D. Level of Contribution of the COs to POs and PSOs | |
| 12 | Syllabus | |
| 13 | Tentative Schedule of Instructions | |
| 14 | Specific Goals for the Course | |
| 15 | History of Changes | |

**Signature of Course Coordinator** **HOD, CE**

Mr. K. Anand Goud, Assistant Professor

# INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

## COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">Civil Engineering</td></tr>
<tr><td>Course Title</td><td colspan="5">Finite Element Analysis</td></tr>
<tr><td>Course Code</td><td colspan="5">BSTE13</td></tr>
<tr><td>Program</td><td colspan="5">M. Tech (ST)</td></tr>
<tr><td>Semester</td><td colspan="5">II</td></tr>
<tr><td>Course Type</td><td colspan="5">Core</td></tr>
<tr><td>Regulation</td><td colspan="5">MT25</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr.Gude Ramakrishna, Assistant Professor</td></tr>
</table>

## I COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites |
|---|---|---|---|
| M.Tech | BSTD01 | I | Advanced Structural Analysis |

## II COURSE OVERVIEW:

The Finite Element Method (FEM) is widely used in industry for analyzing and modelling structures and continua, whose physical behavior is described by ordinary and partial differential equations. The FEM is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of the Finite Element Method for obtaining an approximate solution of ordinary and partial differential equations. In this course you will attend lectures on the fundamentals of the Finite Element Method. The learning process will be enhanced by completing assignments using mathematical software. You will also be introduced to a commercial Finite Element software package–ANSYS during lectures with computer laboratories providing opportunities to practice on, and to complete practical assignments, using ANSYS.

## III MARKS DISTRIBUTION:

| Subject | SEE Examination | CIE Examination | Total Marks |
|---|---|---|---|
| Finite Element Analysis | 60 Marks | 40 Marks | 100 |

## IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

<table>
<tr><td>✓</td><td>Power Point Presentations</td><td>✓</td><td>Chalk & Talk</td><td>x</td><td>Assignments</td><td>x</td><td>MOOC</td></tr>
<tr><td>x</td><td>Open Ended Experiments</td><td>✓</td><td>Seminars</td><td>x</td><td>Mini Project</td><td>x</td><td>Videos</td></tr>
<tr><td>x</td><td colspan="7">Others</td></tr>
</table>

## V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

**Semester End Examination (SEE):** The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

| | |
|---|---|
| 50 % | To test the objectiveness of the concept |
| 30% | To test the analytical skill of the concept |
| 20% | To test the application skill of the concept |

### Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper Outline of the Continuous Internal Assessments (CIA – 1 and CIA – 2) and SEE

| Activities | CIA - I | CIA - II | SEE | Total Marks |
|---|---|---|---|---|
| Continuous Internal Examination( CIE) | 10 Marks | 10 Marks | - | 20 Marks |
| Assignment / Quiz | 05 Marks | 05 Marks | - | 10 Marks |
| Alternative Assessment Tool (AAT) | 05 Marks | 05 Marks | - | 10 Marks |
| Semester End Examination (SEE) | - | - | 60 Marks | 60 Marks |
| Total | - | - | - | 100 Marks |

### Continuous Internal Examination (CIE ):

CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.

### Technical Seminar and Term Paper:

Two seminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations.

## VI COURSE OBJECTIVES:

**The students will try to learn:**

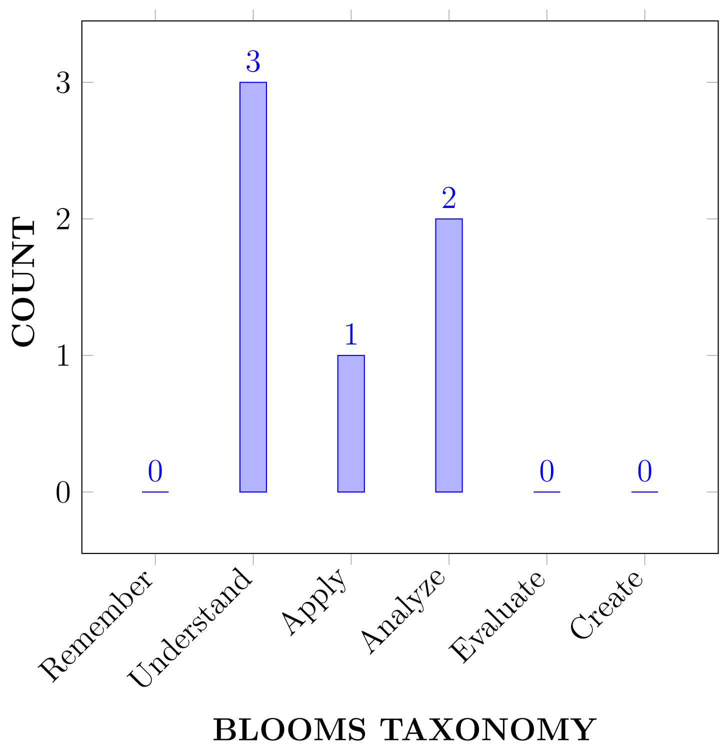
| | |
|---|---|
| I | The Use of Finite Element Method for structural analysis. |
| II | The Execution of the Finite Element Program by using Software tools. |
| III | The continuum problems using finite element analysis |

## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** the concepts of matrix analysis of structures for understanding the Finite Element Analysis. | Understand |
| CO 2 | **Develop** the concepts of elasticity, plane stress and plane strain conditions for the design purpose. | Apply |
| CO 3 | **Analyze** the one- and two-dimensional structures elements | Analyze |
| CO 4 | **Explain** the concepts of iso-parametric elements for the analysis of Structures. | Understand |
| CO 5 | **Analyze** the plates like slabs using plate elements. | Analyze |
| CO 6 | **Summarize** the concepts of iso-parametric elements for analyzing the real world situations | Understand |

## COURSE KNOWLEDGE COMPETENCY LEVEL



## VIII PROGRAM OUTCOMES:

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. |
| PO 2 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 3 | An ability to Write and present a substantial technical report/document. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 3 | CIE, SEE |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 2 | CIE,SEE |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 3 | CIE,SEE |

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

## X MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | ✓ | - | - |
| CO 2 | - | - | ✓ | ✓ | ✓ | - |
| CO 3 | - | - | ✓ | ✓ | - | - |
| CO 4 | - | - | ✓ | ✓ | ✓ | - |
| CO 5 | - | - | ✓ | ✓ | - | - |
| CO 6 | - | - | - | ✓ | ✓ | - |

## XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO 1 | PO 4 | Recall the concepts of of FEM, steps involved and understand **structural applications** for its behaviour by **analyze and design** the structure. | 2 |
| CO2 | PO3 | Develop procedure to **understand** different elements stress and stran values and stiffness matrix to slove problems and **solution developed** for particular condition and check for **validation of results.** | 3 |
| | PO4 | Apply the appropriate method to **understand**mathematical concept of **analysis and design**of the structural members es for **Interpretation of results**. | 3 |
| | PO5 | Select the appropriate method for **design and analysis** of problems in structural engineering and allied fields for **Interpretation of results and Validation**. | 2 |
| CO3 | PO 3 | Understand the application of **Problem formulation** of finite 3-D elements and **design process and evaluate outcomes** of member forces and applied loads. | 2 |
| | PO4 | Use and **create** the finite elements and **obtain Solution and implimentation on** beam,bar and isoperimetric elements. | 2 |
| CO4 | PO3 | Recall (knowledge) the principles of membrane and bending analysis and form the stiffness and flexibility matrices by applying the principles of**to manage the design process** for the buckling of plates and shells to obtain **interpretation of results and validation**. | 2 |
| | PO4 | Select the appropriate method for the bulking analysis of plate elements using **analyze and design principles** for different loadimg condition **interpretation of results** of plate and shel elements. | 2 |
| | PO5 | Select the appropriate method for finite element analysis of structures using **requirements of engineering activities** for desing purpose | 1 |
| CO5 | PO3 | Undderstand the **experimental design** concepts of shapes functions to obtain stiffness matrix for shell elements by using **modern tools.** | 2 |
| | PO4 | **Identify the problem, formulate** stiffness matrix for plate and shell elements **for solution development** to get substantiated conclusions by the **interpretation of results.** | 3 |
| CO6 | PO3 | **Understanding and demonstrations** of basic engineering non linear analysis. | 1 |
| | PO5 | Make use of non linear analysis for the **requirement of engineering activities to promote sustainable development** in finite element analysis. | 1 |

## XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | 2 | - | - |
| CO 2 | - | - | 3 | 3 | 2 | - |
| CO 3 | - | - | 2 | 2 | - | - |
| CO 4 | - | - | 2 | 2 | 1 | - |
| CO 5 | - | - | 2 | 3 | - | - |
| CO 6 | - | - | 1 | - | 1 | - |

## XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | 25 | - | - |
| CO 2 | - | - | 42.85 | 37.50 | 40 | - |
| CO 3 | - | - | 28.57 | 25 | - | - |
| CO 4 | - | - | 28.57 | 25 | 100 | - |
| CO 5 | - | - | 28.57 | 37.5 | - | - |
| CO 6 | - | - | 15 | - | 12.70 | - |

## XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq C \leq 5\%$ – No correlation

***1*** -$5 < C \leq 40\%$ – Low/ Slight

***2*** - $40\ \% < C < 60\%$ –Moderate

***3*** - $60\% \leq C < 100\%$ – Substantial /High

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | 2 | - | - |
| CO 2 | - | - | 3 | 3 | 3 | - |
| CO 3 | - | - | 3 | 2 | - | - |
| CO 4 | - | - | 3 | 2 | 3 | - |
| CO 5 | - | - | 2 | 3 | - | - |
| CO 6 | - | - | 1 | - | 3 | - |
| **Total** | - | - | 12 | 12 | 9 | - |
| **Average** | - | - | 3 | 2 | 3 | – |

## XV ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | ✓ | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## XVI ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## XVII SYLLABUS:

| | |
|---|---|
| MODULE I | **INTRODUCTION TO FEM AND PRINCIPLES OF ELASTICITY** |
| | Introduction: Concepts of FEM, steps involved merits and demerits, energy principles, discrimination, raleigh, ritz method of functional approximation. Principles of Elasticity: Stress equations, strain displacement relationships in matrix form plane stress, plane strain and axi-symmetric bodies of revolution with axi-symmetric loading. |
| MODULE II | **1D AND 2D FEM** |
| | One dimensional FEM: Stiffness matrix for beam and bar elements, shape functions foe ID elements.Two dimensional FEM: Different types of elements for plane stress and plane strain analysis, displacement models, generalized coordinates, shape functions, convergent and compatibility requirements, geometric invariance, natural coordinate system, area and volume coordinates, generation of element stiffness and nodal load matrices. |
| MODULE III | **DIFFERENT FORMULATIONS AND 3D FEM** |
| | Iso-parametric formulation: Concept, different iso-parametric elements for 2D analysis, formulation of 4- noded and 8-noded isoperimetric quadrilateral elements, lagrange elements, serendipity elements.<br>Axi Symmetric Analysis: Bodies of revolution, axi symmetric modeling, strain displacement relationship, formulation of axi symmetric elements. Three dimensional FEM: Different 3-D elementsstrain, displacement relationship, formulation of hexahedral and isoparametric solid element. |
| MODULE IV | **ANALYSIS OF PLATES** |
| | Introduction to finite element analysis of plates: Basic theory of plate bending, thin plate theory, stress resultants, mindlin's approximations, formulation of 4-noded isoperimetric quadrilateral plate element, shell element. . |
| MODULE V | **NON-LINEAR ANALYSIS** |
| | Introduction to non linear analysis: basic methods, application to special structures. |

## TEXTBOOKS


1. Seshu P, “Finite Element Analysis”, Prentice-Hall of India, 1st Edition, 2003.
2. Cook R. D, “Concepts and Applications of Finite Element Analysis”, Wiley J., New York, 4 th Edition, 2001.
3. Krishnamoorthy C.S, ”Finite Elements Analysis - Theory and Programming”, Tata McGraw Hill publishing company limited, New Delhi, 2nd Edition, 2017.


## REFERENCE BOOKS:


1. Hutton David, “Fundamentals of Finite Element Analysis”, McGraw Hill, 2nd Edition, 2017.
2. Zienkiewicz O.C. and Taylor R.L, “Finite Element Method”,. Vol. I, II and III, Elsevier, 3rd Edition, 2000
3. Buchanan G.R, “Finite Element Analysis, McGraw Hill Publications, New York, 1st Edition, 1995.
4. Belegundu A.D., Chandrupatla, “Finite Element Methods in Engineering”, T.R., Prentice Hall, India, 1st Edition, 1991.


## WEB REFERENCES:


1. https://nptel.ac.in/courses/105106051
2. http:// nptel.ac.in/courses/1051050


## XVIII COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's | Reference T1, T2 |
|---|---|---|---|
| **OBE DISCUSSION** | | | |
| 1 | Discussion on OBE, CO's and CLO's of subject Finite Element Analysis | | |
| **CONTENT DELIVERY (THEORY)** | | | |
| 1 | Introduction, Concepts of FEM, steps involved merits and demerits | CO1 | T1,T2 |
| 2 | Energy principles. | CO1 | T1,T2 |
| 3 | Discrimination. | CO1 | T1,T2 |
| 4 | Raleigh, ritz method of functional approximation. | CO1 | T1,T2 |
| 5 | Principles of Elasticity: Stress equations, strain displacement relationships in matrix form plane stress | CO1 | T1,T2 |
| 6 | Direct Stiffness Method. | CO1 | T1:2.5, |
| 7 | One dimensional FEM: Stiffness matrix for beam and bar elements. shape functions for ID elements | CO1 | T1,T2 |
| 8 | Beam and bar element. | CO2 | T1,T2 |
| 9 | Different types of elements for plane stress and plane strain. | CO2 | T1,T2 |
| 10 | Analysis different types of elements . | CO2 | T1,T2 |
| 11 | Displacement models. | CO2 | T1,T2 |

| | | | |
|---|---|---|---|
| 12 | Geometric invariance, natural coordinate system. | CO2 | T1,T2 |
| 13 | Area and volume coordinates | CO2 | T1,T2 |
| 14 | Element Load Vector. | CO2 | T1,T2 |
| 15 | Isoparametric formulation: Concept, different iso-parametric elements for 2D analysis. | CO2 | T1,T2 |
| 16 | stiffness matrix for global coordinates | CO2 | T1,T2 |
| 17 | concepts on solution of stiffness matrix equations | CO3 | T1,T2 |
| 18 | calculation of reactions and member forces | CO3 | T1,T2 |
| 19 | Step by step procedure for stiffness method | CO3 | T1,T2 |
| 20 | stiffness method for beams | CO3 | T1,T2 |
| 21 | Problem solving for beams by stiffness method | CO3 | T1,T2 |
| 22 | Problem solving for cantilever beams by stiffness method | CO3 | T1,T2 |
| 23 | Problem solving for continunous beams by stiffness method | CO3 | T1,T2 |
| 24 | Problem solving for continunous beams with settelment by stiffness method | CO3 | T1,T2 |
| 25 | Problem solving for portal frame by stiffness method | CO3 | T1,T2 |
| 26 | stiffness method for plane trusses | CO3 | T1,T2 |
| 27 | flexibilty method | CO4 | T1,T2 |
| 28 | flexibilty method for beam | CO4 | T1,T2 |
| 29 | flexibilty method for beamdifferent shapes | CO4 | T1,T2 |
| 30 | Problem solving for beams by stiffness method and flexibilty method | CO4 | T1,T2 |
| 31 | Analysis, axi symmetric modeling, strain displacement relationship. frames. | CO4 | T1,T2 |
| 32 | formulation of grid structures | CO4 | T1,T2 |
| 33 | CST Element, Plane Strain Rectangular Element. | CO5 | T1,T2 |
| 34 | Introduction to Isoperimetric Formulation of the Plane Quadrilateral Element, Axi- Symmetric element. | CO5 | T1,T2 |
| 35 | classification of element : One dimensional elements, Two dimensional elements, Axi-symmetric elements and Three dimensional elements. | CO5 | T1,T2 |
| 36 | Different boundary conditions | CO5 | T1,T2 |
| 37 | solutions for boundary value problems | CO5 | T1,T2 |
| 38 | Introduction to non linear analysis | CO6 | T1,T2 |
| 39 | Importanance of non linear analysis | CO6 | T1,T2 |
| 40 | Non linear analysis methods. | CO6 | T1,T2 |
| 41 | The matrix formulation of the modified galerkin method. | CO6 | T1,T2 |
| 42 | Explain procedure for modified galerkin method. | CO6 | T1,T2 |
| 43 | Non linear analysis. | CO6 | T1,T2 |
| 44 | Application to special structures. | CO6 | T1,T2 |
| 45 | Problem solving on Non linear analysis. | CO6 | T1,T2 |
| 46 | Problems on static indeterminacy and Kinematic Indeterminacy of Structures | CO 5 | T1,T2 |
| 47 | Problems on continuous beam by stiffness matrix method | CO 2 | T1,T2 |
| 47 | Problems on truss by stiffness matrix method | CO 6 | T1,T2 |

| | | | |
|---|---|---|---|
| 49 | Problems on rigid frame by flexibilty and stiffness matrix method | CO 6 | T1,T2 |
| 50 | Develop the stiffness matrix for global coordinates for boundary conditions. | CO 4 | T1,T2 |
| 51 | Problems on plane rigid jointed frames by flexibilty and stiffness matrix method | CO 4 | T1,T2 |
| 52 | Problems on boundary value problems | CO 5 | T1,T2 |
| 53 | Formulation of general one dimensional equilibrium problem. | CO5 | T1,T2 |
| 54 | Problems on shape functions for linear elements. | CO 6 | T1,T2 |
| 55 | Problems on modified galerkin method | CO 6 | T1,T2 |
| 56 | degree of freedom, statically indeterminate structure ,static indeterminacy and Kinematic Indeterminacy of Structures | CO 5 | T1,T2 |
| 57 | local and global coordinates, stiffness matrix | CO6 | T1,T2 |
| 58 | Distinction between flexibilty method and stiffness method | CO5 | T1,T2 |
| 59 | shape function, one and two diamensional element | CO6 | T1,T2 |
| 60 | Explain the Analysis Software based on the structure of a FEA program. | CO6 | T1,T2 |
| 61 | Explain about material nonlinearity | CO5 | T1,T2 |
| 62 | Minimum Potential Energy, the Variation Principle | CO6 | T1,T2 |
| 63 | Differentiate Between Linear and Nonlinear Analysis | CO6 | T1,T2 |
| **DISCUSSION OF QUESTION BANK** | | | |
| 1 | What is static indeterminacy and Kinematic Indeterminacy of Structures? solutionn for indeterminacy . | CO1 | T1,T2 |
| 2 | stiffness matrix problem solution for beam, truss and rigid frames | CO2 | T1,T2 |
| 3 | force method and displacement method | CO6, | T1,T2 |
| 4 | shape function for one diamensional element | CO4 | T1,T2 |
| 5 | solution for modified galerkin method | CO5 | T1,T2 |

**Signature of Course Coordinator** **HOD,CE**
**Mr.Gude Ramakrishna.**

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

## STRUCTURAL DYNAMICS
## COURSE TEMPLATE

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Department | **CIVIL ENGINEERING (STRUCTURAL ENGINEERING)** | | | | |
| 2 | Course Title | **STRUCTURAL DYNAMICS** | | | | |
| 3 | Course Code | BSTE14 | | | | |
| 4 | Program | M. Tech (STE) | | | | |
| 5 | Semester | II Semester | | | | |
| 6 | Regulation | MT-25 | | | | |
| 7 | Structure of the course | Theory | | | Practical | |
| | | Lecture | Tutorials | Credits | Lab | Credits |
| | | 3 | 0 | 3 | - | - |
| 8 | Type of course (**Tick type of course**) | Core ✓ | Professional Elective - | Open Elective - | VAC - | MOOCs - |
| 9 | Course Offered | Odd Semester X | | Even Semester ✓ | | |
| 10 | **Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)** | | | | | |
| | Lectures: ....... hours | | Tutorials: ....... hours | | Practical: ....... hours | |
| 11 | Course Coordinator | Dr. BDY Sunil | | | | |
| 12 | Date Approved by BOS | DD/MM/YYYY | | | | |
| 13 | Course Webpage | www.iare.ac.in/—-/—- | | | | |
| 14 | Course Prerequistes | **Level** | **Course Code** | **Semester** | **Prerequisites** | |
| | | B.Tech | | I | Matrices and Calculus | |
| | | B.Tech | | I | XXXX | |

## 15. COURSE OVERVIEW:

Structural Dynamics is of utmost importance for understanding the analysis and design consideration of structures subjected to dynamic loading. This course introduces the basic concepts of dynamic loading and the response of structures to such loads, and then uses these concepts to illustrate applications in practical structures. It begins with the derivation of the basic equations of motion for an ideal single degree-of-freedom structure using various approaches, and the solution of these equations for different types of loading. Further, the development of equations for multi-degree-of-freedom structures is considered, with multi-storied buildings as the example structures, and free and forced vibration response analysis of these multi-storied buildings shall be discussed.

## 16. Employability Skills

| |
|---|
| **Example: Communication skills / Programming skills / Project based skills /** |
| **Analytical skills / Problem-solving skills / Structural analysis skills** |
| **Mathematical modeling skills / Engineering judgment skills** |
| **STechnical communication skills / Project-based learning skills** |

## 17. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

| | | |
|---|---|---|
| 1 | NO POVERTY | |
| 2 | ZERO HUNGER | |
| 3 | GOOD HEALTH AND WELL-BEING | |
| 4 | QUALITY EDUCATION | **Quality Education:**Enhancing technical knowledge and employability skills through engineering education. |
| 5 | GENDER EQUALITY | |
| 6 | CLEAN WATER AND SANITATION | |

| | | |
|---|---|---|
| 7 | AFFORDABLE AND CLEAN ENERGY | |
| 8 | DECENT WORK AND ECONOMIC GROWTH | Developing problem-solving and project-based skills to increase employability and entrepreneurship opportunities. |
| 9 | INDUSTRY, INNOVATION AND INFRASTRUCTURE | Promoting innovation through mathematical modeling, structural analysis, and numerical methods to improve engineering practices. |
| 10 | 10.png | |
| 11 | SUSTAINABLE CITIES AND COMMUNITIES | Applying engineering skills to design and maintain sustainable and resilient structures and communities. |
| 12 | RESPONSIBLE CONSUMPTION AND PRODUCTION | |
| 13 | CLIMATE ACTION | |

| | | |
|---|---|---|
| 14 |  | |
| 15 |  | |
| 16 |  | |
| 17 |  | |

## 18. Content Delivery / Instructional Methologies:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ✓ | Power Point Pressentation | ✓ | Chalk & Talk | ✓ | 20.png Assignments | x | MOOC |
| x | Open Ended Experiments | x | Seminars | x | Mini Project | ✓ | Videos |

## 19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

| **Activities** | **CIA - I** | **CIA - II** | **SEE** | **Total Marks** |
|---|---|---|---|---|
| Continuous Internal Examination (CIE) | 10 Marks | 10 Marks | | 20 Marks |
| Definitions and Terminology / Quiz | 05 Marks | 05 Marks | | 10 Marks |
| Tech Talk / Assignment | 05 Marks | 05 Marks | | 10 Marks |
| Semester End Examination (SEE) | - | - | 60 Marks | 60 Marks |
| Total | - | - | **100 Marks** | |

**Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

| Percentage of Cognitive Level | Blooms Taxonomy Level |
|---|---|
| 10% | Remember |
| 35% | Understand |
| 55% | Apply |

## 20. COURSE OBJECTIVES:

**The students will try to learn:**

| | |
|---|---|
| I | The dynamics response of single and multi-degree freedom systems using fundamental theory and equations of motion. |
| II | The numerical solution of structural responses of different loading conditions for the design of structures. |
| III | The responses of structures subjected to earthquakes and blasts for the efficient and economic design of structures. |

## 21. COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** the concepts response of a system under vibrations on the structures for understanding the behavior of structures. | Understand |
| CO 2 | **Outline** the concept of damped vibrations of single degree freedom systems for the analysis of structures subjected to dynamic loads. | Understand |
| CO 3 | **Develop** the expressions for response of single degree freedom systems based on loading functionfor the response of structure used in design. | Apply |
| CO 4 | **Develop** the equations of structural response to dynamic loads using Duhamel's integral and fourier analysis. | Apply |
| CO 5 | **Analyse** the two-degree freedom systems subjected to free and forced vibrations for the design purpose. | Analyse |
| CO 6 | **Analyse** the multiple degree of freedom systems to know the natural frequencies, modes and mode shapes using orthogonality and normality principles and superposition method. | Analyse |

************
*************

## 22. Topic Learning Outcome (TLOs):

| TLO No | Topic Learning Outcome's | Course Outcome: | Blooms Level |
|---|---|---|---|
| TLO 1 | Explain elasticity and stress-strain relationships. | CO 1 | Understand |
| TLO 2 | Analyze plane stress and plane strain conditions. | CO 1 | Apply |
| TLO 3 | Derive the equations of equilibrium in elasticity. | CO 1 | Apply |
| TLO 4 | Identify compatibility conditions in 2D stress fields. | CO 2 | Understand |
| TLO 5 | Solve boundary value problems in elasticity. | CO 2 | Apply |
| TLO 6 | Formulate Airy's stress function for 2D problems. | CO 2 | Analyze |
| TLO 7 | Apply St. Venant's principle in elasticity problems. | CO 2 | Apply |
| TLO 8 | Derive displacement equations from stress-strain relations. | CO 3 | Apply |
| TLO 9 | Solve for deflections in simple beams. | CO 3 | Apply |
| TLO 10 | Understand theory of vibrations and dynamic loading. | CO 1 | Understand |
| TLO 11 | Analyze free vibrations of undamped SDOF systems. | CO 1 | Apply |
| TLO 12 | Analyze damped vibrations of SDOF systems. | CO 2 | Apply |
| TLO 13 | Develop solutions for harmonic excitation problems. | CO 2 | Apply |
| TLO 14 | Derive response to periodic loads using Fourier series. | CO 3 | Analyze |
| TLO 15 | Apply Duhamel's integral to find system response. | CO 3 | Analyze |
| TLO 16 | Analyze free vibrations of undamped 2DOF systems. | CO 4 | Analyze |
| TLO 17 | Analyze forced vibrations of damped 2DOF systems. | CO 4 | Analyze |
| TLO 18 | Develop vibration isolation methods. | CO 5 | Apply |
| TLO 19 | Derive natural frequencies and mode shapes for MDOF. | CO 5 | Analyze |
| TLO 20 | Apply orthogonality principle in mode shapes. | CO 6 | Analyze |
| TLO 21 | Analyze superposition in MDOF systems. | CO 6 | Analyze |
| TLO 22 | Understand damping characteristics and measurements. | CO 2 | Understand |
| TLO 23 | Derive equivalent stiffness for combined systems. | CO 1 | Apply |
| TLO 24 | Solve differential equations using Laplace transforms. | CO 3 | Analyze |
| TLO 25 | Evaluate influence of gravitational forces in dynamic systems. | CO 1 | Understand |

## 23. SYLLABUS:

| MODULE I | **THEORY OF VIBRATIONS** |
|---|---|
| | Introduction, basic concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force. |
| MODULE II | **DAMPED VIBRATIONS OF SDOF SYSTEM** |

| | |
|---|---|
| | Introduction types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation. |
| MODULE III | **RESPONSE TO PERODIC AND IMPULSIVE LOADING** |
| | Introduction to periodic loading, Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral. |
| MODULE IV | **TWO DEGREE OF FREEDOM SYSTEM** |
| | Introduction, concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system. |
| MODULE V | **MULTIPLE DEGREE OF FREEDOM SYSTEM** |
| | Introduction, Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration. |

## TEXTBOOKS


1. S. Kavita and S. R. Damodaraswamy, "Basics of structural Dynamics and Aseismic Design", PHI Learning Pvt. Ltd., 1st Edition, 2012.
2. Clough R. W. and Penzien J, "Dynamics of Structures", 1st Edition, McGraw Hill, 1993.
3. Chopra A. K, "Structural Dynamics and Introduction to Earthquake Engineering", illustrated, Prentice Hall, 4th Edition, 2012.
4. Smith J. W, "Vibration of Structures - Application in Civil Engineering Design", Chapman and Hall, 1st Edition, 1988.

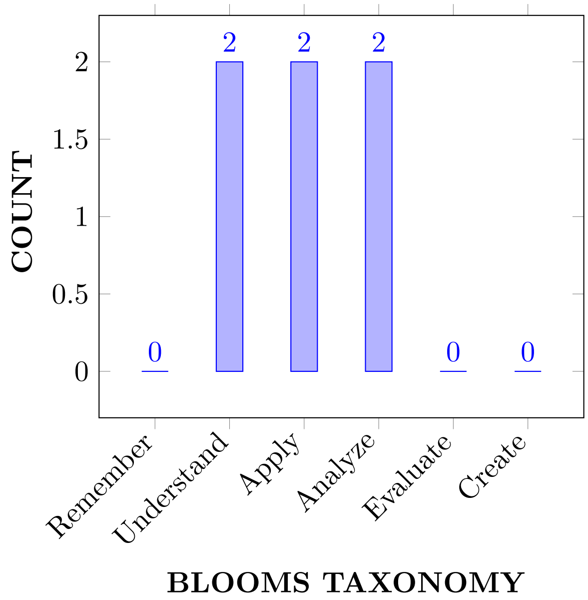

## REFERENCE BOOKS:


1. Humar J. L., "Dynamics of Structures", Prentice Hall, 2nd Edition, 2002.
2. Paz Mario, "Structural Dynamics Theory and Computation", CBS Publication, 5th Edition, 2002.
3. Hart and Wong, "Dynamics of Structures", John Wiley, 1st Edition, 1999.


## WEB REFERENCES:


1. http://nptel.ac.in/courses/105101006/

## 24. COURSE KNOWLEDGE COMPETENCY LEVEL




## 25. PROGRAM OUTCOMES:

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## 26. HOW PROGRAM OUTCOMES ARE ASSESSED:

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. | 1 | CIE, SEE |

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 1 | CIE, SEE |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 2 | CIE, SEE |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 3 | CIE, SEE |

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

## 27. MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | ✓ | ✓ | - | - |
| CO 2 | ✓ | - | - | ✓ | ✓ | - |
| CO 3 | ✓ | - | ✓ | ✓ | ✓ | - |
| CO 4 | ✓ | - | - | ✓ | ✓ | - |
| CO 5 | - | - | ✓ | ✓ | ✓ | - |
| CO 6 | - | - | ✓ | ✓ | - | - |

## 28. JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO 1 | PO3 | Analyze the given **problem statement** and find the response of the structures to establish innovative solutions in structural system and **Interpret the result** on various applications. | 2 |
| | PO4 | Demonstrate the importance of structural response for solving society relevant problems for applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| CO2 | PO1 | Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure using damped vibrations. | 2 |
| | PO4 | Analyse the single degree freedom system with damped vibrations for the analysis of different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO3 | PO1 | Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure in terms of response for a given loading function. | 2 |
| | PO3 | Analyze the given **problem statement** and find the structural response for different loading function to establish innovative solutions in structural system and **Interpret the results.** | 2 |
| | PO 4 | Analyse the structural repsonse of a gien loading function by Selecting the appropriate method for different structural elements by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO4 | PO1 | Independently carry out research / investigation by **resource identification, implementation and demonstrate the solution** related to a given structure and develop the structural reponse using duhamel's integration. | 2 |

| Course Outcomes | PO'S | Justification for mapping (Students will be able to) | No. of Key competencies matched. |
|---|---|---|---|
| | PO4 | Apply the knowldege of duhamel's integration to get the response of a structure by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.** | 2 |
| | PO5 | Analyse the structural systems for the design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO5 | PO3 | Analyze the given **problem statement** and find the response of a two degree freedom system subjected to free and forced vibrations to establish innovative solutions in structural system and **Interpret the results.** | 2 |
| | PO4 | Demonstrate the importance of response of structure in analysing the two degree freedom system by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish solutions.** | 2 |
| | PO5 | Utilize the concepts of response of structure for the analysis and design of civil engineering structures understanding **experimental design, design process, requirements of engineering activities, legal requirements, safety and risk issues.** | 4 |
| CO6 | PO3 | Analyze the given **problem statement** and find the solution of multiple degree freedom system for frequencies, modes and mode shapes using different methods for innovative solutions in structural system and **Interpret the result** on various applications. | 2 |
| | PO4 | Analyse the multiple degree freedom systems for frequncies, modes and mode shapes by applying **knowledge, understanding and demonstrations of structural applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate effectively in writing / orally societal problems.** | 4 |

## 29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | 2 | 4 | - | - |
| CO 2 | 2 | - | - | 4 | 4 | - |
| CO 3 | 2 | - | 2 | 4 | 4 | - |

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 4 | 2 | - | - | 2 | 4 | - |
| CO 5 | - | - | 2 | 2 | 4 | - |
| CO 6 | - | - | 2 | 4 | - | - |

## 30. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 28.5 | 50.0 | 0.0 | 0.0 |
| CO 2 | 28.5 | 0.0 | 0.0 | 50.0 | 80.0 | 0.0 |
| CO 3 | 28.5 | 0.0 | 28.5 | 50.0 | 80.0 | 0.0 |
| CO 4 | 28.5 | 0.0 | 0.0 | 25.0 | 80.0 | 0.0 |
| CO 5 | 0.0 | 0.0 | 28.5 | 25.0 | 80.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 28.5 | 50.0 | 0.0 | 0.0 |

## 31. COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.
***0*** - $0 \leq$ C$\leq$ 5% – No correlation
***1*** -5 <C$\leq$ 40% – Low/ Slight
***2*** - 40 % <C $<$ 60% –Moderate
***3*** - 60% $\leq$ C $<$ 100% – Substantial /High

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 |
| CO 2 | 1.0 | 0.0 | 0.0 | 2.0 | 3.0 | 0.0 |
| CO 3 | 1.0 | 0.0 | 1.0 | 2.0 | 3.0 | 0.0 |
| CO 4 | 1.0 | 0.0 | 0.0 | 1.0 | 3.0 | 0.0 |
| CO 5 | 0.0 | 0.0 | 1.0 | 1.0 | 3.0 | 0.0 |
| CO 6 | 0.0 | 0.0 | 1.0 | 2.0 | 0.0 | 0.0 |
| **Total** | 2.0 | 0.0 | 3.0 | 10.0 | 12.0 | 0.0 |
| **Average** | 1 | 0 | 1 | 2 | 3 | 0 |

## 32. ASSESSMENT METHODOLOGY-DIRECT:

| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
|---|---|---|---|---|---|
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | - | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## 33. ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## 34. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| **S.No** | **Topics to be covered** | **CO's** | **Reference T1: R1:** |
|---|---|---|---|
| | **OBE DISCUSSION** | | |
| 1 | Discussion on OBE, POs and COs of Structural Dynamics | | |
| | **CONTENT DELIVERY (THEORY)** | | |
| 1 | Introduction | CO1 | T1,T2 |
| 2 | Basic concepts of vibration | CO1 | T1,T2 |
| 3 | Dynamic loading | CO1 | T1,T2 |
| 4 | Comparison of static loading and dynamic loading | CO1 | T1,T2 |
| 5 | Causes od dynamic effects | CO1 | T1,T2 |
| 6 | Basic definitions types of vibration | CO1 | T1,T2 |
| 7 | Degrees of freedom, SHM | CO1 | T1,T2 |
| 8 | Consequences of vibration | CO1 | T1,T2 |
| 9 | Introduction to undamped vibrations | CO1 | T1,T2 |
| 10 | Vibration analysis | CO1 | T1,T2 |
| 11 | Free vibration of undamped SDOF system | CO1 | T1,T2 |
| 12 | Derivation of equation of motion | CO2 | T1,T2 |
| 13 | Solution of the equation of motion | CO2 | T1,T2 |
| 14 | Equivalent stiffness of spring combinations | CO2 | T1,T2 |
| 15 | Natural frequency, time period | CO2 | T1,T2 |
| 16 | Influence of gravitational force | CO2 | T1,T2 |
| 17 | Introduction types of damping | CO2 | T1,T2 |

| | | | |
|---|---|---|---|
| 18 | Measurement of damping | CO2 | T1,T2 |
| 19 | Introduction to harmonic excitation | CO2 | T1,T2 |
| 20 | Undamped harmonic excitation | CO2 | T1,T2 |
| 21 | Damped harmonic excitation | CO2 | T1,T2 |
| 22 | Characteristics curves | CO2 | T1,T2 |
| 23 | Measurement of damping | CO3 | T1,T2 |
| 24 | Vibration measuring instruments | CO3 | T1,T2 |
| 25 | Vibration isolation | CO3 | T1,T2 |
| 26 | Introduction to periodic loading | CO3 | T1,T2 |
| 27 | Fourier series and analysis and response | CO3 | T1,T2 |
| 28 | Derive an expression for the response of an SDOF system for the given loading function | CO3 | T1,T2 |
| 29 | Derive an expression for the response of an SDOF system for the given loading function | CO3 | T1,T2 |
| 30 | Introduction to impulsive loading | CO4 | T1,T2 |
| 31 | Differential equation method | CO4 | T1,T2 |
| 32 | Duhamel's integral | CO4 | T1,T2 |
| 33 | Concept of shear building | CO5 | T1,T2 |
| 34 | Free vibrations of undamped system | CO5 | T1,T2 |
| 35 | Damped free vibration | CO5 | T1,T2 |
| 36 | Forced vibrations of undamped system | CO5 | T1,T2 |
| 37 | Forced vibrations of damped system | CO5 | T1,T2 |
| 38 | Free vibration analysis | CO6 | T1,T2 |
| 39 | Undamped system | CO6 | T1,T2 |
| 40 | Natural frequencies and normal modes | CO6 | T1,T2 |
| 41 | Orthogonality and normality principles | CO6 | T1,T2 |
| 42 | Damped systems, decoupling of equations | CO6 | T1,T2 |
| 43 | Superposition method | CO6 | T1,T2 |
| 44 | Forced vibration | CO6 | T1,T2 |
| 45 | Forced vibration examples | CO6 | T1,T2 |
| **PROBLEM SOLVING/ CASE STUDIES** | | | |
| 1 | Problems on equation of motion | CO 1 | T1,T2 |
| 2 | Problems on equivalent stiffness | CO 2 | T1,T2 |
| 3 | Problems on natural frequency and time period | CO 2 | T1,T2 |
| 4 | Problems on measurement of damping | CO 2 | T1,T2 |
| 5 | Problems on hormonic excitation of system | CO 2 | T1,T2 |
| 6 | Problems on fourier series and respose analysis | CO 3 | T1,T2 |
| 7 | Problems on response of single degree freedom system | CO 3 | T1,T2 |

| | | | |
|---|---|---|---|
| 8 | Problems on impulsive loading | CO 4 | T1,T2 |
| 9 | Problems on differential equation method | CO 4 | T1,T2 |
| 10 | Problems on duhamel's integral | CO 4 | T1,T2 |
| 11 | Problems on free and forced vibration undamped system | CO 5 | T1,T2 |
| 12 | Problems on free and forced vibration damped system | CO 5 | T1,T2 |
| 13 | Problems on natural frequencies and normal modes | CO 6 | T1,T2 |
| 14 | Problems on superposition method | CO 6 | T1,T2 |
| **DISCUSSION OF DEFINITION AND TERMINOLOGY** | | | |
| 1 | Concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force | CO 1 | T1,T2 |
| 2 | Types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation | CO2 | T1,T2 |
| 3 | Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral. | CO3, CO4 | T1,T2 |
| 4 | Concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system. | CO5 | T1,T2 |
| 5 | Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration. | CO6 | T1,T2 |
| **DISCUSSION OF QUESTION BANK** | | | |
| 1 | Concepts of vibration, dynamic loading, comparison of static loading and dynamic loading, causes od dynamic effects, basic definitions types of vibration, response of the system, degrees of freedom, SHM, Consequences of vibration. Introduction to undamped vibrations, vibration analysis, free vibration of undamped SDOF system, derivation of equation of motion, solution of the equation of motion, equivalent stiffness of spring combinations, natural frequency, time period, influence of gravitational force | CO1 | T1,T2 |

| | | | |
|---|---|---|---|
| 2 | Types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation | CO2 | T1,T2 |
| 3 | Fourier series and analysis and response, derive an expression for the response of an SDOF system for the given loading function. Introduction to impulsive loading, differential equation method, Duhamel's integral. | CO3, CO4, | T1,T2 |
| 4 | Concept of shear building, free vibrations of undamped system, damped free vibration, forced vibrations of undamped system, forced vibrations of damped system. | CO5 | T1,T2 |
| 5 | Free vibration analysis, undamped system, natural frequencies and normal modes, orthogonality and normality principles, damped systems, decoupling of equations, superposition method, forced vibration. | CO6 | T1,T2 |

**Signature of Course Coordinator** **HOD,CE**
**Dr. Venu M**

# INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

## COURSE DESCRIPTION

<table>
<tr><td>Department</td><td colspan="5">Civil Engineering</td></tr>
<tr><td>Course Title</td><td colspan="5">DESIGN OF ADVANCED CONCRETE STRUCTURES</td></tr>
<tr><td>Course Code</td><td colspan="5">BSTE15</td></tr>
<tr><td>Program</td><td colspan="5">M.Tech(ST)</td></tr>
<tr><td>Semester</td><td colspan="5">II</td></tr>
<tr><td>Course Type</td><td colspan="5">Elective</td></tr>
<tr><td>Regulation</td><td colspan="5">MT25</td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>3</td><td>-</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr Gude Ramakrishna, Assistant Professor</td></tr>
</table>

## I COURSE PRE-REQUISITES:

| **Level** | **Course Code** | **Semester** | **Prerequisites** |
|---|---|---|---|
| - | - | - | - |

## II COURSE OVERVIEW:

Design of reinforced concrete structures is an introductory design course in civil engineering. In this course, basic elements governed by bending, shear, axial forces or combination of them are identified and are considered as building blocks of the whole structure. The design will be done as per IS 456:2000.

## III MARKS DISTRIBUTION:

| **Subject** | **SEE Examination** | **CIE Examination** | **Total Marks** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Design of Advanced Concrete Structures | 60 Marks | 40 Marks | 100 |

## IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | PPT | ✓ | Chalk & Talk | x | Assignments | x | MOOC |
| x | Open Ended Experiments | ✓ | Seminars | x | Mini Project | x | Videos |
| x | Others | | | | | | |

## V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

**Semester End Examination (SEE):** The SEE is conducted for 60 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria .

| | |
|---|---|
| 50% | To test the objectiveness of the concept |
| 30 % | To test the analytical skill of the concept |
| 20 % | To test the application skill of the concept |

**Continuous Internal Assessment (CIA):**

CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper Outline of the Continuous Internal Assessments (CIA– 1 and CIA– 2) and SEE

| Activities | CIA- I | CIA- II | SEE | Total Marks |
|---|---|---|---|---|
| Continuous Internal Examination( CIE) | 10 Marks | 10 Marks | - | 20 Marks |
| Assignment / Quiz | 05 Marks | 05 Marks | - | 10 Marks |
| Alternative Assessment Tool (AAT) | 05 Marks | 05 Marks | - | 10 Marks |
| Semester End Examination (SEE) | - | - | 60 Marks | 60 Marks |
| Total | - | - | - | 100 Marks |

**Continuous Internal Examination (CIE ):**
100 Marks CIA is conducted for a total of 40 marks, with 30 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment and AAT shall be considered for computing the final CIA of a student in a given course.
**Technical Seminar and Term Paper:**
Twoseminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations. Page

## VI COURSE OBJECTIVES:

**The students will try to learn:**

| | |
|---|---|
| I | The design of special structures by understanding their behavior in terms of shear force and bending moment. |
| II | Design and prepare detail structural drawings for execution citing relevant IS codes. |
| III | The Design independently civil engineering structures as per the requirements of client and provide detailed design drawings, quality control reports during construction for ensuring quality and economical structures. |

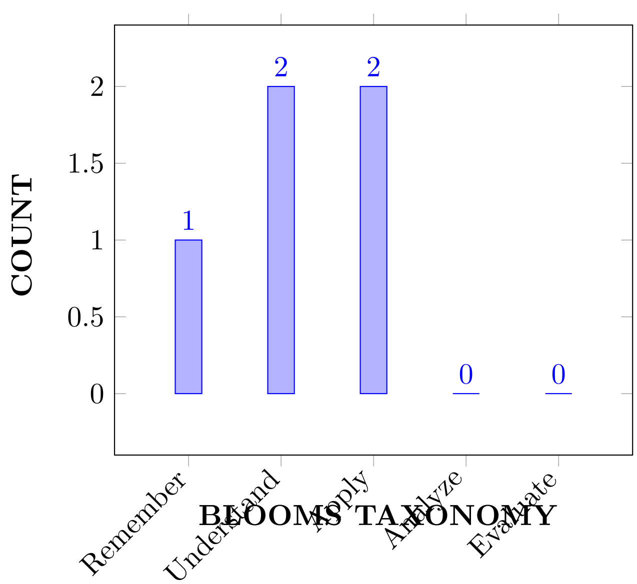
## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** the behavior of reinforced concrete under flexure and shear for designing beams, slabs and columns under various load condition. | Remember |

| | | |
|---|---|---|
| CO 2 | **Explain** the concepts of plastic hinge and plastic moment for understanding the redistribution of moments and moment rotation characteristics of reinforced concrete members. | Understand |
| CO 3 | **Analyse** flat and ribbed slabs under given loading for designing and obtaining the reinforcement detailing in end and middle strips of the slab. | Apply |
| CO 4 | **Analyse** the load distribution in deep beams for designing and fixing of reinforcement details in deep beams. | Apply |
| CO 5 | **Develop** the concept of axial, uni-axial and bi-axial loading on compression members for designing the same to meet the safety and serviceability conditions. | Understand |
| CO 6 | **Analyse** the soil properties for designing various types of footings for transferring the superimposed loads safely to the soil beneath. | Apply |

## COURSE KNOWLEDGE COMPETENCY LEVEL



## VIII PROGRAM OUTCOMES:

| | **ProgramOutcomes** |
|---|---|
| PO 1 | Anability to Independently carry out research/investigation and developmen twork to solve practical problems. |
| PO 2 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 3 | An ability to Write and present a substantial technical report/document. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engagein life-long learning for continuing education in research-level studies and professiona ldevelopment. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| **Program** | | **Strength** | **Proficiency Assessed by** |
|---|---|---|---|
| PO 1 | **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. | 3 | CIE,SEE |
| PO 2 | Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. | 1 | CIE,SEE |
| PO 3 | Design/Development of Solutions: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations | 1 | CIE,SEE |
| PO 5 | Modern Tool Usage: Create, select, 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 | 2 | CIE,SEE |

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

## X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

| Program | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PSO 1 | Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards | 3 | CIA,SEE |

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

## XI MAPPING OF EACH CO WITH PO(s):

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | ✓ | - | - | ✓ | - | - |
| CO 2 | ✓ | - | ✓ | ✓ | ✓ | - |
| CO 3 | ✓ | - | ✓ | ✓ | - | - |
| CO 4 | ✓ | - | ✓ | ✓ | ✓ | - |
| CO 5 | ✓ | - | ✓ | ✓ | - | - |
| CO 6 | - | - | - | ✓ | ✓ | - |

## XII JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

| COURSE OUTCOMES | PO'S PSO'S | Justification for mapping (Students will be able to) | No. of Key Competencies |
|---|---|---|---|
| CO 1 | PO 1 | Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesto classify various rocket propulsion systems and missiles | 3 |
| | PO 2 | Identify the problem statement (mission requirement), select the appropriate missile required for destroying target by reviewing the literature (information and data collection) suitable to mission requirement | 2 |

| | | | |
|---|---|---|---|
| CO 2 | PO 1 | Apply the knowledge of Mathematics, Sciences and Engineering fundamentals principlesand derive the rocket thrust equation under different flight conditions | 3 |
| | PO 2 | Analyze the performance parameters of rocket and various forces acting on a rocket using first principles of Mathematics and engineering sciences. | 2 |
| CO 3 | PO 1 | Identify various chemical rocket propulsion systemsand its propellants using principles of mathematics, science, and engineering fundamentals. | 3 |
| CO 4 | PO 1 | Apply the knowledge of different forces (scientific Principles and mathematical principles) for chemical rocket engine and describe different performance parameters. | 3 |
| | PO 2 | Determine the grain parameters and rocket performance parameters using first principles and Mathematics and Engineering sciences. | 2 |
| | PO 5 | Illustrate Thrust vs time graph of solid rocket motor using modern Engineering and IT tools (Matlab) to solve complex engineering problems. | 1 |
| CO 5 | PO 1 | Understand the advantages of solid propellant, monopropellant and Bi-propellant to determine the desirable properties of oxidizer, Inert gas and fuel using the fundamentals of engineering and mathematical equations | 3 |
| CO 6 | PO 1 | Analyze different Engine cycles used for propulsion system of a chemical rocket engine using fundamentals of science &and engineering fundamentals. | 3 |
| | PO 2 | Categorize the concept of Pyrotechnics based on its physical state and its usage in complex engineering problems. | 3 |
| | PO 3 | Investigate and define a problem and identify constraints of Pyrotechnics including environmental and sustainability limitations, health and safety and risk assessment issues when dealing with performance of gaseous mixtures and their application on real world problems | 2 |
| CO 7 | PO 1 | Understand (knowledge) different combustion instabilities w.r.t time for various chemical rocket engines during flight by applying the knowledge of sciences and Engineering fundamentals principles | 3 |
| | PSO 1 | Synthesize and analyze different combustion systems for non-air breathing engines to provide thrust for the Rockets and missiles | 2 |
| CO 8 | PO 1 | Describe (Knowledge) different guidance phases and guidance systems for a cruise and ballistic missile using principles of mathematics, natural science, and engineering fundamentals. | 3 |

| | | | |
|---|---|---|---|
| | PSO 2 | Extend the focus to understand the innovative and dynamic challenges involve the guidance system of rocket and missiles for specific role. | 1 |
| CO 9 | PO 1 | Evaluate the performance characteristics of single stage and multistage rocket using the basic understanding of engineering science and mathematical equations | 3 |
| | PO 2 | Identify the problem statement (mission requirement), select the number of stages required for placing a payload into the orbit by reviewing the literature (information and data collection) suitable to mission requirement | 2 |
| CO 10 | PO 1 | Apply the knowledge of engineering fundamentals to test the prototype of rockets and various safety measures that should be taken while testing. | 3 |
| CO 11 | PO 1 | Apply the knowledge of Sciences and Engineering fundamentals for design and development of TVC mechanism and cooling systems for rocket propulsion system. | 3 |
| | PO 2 | Identify the proper cooling system and TVC mechanism for a chemical rocket engine (complex system) using first principle of natural sciences and Engineering sciences. | 2 |
| CO 12 | PO 1 | Apply the knowledge of sciences and Engineering fundamentals principles to design a prototype of different rocket components. | 3 |
| | PO 5 | Make use of computational/ Experimental tools to synthesize and analyze rocket aerodynamics by application of Modern tools. | 1 |
| | PO 12 | Make use of broad knowledge of propellant composition in innovative, dynamic challenging environment for design and development of new products. | 4 |

## XIII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| **Course Outcomes** | **PROGRAM OUTCOMES** | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | - | - | - | 2 | - | - |
| CO 2 | - | - | 3 | 3 | 2 | - |
| CO 3 | - | - | 2 | 2 | - | - |
| CO 4 | - | - | 2 | 2 | 1 | - |
| CO 5 | - | - | 2 | 3 | - | - |
| CO 6 | - | - | 1 | - | 1 | - |

## XIV PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 37.50 | - | - | 25 | - | - |
| CO 2 | 25 | - | 42.85 | 37.50 | 40 | - |
| CO 3 | 25 | - | 28.57 | 25 | - | - |
| CO 4 | 37.5 | - | 28.57 | 25 | 100 | - |
| CO 5 | 100 | - | 28.57 | 37.5 | - | - |
| CO 6 | - | - | 15 | - | 12.70 | - |

## XV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq$ C$\leq$ 5% – No correlation
***1*** -5 <C$\leq$ 40% – Low/ Slight
***2*** - 40 % <C < 60% –Moderate
***3*** - 60% $\leq$ C < 100% – Substantial /High

| Course Outcomes | PROGRAM OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| CO 1 | 3 | - | - | 2 | - | - |
| CO 2 | 2 | - | 3 | 3 | 3 | - |
| CO 3 | 2 | - | 3 | 2 | - | - |
| CO 4 | 2 | - | 3 | 2 | 3 | - |
| CO 5 | 3 | - | 2 | 3 | - | - |
| CO 6 | - | - | 1 | - | 3 | - |
| **Total** | 12 | - | 12 | 12 | 9 | - |
| **Average** | 2 | - | 3 | 2 | 3 | – |

## XVI ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | ✓ |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | 5 Minutes Video | ✓ | Open Ended Experiments | - |
| Assignments | ✓ | | | | |

## XVII ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## XVIII SYLLABUS:

| | |
|---|---|
| MODULE I | **BASIC DESIGN CONCEPTS** |
| | Behavior in flexure, design of singly reinforced rectangular sections, design of doubly reinforced rectangular sections, design of flanged beams, design of shear, design for torsion, Limit state of serviceability: Deflections of reinforced concrete beams and slabs, short term deflection and long-term deflection, estimation of crack width in RCC members, calculation of crack widths. |
| MODULE II | **LIMIT ANALYSIS OF R.C. STRUCTURES** |
| | Rotation of a plastic hinge, redistribution of moments, moment rotation characteristics of RC member, I.S. code provisions, applications for fixed and continuous beam. Yield line analysis for slabs: Upper bound and lower bound theorems, yield line criterion, virtual work and equilibrium methods of analysis for square and circulars slabs with simple and continuous end conditions. |
| MODULE III | **DESIGN OF RIBBED SLABS, FLAT SLABS** |
| | Analysis of the slabs for moment and shears, ultimate moment of resistance, design for shear, deflection, arrangement of reinforcements. Flat slabs: Direct design method, distribution of moments in column strips and middle strip moment.<br>Shear transfer from slabs to columns, shear in flat slabs, check for one way and two-way shears, introduction to equivalent frame method. Limitations of direct design method, distribution of moments in column strips and middle strip. |
| MODULE IV | **DESIGN OF REINFORCED CONCRETE DEEP BEAMS AND CORBEL** |
| | Steps of designing deep beams, design by IS 456, checking for local failures, detailing of deep beams, design of curved beams, analysis of forces in a corbel, design of procedure of corbels, design of nibs. |
| MODULE V | **DESIGN OF CHIMNEY, BUNKER AND SILOS** |
| | Design of chimneys: parts of chimney, design factors, stresses in RC shafts due to self-weight, wind load and temperature difference, reinforcement details, Design of bunkers and silos: Difference between bunker and silo, design of square or rectangular bunkers, design of circular bunkers, design of silos, Design concepts and IS code provisions. |

### TEXTBOOKS


1. Pillai S. U. and Menon D, Reinforced Concrete Design", Tata McGraw-Hill, 3rd edition, 1999.

2. Reinforced concrete design by S. Unnikrishna Pillai and Menon, Tata McGraw Hill, 3rd edition, 2009

3. Park R. and Paulay T, "Reinforced Concrete Structures", John Wiley and Sons, 1995.


### REFERENCE BOOKS:

1. Varghese P. C, "Advanced Reinforced Concrete Design", Prentice Hall of India, New Delhi, 1995.
2. Hsu T. T. C. and Mo Y. L, "Unified Theory of Concrete Structures", John Wiley and Sons, 2010.
3. Salmon C. G., Johnson J. E. and Malhas F. A. "Steel Structures Design and Behavior Emphasizing Load and Resistance Factor Design", Pearson Education, 5th Edition, 2009.
4. Ramchandra, "Design of Steel Structures", Vol. II, Standard Book House, Delhi, 1999.

## XIX COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | **Topics to be covered** | **CO's** | **Reference T1: 4.1** |
|---|---|---|---|
| 1-2 | Behavior in flexure, design of singly reinforced rectangular sections | CO 1, CO 2 | T2: 1.1-1.5, |
| 3-4 | Design of doubly reinforced rectangular sections | CO 1 | T2: 2.1-2.2, |
| 5-6 | design of flanged beams | CO 1 | T2: 2.3-2.4 |
| 7-8 | Deflections of reinforced concrete beams | CO 1 | T2: 2.5-2.6, |
| 9-10 | short term deflection and long-term | CO 4 | T2: 3.3 |
| 11-12 | Rotation of a plastic hinge, redistribution of moments | CO 3 | T2: 3.4 |
| 13-14 | Design considerations, propellant grain design, grain mechanical properties. | CO 5 | T2: 3.3 |
| 15-16 | For square and circulars labs with simple and continuous end conditions. | CO 3 | R2: 4.2 |
| 17-18 | Moment rotation characteristics of RC member | CO 4 | T2: 5.1 |
| 19-20 | Analysis of the slabs for moment and shears, ultimate moment of resistance | CO 6 | T2: 5.2 |
| 21-22 | Square and circulars slabs with simple and continuous end conditions | CO 3 | T2: 4.5 |
| 23-24 | Thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations. | CO 3 | T1: 4.1 |
| 25-26 | , s, design of curved beams, analysis of forces in a corbel, design of procedure of corbels, design of nibs. | CO 5 | T1: 4.2 |
| 27-28 | Steps of designing deep beams, design by IS 456 | CO 4 | T1: 4.3 |
| 29-30 | Checking for local failures, detailing of deep beam | CO | T2: 5.2 |
| 31-32 | Aerodynamic control systems of missiles, | CO 2 | T2: 5.2 |
| 33-34 | Design of chimneys: parts of chimney, design factors | CO 5 | T2: 5.2 |

| | | | |
|---|---|---|---|
| 35-36 | Stresses in RC shafts due to self-weight, wind load and temperature difference, reinforcement details | CO 5 | R3: 7.2 |
| 37-38 | Design of bunkers and silos | CO 6 | T1: 7.5 |
| 39 | Design concepts and IS code provisions | CO 6 | R2:7.5 |

**Signature of Course Coordinator** **HOD,CE**

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

## MAINTENANCE AND REHABILITATION OF STRUCTURES COURSE TEMPLATE

<table>
<tr><td>1</td><td>Department</td><td colspan="5">CIVIL ENGINEERING (STRUCTURAL ENGINEERING)</td></tr>
<tr><td>2</td><td>Course Title</td><td colspan="5">MAINTENANCE AND REHABILITATION OF STRUCTURES</td></tr>
<tr><td>3</td><td>Course Code</td><td colspan="5">BSTE22</td></tr>
<tr><td>4</td><td>Program</td><td colspan="5">M. Tech (STE)</td></tr>
<tr><td>5</td><td>Semester</td><td colspan="5">II Semester</td></tr>
<tr><td>6</td><td>Regulation</td><td colspan="5">MT-25</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Structure of the course</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture<br>3</td><td>Tutorials<br>0</td><td>Credits<br>3</td><td>Lab<br>-</td><td>Credits<br>-</td></tr>
<tr><td>8</td><td>Type of course<br>(Tick type of course)</td><td>Core<br>-</td><td>Professional Elective<br>✓</td><td>Open Elective<br>-</td><td>VAC<br>-</td><td>MOOCs<br>-</td></tr>
<tr><td>9</td><td>Course Offered</td><td colspan="2">Odd Semester X</td><td colspan="3">Even Semester ✓</td></tr>
<tr><td rowspan="2">10</td><td colspan="6">Total lecture, tutorial and practical hours for this course (16 weeks of teaching per semester)</td></tr>
<tr><td colspan="2">Lectures: ....... hours</td><td colspan="2">Tutorials: ....... hours</td><td colspan="2">Practical: ....... hours</td></tr>
<tr><td>11</td><td>Course Coordinator</td><td colspan="5">Mr. Gude Ramakrishna</td></tr>
<tr><td>12</td><td>Date Approved by BOS</td><td colspan="5">DD/MM/YYYY</td></tr>
<tr><td>13</td><td>Course Webpage</td><td colspan="5">www.iare.ac.in/—-/—-</td></tr>
<tr><td rowspan="3">14</td><td rowspan="3">Course Prerequistes</td><td>Level</td><td>Course Code</td><td>Semester</td><td colspan="2">Prerequisites</td></tr>
<tr><td>B.Tech</td><td></td><td>I</td><td colspan="2">-</td></tr>
<tr><td>B.Tech</td><td></td><td>I</td><td colspan="2">-</td></tr>
</table>

## 15 COURSE OVERVIEW:

Maintenance and Rehabilitation of Structures focus on extending the service life of civil engineering structures through systematic inspection, repair, strengthening, and preventive measures. This course provides an overview of structural deterioration mechanisms, condition assessment methods, and modern rehabilitation techniques in line with national and international standards. It emphasizes durability, safety, and sustainability by integrating advanced repair materials, non-destructive testing (NDT) technologies, and retrofitting strategies. Topics include causes of structural damage, evaluation and monitoring tools, repair and strengthening methods, rehabilitation of concrete, steel, and masonry structures, use of composites and polymers, seismic retrofitting, and case studies of restoration projects to ensure structural resilience and long-term performance.

## 16. Employability Skills

| |
|---|
| **Example: Communication skills / Programming skills / Project based skills /** |
| **Analytical skills / Problem-solving skills / Structural analysis skills** |
| **Mathematical modeling skills / Engineering judgment skills** |
| **STechnical communication skills / Project-based learning skills** |

## 17. Relevance to Sustainability goals

Write brief description about the course and how its relevance to SDGs.

| | | |
|---|---|---|
| 4 | QUALITY EDUCATION | **Quality Education:**Enhancing technical knowledge and employability skills through engineering education. |
| 8 | DECENT WORK AND ECONOMIC GROWTH | Developing problem-solving and project-based skills to increase employability and entrepreneurship opportunities. |
| 9 | INDUSTRY, INNOVATION AND INFRASTRUCTURE | Promoting innovation through mathematical modeling, structural analysis, and numerical methods to improve engineering practices. |
| 11 | SUSTAINABLE CITIES AND COMMUNITIES | Applying engineering skills to design and maintain sustainable and resilient structures and communities. |

## 18. Content Delivery / Instructional Methologies:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Power Point Presentation | ✓ | Chalk & Talk | ✓ | Assignments | x | MOOC |
| x | Open Ended Experiments | x | Seminars | x | Mini Project | ✓ | Videos |

## 19. Evaluation Methodology:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal

Assessment (CIA) and 60 marks for Semester End Examination (SEE). CIA is conducted for a total of 40 marks, with 20 marks for Continuous Internal Examination (CIE), and and 05 marks for each Definitions and Terminology / Quiz and remaining 10 marks for Tech Talk / Assignments.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

<table>
<tr><th>Activities</th><th>CIA - I</th><th>CIA - II</th><th>SEE</th><th>Total Marks</th></tr>
<tr><td>Continuous Internal Examination (CIE)</td><td>10 Marks</td><td>10 Marks</td><td rowspan="3"></td><td>20 Marks</td></tr>
<tr><td>Definitions and Terminology / Quiz</td><td>05 Marks</td><td>05 Marks</td><td>10 Marks</td></tr>
<tr><td>Tech Talk / Assignment</td><td>05 Marks</td><td>05 Marks</td><td>10 Marks</td></tr>
<tr><td>Semester End Examination (SEE)</td><td>-</td><td>-</td><td>60 Marks</td><td>60 Marks</td></tr>
<tr><td>Total</td><td>-</td><td>-</td><td colspan="2">100 Marks</td></tr>
</table>

**Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 12 marks. There could be a maximum of two sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

| Percentage of Cognitive Level | Blooms Taxonomy Level |
|---|---|
| 10% | Remember |
| 35% | Understand |
| 55% | Apply |

## 20. COURSE OBJECTIVES:

**The students will try to learn:**

| | |
|---|---|
| I | Fundamentals of structural deterioration, distress mechanisms, and durability concerns affecting the service life of civil engineering structures. |
| II | Structural health assessment using non-destructive testing (NDT), condition evaluation, and monitoring techniques for identifying damage and performance issues. |
| III | Advanced repair, strengthening, and retrofitting techniques using modern materials and sustainable technologies to enhance structural performance and resilience. |
| IV | Case studies on maintenance, rehabilitation, and seismic retrofitting to understand effective practices, challenges, and strategies for extending structural life cycles. |

## 21 COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | **Explain** the concepts of repair, retrofitting, strengthening, and rehabilitation by analyzing deterioration mechanisms and preventive measures for improving the durability of concrete structures. | Understand |
| CO 2 | **Evaluate** corrosion mechanisms in steel reinforcement and assess structural damages due to fire, climate, and material deficiencies by applying destructive, non-destructive, and semi-destructive testing systems. | Understand |
| CO 3 | **Apply** modern repair and strengthening techniques such as grouting, shotcreting, jacketing, and fiber wrapping for effective rehabilitation of masonry and concrete structures. | Understand |
| CO 4 | **Evaluate** corrosion protection methods and crack repair techniques for improving durability and long-term performance of concrete and masonry structures. | Remember |
| CO 5 | **Analyze** maintenance and retrofitting techniques such as jacketing, externally bonded reinforcement, and seismic rehabilitation strategies for enhancing safety and service life. | Apply |
| CO 6 | **Utilize** advanced materials such as fiber-reinforced polymers, epoxy resins, special concretes, and monitoring tools for effective repair, retrofitting, and health assessment of structures. | Apply |

## 22. Topic Learning Outcome (TLOs):

| **TLO No** | **Topic Learning Outcome's** | **Course Outcome:** | Blooms Level |
|---|---|---|---|
| TLO 1 | Elasticity, notation for forces and stresses, components of stresses, components of strain, Hooke's law. | CO 1 | Understand |
| TLO 2 | Constitutive relationships for stress and strain in linear elastic solids. | CO 1 | Create |
| TLO 3 | Plane stress and plane strain analysis. | CO 1 | Analyze |
| TLO 4 | Differential equations of equilibrium and compatibility conditions. | CO 1 | Understand |
| TLO 5 | Airy's stress function and boundary conditions. | CO 2 | Apply |
| TLO 6 | Solution of two-dimensional problems in rectangular coordinates. | CO 2 | Apply |
| TLO 7 | Solution of two-dimensional problems in polar coordinates. | CO 2 | Analyze |
| TLO 8 | Principal stresses, principal strains, and stress invariants. | CO 2 | Analyze |
| TLO 9 | Stress distribution in beams under bending. | CO 3 | Analyze |
| TLO 10 | Stress distribution in beams under shear. | CO 3 | Apply |
| TLO 11 | Torsion of circular shafts and thin-walled tubes. | CO 3 | Understand |
| TLO 12 | Torsion of non-circular sections. | CO 3 | Analyze |

| TLO No | Topic Learning Outcome's | Course Outcome: | Blooms Level |
|---|---|---|---|
| TLO 13 | Strain energy and energy methods in elasticity. | CO 4 | Understand |
| TLO 14 | Castigliano's theorems and applications to beams and frames. | CO 4 | Apply |
| TLO 15 | Introduction to stiffness method for elasticity problems. | CO 4 | Create |
| TLO 16 | Differential equations for displacement and stresses in elasticity. | CO 4 | Apply |
| TLO 17 | Finite element basics for stress and deformation analysis. | CO 5 | Understand |
| TLO 18 | Torsion of prismatic bars with different cross-sections. | CO 5 | Analyze |
| TLO 19 | Stress concentration factors and their significance. | CO 5 | Analyze |
| TLO 20 | Introduction to plasticity: concepts and assumptions. | CO 6 | Understand |
| TLO 21 | Ideally plastic solids and yield criteria. | CO 6 | Analyze |
| TLO 22 | Strain hardening and plastic potential surfaces. | CO 6 | Analyze |
| TLO 23 | Flow rule and stress-strain relations in plasticity. | CO 6 | Analyze |
| TLO 24 | Multi-axial loading and yield surface evolution. | CO 6 | Analyze |
| TLO 25 | Application of different yield criteria to engineering problems. | CO 6 | Analyze |

## 23. SYLLABUS:

| MODULE- I | **MAINTENANCE AND REPAIR STRATEGIES** |
|---|---|
| | Definition of Repair, Retrofitting, Strengthening and rehabilitation, Deterioration of Structures – Distress in Structures – Causes and Prevention, Mechanism of Damage – Types of Damage, Physical and Chemical Causes of deterioration of concrete structures, Evaluation of structural damages to the concrete structural elements due to earthquake. |
| MODULE- II | **CORROSION OF STEEL REINFORCEMENT** |
| | Causes – Mechanism and Prevention. Damage of Structures due to Fire – Fire Rating of Structures – Phenomena of Desiccation, Damage Assessment -,Purpose of assessment, Rapid assessment, Investigation of damage, Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems -Influence on Serviceability and Durability-Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodic protection. |
| MODULE- III | **REPAIRS TO MASONRY AND CONCRETE STRUCTURES** |

| | |
|---|---|
| | Methods of crack repair in masonry and concrete structures, routing and sealing of cracks, removal and surface preparation in masonry and concrete structures, reinforcement repair, anchorage, placement methods; Shot-creting and guniting, Grouting- Portland cement grouting, chemical grouting, Dry packing, polymer impregnation. Strengthening of structures flexural strengthening, Shear Strengthening, strengthening of columns- jacketing of Columns, strengthening by interior and external reinforcing, external Pre- stressing, Fiber wrapping, Corrosion Protection: surface treatment, joint sealants, cathodic protection. |
| MODULE- IV | **MAINTENANCE AND RETROFITTING TECHNIQUES** |
| | Definitions: Maintenance, Facts of Maintenance and importance of Maintenance Need for retrofitting, retrofitting of structural members i.e., column and beams by Jacketing technique, Externally bonding (ERB) technique, near surface mounted (NSM) technique, External post- tensioning, Section enlargement and guidelines for seismic rehabilitation of existing building, Inspection and Testing – Symptoms and Diagnosis of Distress - Damage assessment– NDT. |
| MODULE- V | **MATERIALS FOR REPAIR AND RETROFITTING** |
| | Artificial fibre reinforced polymer like CFRP, GFRP, AFRP and natural fiber like Sisal and Jute. Adhesive like, Epoxy Resin, Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete Epoxy injection, Mortar repair for cracks, shoring and underpinning- Health Monitoring of Structures – Use of Sensors – Building Instrumentation. |

## TEXTBOOKS


1. Den Campbell, Allen and Harold Roper, “Concrete Structures Materials, Maintenance and Repair”, Longman Scientific and Technical, UK, 1991.
2. Allen .R.T. and Edwards .S.C., ”Repair of Concrete Structures” Blakie and Sons, UK 1987.
3. Philip H. Perkins, “Repair, Protection and Waterproofing of Concrete Structures”, Elsevier Applied Science Publisher, London, New York, 1986.

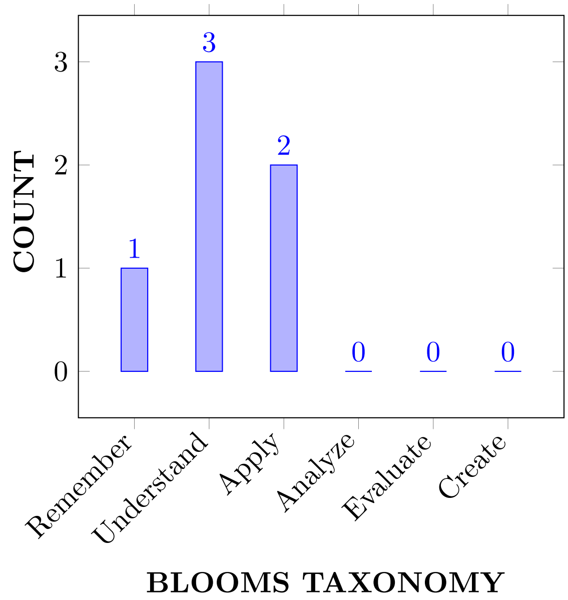

## REFERENCE BOOKS:


1. Poonam I. Modi, Chirag N. Patel, “Repair and Rehabilitation of Concrete Structures,” PHI Learning, 2016.
2. A.R. Santakumar, “Concrete Technology,” Oxford University Press, 2018.
3. Revision compbell, Allen and Itarold Roper, ”Concrete Structures Materials Maintenance and Repair” Longman Scientific and Technical UK 1991.


## WEB REFERENCES:


1. https://www.vidyarthiplus.com/vp/thread-24896.html
2. http://nptel.ac.in/courses/105101088/

## 24. COURSE KNOWLEDGE COMPETENCY LEVEL




## 25. PROGRAM OUTCOMES:

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## 26. HOW PROGRAM OUTCOMES ARE ASSESSED:

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | Engineering knowledge: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems. | 2 | CIE/SEE/AAT |

| PROGRAM OUTCOMES | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 2 | Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences | 1 | CIE/SEE/AAT |
| PO 3 | Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. | 1 | CIE/SEE/AAT |
| PO 4 | Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. | 1 | CIE/SEE/AAT |
| PO 5 | Modern Tool Usage: Create, select, 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. | 3 | CIE/SEE/AAT |

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

## 27. MAPPING OF EACH CO WITH PO(s),PSO(s):

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | ✓ | - | - |
| CO 2 | - | - | ✓ | ✓ | - | - | - | - | - | - | - | - | ✓ | ✓ | - |
| CO 3 | ✓ | ✓ | - | ✓ | - | - | - | - | - | - | - | - | ✓ | ✓ | - |
| CO 4 | ✓ | - | ✓ | - | ✓ | - | - | - | - | - | - | - | - | ✓ | - |
| CO 5 | - | - | - | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | - | ✓ | ✓ | - | - | - | - | - | - | - | ✓ | - | - |

## 28. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING -DIRECT:

| Course Outcomes | PO'S PSO'S | Justification for mapping (Students will be able to) | No. of key competencies matched. |
|---|---|---|---|
| CO 1 | PO 1 | Explain the mechanism of damages involved in the deterioration by using **engineering fundamentals and principles of science.** | 2 |
| | PO 2 | **Identify** the damages based on the symptoms and develop the solutions to prevent the **deterioration of structures** | 2 |
| | PSO 1 | Explain the mechanism of damages caused due to **environmental impacts** on residential, industrial buildings, **water treatment and distribution systems** based on **material knowledge** to **ensure the quality of structures** and to improve efficiency of **retrofitting techniques.** | 5 |
| CO 2 | PO 3 | Describe the importance of **aesthetics** and **maintenance** of structure by developing the **solutions** to avoid the **environmental** effects and safety issues. | 4 |
| | PO 4 | Understand the importance and facets of maintenance by appropriate **codes of practices and industry standards** with the **knowledge of material characteristics** and processes to **improve the quality of structures** | 3 |
| | PSO 1 | Supervise sub-structures, superstructures, and identify the performance of structures using **codes of practices, material knowledge** by **regular inspection** and remediation measures for **quality assurance.** | 4 |
| | PSO 2 | Focus on improving performance of structures with Reference to **safety & serviceability** and sustainable green building technology by assessment procedures. | 2 |
| CO 3 | PO 1 | Explain the damages and their remedies involved in the deterioration by using **engineering fundamentals and principles of science.** | 2 |
| | PO 2 | Identify the corrosion damage and explain the mechanism of corrosion which is involved in the **deterioration of structures and develop the solutions** to prevent the corrosion. | 2 |
| | PO 4 | Understand industry standards with the knowledge of **material characteristics and processes** to improve the quality of structures. | 2 |

| | | | |
|---|---|---|---|
| | PSO 1 | Explain Corrosion protection methods of residential, industrial building, **Water treatment and distribution systems** based on **material knowledge, codes of practices** to ensure the quality of structure and to improve efficiency of **retrofitting techniques.** | 5 |
| | PSO 2 | Focus on protection methods of corrosion for improving performance of structures with reference to **safety, serviceability.** | 2 |
| CO 4 | PO 1 | Identify the materials for repair and rehabilitation of structures by understanding the characteristics and applications with the basic knowledge of **engineering fundamentals.** | 1 |
| | PO 3 | Identify the materials to establish **innovative solutions** for rehabilitation of structure by considering **environmental and sustainability limitations.** | 3 |
| | PO 5 | Make use of different techniques for structural retrofitting.Select and apply appropriate techniquesfor retrofitting of structures by **understanding the limitations.** | 1 |
| | PSO 2 | Focus on protection methods of corrosion for **improving performance** of structures with reference to **safety,serviceability** | 3 |
| CO 5 | PO 4 | Perform non-destructive testing on existing structures by understanding the **industry standards and technical literature** | 2 |
| | PO 5 | Select and apply appropriate non-destructive technique to know the durability of structure by **understanding the limitations** | 1 |
| CO 6 | PO 4 | Choose suitable demolition techniques due to the quality issues of structures with the knowledge of characteristics of **particular materials, equipment**, processes and understanding the contexts in which **engineering knowledge** can be applied. | 3 |
| | PO 5 | Select and apply appropriate **demolition technique** by understanding the effect of damage of structure. | 1 |
| | PSO 1 | Explain engineered and non-engineered **techniques of strengthening**, demolition and supervise sub-structures and superstructures for residential and public buildings for **safety**. | 2 |

## 29. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 5 | - | - |
| CO 2 | - | - | 4 | 3 | - | - | - | - | - | - | - | - | 4 | 2 | - |
| CO 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - | - | 5 | 2 | - |
| CO 4 | 1 | - | 3 | - | 1 | - | - | - | - | - | - | - | - | 3 | - |
| CO 5 | - | - | - | 2 | 1 | - | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | - | 3 | 1 | - | - | - | - | - | - | - | 2 | - | - |

## 30. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 66.7 | 20 | - | - | - | - | - | - | - | - | - | - | 50 | - | - |
| CO 2 | - | - | 40 | 27.3 | - | - | - | - | - | - | - | - | 40 | 66.7 | - |
| CO 3 | 66.7 | 20 | - | 18.2 | - | - | - | - | - | - | - | - | 50 | 66.7 | - |
| CO 4 | 33.3 | - | 30 | - | 100 | - | - | - | - | - | - | - | - | 100 | - |
| CO 5 | - | - | - | 18.2 | 100 | - | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | - | 27.3 | 100 | - | - | - | - | - | - | - | 66.7 | - | - |

## 31. COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - $0 \leq$ C$\leq$ 5% – No correlation

***1-5*** <C$\leq$ 40% – Low/ Slight

***2*** - 40 % <C < 60% –Moderate

***3*** - 60% $\leq$ C < 100% – Substantial /High

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | 2 | - | - |

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 2 | - | - | 1 | 1 | - | - | - | - | - | - | - | - | 1 | 3 | - |
| CO 3 | 3 | 1 | - | 1 | - | - | - | - | - | - | - | - | 2 | 3 | - |
| CO 4 | 1 | - | 1 | - | 3 | - | - | - | - | - | - | - | - | 3 | - |
| CO 5 | - | - | - | 1 | 3 | - | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | - | 1 | 3 | - | - | - | - | - | - | - | 2 | - | - |
| TOTAL | 7 | 2 | 2 | 4 | 9 | - | - | - | - | - | - | - | 7 | 9 | - |
| AVERAGE | 2 | 1 | 1 | 1 | 3 | - | - | - | - | - | - | - | 2 | 3 | - |

## 32. ASSESSMENT METHODOLOGY-DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | - |
| Laboratory Practices | - | Student Viva | - | Certification | - |
| Term Paper | - | Concept Video | ✓ | Open Ended Experiments | - |
| Assignments | ✓ | Tech talk | ✓ | | |

## 33. ASSESSMENT METHODOLOGY-INDIRECT:

| | | | |
|---|---|---|---|
| | Assessment of mini projects by experts | ✓ | End Semester OBE Feedback |

## 34. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's | Reference T1: 4.1 |
|---|---|---|---|
| **OBE DISCUSSION** | | | |
| 1 | Course objectives, Course outcomes, Program Outcomes and CO-PO Mapping | | |
| **CONTENT DELIVERY (THEORY)** | | | |
| 2 | Introduction to Rehabilitation and Retrofitting of Structures. | CO 1 | T2:26.3<br>R2: 3.1 |
| 3 | Deterioration of structures. | CO 1 | T2:2.2.2 |

| | | | |
|---|---|---|---|
| 4 | Causes for deterioration of structures | CO 1 | T2:2.2.2<br>R3:3.7 |
| 5 | Mechanism of damage | CO 1 | T2:2.2.2 |
| 6 | types of damage. | CO 1 | T1:8.1 |
| 7 | damage under accidental loads | CO 1 | T1:7.1<br>R2: 1.2 |
| 8 | damage under cyclic loads | CO 1 | T2:3.2.3<br>R2: 1.3 |
| 9 | cracking in structures | CO 2 | T2:4.2.3 |
| 10 | cracking in structures | CO 2 | T2:4.5.2 |
| 11 | evaluation of damage | CO 2 | T2:4.7.9 |
| 12 | Defibitions of Maintenance, repair and rehabilitation | CO 2 | T2:5.2.1<br>R2: 6.4 |
| 13 | facets of maintenance | CO 3 | T2:5.4 |
| 14 | importance of maintenance | CO 3 | T2:5.5.3 |
| 15 | various aspects of inspection. | CO 3 | T2:6.2.2 |
| 16 | Assessment procedure for evaluating a damaged structure. | CO 3 | R1:2.5<br>R2: 8.2 |
| 17 | Diagnosis of construction failures. | CO 3 | R2:2.2.5<br>R2: 9.2 |
| 18 | Corrosion damage of reinforced concrete | CO 3 | R3:5.6.2 |
| 19 | methods of corrosion protection | CO 3 | R3:5.4.8<br>R2: 9.6 |
| 20 | corrosion inhibitors | CO 4 | T2:8.1.2 |
| 21 | corrosion resistant steels | CO 4 | T2:8.3.5<br>R2: 5.3 |
| 22 | cathodic protection | CO 4 | T2:8.5 |
| 23 | rust eliminators | CO 4 | T2:8.9.2 |
| 24 | Causes of deterioration of concrete | CO 4 | T2:9.2<br>R3: 4.6 |
| 25 | Causes of deterioration of steel, masonry and timber structures | CO 5 | T2:9.5.3 |
| 26 | surface deterioration | CO 6 | T2:9.6.2 |
| 27 | efflorescence, | CO 6 | T2:9.7.5<br>R3: 8.12 |
| 28 | causes and preventive measures. | CO 6 | T2:9.6.2 |
| 29 | coatings for embedded steel and set concrete. | CO 6 | T2:9.6.2 |
| 30 | Special concrete and mortar | CO 6 | T2:9.6.2 |

| | | | |
|---|---|---|---|
| 31 | concrete chemicals | CO 6 | T2:9.6.2 |
| 32 | polymer concrete. | CO 6 | T2:9.6.2 |
| 33 | sulphurinfiltrated concrete | CO 6 | T2:9.6.2 |
| 34 | ferro cement | CO 6 | T2:9.6.2 |
| 35 | fiber reinforced concrete | CO 6 | T2:9.6.2 |
| 36 | methods of repair in concrete | CO 6 | T2:9.6.2 |
| 37 | methods of repair in steel, masonry and timber structures | CO 6 | T2:9.6.2 |
| 38 | Gunite and shotcrete, epoxy injection | CO 6 | T2:9.6.2 |
| 39 | Strengthening of existing structures | CO 6 | T2:9.6.2 |
| 40 | repairs to overcome low member strength, deflection | CO 6 | T2:9.6.2 |
| 41 | repairs to overcome cracking, chemical disruption | CO 6 | T2:9.6.2 |
| 42 | weathering, wear, fire, leakage, marine exposure | CO 6 | T2:9.6.2 |
| 43 | use of non-destructive testing techniques for evaluation | CO 6 | T2:9.6.2 |
| 44 | load testing of structure | CO 6 | T2:9.6.2 |
| 45 | demolition of structures using engineered and non-engineered techniques | CO 6 | T2:9.6.2 |
| 46 | case studies | CO 6 | T2:9.6.2 |
| **PROBLEM SOLVING / CASE STUDIES** | | | |
| 1 | Rehabilitation and Retrofitting of Structures. | CO 1 | T2:26.3<br>R2: 3.1 |
| 2 | Damage of structures | CO 1 | T1:8.1 |
| 3 | Mechanism of damage and types of damage. | CO 1 | T2:2.2.2 |
| 4 | Facets of maintenance | CO 2 | T2:26.3<br>R2: 3.1 |
| 5 | various aspects of inspection. | CO 2 | T2:26.3<br>R2: 3.1 |
| 6 | Assessment procedure for evaluating a damaged structure. | CO 2 | T2:5.2.1<br>R2: 6.4 |
| 7 | Different methods of corrosion protection. | CO 3 | T2:26.3<br>R2: 3.1 |
| 8 | Different causes and preventive measures of surface deterioration and efflorescence. | CO 3 | T2:26.3<br>R2: 3.1 |
| 9 | different methods of repairs in concrete, steel, masonry and timber structures. | CO 4 | T2:26.3<br>R2: 3.1 |
| 10 | strengthening techniques for existing structures. | CO 4 | T2:26.3<br>R2: 3.1 |

| | | | |
|---|---|---|---|
| 11 | Various repair works to overcome low member strength, deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure. | CO 4 | T2:9.2<br>R3: 4.6 |
| 12 | Non –destructive techniques for evaluation. | CO 5 | T2:26.3,<br>R2: 3.1 |
| 13 | Gunite and shotcrete, epoxy injection | CO 5 | T2:26.3<br>R2: 3.1 |
| 14 | demolition of structure using engineered technique. | CO 6 | T2:26.3<br>R2: 3.1 |
| 15 | Non-engineered techniques used for demolition of structures. | CO 6 | T2:26.3<br>R2: 3.1 |
| **DISCUSSION OF DEFINATION AND TERMINOLOGY** | | | |
| 1 | Introduction | CO 1 | R4:2.1 |
| 2 | Maintenance and diagnosis of failure | CO 2 | T4:7.3 |
| 3 | Damages and their remedies | CO 3 | R4:5.1 |
| 4 | Materials and techniques of repair | CO 4 | T1:7.5 |
| 5 | Strengthening and demolition aspect | CO 5,6 | T1: 4.1 |
| **DISCUSSION OF QUESTION BANK** | | | |
| 1 | Introduction | CO 1 | R4:2.1 |
| 2 | Maintenance and diagnosis of failure | CO 2 | T4:7.3 |
| 3 | Damages and their remedies | CO 3 | R4:5.1 |
| 4 | Materials and techniques of repair | CO 4 | T1:7.5 |
| 5 | Strengthening and demolition aspect | CO 5, 6 | T1: 4.1 |

**Signature of Course Coordinator** **HOD,CE**
**Mr. Gude Ramakrishna, Assistant Professor**

# INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

## CIVIL ENGINEERING
## COURSE DESCRIPTION

| | | | | | |
|---|---|---|---|---|---|
| Course Title | STRUCTURAL DESIGN LABORATORY | | | | |
| Course Code | BSTE23 | | | | |
| Program | M.Tech | | | | |
| Semester | II | | | | |
| Course Type | Laboratory | | | | |
| Regulation | MT25 | | | | |
| Course Structure | Theory | | | Practical | |
| | Lecture | Tutorials | Credits | Laboratory | Credits |
| | - | - | - | 4 | 2 |
| Course Coordinator | Gude Ramakrishna Assistant Professor | | | | |

## I COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites |
|---|---|---|---|
| B.Tech | - | - | - |

## II COURSE OVERVIEW:

Structural Design Laboratory will summarize the key engineering, operational, safety, and sustainability considerations for the design of RC framed buildings. Introduces the design and behavior of large-scale structures and structural materials. This course emphasizes the development of structural form and the principles of structural design. This Laboratory used to solve structural problems by building and testing simple mathematical models. STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It can be used for analysis and design of all types of structural projects from buildings, bridges to towers, tunnels, metro stations, water/wastewater treatment plants and more.

## III MARKS DISTRIBUTION:

| Subject | SEE Examination | CIE Examination | Total Marks |
|---|---|---|---|
| Structural Design Laboratory | 60 Marks | 40 Marks | 100 |

## IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Demo Video | ✓ | Lab Worksheets | ✓ | Viva Questions | ✓ | Probing further Questions |

## V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks forinternal assessment and 60 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

**Semester End Examination (SEE):**The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

| SEE | Experiment Based | Programming based |
|---|---|---|
| 20 % | Objective | Purpose |
| 20 % | Analysis | Algorithm |
| 20 % | Design | Programme |
| 20 % | Conclusion | Conclusion |
| 20 % | Viva | Viva |

### Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

| **Component** | **Laboratory** | | **Total Marks** |
|---|---|---|---|
| **Type of Assessment** | **Day to day performance** | **Final internal lab assessment** | |
| CIA Marks | 20 | 10 | 30 |

### Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

| Objective | Analysis | Design | Conclusion | Viva | Total |
|---|---|---|---|---|---|
| 2 | 2 | 2 | 2 | 2 | 10 |

2. **Programming Based**

| Objective | Analysis | Design | Conclusion | Viva | Total |
|---|---|---|---|---|---|
| 2 | 2 | 2 | 2 | 2 | 10 |

## VI COURSE OBJECTIVES:

**The students will try to learn:**

| | |
|---|---|
| I | The basic elements with different loading type and supports with the aid of STAAD Pro software. |
| II | The Analysis and design of 2D Frame and multi-storey buildings with different load sets. |
| III | The Modeling and analysis of steel structures like beams and columns. |

## VII COURSE OUTCOMES:

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

| | | |
|---|---|---|
| CO 1 | Explain the basic commands of STADD Pro software for analysis and design of structural elements. | Understand |
| CO 2 | Analyse the trusses courseed to different loading conditions using Indian standard specifications. | Apply |
| CO 3 | Analyse the rigid jointed frames courseed to different loading conditions using Indian standard specifications. | Analyze |
| CO 4 | Design of steel 2D and 3D trusses for industrial and bridge structures. | Analyze |
| CO 5 | Design of reinforced concrete rigid frames for multistoried structures. | Create |
| CO 6 | Make use of latest tools for analysis and design of sub-structures | Create |

## VIII PROGRAM OUTCOMES:

| **Program Outcomes** | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## IX HOW PROGRAM OUTCOMES ARE ASSESSED:

| **Program** | | **Strength** | **Proficiency Assessed by** |
|---|---|---|---|
| PO3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 2 | CIE |

| | | | |
|---|---|---|---|
| PO4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. | 3 | CIE |
| PO5 | Conceptualize and design civil engineering structures considering various socio-economic factors. | 2 | CIE |

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

## X HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

| **Program** | | **Strength** | **Proficiency Assessed by** |
|---|---|---|---|
| PSO3 | Engage in life-long learning for continuing education in research-level studies and professional development. | 2 | SEE |

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

## XI MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

| **COURSE OUTCOMES** | PROGRAM OUTCOMES | | | PSO'S |
|---|---|---|---|---|
| | PO 3 | PO 4 | PO 5 | PSO 3 |
| CO 1 | - | 3 | 2 | - |
| CO 2 | 2 | - | - | - |
| CO 3 | 3 | 2 | 2 | 1 |
| CO 4 | - | - | - | - |
| CO 5 | - | 2 | 3 | 3 |
| CO 6 | 2 | - | - | - |

## XII ASSESSMENT METHODOLOGY DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Seminars | - |
| Laboratory Practices | ✓ | Student Viva | ✓ | Certification | - |

## XIII ASSESSMENT METHODOLOGY INDIRECT:

| | | | |
|---|---|---|---|
| ✓ | Early Semester Feedback | ✓ | End Semester OBE Feedback |
| **X** | Assessment of Mini Projects by Experts | | |

## XIV SYLLABUS:

| | |
|---|---|
| WEEK I | **INTRODUCTION TO STAAD SOFTWARE** |
| | Introduction |
| WEEK II | **STRUCTURAL SYSTEMS** |
| | General Description-Type of structure, Unit systems, structure geometry and Co-ordinate systems. |
| WEEK III | **COMMAND INPUTS** |
| | STAAD Pro –Commands- Using Edit Input-Command Formats-Text Input. |
| WEEK IV | **DEVELOPING GEOMETRY AND DIMENSIONING** |
| | Pre- Graphical Input Generation-Library- Geometry Generation – Dimensioning in STAAD Pro. |
| WEEK V | **3D MODEL DEVELOPMENT** |
| | Graphical Post Processing – Animation – Icons – Isometric View – Zooming-Results of Analysis and Design – Query reports in STAAD Pro. |
| WEEK VI | **ASSIGNING DIFFERENT LOAD PARAMETERS** |
| | Member Load, Element Load, Joint Load, Floor Load, Self-weight Command, Load case no, Load Combination. |
| WEEK VII | **ANALYIS CONTINUOUS BEAM** |
| | Analysis of continuous Beams using STAAD Pro. |
| WEEK VIII | **ANALYIS OF TRUSS** |
| | Analysis of 2D Truss using STAAD Pro |
| WEEK IX | **ANALYIS OF RIGID FRAMES** |
| | Analysis of 2D and 3D rigid frames using STAAD Pro. |
| WEEK X | **DESIGN OF RC BEAMS AND COLOMUNS** |
| | Design of RC framed structures (Beams, columns) using STAAD Pro. |
| WEEK XI | **DESIGN OF SLABS** |
| | Design of RC slabs using STAAD Pro. |
| WEEK XII | **DESIGN OF FOOTINGS** |
| | Design of RC footing STAAD Pro. |
| WEEK XIII | **DESIGN OF CIRCULAR WATER TANKS** |
| | Design of circular water tanks using STAAD Pro. |
| WEEK XIV | **ANALYSIS AND DESIGN OF STEEL STRUCTURES** |
| | Analysis and Design of steel structures (Beams, columns) |

## TEXTBOOKS

1. T.S.Sarma, "Staad.Pro v8i for beginners" Notion press, 2014.
2. Siva kumar Naganathan, "Learn Yourself Staad Pro V8i", Lap Lambert Academic Publishing GmbH KG, 2012.

## REFERENCE BOOKS:


1. Subramanian N., "Design of Steel Structures", Oxford Publication, 4th edition, 2008.


## XV COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's | Reference |
|---|---|---|---|
| 1 | What role does lighting play in your 3D modeling process, and how do you incorporate it. | CO1 | T1: 2.4 R1:3.6 |
| 2 | Structural Systems | CO1 | T2: 3.7 R1:5.3 |
| 3 | Command Inputs | CO2 | T2: 4.10 R1:3.15 |
| 4 | GauDeveloping Geometry and Dimensioning | CO2 | T2: 1.15 R1:1.16 |
| 5 | 3D Model Development | CO3 | T2: 1.19 R1:1.13.3 |
| 6 | Assigning Different Load Parameters | CO3 | T2:7.3 R1:2.8 |
| 7 | Analysis of continuous Beam | CO5 | T2:6.5 R1:2.6.2 |
| 8 | Analysis of Truss | CO1 | T2:7.5,7.6 R1:2.9.2 |
| 9 | Analysis of rigid frames | CO4 | T2:7.7 R1:2.10 |
| 10 | Design of RC Beams and Column | CO4 | T2:7.7 R1:2.10 |
| 11 | Design of RC slabs | CO5 | T2:7.11 R1:2.10.2 |
| 12 | Design of RC footing | CO2 | T2:15.7 R1:8.3.3 |
| 13 | Design of circular water tank | CO6 | T2:2.1 R1:7.9.2 |
| 14 | Analysis and design of steel structures | CO6 | T2:2.2 R1:7.9.1 |

## XVI EXPERIMENTS FOR ENHANCED LEARNING (EEL):

| S.No | Design Oriented Experiments |
|---|---|
| 1 | Analysis and design of a flexural member using STAAD Pro. |
| 2 | Analysis and design of a simple RCC frame one-bay two storey using STAAD Pro. |
| 3 | Analysis of Continuous Beam. |
| 4 | Analysis of single storey frame using STAAD Pro. |
| 5 | What role does lighting play in your 3D modeling process, and how do you incorporate it |

**Signature of Course Coordinator** **HOD,CE**

# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

## NUMERICAL ANALYSIS LABORATORY
## COURSE TEMPLATE

| | | | | | |
|---|---|---|---|---|---|
| 1 | Department | **CIVIL ENGINEERING** | | | |
| 2 | Course Title | **NUMERICAL ANALYSIS LABORATORY** | | | |
| 3 | Course Code | BSTE24 | | | |
| 4 | Program | M.Tech | | | |
| 5 | Semester | II Semester | | | |
| 6 | Regulation | MT-25 | | | |
| 7 | Structure of the course | Practical | | | |
| | | Tutorial Hours | | | Practical Hours |
| | | 1 | | | 2 |
| 8 | Course Offered | Odd Semester ✓ | | Even Semester × | |
| 9 | Course Coordinator | Dr. M.Maheswara Rao | | | |
| 10 | Date Approved by BOS | 25/08/2023 | | | |
| 11 | Course Webpage | www.iare.ac.in/—-/—- | | | |
| 12 | Course Prerequistes | **Level** | **Course Code** | **Semester** | **Prerequisites** |
| | | - | - | - | - |
| | | - | - | - | - |

## 13. COURSE OVERVIEW

This course deals with the numerical solutions of linear and non-linear equations by using different algorithms. These includes bi section method, newton's method, method of least squares, gauss elimination method, gauss zordan method, gauss seidal method, trapezoidal rule, Simpson's rule and ranga-kutta method. This will enable the students to accostum with programming using different computer languages.

## 14. EMPLOYABILITY SKILLS

| |
|---|
| 1. **Numerical Analysis and Equation Solving Skills:** Students gain hands-on experience in solving non-linear and linear systems of equations using techniques such as bisection, Newton's method, Gauss elimination, Gauss-Seidel, and Gauss-Jordan methods. These skills are essential for performing engineering computations and simulations accurately. |
| 2. **Numerical Methods for Engineering Applications:** Through the application of numerical integration (trapezoidal and Simpson's rules) and differential equation solving techniques (Euler's and Runge-Kutta methods), students develop strong problem-solving capabilities for modeling and analyzing engineering systems dynamically and effectively. |

## 15.RELEVANCE TO SUSTAINABILITY GOALS

Write brief description about the course and how its relevance to SDGs.

| | | |
|---|---|---|
| X | NO POVERTY | |
| X | ZERO HUNGER | |
| X | GOOD HEALTH AND WELL-BEING | |
| ✓ | QUALITY EDUCATION | **Quality Education:**<br>By promoting technical knowledge and practical skills in numerical methods, the course fosters high-quality education that empowers students for professional and academic success. |
| X | GENDER EQUALITY | |
| X | CLEAN WATER AND SANITATION | |
| X | AFFORDABLE AND CLEAN ENERGY | |
| X | DECENT WORK AND ECONOMIC GROWTH | |

| | | |
|---|---|---|
| ✓ |  | **Industry, Innovation, and Infrastructure:** Numerical methods are critical for innovation in engineering design, structural analysis, and the development of sustainable infrastructure, aligning with advancements in industry and technology. |
| X |  | |
| ✓ |  | **Sustainable Cities and Communities:** Application of numerical methods enables efficient planning, modeling, and analysis in urban development and civil infrastructure projects, contributing to sustainable, resilient cities. |
| X |  | |
| ✓ |  | **Climate Action:** Climate Action By supporting modeling and simulations used in environmental and civil engineering, students can contribute to designing sustainable systems that mitigate climate change impacts. |
| X |  | |
| X |  | |
| X |  | |
| X |  | |

## 16. CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Day to Day lab evaluation | ✓ | Demo Video | ✓ | Expected Viva Voce questions | ✓ | Open Ended Experiments |
| X | Competitions | X | hackathons | ✓ | Certifications | ✓ | Probing Further Questions |

## 17. EVALUATION METHODOLOGY

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

**Continuous Internal Assessment (CIA):**
CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 2: CIA marks distribution

| **Component** | | | | |
|---|---|---|---|---|
| Type of Assessment | Day to Day performance and viva voce examination | Final internal lab assessment | Laboratory Report / Project and Presentation | Total Marks |
| CIA marks | 20 | 10 | 10 | 40 |

**Continuous Internal Examination (CIE):** One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Table 3: Experiment based

| Objective | Analysis | Design | Conclusion | Viva voce | Total |
|---|---|---|---|---|---|
| | | | | | 20 |

Table 4: Programming based

| Objective | Analysis | Program | Results | Viva voce | Total |
|---|---|---|---|---|---|
| 4 | 4 | 6 | 4 | 2 | 20 |

**Semester End Examination:**
The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.
In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

## 18. COURSE OBJECTIVES

**The students will try to learn:**

| | |
|---|---|
| I | The Roots of non-linear equations by Bisection method and Newton's method. |
| II | The system of Linear Equations using Gauss - Elimination/ Gauss - Seidal Iteration/Gauss - Jorden Method. |
| III | The integrations numerically using Trapezoidal and Simpson's rules |

## 19. COURSE OUTCOMES

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

| | | |
|---|---|---|
| CO 1 | Analyze the roots of non-linear equation using bisection and newton's method. | Analyze |
| CO 2 | Evaluate the curve fitting by using method of least squares approximations. | Evaluate |
| CO 3 | Determine the linear system of equations using Gauss elimination, Gauss Seidal and gauss Jordan methods. | Apply |
| CO 4 | Solve the integrations numerically using trapezoidal and Simpson's rule. | Apply |
| CO 5 | Explain the numerical solution of ordinary differential equations using Euler's Method. | understand |
| CO 6 | Analyze the numerical solution of ordinary differential equations by using Runge- Kutta Method. | Analyze |

## 20. SYLLABUS

| | |
|---|---|
| CO 1 | **Analyze the roots of non-linear equations using bisection and Newton's method.** |
| | 1. Find the Roots of Non-Linear Equation Using Bisection Method<br>2. Find the Roots of Non-Linear Equation Using Newton's Method.<br>3. Numerical Solution of Ordinary Differential Equations Newton – Raphson Method<br>4. Numerical Solution of Ordinary Differential Equations secant method<br>5. Numerical Solution of Ordinary Differential Equations Brent's method<br>6. Numerical Solution of Ordinary Differential Equations Muller's method |
| CO 2 | **Evaluate the curve fitting by using method of least squares approximations.** |
| | 1. Curve Fitting by Least Square Approximations. |
| CO 3 | **Determine the linear system of equations using Gauss elimination, Gauss-Seidel and Gauss-Jordan methods.** |
| | 1. Solve the System of Linear Equations Using Gauss - Elimination Method.<br>2. Solve the System of Linear Equations Using Gauss - Seidal Iteration Method.<br>3. Solve the System of Linear Equations Using Gauss - Jorden Method |
| CO 4 | **Solve the integrations numerically using trapezoidal and Simpson's rule.** |
| | 1. Integrate numerically using Trapezoidal Rule.<br>2. Integrate numerically using Simpson's Rules. |
| CO 5 | **Explain the numerical solution of ordinary differential equations using Euler's Method.** |
| | 1. Numerical Solution of Ordinary Differential Equations by Euler's Method. |
| CO 6 | **Analyze the numerical solution of ordinary differential equations by using Runge-Kutta Method.** |
| | 1. Numerical Solution of Ordinary Differential Equations by Runge- Kutta Method. |

Note: One Course Outcome may be mapped to multiple number of experiments.

### Text Books

1. Steven Chapra and Raymond Canale, "Numerical Methods for Engineers", McGraw Hill, 7th edition, 2015.

### Reference Books

1. K. Sankara Rao, “Numerical Methods for Scientists and Engineers”, PHI Learning, 4th edition, 2018.

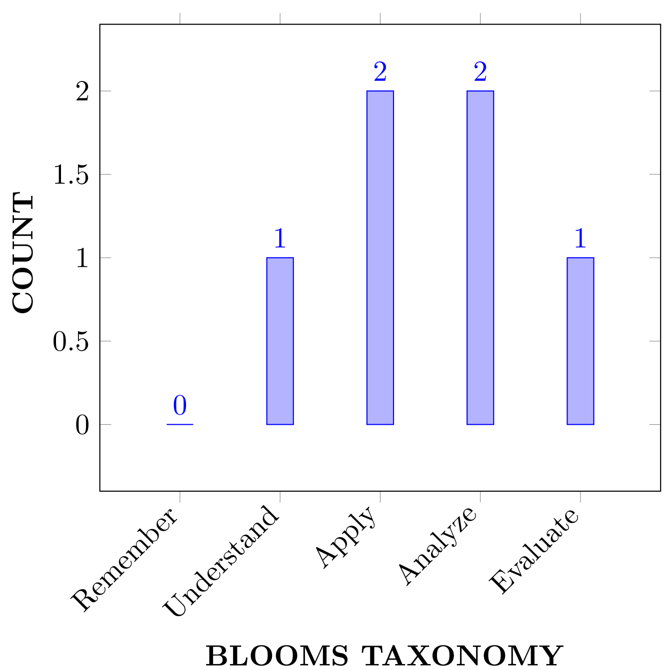
### ELECTRONICS RESOURCES:

1. http://www.iitg.ac.in/physics/fac/charu/courses/ph508/lab5.pdf
2. https://www.researchgate.net_publication_275014975A_Numerical_Analysis_Lab_Solving_System/of_Linear_Equations

### Materials Online

1. Course Template
2. Tutorial Question Bank
3. Assignments
4. Model Question Paper – I
5. Model Question Paper - II
6. Lecture Notes
7. Power point presentation

## 21. COURSE KNOWLEDGE COMPETENCY LEVEL




## 22. PROGRAM OUTCOMES

| Program Outcomes | |
|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems |
| PO 2 | An ability to Write and present a substantial technical report/document. |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| PO 4 | Capable to apply the core, multidisciplinary knowledge for understanding the problems in structural engineering and allied fields. |
| PO 5 | Conceptualize and design civil engineering structures considering various socio-economic factors. |
| PO 6 | Engage in life-long learning for continuing education in research-level studies and professional development. |

## 23. HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program Outcomes | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | An ability to Independently carry out research/investigation and development work to solve practical problems. problems. | 1 | LAB PROGRAMS/CIE/SEE |
| PO 2 | An ability to Write and present a substantial technical report/document. | 2 | LAB PROGRAMS/CIE/SEE |
| PO 3 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. | 3 | LAB PROGRAMS/CIE/SEE |

## 24. MAPPING OF EACH CO WITH PO(s):

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | ✓ | - | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - |
| CO 2 | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | ✓ | - | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - |
| CO 4 | ✓ | - | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - |
| CO 6 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - | - | - | - | - | - |

## 25. JUSTIFICATIONS FOR CO – PO MAPPING - DIRECT:

| COURSE OUTCOMES | PO'S PSO'S | Justification for mapping (Students will be able to) | No. of Key Competencies |
|---|---|---|---|
| CO 1 | PO 1 | Involves analytical thinking to solve practical mathematical problems using numerical methods. | 3 |
| | PO 3 | Demonstrates mastery over mathematical tools required for solving real-time engineering problems. | 3 |
| | PO 4 | Applies core mathematics and computational techniques to engineering problem-solving. | 3 |

| | | | |
|---|---|---|---|
| CO 2 | PO 1 | Enables analysis of data through mathematical modeling and evaluation. | 3 |
| | PO 2 | Requires preparation and presentation of technical results in a structured manner. | 3 |
| | PO 3 | Reflects understanding and mastery over mathematical data interpretation skills. | 3 |
| CO 3 | PO 1 | Encourages the use of numerical algorithms to find efficient solutions. | 3 |
| | PO 3 | Demonstrates thorough understanding of solution strategies for engineering systems. | 3 |
| | PO 4 | Applies mathematical principles in multidisciplinary contexts of structural and civil engineering. | 3 |
| CO 4 | PO 1 | Engages in identifying and applying suitable numerical techniques for integration. — | 3 |
| | PO 3 | Reinforces knowledge of calculus-based applications in engineering. | 3 |
| | PO 4 | Supports problem-solving using integrated approaches from different fields. | 3 |
| CO 5 | PO 1 | Develops computational thinking to simulate dynamic systems. | 3 |
| | PO 2 | Helps in writing and interpreting numerical solutions clearly. | 3 |
| | PO 3 | Builds competence in advanced mathematical techniques. | 3 |
| | PO 4 | Applies core methods to solve multi-domain engineering problems. | 3 |
| CO 6 | PO 1 | Involves advanced problem-solving and independent computation skills. | 3 |
| | PO2 | Fosters preparation of technical documentation of methods and results. | 3 |
| | PO3 | Demonstrates in-depth understanding of high-order solution techniques. | 3 |
| | PO4 | Integrates mathematics and applied engineering methods. | 3 |
| | PO5 | Encourages designing accurate numerical models for dynamic systems. | 3 |
| | PO6 | Promotes self-learning and research aptitude in engineering computation. | 3 |

## 26. TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO MAPPING:

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 3 | - | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 4 | 3 | - | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| CO 6 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - - |

## 27. PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 25 | - | 25 | 25 | 25 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 33.3 | 33.3 | - | 33.3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | 33.3 | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | 33.3 | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | 33.3 | - | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - |
| CO 6 | - | - | 33.3 | - | 33.3 | 33.3 | - | - | - | - | - | - | - | - | - |

## 28. COURSE ARTICULATION MATRIX (PO MAPPING):

CO'S and PO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

***0*** - 0≤ C≤ 5% – No correlation

***2*** - 40 % <C < 60% –Moderate

***1-5*** <C≤ 40% – Low/ Slight

***3*** - 60% ≤ C < 100% – Substantial /High

| COURSE OUTCOMES | PROGRAM OUTCOMES | | | | | | | | | | | | PSO'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| CO 1 | 1 | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 1 | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | | - |
| CO 6 | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | - | - |
| **TOTAL** | 2 | 2 | 5 | 4 | 4 | 2 | - | - | - | - | - | - | - | - | - |
| **AVERAGE** | 1 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - |

## 29. ASSESSMENT METHODOLOGY DIRECT:

| | | | | | |
|---|---|---|---|---|---|
| CIE Exams | ✓ | SEE Exams | ✓ | Laboratory Practices | ✓ |
| Certification | - | Student Viva | ✓ | Open Ended Experiments | - |

## 30. ASSESSMENT METHODOLOGY INDIRECT:

| | | | |
|---|---|---|---|
| x | Assessment of Mini Projects by Experts | ✓ | End Semester OBE Feedback |

## 31. COURSE PLAN

The course plan is meant as a guideline. Probably there may be changes.

| S.No | Topics to be covered | CO's |
|---|---|---|
| 1 | Find the Roots of Non-Linear Equation Using Bisection Method | CO 1 |
| 2 | Find the Roots of Non-Linear Equation Using Newton's Method | CO 1 |
| 3 | Curve Fitting by Least Square Approximations. | CO2 |
| 4 | Solve the System of Linear Equations Using Gauss - Elimination Method. | CO 3 |
| 5 | Solve the System of Linear Equations Using Gauss - Seidal Iteration Method. | CO 3 |
| 6 | Solve the System of Linear Equations Using Gauss - Jorden Method | CO 3 |
| 7 | Integrate numerically using Trapezoidal Rule. | CO 4 |
| 8 | Integrate numerically using Simpson's Rules. | CO4 |
| 9 | Numerical Solution of Ordinary Differential Equations by Euler's Method. | CO 5 |
| 10 | Numerical Solution of Ordinary Differential Equations by Runge- Kutta Method. | CO6 |
| 11 | Numerical Solution of Ordinary Differential Equations Newton – Raphson Method | CO 1 |
| 12 | Numerical Solution of Ordinary Differential Equations secant method | CO 1 |
| 13 | Numerical Solution of Ordinary Differential Equations Brent's method | CO 1 |
| 14 | Numerical Solution of Ordinary Differential Equations Muller's method | CO 1 |

## Experiments for enhanced learning (EEL):

| S.No | Design Oriented Experiments |
|---|---|
| 1. | MATLAB/Python Programming: Implement numerical methods such as Bisection, Newton-Raphson, and Runge-Kutta using MATLAB or Python to solve engineering problems, enhancing coding skills and computational accuracy. |
| 2. | Real-Time Engineering Problem Solving: Apply numerical integration and differential equation methods to real-world civil engineering scenarios such as water flow analysis, structural deflection modeling, or traffic simulations, to strengthen analytical thinking and application skills. |

**Approved by: Board of Studies in the meeting conducted on** ____________________.

**Signature of Course Coordinator** **HOD,CSE**
**Dr. M.Maheswara Rao, Assistant Professor**

# COURSE OUTLINE DESCRIPTION

| SECTION 1: General Information about the Course | |
|---|---|
| Course Title | **DESIGN OF PRESTRESSED CONCRETE STRUCTURES** |
| Course Code | BSTE26 |
| Course Start | III |
| Course Type | Professional Elective |
| Regulation | IARE - MT 25 |
| Prerequisite Courses | Reinforced Concrete Structures Design and Drawing |
| Department | Civil Engineering |
| Number of Credits | 3 Credit hours |
| Academic Year | 2025-26 |
| Method(s) of Instruction | Theory |
| Course Administrator | **Dr. U. Vamsi Mohan**<br>Professor of Civil Engineering<br>IARE10660<br>**u.vamshimohan@iare.ac.in** |
| Course Coordinator's Name | **Dr. Praveena Rao**<br>Assistant Professor of Civil Engineering<br>IARE10485<br>**praveenarao@iare.ac.in** |
| Prior Learning Assessment and Recognition (PLAR) | Students interested in PLAR pathways for open learning can register one semester prior to the start of semester. Students will receive the necessary contact information one semester in advance. |
| Open Learning Faculty Member Information | Open Learning Faculty (OLF) is available to assist students. Students will receive the necessary contact information at the start of the course. |
| Course Webpage | https://akanksha.iare.ac.in/index?route=course/details&course_id=1604 |
| Course Description | A prestressed concrete structure is different from a conventional reinforced concrete structure due to the application of an initial load on the structure prior to its use. In prestressed concrete high strength concrete and high strength steel are combined such that the full section is effective in resisting tension and compression. This is an active combination of the two materials. This subject provides students an understanding and ability to analyse and design prestressed concrete structural elements. The primary topics includes the concept and principles of prestressing, methods of prestressing concrete, stress limits, losses of prestress, selection of section, serviceability and strength requirements. Students will also be able to complete analysis and design procedure of simply supported prestressed concrete non-composite and composite beams. |
| Course Objectives | **The students will try to learn:**<br>a. The concepts of prestressed concrete structures and the behaviour of these structures subjected to loads for the design purpose.<br>b. The design of structural elements necessary for creating efficient and economic prestressed concrete structures.<br>c. The design and drawing of multi storeyed industrial and residential structures including bridges for creating high performance and durable structures. |

| | |
|---|---|
| Text and Reference Books | **Text Books**<br>1. N. Krishna Raju, "Pre-stressed Concrete", Tata McGraw Hill Book Education Pvt. Ltd, 6th Edition, 2018.<br>2. N. Rajagopalan, "Prestressed Concrete", Alpha Science International Ltd, 2nd edition, 2005.<br><br>**Reference Books**<br>1. 1. T.Y. Lin and Burn, "Design of Pre-stress Concrete Structures", John Wiley, New York.<br>2. 2. S. Ramarnrutham, "Prestressed Concrete", Dhanpat Rai & Sons, Delhi. |
| Learning Resources | **Course full stack** is made available in IARE learning management portal – Akanksha, which includes lecture notes, tutorial question bank, definition and terminology, tech-talk topics, assignments, Model question papers (2 sets), complex engineering problem solving statements, power point presentations (PPTs) and ELRV lecture recordings at:<br>• https://www.youtube.com/watch?v=TnAsK6H4O7Q |
| Supplemental Materials | **Readings, Videos, and Links**<br>1. https://nptel.ac.in/courses/105106118<br>2. https://odp.inflibnet.ac.in/index.php/module details?course=prestressed%20concrete %20structures&source=swayam&subsource=NPTEL |
| Learning and Teaching Strategies | Online material will provide the foundation of the learning resources, requiring the students to log in and engage regularly throughout the sixteen weeks of the course.<br><br>There will be a mix of suggested readings, discussions and video content containing embedded digital content and undertake the assessment tasks. |

**SECTION 2: Teaching Learning Scheme**

At least 48 lecture hours of scheduled teaching and learning activities (TLA) will be delivered in person, with the remaining hours for scheduled and self-scheduled teaching and learning activities delivered either in person or online.

Notional Study Time: 90 Hours (Lecture hours: 48, Tutorial hours: 8, Guided independent study hours: 10, Homework / Programming assignment hours: 9, Course project / Preparation for complex problem solving hours: 15)

| TLA Code | Teaching and Learning Activities | Number | Duration (Hours) | Total Workload |
|---|---|---|---|---|
| TLA 1 | Lectures | 48 | 01 | 48 |
| TLA 2 | Tutorials | 08 | 01 | 08 |
| TLA 3 | Case Study | | | |
| TLA 4 | Problem Solving | | | |
| TLA 5 | Demonstration | | | |
| TLA 6 | Scheduled revision sessions | | | |
| TLA 7 | Guided independent study: Directed viewing of video materials / PPTs | | | 10 |
| TLA 8 | Independent private study | | | |
| TLA 9 | Laboratory Exercises | | | |
| TLA 10 | Homework assignments / Programming assignments | | | 9 |
| TLA 11 | Placement / work based learning or Specific | | | |

| | | | | |
|---|---|---|---|---|
| | practical training | | | |
| TLA 12 | Presentation / Seminar Preparation | | | |
| TLA 13 | Course Project / Preparation for Complex Problem Solving | | | 15 |
| TLA 14 | Technical visit | | | |
| TLA 15 | Field activities | | | |
| | | | **Total study hours** | **90** |
| | | | **Expected total study hours** | **90** |

| **SECTION 3A: Course Outcomes** | | |
|---|---|---|
| After successfully completing this course, the student will be able to: | | |
| **Outcome Number** | **Course Outcomes** | **Learning Domain** |
| CO1 | **Explain the concept of methods of pre and post tensioning and the systems of prestressing for the designing of prestressed concrete structural elements.** | Understand |
| CO2 | **Estimate the losses in the prestress and post tensioned members for the efficient design of prestressed concrete structures.** | Analyse |
| CO3 | **Analyse prestressed concrete structural elements subjected to flexure for the design purpose.** | Analyse |
| CO4 | **Design prestressed concrete structural elements subjected to shear using Indian standard code method.** | Apply |
| CO5 | **Apply the concepts of transfer of prestress in pre and post tensioned members through bond for effective utilisation of prestressing force.** | Apply |
| CO6 | **Design the composite prestressed concrete structural elements subjected to flexure and shear for designing multi storied structures.** | Apply |

| **SECTION 3B: Cognitive Levels** | |
|---|---|
| **Blooms Taxonomy Level** | **Cognitive Level in Percentage (%)** |
| Remember | **0** |
| Understand | 16.67 |
| Apply | 50 |
| Analyse | 33.33 |
| Evaluate | 0 |
| Create | 0 |

| **SECTION 4: Content and Context of Engineering Surveying** | |
|---|---|
| **CO1** | **Explain the concept of methods of pre and post tensioning and the systems of prestressing for the designing of prestressed concrete structural elements.** |
| | Prestressed concrete is a type of reinforced concrete where internal stresses are intentionally introduced to counteract the tensile stresses that occur during service. This improves the structural capacity and performance of concrete, especially in elements like beams, slabs, and bridges.<br><br>1. **General principles of pre-stressing pre-tensioning and post tensioning:** The general principles of prestressing, whether by pre-tensioning or post-tensioning, are based on the concept of introducing internal compressive forces in a concrete structural element to counteract external tensile stresses. This significantly improves the structural performance of concrete, which is strong in compression but weak in tension.<br>2. **Advantages and limitations of Prestressed concrete:** Prestressed members require smaller cross-sections, reducing the overall dead weight of the structure and saving on material costs. Prestressed concrete can resist higher loads compared to conventional reinforced concrete due |

<table>
<tr><td></td><td>to the introduction of compressive stresses that counteract tensile forces.<br>3. Classification and types of pre-stressing: Prestressing is a technique used to improve the performance of concrete by introducing internal compressive stresses to counteract external tensile stresses. It can be classified based on various factors such as the method of application, type of construction, and extent of prestressing.<br>4. Pre-tensioning and Post-tensioning methods: There are two primary methods of prestressing, In the pre-tensioning method, the steel tendons (wires or strands) are tensioned before the concrete is cast. Once the concrete sets and gains strength, the tendons are released, transferring stress to the concrete. In the post-tensioning method, the steel tendons are tensioned after the concrete has been cast and gained strength. The prestressing force is applied using hydraulic jacks and is transferred to the concrete through end anchorages.</td></tr>
<tr><td>CO2</td><td>Estimate the losses in the prestress and post tensioned members for the efficient design of prestressed concrete structures.</td></tr>
<tr><td></td><td>In prestressed concrete, prestress losses refer to the reduction in the initial prestressing force over time due to several factors. Accurately estimating these losses is critical to ensure that the structure performs as intended during its service life.<br><br>1. Loss of pre-stress in pre-tensioned: In pre-tensioned concrete, tendons (typically high-strength steel wires or strands) are tensioned before the concrete is cast. After the concrete hardens, the tendons are released, and the prestressing force is transferred to the concrete through bond. However, over time, part of the initial prestressing force is lost due to several factors, which must be accounted for in design to ensure safety and serviceability.<br><br>2. Loss of pre-stress in post-tensioned members: In post-tensioned concrete, the tendons are placed inside ducts before concrete casting and are tensioned after the concrete has hardened. While transferring and maintaining the prestressing force, several losses occur due to physical and time-dependent factors. These prestress losses must be accurately estimated during the design phase to ensure structural efficiency and durability.<br><br>3. Frictional losses: Frictional losses refer to the reduction in the prestressing force along the length of a post-tensioned tendon due to friction between the tendon and its surrounding duct during the tensioning process. These losses occur only in post-tensioning systems (not in pre-tensioning), particularly when the tendons are stressed from one or both ends.</td></tr>
<tr><td>CO3</td><td>Analyse prestressed concrete structural elements subjected to flexure for the design purpose.</td></tr>
<tr><td></td><td>Prestressed concrete members are primarily designed to resist flexural stresses caused by bending moments. The analysis aims to ensure that the concrete and prestressing steel together safely carry the applied loads while controlling deflections and cracking.<br><br>1. Analysis of sections for flexure: Prestressed concrete sections are specially designed to resist bending moments by inducing a prestressing force that counteracts tensile stresses caused by external loads. The analysis of such sections for flexure ensures that stresses in concrete and prestressing steel remain within permissible limits and the section achieves the required strength and serviceability.<br><br>2. Beams pre-stressed with straight, concentric, eccentric, bent and parabolic tendons: Prestressing tendons can be arranged in various profiles within beams to optimize structural performance by controlling the stress distribution due to bending. The shape and position of the tendons directly affect how the prestressing force counteracts applied loads.<br><br>3. Elastic design of PSC beams of rectangular and I section: The elastic design approach involves analyzing prestressed concrete beams assuming linear elastic behavior of materials under service loads. This design ensures that stresses in concrete and prestressing steel remain within permissible limits during service to avoid cracking and excessive deflections.</td></tr>
<tr><td>CO4</td><td>Design prestressed concrete structural elements subjected to shear using Indian standard code method.</td></tr>
<tr><td></td><td>Prestressed concrete (PSC) members are subjected to shear forces along with bending moments. The</td></tr>
</table>

| | |
|---|---|
| | design for shear ensures that the member can safely resist these forces without shear failure, which is often sudden and brittle.<br>1. **General considerations for shear design:** Shear design in prestressed concrete (PSC) beams is a critical aspect of structural safety and serviceability. Shear failure can be sudden and brittle, so proper design ensures the beam safely carries shear forces along with bending moments.<br><br>2. **Design of shear reinforcements**: Shear reinforcement is essential in prestressed concrete (PSC) elements to resist shear forces exceeding the concrete's inherent shear capacity and to control crack widths. Proper design ensures safety, ductility, and durability of the structure.<br><br>3. **Improving shear resistance of concrete:** Shear resistance is a critical factor in the design and safety of prestressed concrete (PSC) elements. Since shear failure can be sudden and brittle, improving the shear capacity of the concrete portion of PSC members enhances overall structural reliability and performance. |
| **CO5** | **Apply the concepts of transfer of prestress in pre and post tensioned members through bond for effective utilisation of prestressing force.** |
| | In prestressed concrete (PSC) members, the transfer of prestressing force from the prestressing tendons (steel strands or wires) to the concrete is a critical step to ensure that the concrete benefits fully from the applied prestress. This transfer is achieved primarily through bond between the steel and concrete.<br><br>1. **Transmission of pre-stressing force by bond:** In prestressed concrete members, the transmission of pre-stressing force by bond refers to how the tensile force applied to the prestressing steel (tendons or strands) is gradually transferred to the surrounding concrete through the interface between steel and concrete. This process is essential for the effective functioning of prestressed concrete elements.<br><br>2. **Transmission length and flexural bond stresses:** Transmission length is a fundamental concept in prestressed concrete design. It represents the length along the prestressing tendon over which the prestressing force is gradually transferred from the tendon to the surrounding concrete through bond action.<br><br>3. **Stress distribution in end block:** When prestressing tendons are anchored, the force is transferred from the small cross-sectional area of the steel to the relatively larger concrete area. This sudden transfer results in non-uniform, high compressive stresses and tensile stresses (due to bursting forces) in the end block.<br><br>4. **Anchorage zone reinforcement:** Reinforcement in anchorage zone is usually arranged as closed ties or hoops around the prestressing tendons. Ties prevent the concrete from splitting due to radial tensile stresses. Stirrups are placed closely near anchorage and spaced progressively wider away from the anchorage. |
| **CO6** | **Design the composite prestressed concrete structural elements subjected to flexure and shear for designing multi storied structures.** |
| | Composite prestressed concrete elements combine prestressing with composite action (often involving steel and concrete or different concrete types) to optimize strength and serviceability. In multi-storied structures, these elements often carry large flexural and shear loads and must be designed carefully to ensure safety, durability, and economy.<br><br>1. **Analysis of composite beams:** Composite beams combine two or more materials (commonly concrete and steel) to act as a single structural element. In prestressed concrete composite beams, prestressing tendons are used to enhance the flexural capacity and control deflections, while composite action (e.g., between a prestressed concrete slab and a steel beam) provides additional strength and stiffness.<br><br>2. **Types of composite beams - Propped and Unpropped:** Composite prestressed concrete beams are widely used in construction to combine the advantages of prestressing with composite action, often involving a concrete slab and steel beam. Based on the support conditions during construction and loading, these beams are classified as Propped or Unpropped. |

| | |
|---|---|
| | 3. **Importance of control of deflections:** Deflection refers to the vertical displacement or bending of a beam under load. In prestressed concrete beams, controlling deflections is crucial for the structural performance, serviceability, and durability of the structure.<br><br>4. **Short term and long term deflections:** Deflections in prestressed concrete (PSC) beams occur over time due to applied loads and material behavior. These deflections are broadly classified into short-term deflections that occur immediately or shortly after the application of loads. Long-term deflections develop gradually over time due to sustained loads and time-dependent effects of materials. |

| SECTION 5: Complex Engineering Problem Solving |
|---|
| **Complex engineering problem solving projects**<br>There is one piece of assessed coursework, involving a mixture of theoretical work and practical work. We encourage to use the laboratory for practical purpose. For the calculation part in the project, they have to develop the programme code in java or python.<br><br>**Error analysis and adjustment techniques:** The core surveying curriculum typically focuses on fundamental measurement techniques and calculations. However, real-world surveys are subject to various errors. Therefore, an introduction to error analysis and adjustment techniques will be incorporated into the course. |

**SECTION 6A: Assessment Methods – Direct**

| Item | Evaluation Components | Week in / out | Marks |
|---|---|---|---|
| AAT: 1 - 1 | Tech-Talk | Week – 2 / 5 | 05 |
| AAT: 1 - 2 | Assignments | Week – 4 / 7 | 05 |
| AAT: 2 - 1 | Complex Engineering Problem Solving | Week – 9 / 12 | 05 |
| AAT: 2 - 2 | Definitions and Terminology | Week – 12 / 15 | 05 |
| CIE - 1 | 2 hours - Answer 4 out of 5 questions | Week - 9 | 10 |
| CIE - 2 | 2 hours - Answer 4 out of 5 questions | Week - 17 | 10 |
| SEE | 3 hours - Answer 1 from each module | Week - 18 | 60 |
| | | **Total Marks** | **100** |

**Department's Late Submission Policy:**

1. 1 – 24 hours: 25% of the mark will be deducted
2. > 24 hours: Not accepted

| SECTION 6B: Assessment Methods –Indirect | |
|---|---|
| Course End Survey (End Semester OBE Feedback) | ✓ |

**SECTION 7: Engineering Competencies (ECs) Focused**
Please tick (✓) relevant engineering competency profile covered

| EC Number | Attributes | Profiles | (✓) |
|---|---|---|---|
| EC1 | Depth of knowledge required (CP) | Ensures that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic requirements applicable to the engineering discipline | ✓ |
| EC2 | Depth of analysis | Have no obvious solution and require abstract thinking, | ✓ |

| | | | |
|---|---|---|---|
| | required (CP) | originality in analysis to formulate suitable models. | |
| EC3 | Design and development of solutions (CA) | Support sustainable development solutions by ensuring functional requirements, minimize environmental impact and optimize resource utilization throughout the life cycle, while balancing performance and cost effectiveness. | - |
| EC4 | Range of conflicting requirements (CP) | Competently addresses complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging or conflicting technical, engineering and other issues. | ✓ |
| EC5 | Infrequently encountered issues (CP) | Conceptualizes alternative engineering approaches and evaluates potential outcomes against appropriate criteria to justify an optimal solution choice. | - |
| EC6 | Protection of society (CA) | Identifies, quantifies, mitigates and manages technical, health, environmental, safety, economic and other contextual risks associated to seek achievable sustainable outcomes with engineering application in the designated engineering discipline. | - |
| EC7 | Range of resources (CA) | Involve the coordination of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies) in the timely delivery of outcomes | ✓ |
| EC8 | Extent of stakeholder involvement (CP) | Design and develop solution to complex engineering problem considering a very perspective and taking account of stakeholder views with widely varying needs. | - |
| EC9 | Extent of applicable codes, legal and regulatory (CP) | Meet all level, legal, regulatory, relevant standards and codes of practice, protect public health and safety in the course of all engineering activities. | ✓ |
| EC10 | Interdependence (CP) | High level problems including many component parts or sub-problems, partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then re-combines to form a whole, with the integrity and performance of the overall system as the top consideration. | ✓ |
| EC11 | Continuing professional development (CPD) and lifelong learning (CA) | Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work. | ✓ |
| EC12 | Judgement (CA) | Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Require judgement in decision making in the course of all complex engineering activities. | - |

## SECTION 8: Employability Skills

**Example: Communication skills / Programming skills / Project based skills**

Studying Prestressed concrete structures equips the students with a range of employability skills that are highly valued in industries.

**Communication skills:**

- Effectively convey complex technical information to both technical and non-technical stakeholders.
- Actively listen to clients and colleagues to understand their needs and perspectives.
- Prepare clear and concise written reports, proposals, and presentations.
- confidently present findings and recommendations to diverse audiences.
- Collaborate effectively with team members from various disciplines.
- Negotiate and resolve conflicts constructively.

**Project-based skills**

- Ability to analyze beams and slabs for bending moments, shear forces, and stresses considering prestressing effects.
- Designing composite prestressed beams and slabs combining steel and concrete.
- Applying Indian Standards (IS 1343, IS 456) or relevant international codes for safe and economical designs.

- Hands-on experience with structural analysis software capable of modeling prestressed concrete elements.

| SECTION 9: Relevance to Sustainability goals<br>Brief description about the course and its correlation with Sustainability Development Goal (SDGs). | | |
|---|---|---|
| **SDG Goals** | | **Correlation with SDG** |
| 4 | QUALITY EDUCATION | **Quality Education:** This course provides high-quality technical education and equips students with essential skills to analyze and design safe, efficient, and sustainable materials and structures. |
| 9 | INDUSTRY, INNOVATION AND INFRASTRUCTURE | **Industry, Innovation, and Infrastructure:** Prepares students to design and maintain resilient infrastructure by understanding material behavior, promoting innovation in material use, and ensuring structural safety. |
| 11 | SUSTAINABLE CITIES AND COMMUNITIES | **Sustainable Cities and Communities:** Enhances the ability to create sustainable buildings and urban infrastructure by selecting appropriate materials and designs that ensure durability and minimize environmental impact. |
| 12 | RESPONSIBLE CONSUMPTION AND PRODUCTION | **Responsible Consumption and Production:** Encourages efficient use of materials through optimization and design, reducing waste and promoting responsible material selection in engineering projects. |
| 13 | CLIMATE ACTION | **Climate Action:** Supports the development of climate-resilient infrastructure and promotes the use of materials that minimize environmental impact in changing climate conditions. |

**SECTION 10A: Mapping between COs and POs / PSOs**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 | 3 |
| CO1 | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - | - |
| CO2 | ✓ | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO3 | ✓ | ✓ | - | - | ✓ | - | - | - | - | - | - | ✓ | - | - |
| CO4 | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - | - |
| CO5 | ✓ | - | - | - | - | - | - | - | - | - | - | ✓ | - | - |
| CO6 | ✓ | ✓ | - | - | - | - | - | - | - | - | - | - | - | - |

| Outcomes | | WKS and Indicators of attainment and Justification for mapping(students will be able to) | | | | | | | | | IAs Count |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | POs | WK 1 | WK 2 | WK 3 | WK 4 | WK 5 | WK 6 | WK 7 | WK 8 | WK 9 | |

| | | a | a | b | c | d | e | f | g | h | a | b | c | a | b | c | a | b | c | d | e | f | a | b | c | a | b | c | d | a | b | c | d | e | f | g | a | b | c | d | e | f | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 2 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 3 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 5 | | • | • | • | | • | • | • | • | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | | | | | 10 |
| | PSO 1 | • | | • | | | • | • | • | • | | | | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | | 9 |
| CO 4 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| CO 5 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PSO 1 | • | | • | | | • | • | • | • | | | | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | | 9 |
| CO 6 | PO 1 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| | PO 2 | • | • | • | • | • | • | • | | | • | • | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |

**SECTION 10B: Indicators of Attainment with COs to POs and PSOs**

| Course Outcomes | Percentage of Indicators of Attainments (IA) with POs and PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO | | | | | | | | | | | PSO | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 | 3 |
| CO1 | 73 | 73 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO2 | 73 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO3 | 73 | 73 | - | - | 90 | - | - | - | - | - | - | 69 | - | - |
| CO4 | 73 | 73 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO5 | 73 | - | - | - | - | - | - | - | - | - | - | 69 | - | - |
| CO6 | 73 | 73 | - | - | - | - | - | - | - | - | - | - | - | - |

**SECTION 10C: Course Articulation Matrix of COs to POs**

| **0**<br>No Contribution (0-5%) | **1**<br>Low (≥5 - <40%) | **2**<br>Moderate (≥40 - <60%) | **3**<br>High (≥60%) |
|---|---|---|---|

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 | 3 |
| CO1 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO2 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO3 | 3 | 3 | - | - | 3 | - | - | - | - | - | - | 3 | - | - |
| CO4 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO5 | 3 | - | - | - | - | - | - | - | - | - | - | 3 | - | - |
| CO6 | 3 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 18 | 12 | - | - | 3 | - | - | - | - | - | - | 6 | - | - |
| **Average** | **3** | **3** | | | **3** | | | | | | | **3** | | |

**SECTION 10D: Level of Contribution of the COs to POs and PSOs**

| Number | Programme Outcomes | Proficiency Assessed by | Contribution Level (from 1 to 3) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PO 1 | Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in **WK1 to WK4** respectively to develop to the solution of **complex engineering problems**. | CIE / SEE / AAT:1 – 2 Assignments / Open-ended problems | **3** |
| PO 2 | Identify, formulate, review research literature and analyse **complex engineering problems** reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4). | CIE / SEE / AAT:1 – 2 | **3** |
| PO 5 | Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognising their limitations to solve **complex engineering problems**. (WK2 and WK6). | CIE / SEE / AAT:2 – 2 | **3** |
| PSO 1 | Design and supervise sub-structures and super structures for residential and public buildings, industrial structures, irrigation structures, power houses, highways, railways, airways, docs and harbours. | AAT: 1 – 1 Tech-Talk | **3** |

| **SECTION 11: Course Content** | |
|---|---|
| **MODULE - I** | **INTRODUCTION** |
| | Historic development- General principles of pre-stressing pre-tensioning and post tensioning- Advantages and limitations of Prestressed concrete- General principles of PSC- Classification and types of pre-stressing Materials- high strength concrete and high tensile steel their characteristics. Methods and Systems of prestressing: Pre-tensioning and Post-tensioning methods and systems of prestressing like Hoyer system, Magnel Blaton system, Freyssinet system and Gifford- Udall System- Lee McCall system. |
| **MODULE - II** | **LOSSES OF PRE-STRESS** |
| | Loss of pre-stress in pre-tensioned and post-tensioned members due to various causes like elastic shortage of concrete, shrinkage of concrete, creep of concrete, relaxation of stress in steel, slip in anchorage, frictional losses. |
| **MODULE - III** | **FLEXURE** |
| | Analysis of sections for flexure, beams pre-stressed with straight, concentric, eccentric, bent and parabolic tendons- stress diagrams, Elastic design of PSC beams of rectangular and I section Kern line, Cable profile and cable layout.<br>Shear: General Considerations, Principal tension and compression, improving shear resistance of concrete by horizontal and vertical pre-stressing and by using inclined or parabolic cables, Analysis of rectangular and I beam for shear, Design of shear reinforcements- Bureau of Indian Standards (BIS) Code provisions. |
| **MODULE - IV** | **TRANSFER OF PRE-STRESS IN PRE-TENSIONED MEMBERS** |
| | Transmission of pre-stressing force by bond, Transmission length, Flexural bond stresses, IS code provisions, Anchorage zone stresses in post tensioned members, stress distribution in End block, Analysis by Guyon, Magnel, Zielinski and Rowe’s methods, Anchorage zone reinforcement, BIS Provisions. |
| **MODULE - V** | **COMPOSITE BEAMS AND DEFLECTIONS** |
| | Different Types: Propped and Unpropped, stress distribution, Differential shrinkage, Analysis of composite beams, General design considerations.<br>Deflections: Importance of control of deflections, Factors influencing deflections, short term deflections of uncracked beams, prediction of longtime deflections, BIS code requirements. |

| **SECTION 12: Tentative Schedule of Instructions** |
|---|

| Week Number | Topics | Duration (Hours) |
|---|---|---|
| 1 | 1.1 Historic development of pre-stressing technology.<br>1.2 General principles of pre-tensioning and post-tensioning.<br>1.3 Advantages and limitations of pre-stressed concrete. | 3 |
| 2 | 2.1 General principles of PSC.<br>2.2 classifications and types of pre-stressing methods.<br>2.3 Pre-stressing Materials. | 3 |
| 3 | 3.1 High strength concrete and high tensile steel.<br>3.2 Advantages of pre-stressed concrete.<br>3.3 Limitations of pre-stressed concrete. | 3 |
| 4 | 4.1 Characteristics of pre-stressed concrete.<br>4.2 Methods and Systems of pre-stressing.<br>4.3 Pre-tensioning methods. | 3 |
| 5 | 5.1 Post-tensioning methods.<br>5.2 Hoyer system of pre-stressing.<br>5.3 Magnel Blaton system of pre-stressing. | 3 |
| 6 | 6.1 Freyssinet system of pre-stressing.<br>6.2 Gifford- Udall System of pre-stressing.<br>6.3 Lee McCall system of pre-stressing. | 3 |
| 7 | 7.1 Nature of loss of prestress.<br>7.2 Loss of prestress in pre-tensioned.<br>7.3 Loss of prestress in post-tensioned members. | 3 |
| 8 | 8.1 Loss of prestress due to elastic deformation.<br>8.2 Loss of prestress due to shrinkage.<br>8.3 Loss of prestress due to creep. | 3 |
| **CONTINUOUS INTERNAL EXAMINATION (CIE- I)** | | |
| 9 | 9.1 Loss of prestress due to Relaxation of stress in steel.<br>9.2 Loss of prestress due to Slip in anchorage.<br>9.3 Loss of prestress due to frictional losses. | 3 |
| 10 | 10.1 Analysis of sections for flexure.<br>10.2 Beams prestressed with straight tendon and concentric tendon.<br>10.3 Beams prestressed with eccentric tendon, bent and parabolic tendons. | 3 |
| 11 | 11.1 Stress diagrams for stress distribution.<br>11.2 Elastic design of PSC beams of rectangular section and I section<br>11.3 Kern line concept of analysis. | 3 |
| 12 | 12.1 Analysis for cable profile and cable layout.<br>12.2 General Considerations for shear design.<br>12.3 Principal tension and compression. | 3 |
| 13 | 13.1 Analysis of rectangular beam for shear.<br>13.2 Analysis of I - beam for shear analysis.<br>13.3 Design of shear reinforcements as per Code provisions. | 3 |
| 14 | 14.1 Improving shear resistance of concrete by horizontal prestressing<br>14.2 Transmission length, Flexural bond stresses<br>14.3 Anchorage zone stresses in post tensioned members | 3 |
| 15 | 15.1 Stress distribution in End block<br>15.2 Analysis by Guyon, Magnel, Zielinski and Rowe’s methods, Anchorage zone reinforcement<br>15.3 Composite Beams: Different Types, Propped and Unpropped | 3 |
| 16 | 16.1 Differential shrinkage, Analysis of composite beams.<br>16.2 Importance of control of deflections, Factors influencing deflections<br>16.3 Short term deflections of uncracked beams and Prediction of long-term deflections | 3 |
| | **Total** | **48** |

| **SECTION 13: Specific Goals for the Course** |
|---|
| **The following table shows the knowledge and skills covered by the unit outcomes:** |

| Knowledge | Skills |
|---|---|
| **Learners should understand:**<br>• General principles of Prestressed Concrete<br>• Classifications and types of pre-stressing<br>• Advantages and limitations of pre-stressed concrete<br>• Pre-tensioning and Post-tensioning methods<br>• Systems of pre-stressing like Hoyer system, Magnel Blaton system, Freyssinet system and Gifford- Udall System and Lee McCall system<br>• Loss of prestress in pre-tensioned and post-tensioned members<br>• Analysis of sections for flexure<br>• Design of shear reinforcements<br>• Transmission of prestressing force by bond<br>• Analysis by Guyon, Magnel, Zielinski and Rowe's methods<br>• Different Types, Propped and Unpropped<br>• Importance of control of deflections | **Learners can:**<br>• Ability to analyze prestressed concrete beams, slabs, and other structural members for different stages<br>• Proficiency in designing prestressed concrete elements for flexure (bending), shear, bond, deflection control and crack width limitation<br>• Familiarity with design codes such as IS: 1343, IRC, or ACI codes related to prestressed concrete<br>• Ability to interpret and apply code-based limit state and working stress methods.<br>• Skill in using load balancing method and cable profile optimization.<br>• Knowledge of construction techniques, equipment used, and detailing of prestressing tendons.<br>• Evaluating long-term deflections, crack control, and durability aspects of prestressed structures.<br>• Ability to compare alternatives and select the most economical and safe design solution.<br>• Skill in preparing design reports, drawings, and technical documentation. |

## Administrative Information

**SECTION 15: History of changes**

| Regulations | Description of change | BOS Date |
|---|---|---|
| R 16 | No Changes R15 JNTUH, Hyderabad to R16 IARE regulations | 15.12.2016 |
| R 18 | No Changes from R16 to R18 regulation | 10.07.2018 |
| UG 20 | No Changes from R18 to UG 20 regulation | 17.11.2020 |
| BT 23 | No Changes from UG 20 to BT 23 regulation | 21.08.2023 |

**Course Outline Approvals**

| Course Coordinator | Head of the Department |
|---|---|
| Name: Dr. Praveena Rao | Name: Dr. R. Ramya Swetha |
| Signature: | Signature: |
| Date: 18.8.2025 | Date: 18.8.2025 |

**Course Outline Approvals: The course outline description approved by Outcome Based Teaching Learning (OBTL) committee on *date* in meetings *IARE - OBTL – COD /104/25***

| Dean of Outcome Based Teaching and Learning | Dean of Academics |
|---|---|
| Name: Dr. Ch. Srinivasulu | Name: Dr. G. Chandra Sekhar |
| Signature: | Signature: |
| Date: 18.8.2025 | Date: 18.8.2025 |

**Check List**

| Section | Description | Please tick (✓) |
|---|---|---|
| 1 | General Information about the Course | ✓ |
| 2 | Notional Study Time | ✓ |
| 3 | A. Course Outcomes | ✓ |
| | B. Cognitive Levels | ✓ |
| 4 | Content and Context of the Course | ✓ |
| 5 | Complex Engineering Problem Solving | ✓ |
| 6 | A. Assessment Methods – Direct | ✓ |
| | B. Assessment Methods – Indirect | ✓ |
| 7 | Content Delivery / Instructional Methodologies | ✓ |
| 8 | Engineering Competencies (ECs) Focused | ✓ |
| 9 | Employability Skills | ✓ |
| 10 | Relevance to Sustainability goals | ✓ |
| 11 | A. Mapping between COs and POs / PSOs | ✓ |
| | B. Indicators of Attainment with COs to POs and PSOs | ✓ |
| | C. Course Articulation Matrix of COs to POs | ✓ |
| | D. Level of Contribution of the COs to POs and PSOs | ✓ |
| 12 | Syllabus | ✓ |
| 13 | Tentative Schedule of Instructions | ✓ |
| 14 | Specific Goals for the Course | ✓ |
| 15 | History of Changes | ✓ |