Computational Structural Mechanics – Classical & FE Approach

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –II

Subject Code	**MCSE201**	CIE	50
Number of Lecture Hours/Week (L:P:SDA)	3:0:0	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS– 03

Objectives:

The course aims to equip students with a comprehensive understanding of the direct stiffness method and finite element analysis. Students will learn to analyze trusses, continuous beams, and 2D frames under various conditions, develop proficiency in deriving stiffness matrices, and implement computer programs for practical engineering applications.

Course Outcomes

At the end of the course the students will be able to

- **CO1**: Understand the basic principles of the direct stiffness method for analyzing trusses, including degrees of static and kinematic indeterminacy, local and global coordinate systems, and stiffness matrix formulation. **RBT Level**: **Understanding** (Level 2)
- **CO2**: Apply the direct stiffness method to analyze continuous beams and 2D frames with different boundary conditions, including the ability to incorporate support settlements and elastic supports. **RBT Level**: **Applying** (Level 3)
- **CO3**: Gain a comprehensive understanding of the finite element method (FEM), including the principles of virtual work, minimum potential energy, and Galerkin's method, and apply them to solve simple structural problems. **RBT Level**: **Understanding** (Level 2) and **Applying** (Level 3)
- **CO4**: Develop proficiency in deriving shape functions and stiffness matrices for axial force elements and beam elements, including those with linear, higher-order, and Hermitian interpolation, and apply them to real-world engineering problems. **RBT Level**: **Analyzing** (Level 4)
- **CO5**: Demonstrate the ability to develop and implement computer programs to generate stiffness matrices and analyze trusses, continuous beams, and 2D frames using programming languages, applying this knowledge to practical engineering scenarios. **RBT Level**: **Creating** (Level 6)

Modules

Module-1

Direct Stiffness Method–Analysis of Trusses

Degrees of static and kinematic indeterminacies, degrees of freedom, discrete and continuous systems, local and global coordinate systems. Concepts of flexibility and stiffness, local and global coordinate systems, rotation transformation matrix, and element stiffness matrix for two-noded bar elements and two-noded beam elements. Analysis of simple pin-jointed trusses with and without initial strains for different combinations of support conditions (upto3DOF)and simple problems of trusses involving support settlement. **Self-StudyComponent**: Develop a program for generating the overall stiffness matrix for a truss using any programming language.

Teaching-Learning Process	**L2, L3**

Module-2

Direct Stiffness Method-Analysis of Continuous Beams and 2-DFrames

Analysis of continuous beams for different types of boundary conditions, such as fixed, hinged, roller, slider, elastic (spring)supports,and support settlement.Analysis of simple 2-D frames with and without sway.**Self-Study Component**: Develop a program for the analysis of continuous beams and 2-D frames using any programming language.

Teaching-Learning Process	L3

Module-3

Introduction to FEM & Discretization

Basic steps in FEM, Advantages &disadvantages.Types of elements – Natural subdivision at discontinuities, minimization of band width, element aspect ratio, discretization of very large bodies and infinite bodies. ***Self Study Component:*** Learn about different elements available in different finite element packages

Teaching-Learning Process	L2

Module-4

Displacement Functions and Shape Functions.

Selection of displacement functions, convergence requirements, geometric invariance, Pascal triangle, Different coordinate systems.Shape functions, Lagrange's shape functions for one dimensional and two dimensional rectangular elements. Serendipity elements & isoparametric elements.

Self Study Component: Learn to draw the various shape function diagrams.

Teaching-Learning Process	L2, L3

Module-5

Computation of Element Stiffness Matrix

Derivation of element stiffness matrix for truss element and beam element by direct approach and variational approach, Lumped loads, Numerical problems on analysis of plane trusses and beams.

Self-StudyComponent: Develop a program for generating the overall stiffness matrix for beam elements using any programming language.

Teaching-Learning Process	L2, L3

Question paper pattern:

The question paper will have ten questions; each question carries equal marks. There will be two full questions or a maximum of four sub-questions from each module. Students will have to attend five full questions from each module.

Text Books:

1. Rajasekaran.S,“ComputationalStructuralMechanics”,PHI,NewDelhi2001.
2. Reddy.C.S,“BasicStructuralAnalysis,”TMH,NewDelhi2001
3. Robert D Cook et al, “Concepts and Applications of Finite Element Analysis”, 3rd Edition, Jo Wiley and Sons, New York,2007

Reference Books:

- **Beaufait, F. W. et al.**, *Computer Methods of Structural Analysis*, Prentice Hall, 1970.
- **Weaver, W. and Gere, J. H.**, *Matrix Analysis of Framed Structures*, Van Nostrand, 1980.
- **Rubinstein, M. F.**, *Matrix Computer Methods of Structural Analysis*, Prentice Hall, 1966.
- **Bathe, K. J.**, *Finite Element Procedures in Engineering Analysis*, PHI, New Delhi, 2006

Skill Development Activities

- Develop computer programs for analyzing trusses and continuous beams using the direct stiffness method.
- Create simulations to visualize the behavior of structures under different loading conditions.
- Conduct hands-on workshops on finite element modeling using software tools.
- Analyze real-world case studies of structural failures to understand design considerations.
- Participate in group projects to design and present earthquake-resistant structures using learned principles.

Web links

https://archive.nptel.ac.in/courses/105/107/105107209/
https://onlinecourses.nptel.ac.in/noc23_ce87/preview

CO-PO Mapping Table

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	2	1	1	1	-	-	2
CO2	3	3	2	2	3	1	1	1	-	-	3
CO3	3	3	3	3	3	2	2	2	-	2	3
CO4	3	3	3	3	3	2	2	2	2	2	3
CO5	3	2	2	3	3	2	3	3	2	2	3

Explanation of Scale:

- **3**: Strongly aligned
- **2**: Moderately aligned
- **1**: Slightly aligned
- **-**: Not aligned

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Structural Dynamics and Earthquake Resistant Design of Structures

[As per Choice Based Credit System (CBCS)scheme]

SEMESTER–II

Subject Code	**MCSE202**	CIE Marks	50
Teaching Hours/Week(L:P:SDA)	3:0:2	SEE Marks	50
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS–04

Course objectives: The objective of this syllabus is to provide students with a comprehensive understanding of dynamic analysis in civil engineering, including single and multi-degree-of-freedom systems, seismic forces, and earthquake-resistant design. It aims to equip students with practical skills in modeling, numerical methods, and structural design, using modern engineering tools and adhering to national standards, such as IS 1893, for real-world applications. Evaluate the dynamic characteristics of the structures.

Modules

Module-1

Introduction: Introduction to dynamic problems in civil engineering, concept of degrees of freedom, D'Alembert's principle, principle of virtual displacement, and energy principles.

Dynamics of Single-Degree-of-Freedom Systems: Mathematical models of single-degree-of-freedom systems, free vibration response of damped and undamped systems, including methods for evaluation of damping.

Teaching Learning Process	**L2**

Module-2

Response of Single-Degree-of-Freedom Systems to Harmonic Loading: Including support motion, vibration isolation, and transmissibility. Numerical methods applied to single-degree-of-freedom systems. **Dynamics of Multi-Degree-of-Freedom Systems**: Mathematical models of multi-degree-of-freedom systems, shear building concept, free vibration of undamped multi-degree-of-freedom systems—natural frequencies and mode shapes—orthogonality of modes.

Teaching Learning Process	**L3**

Module-3

Approximate Methods in Dynamic Analysis: Rayleigh's method, Dunkerley's method, Stodola's method. Introduction to engineering seismology, geological and tectonic features of India, origin and propagation of seismic waves, characteristics of earthquakes and their quantification—magnitude and intensity scales, seismic instruments. The response history and strong motion characteristics. Response Spectrum—elastic and inelastic response spectra, tripartite (D-V-A) response spectrum, and the use of response spectrum in earthquake-resistant design.

Teaching Learning Process	**L3,L2**

Module-4

Computation of seismic forces in multi-storied buildings: Using procedures (Equivalent Lateral Force and Dynamic Analysis) as per IS-1893. Introduction to masonry structures and design provisions for these in IS-1893. Effect of infill masonry walls on frames and modeling concepts of infill masonry walls. Concepts for earthquake-resistant masonry buildings—codal provisions.

Teaching Learning Process	**L3,L4**

Module-5

Design of Reinforced Concrete Buildings for Earthquake Resistance: Load Combinations. Confinement of concrete for ductility, design of columns and beams for ductility, and ductile detailing provisions as per IS 1893. Structural behavior, design, and ductile detailing of shear walls. Overview of linear and nonlinear procedures of seismic analysis. Seismic evaluation and retrofitting of structures.

Teaching Learning Process	**L4, L5**

Course out comes:

CO1: Understand the basic principles of dynamic problems in civil engineering, including degrees of freedom, D'Alembert's principle, and energy methods, and apply these to single-degree-of-freedom systems.

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(Bloom's Level: Understanding - L2)

CO2: Analyze the response of single-degree-of-freedom systems to harmonic loading, including support motion, vibration isolation, and transmissibility, and apply numerical methods to solve these problems.

(Bloom's Level: Applying - L3)

CO3: Apply approximate methods such as Rayleigh's, Dunkerley's, and Stodola's methods in dynamic analysis, and understand seismic concepts, including the propagation of seismic waves, earthquake quantification, and response spectrum.

(Bloom's Level: Applying - L3, Understanding - L2)

CO4: Evaluate seismic forces in multi-storied buildings using IS 1893 standards, understand the impact of masonry infill walls on structural performance, and apply earthquake-resistant design provisions for masonry structures.

(Bloom's Level: Evaluating - L4, Applying - L3)

CO5: Design reinforced concrete buildings for earthquake resistance, incorporating load combinations, ductile detailing of beams and columns, and applying IS 1893 provisions to shear walls and retrofitting techniques.

(Bloom's Level: Creating - L5, Analyzing - L4)

Question paper pattern:

The question paper will have ten questions; each question carries equal marks. There will be two full questions and a maximum of four sub-questions from each module. Students will have to attend five full questions from each module.

Reference Books:

1. **Dynamics of Structures** – "Theory and Application to Earthquake Engineering," 2nd ed., Anil K. Chopra, Pearson Education.
2. **Earthquake Resistant Design of Building Structures**, Vinod Hosur, WILEY (India).
3. **Vibrations, Structural Dynamics** – M. Mukhopadhaya, Oxford IBH.
4. **Structural Dynamics** – Mario Paz, CBS Publishers.
5. **Structural Dynamics** – Clough & Penzien, TMH.
6. **Vibration Problems in Engineering** – S. Timoshenko, Van Nostrand Co.
7. • **Earthquake Resistant Design of Structures** – Pankaj Agarwal, Manish Shrikande, PHI India.

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=0KiYC8QQOiM&list=PLyVhmjhvTvDbqByamCNEYw2zDBOscOHR bhttps://www.youtube.com/watch?v=Jlzo8OzoZ_c&list=RDQMjbIvZOwDdoM&start_radio=1

https://www.youtube.com/watch?v=kZFtZKzuo3I&list=PL6XkfCIV_u2Now2UXF1DCLrT06Zyg4UtS

Skill Development Activity

Modeling and Simulation:

Use MATLAB/ANSYS/SAP2000 to simulate SDOF and MDOF systems under dynamic loading.

Vibration Isolation Experiments:

Conduct lab experiments to analyze vibration isolation and transmissibility.

Numerical Methods:

Implement numerical methods (e.g., Newmark-beta) for dynamic problems using Python or MATLAB.

Seismic Analysis Case Studies:

Analyze earthquake data and structural responses using seismic response spectra.

Structural Health Monitoring and Retrofitting:

Learn NDT techniques and retrofitting methods for seismic evaluation.

Seismic Design with Software:

Use ETABS/STAAD Pro to design earthquake-resistant structures as per IS 1893.

Collaborative Project:

Work in teams to design a multi-story building with seismic considerations, integrating various skills.

CO-PO Mapping Table

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	2	-	1	-	-	-	2
CO2	3	3	2	2	3	-	2	1	-	-	3
CO3	3	3	2	2	3	1	2	1	1	-	3
CO4	3	3	3	3	3	2	3	2	1	2	3
CO5	3	3	3	3	3	3	3	2	1	2	3

Explanation of Scale:

- **3**: Strongly aligned
- **2**: Moderately aligned
- **1**: Slightly aligned
- **-**: Not aligned

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Two Unit Tests each of **25 Marks**
4. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

6. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
7. The question paper will have ten full questions carrying equal marks.
8. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
9. Each full question will have a sub-question covering all the topics under a module.
10. The students will have to answer five full questions, selecting one full question from each module

Advanced Design of Structural Elements

[Asper Choice Based Credit System (CBCS)scheme]

SEMESTER–II

Subject Code	**MCSE203**	CIE Marks	50
Teaching Hours /Week(L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: Students should have a foundational understanding of structural engineering principles, including equilibrium and material properties, along with mechanics of materials covering stress, strain, and loading behavior. Familiarity with reinforced concrete and steel design concepts, as well as knowledge of relevant design codes, is essential. Additionally, proficiency in mathematics, including calculus, linear algebra, and differential equations, is required to effectively support structural analysis and design methodologies.

Course objectives: To develop a comprehensive understanding of design principles for structural elements, including flat slabs, continuous beams, and reinforced concrete structures. Students will apply analytical techniques for designing steel beams and cold-formed sections while enhancing problem-solving skills through practical examples. The course encourages integrating multidisciplinary knowledge and promotes lifelong learning and adaptability to keep pace with evolving technologies in structural engineering practices.

Modules

Module-1

- Design of grid floors
- Design of continuous beams with redistribution of moments

Teaching Learning Process	**RBT Levels**: L1 (Remembering), L2 (Understanding), L3 (Applying), L4 (Analyzing), L5 (Evaluating)

Module-2

- Design of flat slabs
- Design of RC silos

Teaching Learning Process	**RBT Levels**: L1 (Remembering), L2 (Understanding), L3 (Applying), L4 (Analyzing), L5 (Evaluating)

Module-3

- Yield line theory of slabs
- Design of chimney

Teaching Learning Process	• **RBT Levels**: L1 (Remembering), L2 (Understanding), L3 (Applying), L4 (Analyzing), L5 (Evaluating)

Module-4

Steel beam with web openings

Shape of the web openings, practical guidelines, and force distribution and failure patterns. Analysis of beams with perforated thin and thick webs. Design of laterally restrained castellated beams for given sectional properties. Vierendeel girders (design for given analysis results).

Teaching Learning Process	**RBT Levels**: L1 (Remembering), L2 (Understanding), L3 (Applying), L4 (Analyzing), L5 (Evaluating)

Module-5

Cold formed steel sections: Techniques and properties, advantages, typical profiles, stiffened and unstiffened elements, local buckling effects, effective section properties, IS 801 and 811 code provisions— numerical examples, beam design, column design.

Fire resistance: Fire resistance level, period of structural adequacy, properties of steel with temperature, limiting steel temperature, protected and unprotected members, methods of fire protection, fire resistance ratings, and numerical examples.

Teaching Learning Process	**RBT Levels**: L1 (Remembering), L2 (Understanding), L3 (Applying), L4 (Analyzing), L5 (Evaluating)

Course out comes:

- **CO1**: Understand and apply principles in the design of flat slabs, grid floors, and continuous beams, incorporating moment redistribution techniques.
- **CO2**: Analyze and design reinforced concrete structures, including chimneys, silos, and bunkers, inaccordance with relevant codes and standards.
- **CO3**: Evaluate the impact of web openings on steel beams and design laterally restrained castellatedbeams and Vierendeel girders effectively.
- **CO4**: Comprehend the characteristics, design techniques, and local buckling effects of cold-formed steel sections, including the relevant IS codes.
- **CO5**: Assess fire resistance levels of steel structures, understanding material behavior under temperature effects and methods of fire protection.

Question paper pattern:

IS 456:2000, IS 800:2007, IS 801:2010, IS 811:1987, and BS 5950 – Part 8 will be allowed, along with steel tables, in the exam.

The question paper will have ten questions, each carrying equal marks. There will be two full questions or a maximum of four sub-questions from each module. Students will have to attempt five full questions from each module.

Reference Books:

1. N.Subramanian, "Design of Steel Structures", Oxford, IBH
2. Duggal,S.K.DesignofSteelStructures,TataMcGraw-Hill3.IS800:2007,IS801-2010,IS811-1987
4. BS5950 Part- 8,
5. INSDAG Teaching Resource Chapter 11 to20:www.steel-insdag.org6. SP 6(5)-1980
6. KrishnaRaju.N.,"AdvancedReinforcedConcreteDesign",CBSPublishers& Distributors

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=qJV5zdx7NJs&t=10shttps://www.youtube.com/watch?v=aLgdv91U2OQ

https://www.youtube.com/watch?v=undsd92MM8w&list=PLbQO4xhI7wEDIYv90NoF7veaJIohpuf0Q

Skill Development Activities Suggested

- **Conduction of technical seminars on recent research activities**
- **Group Discussion**

CO-PO Mapping Table

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2									
CO2	3	2	2	2	3						
CO3	2	2			2						
CO4	2				2	1					
CO5	2		2		2	1	1				2

- **1**: Basic understanding
- **2**: Application of knowledge
- **3**: Advanced application / synthesis

Assessment Details (both CIE and SEE) : The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together..

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**

2. Two assignments each of **25 Marks or one Skill Development Activity of 50 marks to attain the COs and POs**

The sum of two tests, two assignments/skill Development Activities**, will be scaled down to 50 marks CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

MODB & Fracture Mechanics

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE204**	CIE Marks	50
Teaching Hours/Week(L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: Students should have a foundational understanding of basic mechanics, including forces and equilibrium, along with knowledge of material science, particularly the properties of concrete and steel. Proficiency in mathematics, including calculus and differential equations, is essential for elasticity problem-solving. A background in structural analysis principles and skills in reading engineering graphics are also required to facilitate comprehension of advanced topics in elasticity and fracture mechanics.

Course objectives:

This course aims to provide students with a thorough understanding of the theory of elasticity and its applications in civil engineering. Students will learn to analyze stress and strain in various structural components, apply transformation techniques, and solve plane stress and strain problems. The curriculum also covers three-dimensional elasticity problems and introduces fracture mechanics, emphasizing the behavior of concrete. By the end, students will develop the skills to apply these concepts in practical engineering scenarios.

Modules

Module-1

Theory of Elasticity: Introduction: Definition of stress and strain, and strain at a point; components of stress and strain at a point in Cartesian and polar coordinates. Constitutive relations, equilibrium equations, compatibility equations, and boundary conditions in 2-D and 3-D cases.

Teaching Learning Process	Understand (RBT Level 2)

Module-2

Transformation of Stress and Strain at a Point: Principal stresses and principal strains, invariants of stress and strain, hydrostatic and deviatoric stress, spherical and deviatoric strains, maximum shear strain.

Teaching Learning Process	Analyze (RBT Level 3)

Module-3

Plane Stress and Plane Strain: Airy's stress function approach to 2-D problems of elasticity, simple problems of bending of beams. Solution of axisymmetric problems, stress concentration due to the presence of a circular hole in plates.

Teaching Learning Process	Apply (RBT Level 3)

Module-4

Elementary Problems of Elasticity in Three Dimensions: Stretching of a prismatic bar by its own weight, twist of circular shafts, torsion of non-circular sections, membrane analogy, propagation of waves in solid media. Applications of finite difference equations in elasticity.

Teaching Learning Process	Apply (RBT Level 3)

Module-5

Fracture of Concrete: Introduction to fracture mechanics and limitations of theories of linear elastic fracture mechanics in concrete. Review of concrete behavior in tension and compression. Kaplan's experiments, concept of fracture energy, definition of a quasi-brittle material, concept of softening.

Teaching Learning Process	Understand (RBT Level 2)

Course out comes:

CO1: Understand the fundamental concepts of stress and strain in both 2D and 3D elasticity, along with the governing equations.

CO2: Analyze stress and strain transformations, principal stresses, and invariant properties at a point.

CO3: Apply Airy's stress function approach to solve 2D problems and analyze bending of beams.
CO4: Explore the behavior of materials under various loads and the propagation of waves in solid media.
CO5: Grasp the basics of fracture mechanics in concrete and understand concepts related to fracture energy and material softening.

Question paper pattern:

The question paper will have ten questions, each carrying equal marks. There will be two full questions or a maximum of four sub-questions from each module, and students will have to attempt five full questions from each module.

Reference Books:

1. Timoshenko & Goodier, "Theory of Elasticity", McGraw Hill
2. Srinath L. S., *Advanced Mechanics of Solids*, 10th print, Tata McGraw Hill Publishing Company, New Delhi, 1994.
3. Sadhu Singh, "Theory of Elasticity", Khanna Publishers
4. Verma P. D. S, "Theory of Elasticity", Vikas Publishing Pvt. Ltd.
5. Chenn W. P. and Hendry D. J, "Plasticity for Structural Engineers", Springer Verlag
6. Valliappan C, "Continuum Mechanics Fundamentals", Oxford IBH Publishing Co. Ltd.
7. Sadhu Singh, "Applied Stress Analysis", Khanna Publishers
8. Xi Lu, "Theory of Elasticity", John Wiley.
9. T. L. Anderson, "Fracture Mechanics: Fundamentals and Applications", CRC Press

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=eICv1p8WjgI&list=PLbRMhDVUMngcbhsZgRWuYCi2kKQwQ0Av1
https://www.youtube.com/watch?v=lfEh3yWTBuM
https://www.youtube.com/watch?v=PTSFXu19OMghttps://www.youtube.com/watch?v=G5mcTw-PLEI

Skill Development Activities Suggested

- **Case Studies Analysis**: Analyze real-world case studies related to elasticity and fracture mechanics to understand practical applications.
- **Software Simulations**: Use software tools (like ANSYS or ABAQUS) to simulate stress and strain analysis in various structures.
- **Group Discussions**: Facilitate group discussions on recent advancements in elasticity and fracture mechanics to encourage collaborative learning.
- **Research Project**: Conduct a mini-research project on a specific topic within the elasticity domain, focusing on emerging theories or applications.
- **Workshops**: Participate in workshops on advanced material testing techniques for analyzing the mechanical properties of concrete and other materials.

Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1									
CO2	2	2									
CO3	1	2	1								
CO4	2	1		1							
CO5	1		1	2							

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

5. Two Unit Tests each of **25 Marks**
6. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

11. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
12. The question paper will have ten full questions carrying equal marks.
13. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
14. Each full question will have a sub-question covering all the topics under a module.
15. The students will have to answer five full questions, selecting one full question from each module

ADVANCED CONCRETE TECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE215A**	CIE Marks	50
Teaching Hours /Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: Students should have a foundational understanding of material science, particularly in cement and concrete technology. Basic knowledge of chemistry and civil engineering principles is essential for grasping the chemical and physical properties of cement and concrete. Familiarity with construction materials and methods will also be beneficial. Additionally, students should be aware of relevant industry standards and specifications related to concrete production and testing, as this knowledge will enhance their ability to apply theoretical concepts in practical scenarios.

Course objectives: The course aims to provide students with comprehensive knowledge of cement production, hydration chemistry, and the properties of concrete. Students will learn about the impact of chemical and mineral admixtures on concrete performance, the principles of high-performance concrete, and the importance of fresh and hardened concrete properties. Additionally, the course covers advanced topics such as creep, shrinkage, and the latest developments in concrete technology, equipping students with the skills necessary for effective concrete design and analysis.

Modules

Module-1

Module-1

Cement production and composition - Historical use of binding materials, evolution of cement from natural materials to blended cements, evolution of Portland cement production, introduction to the cement production process, raw materials - limestone, clay, gypsum formation and its historic significance. Use of preheaters and pre-calciner in cement production, introduction to the grinding system in cement production. Oxide and compound composition, assumptions in Bogue equations, cement specifications - ASTM, BIS, and EN (Euronorms).

Cement chemistry: Understanding the rate of heat evolution in cement hydration, hydration reactions kinetics, factors affecting hydration rate, comparison of isothermal and adiabatic calorimeters, understanding heat peaks in cementitious systems, composition of pore solution, structure of hydration products - SE micrograph of paste, CSH - Feldman Sereda model, calcium hydroxide, ettringite and mono-sulphate, pores and air voids, types of pores.

Aggregates for concrete - Introduction, aggregate characteristics affecting concrete properties, interfacial transition zone, composition of the ITZ, paste-aggregate bond, effect of aggregate on elastic modulus, shrinkage, and creep of concrete. Common rocks used as aggregate. Engineering considerations of using various rocks as concrete aggregate - alkali-silica reaction, alkali-carbonate reaction.

Teaching Learning Process	• L1: Remembering (Definition and historical context) • L2: Understanding (Explanation of processes and components)

Module-2

Chemical admixtures - Introduction, classification, water reducers - normal (plasticizers) and high-range (superplasticizers), mechanism of action of plasticizers. Types and properties of plasticizers. Compatibility issues and factors affecting compatibility. Marsh cone and mini-slump test for compatibility. Set-controlling chemicals, retarding admixtures, accelerating admixtures, air-entraining admixtures, waterproofing admixtures, corrosion-inhibiting admixtures.

Mineral admixtures - Fly ash, silica fume, slag cement, metakaolin, limestone, quartz, ground granulated blast furnace slag (GGBFS), ceramic microspheres.

Teaching Learning Process	• L1: Remembering (Types of admixtures) • L2: Understanding (Mechanisms and compatibility issues) • L3: Applying (Conducting tests for compatibility)

Module-3

Introduction to high-performance concrete (HPC) - Definition and properties of HPC. Materials used in HPC: high-strength cement, SCMs, chemical admixtures. Proportioning of HPC mixtures: guidelines and design principles.

Rheological properties of HPC - Factors affecting flow, compaction, and setting time. Pumpability and self-compacting concrete (SCC).

Performance characteristics of HPC - Enhanced strength and durability features. Long-term behavior under different environmental conditions.

High-performance concrete mixture proportioning.

Teaching Learning Process	• L1: Remembering (Definition of HPC) • L2: Understanding (Properties and materials) • L3: Applying (Proportioning mixtures)

Module-4

Fresh concrete properties - Workability, rheology, and flow characteristics. Factors affecting fresh concrete: water-cement ratio, admixtures. Pumping of concrete and the role of admixtures. Hardened concrete properties - Compressive, tensile, and flexural strength of concrete. Creep and shrinkage: mechanisms and impacts on long-term behavior. Elastic modulus and the effect of aggregate types. **Concrete durability -** Durability concerns: sulfate attack, carbonation, alkali-silica reaction (ASR). Permeability and resistance to freeze-thaw cycles.

Teaching Learning Process	• L1: Remembering (Properties of fresh and hardened concrete) • L2: Understanding (Factors affecting properties) • L3: Applying (Evaluating performance characteristics)

Creep - Nature of creep, causes of creep, factors affecting creep, positive and negative effects of creep, creep testing.

Shrinkage - Nature of shrinkage, types of shrinkage, factors affecting shrinkage, combined effect of creep and shrinkage, shrinkage testing.

Concrete testing and quality control - Testing methods for cement and concrete: fineness, setting time, strength. Standards for cement (ASTM, IS, BS). Role of quality control in ensuring consistency and performance.

Advances in concrete technology - Nanotechnology in concrete. Geopolymer concrete and its applications. Future trends: smart concrete and self-healing materials.

Teaching Learning Process	• L1: Remembering (Nature and types of creep and shrinkage) • L2: Understanding (Factors affecting behavior) • L3: Applying (Testing methods and quality control)

Course out comes:

- Understand the composition and production processes of cement and its historical significance in construction.
- Analyze the effects of chemical and mineral admixtures on concrete properties and performance.
- Design high-performance concrete mixtures by applying appropriate guidelines and principles.
- Evaluate the fresh and hardened properties of concrete and understand their implications for durability and long-term performance.
- Explore advanced concrete technologies, including nanotechnology and geopolymer concrete.

Question paper pattern:

The question paper will have ten questions; each question carries equal marks, therewillbetwofullquestionsorwithamaximumoffoursubquestionsfromeachmodule, Students will have to attend five full questions from each module.

. **Textbook**

- Mehta, P. K., and Monteiro, P. J. M., 'Concrete: Microstructure, Properties, and Materials,' Fourth Edition (Indian Edition), McGraw Hill, 2014.

. **Reference books**

- Neville, A. M., 'Properties of Concrete,' Pitman Publishing, Inc., MA, 1981.
- Hewlett, P. C., Ed., 'Lea's Chemistry of Cement and Concrete,' Fourth Edition,

Arnold Publishers, NY, 1998.

- Bentur, A., Diamond, S., and Berke, N.S., 'Steel Corrosion in Concrete,' E&FN Spon, UK, 1997.
- Taylor, H. W. F., 'Cement Chemistry,' Academic Press, Inc., San Diego, CA, 1990.
- Lea, F. M., 'The Chemistry of Cement and Concrete,' Chemical Publishing Company, Inc., New York, 1971.
- Mindess, S., and Young, J. F., 'Concrete,' Prentice Hall, Inc., NJ, 1981.
- J. Newman and B. S. Choo, Eds., 'Advanced Concrete Technology', Four Volume Set, Elsevier, 2003

Recommended Reading:

. **"Properties of Concrete"** by A.M. Neville, ELBS, London.
. **"Concrete Technology"** by A.R. Santakumar, Oxford University Press (2007).
. **"Concrete Mix Design"** by N. Krishna Raju, Sehgal Publishers.
. **"Recommended Guidelines for Concrete Mix Design"** - IS: 10262, BIS Publication.
.

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=cx5gPKp9QEc&list=PLbMVogVj5nJQU7M0LdA77p_XaaWBJniNchttps://www.youtube.com/watch?v=cx5gPKp9QEc&list=PLbMVogVj5nJQU7M0LdA77p_XaaWBJniNchttps://www.youtube.com/watch?v=RSnNrQUTEnY&list=PLJAQaaJgEtI11reTaRrGWTDzezOAtGY4q

Skill Development Activities Suggested

- **Conduct Material Experiments**: Perform laboratory experiments to analyze the properties of various cement and concrete mixtures.
- **Field Visits**: Organize visits to construction sites to observe cement production and concrete application processes.
- **Group Projects**: Work on group projects to design and test high-performance concrete mixtures.
- **Research Presentations**: Prepare and present research on advances in concrete technology, including nanotechnology and geopolymer applications.
- **Simulation Software Training**: Learn to use simulation software for modeling concrete behavior under different loading conditions.

CO-PO Table

Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	1									
CO2	2	2									
CO3	1	2	1								
CO4	2	1		1							
CO5	1		1	2							

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

7. Two Unit Tests each of **25 Marks**
8. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

16. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
17. The question paper will have ten full questions carrying equal marks.
18. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
19. Each full question will have a sub-question covering all the topics under a module.
20. The students will have to answer five full questions, selecting one full question from each module

Construction Materials and their Properties

[Asper Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE215B**	CIE Marks	50
Teaching Hours/Week(L:P:SDA)	3:0:0	SEEM arks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: The prerequisites for this course include a foundational understanding of materials science and engineering principles, particularly related to construction materials. Students should be familiar with basic chemistry concepts, including chemical reactions and bonding, as well as principles of thermodynamics and mechanics. Knowledge of analytical techniques and laboratory practices is beneficial for effectively conducting experiments and interpreting results. Additionally, familiarity with mathematical concepts, such as statistics and data analysis, will aid in understanding material characterization methods and their applications.

Course objectives: The course aims to provide a fundamental understanding of calorimetry, X-ray diffraction, and microscopy techniques for analyzing construction materials. Students will evaluate the thermal, mineralogical, and microstructural properties of these materials using various analytical methods. The course will cover advanced techniques such as spectroscopy, porosimetry, and impedance analysis, focusing on effective data interpretation. Additionally, students will explore recent advancements in material characterization, fostering innovation and contributing to the development of the construction materials field.

Modules

Module-1

Introduction; Structure of Construction Materials – An Overview.

Calorimetry: Introduction to calorimetry, definition and principles, types of calorimeters, thermal properties of construction materials, hydration reactions in cementitious materials, calorimetry of bituminous materials, calorimetry of concrete and mortar, advanced applications, case studies, and research applications.

Teaching Learning Process	**RBT Levels:**L1: Remembering (Introduction and definitions) L2: Understanding (Principles and thermal properties) L3: Applying (Case studies and research applications)

Module-2

X-ray Diffraction: Introduction to XRD, principles of XRD, instrumentation and data collection, data analysis and interpretation, phase identification and quantification in cement, concrete, geopolymers, and alternative binders, mineralogical analysis of aggregates, identification of clay minerals, analysis of asphalt cement and aggregates in XRD, in-situ XRD and time-resolved studies, high-temperature and high-pressure XRD, XRD imaging and mapping, recent research developments in XRD for construction materials, industrial applications, and collaborations.

Surface Area Measurement: Introduction, definition, principles, and importance of surface area measurement in construction materials, methods and instruments for surface area measurement, BET (Brunauer-Emmett-Teller) theory and method, Langmuir and Freundlich isotherms, mercury porosimetry, nitrogen adsorption and desorption, image analysis and stereology.

Teaching Learning Process	**RBT Levels:** L1: Remembering (Basic concepts of XRD and surface area measurement) L2: Understanding (Principles, instrumentation, and data analysis) L3: Applying (Phase identification and mineralogical analysis)

Module-3

Optical Microscopy: Introduction to optical microscopy, principles of light microscopy, types of optical microscopes (compound, stereo, polarized light), instrumentation and accessories, sample preparation,

image formation and contrast, microstructure of cement paste and concrete, identification of hydration products and phases, analysis of porosity, cracking, and degradation, microscopy of aggregates and rocks, microstructure of asphalt and bituminous materials, advanced techniques (polarized light microscopy, fluorescence microscopy, confocal microscopy), recent research developments in optical microscopy for construction materials. **Scanning Electron Microscopy:** Principles, techniques, and applications of SEM in analyzing construction materials, sample preparation, image formation and interpretation, advanced techniques like energy-dispersive spectroscopy and electron backscatter diffraction, microstructure of cement, concrete, aggregates, rocks, asphalt, and bituminous materials, and their degradation mechanisms. Case studies and research applications.	
Teaching Learning Process	**RBT Levels:** L1: Remembering (Types of microscopes and basic principles) L2: Understanding (Microstructure analysis and techniques) L3: Applying (Advanced microscopy techniques and their applications)
Module-4	
Image Analysis: Introduction to image analysis, image processing techniques, feature extraction and measurement, texture analysis, pattern recognition, applications in construction materials (cement, concrete, aggregates, asphalt, etc.), case studies, and research applications. **Spectroscopic Techniques:** Introduction to spectroscopy, principles of spectroscopy, types of spectroscopy (infrared (IR), Raman, nuclear magnetic resonance (NMR)), principles and applications in construction materials, other spectroscopic techniques (ultraviolet-visible (UV-Vis), X-ray fluorescence (XRF), X-ray absorption (XAS)), recent research developments in spectroscopic techniques for construction materials.	
Teaching Learning Process	**RBT Levels:** L1: Remembering (Introduction to image analysis and spectroscopy) L2: Understanding (Processing techniques and principles) L3: Applying (Case studies and applications in construction materials)
Module-5	
Mercury Intrusion Porosimetry: Introduction to porosimetry, definition, principles and importance, types of porosimetry (mercury intrusion, gas adsorption, etc.), mercury intrusion technique, Washburn equation and its limitations, contact angle and surface tension effects, instrumentation and sample preparation, pore size distribution (PSD) calculation, pore volume, porosity, and density calculations, data interpretation and limitations, applications of MIP in construction materials (cement paste, concrete, aggregates, rocks, asphalt, and bituminous materials), advanced data analysis techniques (fractal analysis, etc.). **Impedance Analysis and Ultrasonic Methods:** Introduction to impedance analysis, principles, instrumentation, and measurement techniques, data analysis and interpretation, impedance spectroscopy technique and its applications in materials characterization, principles of ultrasonic testing, instrumentation and measurement techniques, ultrasonic velocity and attenuation, elastic properties and stiffness, applications in materials characterization, impedance analysis of cement-based materials, ultrasonic testing of concrete and aggregates, case studies in construction materials research and industry.	
Teaching Learning Process	**RBT Levels:** L1: Remembering (Definitions and principles of porosimetry and impedance analysis) L2: Understanding (Measurement techniques and data interpretation) L3: Applying (Applications in construction materials research)
Course out comes: • Understand the principles and applications of calorimetry in analyzing the thermal properties of construction materials. • Analyze mineralogical compositions and structural properties of construction materials using advanced techniques such as X-ray diffraction and optical microscopy. • Evaluate the microstructure of construction materials through scanning electron microscopy and image analysis methods. • Apply spectroscopic techniques to identify and characterize chemical properties of construction materials.	

- Utilize porosimetry and impedance analysis to assess the performance characteristics of construction materials in various applications.

Question paper pattern:

The question paper will have ten questions, each carrying equal marks. There will be two full questions or a maximum of four sub-questions from each module. Students will have to attempt five full questions from each module.

. Textbook

- **Karen Scrivener, Ruben Snellings, Barbara Lothenbach** - *A Practical Guide to Microstructural Analysis of Cementitious Materials*, CRC Press, 2015.
- **V. S. Ramachandran and James J. Beaudoin** (Eds.) - *Handbook of Analytical Techniques in Concrete Science and Technology*, William Andrew Publishing, New York, 2001.
- **D.A. St. John, A.W. Poole, and I. Sims** - *Concrete Petrography: A Handbook of Investigative Techniques*, Arnold Publishing, London, 1998.
- **William D. Callister** - *Materials Science and Engineering: An Introduction*, Sixth Edition, John Wiley and Sons, 2003.
- **J. M. Illston and P. L. J. Domone** - *Construction Materials: Their Nature and Behaviour*, Third Edition, Spon Press, 2001.
- **Jan Skalny** (Editor) - *Materials Science of Concrete*, Volumes I – VII, American Ceramic Society, 1989 – 2005.
- **J.F. Young, S. Mindess, R.J. Gray, and A. Bentur** - *The Science and Technology of Civil Engineering Materials*, Prentice Hall, 1998.

Web links and Video Lectures (e-Resources):

https://youtube.com/playlist?list=PLyqSpQzTE6M_SPzoDiGiemXR3DjZnDDPw&si=6sEV_C0jKaoDcg-T

Skill Development Activities Suggested

- **Calorimetry Lab Experiment**: Conduct a hands-on experiment to measure the heat of hydration in cement samples using a calorimeter, documenting the results and analyzing the implications for construction materials.
- **XRD Analysis Workshop**: Participate in a workshop focused on X-ray diffraction analysis, learning how to interpret data for identifying mineral compositions in construction materials.
- **Microscopy Techniques Practice**: Gain practical experience by preparing and analyzing samples using optical and scanning electron microscopy, focusing on hydration products and microstructure of concrete.
- **Image Analysis Project**: Utilize image analysis software to evaluate microstructures of various construction materials, applying techniques such as texture analysis and feature extraction.
- **Porosity Measurement Exercise**: Perform a mercury intrusion porosimetry exercise to measure pore size distribution in cement and aggregates, interpreting the results to understand their impact on material properties.

Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1:	2	1									
CO2:	2	2	1								
CO3:	2	1	1								
CO4:	1	2		1							
CO5:	1		2		1						

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

9. Two Unit Tests each of **25 Marks**
10. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

21. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
22. The question paper will have ten full questions carrying equal marks.
23. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
24. Each full question will have a sub-question covering all the topics under a module.
25. The students will have to answer five full questions, selecting one full question from each module

Modern Construction Materials

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE215C**	CIE Marks	50
Teaching Hours / Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: fundamental knowledge of Physics, Chemistry, and Mathematics (Calculus and Differential Equations). Additionally, familiarity with Mechanics of Materials, Strength of Materials, and Structural Analysis is required, along with recommended background knowledge of materials science concepts and construction materials, to effectively understand and apply the course concepts.

Course objectives: to enable students to: understand the fundamental principles of materials science and engineering, classify and characterize various materials, analyze material properties and behavior, apply materials selection criteria for structural engineering applications, evaluate material failure mechanisms, and develop sustainable material solutions. Upon completion, students will demonstrate in-depth knowledge of materials science, critical thinking, and problem-solving skills to design, analyze, and optimize materials for structural engineering applications.

Modules

Module-1

Introduction to the science, engineering, and technology of materials; the need for material science training; materials used in modern civil engineering; levels of information about materials; selection of materials. Review of atomic bonding, elements in the periodic table, Bohr model, electronic configuration, interaction of atoms, interatomic bonds, and bonding energies.

Classification of solids, crystal structure of metals, silica, silicates, kaolinite, polycrystalline structure, defects in crystals, amorphous and polymeric states.

Teaching Learning Process	RBT Level: 1-2

Module-2

Movement of atoms in solids: slip, dislocation, and atomic diffusion; diffusion mechanisms; development of microstructure; crystallization from melts and solutions; phase changes on heating and cooling; phase diagrams; binary phase diagrams; sintering; surface energy and tension; behavior of liquids on solids; superhydrophobic surfaces; adhesion of liquid to solid; surfactants; capillary rise; pressure on liquid surfaces; vapor pressure of liquids; adsorption; stability of colloids.

Response to stress: definition of stress and strain, elastic properties, Hooke's law, Young’s modulus, plasticity, yielding in polycrystalline and amorphous materials, post-yield behavior, stress-strain response, ductile failure, strain hardening, cold working, brittle failure, ductile to brittle transition, fatigue failure, creep of metals, and loading rate effects.

Teaching Learning Process	RBT Level: 2-3

Module-3

Failure theories: failure of structural materials, uniaxial behavior of metals, complex inelastic response of metals, rocks, and concrete; idealized plastic stress-strain curve; multiaxial loading; Rankine theory; Tresca criteria; von Mises theory; maximum shear stress criteria; distortional **strain energy theory;** Mohr-Coulomb failure theory; modified failure theories.

Introduction to fracture mechanics: stress concentration, linear elastic fracture mechanics, brittle-ductile transition, fracture toughness, brittle fracture, elasto-plastic fracture, fracture in polymers, composites, and concrete. Nonlinear fracture mechanics and applications.

Rheology: time-dependent material response, rheological models, viscous behavior of liquids, Newtonian

and non-Newtonian behavior, hysteresis, and thixotropy.
Thermal properties: heat capacity, thermal expansion, thermal stress, thermal conductivity.

Teaching Learning Process	RBT Level: 3-4

Module-4

Wood and wood products: structure, engineering properties, effect of temperature and moisture, processing, and application of timber; wood-based composites and applications.

Introduction to polymers: transition temperature, stress response, use of polymers, additives, fillers, weathering, and durability; fiber-reinforced polymer composites; fiber performance in aggressive environments; composite production technologies; multilayered composites; elastic response; effects of fiber orientation; applications of FRP in repair and strengthening of structures; advantages and disadvantages of FRP; prestressed FRP laminates; behavior of FRP-wrapped concrete.

Metals: forming, joining, oxidation, corrosion prevention, cold-rolled and heat-treated steels, stainless steel, TMT bars, non-ferrous metals, and alloys.

Bituminous materials: composition, structure, properties, and specifications of bitumen; asphalt paving mixtures; asphalt-bitumen interaction; issues due to excessive plastic deformation.

Teaching Learning Process	RBT Level: 2-3

Module-5

Concrete: cement composition, hydration, rate of heat evolution during hydration, morphology of hydration products, role of aggregates, size gradation, mineral admixtures, pozzolanic reactions, supplementary cementitious materials, and chemical admixtures. Requirements of concrete in the fresh state; factors affecting workability; composite response of hardened concrete; modeling concrete failure for structural analysis; nature and effect of shrinkage and creep; types of creep; deterioration due to chemical reactions; effect of fire on concrete.

Glass in buildings: properties, light transmission, performance guidelines, safety and security glass, thermally toughened glass, role in fire protection.

Advancements in waterproofing materials: need for waterproofing, basics of natural and conventional waterproofing, waterproofing materials, challenges in modern RCC buildings, damp proofing, and integral and external waterproofing.

Teaching Learning Process	RBT Level: 3-4

Course out comes:

CO1: Describe the fundamental principles of materials science and engineering, including atomic structure, bonding, and classification of solids.

CO2: Analyze the relationship between material structure, properties, and behavior, including atomic movement, microstructure development, and stress-strain response.

CO3: Evaluate the failure mechanisms and theories in materials, including fracture mechanics, nonlinear fracture mechanics, and rheological models.

CO4: Apply knowledge of material properties and behavior to select and design materials for specific applications, including wood, polymers, composites, metals, and bituminous materials.

CO5: Analyze the composition, properties, and behavior of concrete, glass, and waterproofing materials, and evaluate their performance in various environments.

QP pattern:
The question paper will consist of 10 questions, with each question carrying equal marks. There will be two full questions or a maximum of four sub-questions from each module. Students will be required to answer five full questions, with at least one question from each module.

Text Book:

1. Building Materials, P.C. Varghese, Prentice-Hall India, 2555.

Reference Books:

1. Materials Science and Engineering: An introduction, W.D. Callister, John Wiley, 1994.
2. Materials Science and Engineering, V. Raghavan, Prentice Hall, 1990.
3. Properties of Engineering Materials, R.A. Higgins, Industrial Press, 1994.
4. Construction materials: Their nature and behaviour, Eds. J.M. Illston and P.L.J. Domone, 3rd ed., Spon Press, 2551.

5. The Science and Technology of Civil Engineering Materials, J.F. Young, S. Mindess, R.J. Gray & A. Bentur, Prentice Hall, 1998.
6. Engineering Materials 1: An introduction to their properties & applications, M.F. Ashby and D.R.H. Jones, Butterworth Heinemann, 2553.
7. The Science and Design of Engineering Materials, J.P. Schaffer, A. Saxena, S.D. Antolovich, T.H. Sanders and S.B. Warner, Irwin, 1995.
8. Concrete: Microstructure, properties and materials, P.K. Mehta and P.J.M. Monteiro, McGraw Hill, 2556.
9. Properties of concrete, A.M. Neville, Pearson, 2554.

Web links and Video Lectures (e-Resources)
:https://www.youtube.com/watch?v=cx5gPKp9QEc&list=PLbMVogVj5nJQU7M0LdA77p_XaaWBJniNchttps://www.youtube.com/watch?v=cx5gPKp9QEc&list=PLbMVogVj5nJQU7M0LdA77p_XaaWBJniNchttps://www.youtube.com/watch?v=RSnNrQUTEnY&list=PLJAQaaJgEtI11reTaRrGWTDzezOAtGY4q

Skill Development Activities Suggested

1. **Material Selection Project: Assign students to select materials for a specific application (e.g., bridge construction, aircraft design). They should research and justify their choices.**
2. **Case Study Presentations: Divide students into groups to present case studies on material failures (e.g., Titanic, Chernobyl). They should analyze causes and propose solutions.**
3. **Material Testing Lab: Conduct hands-on lab experiments to test material properties (e.g., tensile strength, hardness). Students analyze results and draw conclusions.**
4. **Technical Report Writing: Assign students to write technical reports on specific materials (e.g., steel, concrete). They should research properties, applications, and limitations.**
5. **Group Discussion Debates: Organize debates on topics like "Sustainability in Materials Science" or "Advantages of Composite Materials." Students develop critical thinking, communication, and teamwork skills.**

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X			X							
CO2	X			X							
CO3	X			X			X				
CO4		X	X		X						
CO5	X			X			X				

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

11. Two Unit Tests each of **25 Marks**
12. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

26. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
27. The question paper will have ten full questions carrying equal marks.
28. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
29. Each full question will have a sub-question covering all the topics under a module.
30. The students will have to answer five full questions, selecting one full question from each module

Advanced Pre-stressed Concrete

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE215D**	CIE Marks	50
Teaching Hours /Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: -

1. Fundamental knowledge of concrete structures, materials science, and structural analysis
2. Understanding of mechanics of materials, strength of materials, and structural engineering principles
3. Familiarity with design codes and standards (e.g., ACI, IS, BS)

Course objectives:

1. To understand the principles and concepts of prestressed concrete structures
2. To analyze and design prestressed concrete members for various loads and conditions
3. To apply design codes and standards for prestressed concrete structures
4. To develop problem-solving skills in prestressed concrete design

Modules

Module-1

Introduction to Design of Pre-Stressed Concrete Structures.
Analysis of Members:
Analysis of Members Under Axial Load – Introduction, Analysis at transfer, Analysis at services loads, Analysis of ultimate strength, Analysis of behavior,
Analysis of Member Under Flexure
Introduction, Analysis at Service Loads, Based on stress concept, Based on force concept, Based on load balancing concept, Cracking moment, Kern point, Pressure line, Variation of stress in steel, Condition at ultimate limit state, Analysis of Rectangular Sections,
Analysis of Flanged Sections, Analysis of Partially Prestressed Sections, Analysis of Un-bonded Post-tensioned Beams, Analysis of Behaviour.
Numerical problems

Teaching Learning Process	**L1,L2,L3,L4**

Module-2

Design of Members -Calculation of demand
Design of members for Axial Tension -Design of prestressing force**,** Analysis of ultimate strength, Analysis of ultimate strength
Design of Member for Flexure-Calculation of moment demand**.,** Preliminary design
Design of Sections for Flexure (Part I)
Final design, Final design for type 1 members, Special case, Final design of type 2 members, Choice of sections, Determination of limiting zone, Post-tensioning in stages, Magnel's graphical method,
Detailing Requirements for Flexure, Detailing Requirements for Shear, Detailing Requirements

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for Torsion **Numerical problems**	
Teaching Learning Process	**L1,L2,L3,L4**
Module-3	
Analysis and Design for Shear and Torsion **Analysis for Shear -** Introduction, Stress in an uncracked beam, Types of cracks, Components of shear resistance, Modes of failure, Effect of prestressing force, **Design for Shear -** Limit state of collapse for shear, Maximum permissible shear stress, Design of transverse reinforcement, Detailing requirement for shear, General comments, Design steps, Design of stirrups for flange, **Analysis for Torsion -**Introduction, Stresses in an uncracked beam, Crack pattern under pure torsion, Components of resistance for pure torsion, Modes of failure, Effect of prestressing force, **Design for Torsion -** Limit state of collapse for torsion, Design of longitudinal reinforcement, Design of transverse reinforcement, Detailing requirements, General comments, Design steps **Numerical problems**	
Teaching Learning Process	**L1,L2,L3,L4,**
Module-4	
Calculations of Deflection and Crack Width **Calculation of Deflection** Deflection due to gravity loads, Deflection due to prestressing force, Total deflection, Limits of deflection, Determination moment of inertia, Limits of span-to-effective depth ratio, **Calculation of Crack Width -**Method of calculation, Limits of crack width Transmission of Prestress Introduction, Pre-tensioned members, Transmission length, Development length, End zone reinforcement, Post-tensioned members, End zone reinforcement, Bearing plate, **Numerical problems**	
Teaching Learning Process	**L1,L2,L4,L3**
Module-5	
Cantilever and Continuous Beams **Cantilever Beams -**Introduction, Analysis, Determination of limiting zone, Cable profile, **Continuous Beams -** Introduction, Analysis, Incorporation of moment due to reactions, Pressure line due to prestressing force, Concordant cable profile, Cable profiles, Partially continuous beams, Analysis at ultimate limit state, Moment redistribution, **Numerical problems**	
Teaching Learning Process	**L1,L2,L3,L4**

Course outcomes:

1. CO1: Understand prestressed concrete principles
2. CO2: Analyze members under axial load and flexure
3. CO3: Determine behavior of prestressed concrete members
4. CO4: Apply analysis methods
5. CO5: Solve numerical problems

Question paper pattern:

The question paper will consist of 10 questions, each carrying equal marks, with two full questions or a maximum of four sub-questions from each module, and students will be required to attempt one full question from each module.

Reference Books:

1. Praveen Nagarajan, "Advanced Concrete Design", Person In Lib
2. P. Dayaratnam, "Prestressed Concrete Structures", Oxford & IBH-Pubs Company, Delhi, 5th Edition Not Available

Lin T Y and Burns N H, 'Design of Pre - stressed Concrete Structures' , John Wiley and Sons, New York

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=undsd92MM8w&list=PLbQO4xhI7wEDIYv90NoF7veaJIohpuf0Q

SkillDevelopmentActivitiesSuggested

1. **Design Project: Prestressed Concrete Beam**
   a. **Objective: Apply analysis and design concepts for prestressed concrete beams.**
   b. **Task: Design a prestressed concrete beam for a given load and span.**
2. **Case Study: Shear and Torsion Analysis**
   a. **Objective: Analyze and design for shear and torsion in prestressed concrete members.**
   b. **Task: Analyze a real-world case study and design reinforcement for shear and torsion.**
3. **Numerical Problem-Solving Session**
   a. **Objective: Develop problem-solving skills for prestressed concrete design.**
   b. **Task: Solve numerical problems related to prestressed concrete design.**
4. **Group Discussion: Prestressed Concrete Design Considerations**
   a. **Objective: Develop critical thinking and communication skills.**
   b. **Task: Discuss design considerations for prestressed concrete structures.**
5. **Technical Report Writing: Prestressed Concrete Design**
   a. **Objective: Improve writing and communication skills.**
   - **Task: Write a technical report on a prestressed concrete design project.**

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X				X	X				
CO2	X	X	X				X				
CO3	X	X		X			X				
CO4	X	X			X		X				
CO5	X	X	X			X					

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

13. Two Unit Tests each of **25 Marks**
14. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

31. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
32. The question paper will have ten full questions carrying equal marks.
33. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
34. Each full question will have a sub-question covering all the topics under a module.
35. The students will have to answer five full questions, selecting one full question from each module

Design of Plates and Shells

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER–II

Subject Code	**MCSE216A**	CIE Marks	50
Number of Lecture Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: Students should have fundamental knowledge of strength of materials, structural analysis, and mathematics (differential equations, calculus). Familiarity with plate and shell structures, and basic understanding of elasticity theory are also essential.

Course objectives:

This course aims to equip students with the knowledge and skills to analyze and design plate and shell structures. Students will learn various methods of analysis, including classical thin plate theory, Navier's solution, Levy's approach, and membrane analysis. The course will enable students to apply these concepts to real-world problems.

Modules

Module-1

Bending of Plates

Classification of plates and methods of analysis. Slope and curvature of slightly bent plates – curvature and twist in any arbitrary direction. Principal curvatures. Classical thin plate theory. Relation between bending moments and curvatures, principal bending moments. Differential equation for laterally loaded rectangular plates. Boundary conditions. Kirchhoff modification of boundary conditions at a free edge. Differential equation for the bending of orthotropic plates. Rectangular plates subjected to edge moments. Cylindrical bending of long rectangular plates. Structural effects due to bending of plates.

Teaching Learning Process	**L1, L2, L3**

Module-2

Simply Supported Rectangular Plates

Subjected to harmonic loading, Navier's solution for simply supported plates subjected to uniformly distributed load (UDL), hydrostatic pressure, patch load, partial UDL, and concentrated load, etc. Bending of rectangular plates subjected to UDL by Levy's approach: (i) all edges simply supported, (ii) two opposite edges simply supported and the other two edges clamped. Bending of rectangular plates subjected to uniformly varying load (UVL): (i) all edges simply supported, (ii) two opposite edges simply supported and the other two edges clamped. Method of superposition for the analysis of rectangular plates with complex boundary conditions.

Teaching Learning Process	**L3, L4, L5**

Module-3

Symmetrical Bending of Circular Plates

Differential equation for symmetrical bending of laterally loaded circular plates. A round simply supported plate subjected to uniformly distributed load (UDL) over the entire surface, a central concentrated load, and constant edge moment. A round clamped plate subjected to UDL over the entire surface and a central concentrated load. Method of superposition. Annular plate subjected to edge moments and UDL over the entire surface.

Teaching Learning Process	**L3, L4, L6**

Module-4

Analysis of Shells

Shapes and forms of shells, geometry of quadric surfaces; general form, standard equation, ellipsoid, hyperboloid, elliptic cone, elliptic paraboloid, hyperbolic paraboloid, quadric cylinder, etc.; classifications of shells, membrane action, and bending action. Membrane analysis of shells of revolution: domes and conical shells.

Teaching Learning Process	L1, L2, L3

Module-5

Analysis of Shells (Contd...)

Membrane analysis of hyperbolic paraboloid shells and membrane analysis of cylindrical shells. Lundgren's Beam theory for bending analysis of cylindrical shells.

Teaching Learning Process	L4, L5, L6

Course outcomes:

On completion of this course, students are able to:

CO1: Analyze and classify different types of plates and shells, applying appropriate theoretical frameworks and methods for their bending and structural analysis.

CO2: Derive and solve differential equations governing the behavior of both rectangular and circular plates under various loading conditions, including uniform and concentrated loads.

CO3: Implement advanced analytical methods, such as Navier's solution and Levy's approach, to effectively analyze simply supported plates with complex boundary conditions.

CO4: Apply principles of membrane and bending action in the analysis of shell structures, understanding their geometric properties and structural behavior.

CO5: Conduct comprehensive analyses of advanced shell forms, including hyperbolic paraboloids and cylindrical shells, integrating practical applications and theoretical knowledge.

QP pattern:

The question paper will consist of ten questions, with two full questions (each containing a maximum of four sub-questions) from each module. Each full question will address various topics covered within the respective module. Students will be required to answer five full questions, selecting one full question from each module.

Reference Books:

1. Timoshenko, S. and Woinowsky-Krieger, W., "Theory of Plates and Shells," 2nd Edition, McGraw-Hill Co., New York, 1959.
2. Ramaswamy, G. S., "Design and Construction of Concrete Shell Roofs," CBS Publishers and Distributors, New Delhi, 1986.
3. Ugural, A. C., "Stresses in Plates and Shells," 2nd Edition, McGraw-Hill, 1999.
4. Szilard, R., "Theory and Analysis of Plates: Classical and Numerical Methods," Prentice Hall, 1994.
5. Chatterjee, B. K., "Theory and Design of Concrete Shells," Chapman & Hall, New York, 3rd Edition, 1988.

Web links and Video Lectures (e-Resources)

:https://www.youtube.com/watch?v=tA_LGwTvre4&list=PLwdnzlV3ogoXQR59FK4dNDzxb5I65IIuuhttps://www.youtube.com/watch?v=CkolEAtY6jY

Skill Development Activities Suggested

1. **Plate Classification Exercise**:
   Create a presentation or poster categorizing different types of plates based on geometrical and material properties, including applications for each type.
   Skills Developed: Research, classification, presentation, and visualization.
2. **Differential Equation Derivation**:
   Work in groups to derive the differential equations governing the bending of rectangular plates under various loading conditions and present findings to the class.
   Skills Developed: Collaborative problem-solving, critical thinking, and mathematical derivation.
3. **Navier's Solution Application**:
   Solve problems related to Navier's solution for simply supported rectangular plates under different loads (e.g., UDL,

concentrated loads) and use software to visualize results.
Skills Developed: Analytical thinking, software proficiency (e.g., MATLAB, ANSYS), and problem-solving.

4. **Membrane Analysis Case Study**:
Conduct a case study on a real-world structure (like a dome or shell roof) using membrane analysis principles, analyzing its design and load-bearing capacity.
Skills Developed: Research, analytical thinking, and application of theoretical concepts to real scenarios.
5. **Hands-On Model Creation**:
Create physical or digital models of shell shapes (e.g., hyperbolic paraboloids, cylindrical shells) using materials like cardboard or 3D modeling software, assessing structural stability.
Skills Developed: Creativity, practical application of theory, spatial awareness, and engineering design.

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X									
CO2	X				X						
CO3	X					X					
CO4	X						X				
CO5				X						X	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

15. Two Unit Tests each of **25 Marks**
16. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

36. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
37. The question paper will have ten full questions carrying equal marks.
38. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
39. Each full question will have a sub-question covering all the topics under a module.
40. The students will have to answer five full questions, selecting one full question from each module

ADVANCED STRUCTURAL ANALYSIS

[As per Choice Based Credit System(CBCS)scheme]

SEMESTER–II

Subject Code	**MCSE216B**	CIE Marks	50
Teaching Hours / Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites: Students should have a solid foundation in basic structural analysis concepts, including determinate and indeterminate structures, methods like moment distribution, slope deflection, and stiffness methods. A strong understanding of material mechanics, such as stress-strain relationships, bending, shear, and torsion, is essential. Familiarity with mathematical techniques, including matrix algebra and differential equations, is also crucial. Prior exposure to software tools like STAAD.Pro or SAP2000 for structural modeling and analysis would be beneficial.

Course objective: This course aims to equip students with the knowledge of mathematics, science, and engineering principles to analyze various complex structural systems. These include the analysis of curved beams, beams on elastic foundations, shear center, unsymmetrical bending, and the buckling of non-prismatic columns and beam-columns. The course will provide students with the tools necessary to effectively address these advanced structural challenges in real-world engineering applications.

Modules

Module-1

Curved Beams: Introduction to curved beams, including assumptions and the derivation of the Winkler-Bach equation. Discussion on the radius to the neutral surface of simple geometric figures and their limitations. Analysis of stress distribution in open curved members, such as hooks and chain links, as well as stress distribution in closed rings and chain links. Examination of deformations in open and closed rings.

Teaching Learning Process	**L1,L2,L3,L4**

Module-2

Beams on Elastic Foundations: Governing differential equation for the elastic line, interpretation of constants. Analysis of infinite beams subjected to point load, moment, and UDL, with relevant problems. Semi-infinite beams with point load, moment, and UDL, along with problems over fixed and hinged support conditions.

Teaching Learning Process	**L1,L2,L3,L4**

Module-3

Shear Centre: Concept of shear center in torsion-induced bending of beams. Expressions for the shear center in symmetrical and unsymmetrical sections. Derivation of the shear center for angles, channels, semicircular, and built-up sections, along with numerical problems.

Teaching Learning Process	**L1,L2,L3,L4**

Module-4

Unsymmetrical Bending (Asymmetrical Bending): Theory behind unsymmetrical bending and its assumptions. Obtaining the stresses in beams, including simply supported and cantilever unsymmetrical beams subjected to inclined loading. Analysis of deflections in unsymmetrical simply supported and cantilever beams, accompanied by numerical problems.

Teaching Learning Process	**L1,L2,L3,L4**

Module-5

Buckling of Non-Prismatic Columns and Beam-Column: Principles behind Euler's theory of buckling. Governing differential equations applied to the buckling of columns, including the evaluation of constants for various boundary conditions. Obtaining the characteristic equation for the buckling load of non-prismatic compound columns. Analysis of beam-columns, including the conceptual theory of magnification stresses and deformations subjected to axial and different types of lateral loads, accompanied by numerical problems.

Teaching Learning Process	**L1,L2,L3,L4**

Course Outcomes:

CO1: Apply Winkler-Bach and Strain Energy principles to calculate stresses and deformations in curved members.

CO2: Derive expressions for foundation pressure, deflection, slope, bending moment (BM), and shear force (SF) of infinite and semi-infinite beams resting on an elastic foundation.

CO3: Formulate equations for determining the shear center in both symmetrical and unsymmetrical sections from fundamental principles.

CO4: Extend bending theory to calculate stresses and deformations in cases of unsymmetrical bending.

CO5: Develop the characteristic equation for the buckling load of compound columns, and analyze stresses and deformations in beam-columns.

Question paper pattern: The question paper will consist of ten questions, each carrying equal marks. There will be two full questions, each containing a maximum of four sub-questions, from each module. Students are required to answer five full questions, selecting one question from each module.

Text Books

1. Krishna Raju N. & Gururaj D. R., **"Advanced Mechanics of Solids and Structures"**, NAROSA Publishers Company, Delhi.
2. Srinath L. S., **"Advanced Mechanics of Solids"**, Tenth Print, Tata McGraw-Hill Publishing Company, New Delhi, 1994.

Reference Books

1. Vazirani V. N. and Ratwani M. M., **"Advanced Theory of Structures and Matrix Method"**, 5th Edition, Khanna Publishers, Delhi, 1995.
2. Hetenyi M., **"Beams on Elastic Foundation"**, 3rd Printing, University of Michigan, USA, 1952.
3. Alexander Chatjes, **"Principles of Structural Stability Theory"**, Prentice-Hall of India, New Delhi, 1974.
4. Sterling Kinney, **"Indeterminate Structural Analysis"**, Oxford & IBH Publishers.

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=s4CN6aVKhPo&list=PLEE5D02698EAAF2C0

Skill Development Activities Suggested

- **Curved Beam Design Project**

Students can design and analyze curved beams under various loading conditions, using both manual calculations and structural analysis software.

  - **Skills Developed**: Design, structural analysis, and software proficiency.

- **Shear Center Experiment**

Conduct a lab experiment to locate the shear center of different cross-sectional shapes and verify results using theoretical calculations.

  - **Skills Developed**: Experimental analysis, critical thinking, and theoretical verification.

- **Elastic Foundation Modeling**

Use software like ANSYS or STAAD.Pro to model beams on elastic foundations, analyzing deflections and stresses under different loads.

  - **Skills Developed**: Software modeling, simulation, and analysis.

- **Buckling Analysis of Non-Prismatic Columns**

Perform a buckling analysis for non-prismatic columns, comparing analytical and numerical results using Euler's formula and software tools.

  - **Skills Developed**: Analytical skills, software tools usage, and understanding of stability theory.

- **Matrix Method Practice Session**

Organize practice sessions where students solve indeterminate structural analysis problems using the matrix method, enhancing their computational efficiency.

  - **Skills Developed**: Computational methods, problem-solving, and mathematical rigor.

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X		X						X	
CO2	X	X		X						X	
CO3	X	X		X						X	
CO4	X	X		X						X	
CO5	X	X		X						X	

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Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

17. Two Unit Tests each of **25 Marks**
18. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

41. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
42. The question paper will have ten full questions carrying equal marks.
43. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
44. Each full question will have a sub-question covering all the topics under a module.
45. The students will have to answer five full questions, selecting one full question from each module

Bridge Engineering

[As per Choice Based Credit System(CBCS)scheme]

SEMESTER–II

Subject Code	**MCSE216C**	CIE Marks	50
Teaching Hours / Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS–03

Prerequisites:

completion of courses in Structural Analysis, Mechanics of Materials, Steel and Concrete Design, Geotechnical Engineering, and Transportation Engineering. Additionally, familiarity with design software such as Autodesk Civil 3D and STAAD, and a basic understanding of mathematics (calculus, statistics) and physics are expected.

Course objectives:

This course aims to equip students with comprehensive knowledge and skills in bridge engineering, enabling them to design, construct, and manage safe, efficient, and sustainable bridges. Upon completion, students will be able to: analyze bridge loads and stresses; design bridge structures using various materials; apply structural analysis and simulation techniques; inspect and evaluate bridge condition; develop maintenance and rehabilitation plans; and apply current design standards and codes. Students will also gain expertise in bridge construction methods, geotechnical considerations, and environmental impact assessment.

Modules

Module-1

Introduction & Design of Slab Culvert: Overview of bridge engineering and its development in the past. Ideal site selection for bridges and bridge classifications. Discussion of forces acting on bridges and analysis for maximum bending moment (BM) and shear force (SF) at critical sections for dead and live loads, as per IRC Class A, B, and AA tracked and wheeled vehicles. Structural design of slab culverts using the limit state method including reinforcement details.

Teaching Learning Process	**L2,L3**

Module-2

Box Culvert: Introduction to box culverts and advantages of structural continuity. Analysis involves determining maximum bending moment (BM) and shear force (SF) at critical sections using the moment distribution method for various load combinations, including dead, surcharge, soil, water, and live loads (as per IRC Class A, B, and AA for tracked and wheeled vehicles). The structural design will utilize the Limit State Method with detailed reinforcement specifications.

Teaching Learning Process	**L2,L3**

Module-3

T-Beam Bridge:

Components of T-Beam Bridge, Load transfer mechanism, Proportioning the Components, Analysis of **Slab** using **Pigeauds Method** for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of **Slab** using limit state method with reinforcement details. Analysis of **Cross Girder** for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of slab using limit state method with reinforcement details. Analysis of **Main Girder** using **Courbon's Method** for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of **Main Girder** using limit state method with reinforcement details

Teaching Learning Process	**L3,L4**

Module-4

PSC-Bridge: Introduction to Pre & Post Tensioning, Proportioning of Components,

Analysis & Structural Design of Slab, Analysis of Main Girder Using **Courbon's Method** for IRC Class AA, Tracked vehicle, Calculations of Pre-stressing Force, Calculations of Stresses, Cable profile, Design of End Block, Detailing of Main Girder.	
Teaching Learning Process	**L3,L4**
Module-5	
Balanced Cantilever Bridge: Introduction & Proportioning of Components, Analysis of Main Girder Using **Courbon's Method** for IRC Class AA, Tracked vehicle Design of Simply Supported Portion, Cantilever Portion, Articulation, using limit state method with reinforcement details.	
Teaching Learning Process	**L3,L4**

Course outcomes:

After studying this course, students will be able to:

CO1: Describe historical growth, select a suitable site and bridge, calculate design parameters of slab culvert at critical sections as per IRC, and outline design and detailing requirements for project execution.

CO2: Carry out analysis of box culvert as per IRC to obtain design parameter values and design and detail components following IS code procedures.

CO3: Demonstrate the application of Pigeaud's Method and Courbon's Method in analyzing T-beam bridges as per IRC. Design to obtain safe dimensions for various components and determine optimum reinforcement requirements following IS code procedures.

CO4: Illustrate the use of Courbon's Method in analyzing Prestressed Concrete (PSC) bridges as per IRC. Design to determine safe prestressing force values and obtain dimensions for various components, ensuring stresses remain within codal provisions following IS code procedures.

CO5: Analyze a balanced cantilever bridge as per IRC to obtain safe design parameter values and design and detail components precisely, adhering to IS code procedures.

Question paper pattern:

The examination will consist of 10 questions, with 2 full questions (each having up to 4 sub-questions) drawn from each of the 5 modules, ensuring comprehensive coverage of all topics. Students are required to answer 5 full questions, selecting one from each module, demonstrating their understanding of the subject matter across all areas of study.

Text Books:

1. Essentials of Bridge Engineering by Dr.D Johnson Victor , Oxford & IBH Publishing Co New Delhi
2. Design of Bridges by Dr N Krishna Raju, Oxford & IBH Publishing Co New Delhi

References:

1. Principles and Practice of Bridge Engineering by S P Bindra, Dhanpat Rai & Sons New Delhi
2. IRC6 -1966 Standard Specifications And Course Code Of Practice For Road Bridges Section II Loads and Stresses, The Indian Road Congress New Delhi
3. IRC 21 - 1966 Standard Specifications And Course Code Of Practice For Road Bridges Section III Cement Concrete (Plain and reinforced) The Indian Road Congress New Delhi
4. IS456 -2000 Indian Standard Plain and Reinforced Concrete Course Code of Practice (Fourth Revision) BIS New Delhi
5. IS1343-Indian Standard Pre-stressed Concrete Course Code of Practice BIS New Delhi

Web links and Video Lectures (e-Resources):https://www.youtube.com/watch?v=RB2k5hSYO3U&list=PLXKZsEFKU_HHtsCMaAIPB3tr5Ht2 Bdgehttps://www.youtube.com/watch?v=RB2k5hSYO3U&list=PL3MO67NH2XxJxMvfgAgdohx5-ksPZruA8

Skill Development Activities Suggested

1. **Bridge Design Software Training**

   Bridge design software training is essential for bridge engineers. This activity involves learning industry-standard software such as Autodesk Civil 3D, STAAD, and ETABS. Participants practice designing various

bridge types, including beam, arch, and suspension bridges. They develop skills in geometry creation, load calculations, structural analysis, and material selection. This training enhances their ability to create efficient and safe bridge designs.

2. **Model Bridge Building and Testing**
   Model bridge building and testing is a hands-on activity that helps bridge engineers develop practical skills. Participants design and build scale models of bridges using various materials. They test these models under different loads to analyze their strength and durability. This activity helps engineers understand structural integrity, materials science, and problem-solving. By refining their designs based on test results, engineers develop innovative solutions.
3. **Bridge Site Visits and Inspection**
   Bridge site visits and inspections provide valuable field experience. Engineers visit existing bridges to observe design and construction aspects. They inspect bridge components, such as foundations, piers, and decks, to identify potential issues. This activity develops skills in condition assessment, maintenance planning, and safety protocols. Engineers gain insight into real-world bridge construction and management.
4. **Online Courses/Certifications**
   Online courses and certifications keep bridge engineers updated on industry trends and standards. Platforms like ASCE, Coursera, and Udemy offer courses on bridge design, construction, and management. Certifications, such as Certified Bridge Engineer, demonstrate expertise. Engineers enhance their knowledge of new technologies, design standards, and best practices. This ongoing education ensures they remain competent and competitive.
5. **Case Study Analysis**
   Case study analysis is a critical thinking exercise for bridge engineers. They examine successful and failed bridge projects to identify factors contributing to success or failure. Engineers discuss lessons learned and best practices, developing skills in critical thinking, problem-solving, and decision-making. By analyzing real-world examples, engineers refine their design and construction approaches, reducing errors and improving bridge performance.

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X								X	
CO2	X	X								X	
CO3	X	X								X	
CO4	X	X								X	
CO5	X	X								X	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

19. Two Unit Tests each of **25 Marks**
20. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

46. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
47. The question paper will have ten full questions carrying equal marks.
48. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
49. Each full question will have a sub-question covering all the topics under a module.
50. The students will have to answer five full questions, selecting one full question from each module

Reliability Analysis and Reliability Based Design of Structures

[As per Choice Based Credit System (CBCS)scheme]

SEMESTER –II

Subject Code	**MCSE216D**	CIE	50
Number of Lecture Hours/Week (L:P:SDA)	3:0:0	SEE	50
Total Number of Lecture Hours	40	ExamHours	03

CREDITS– 03

Pre requisite: To effectively engage with the course on Reliability Analysis and its Based Design of Structures, students should possess a foundational understanding of structural engineering principles and concepts. It is essential for students to have prior knowledge in basic statistics, including probability distributions and statistical parameters, as well as experience in structural analysis methods. Familiarity with concepts such as load types, structural materials, and the fundamental principles of design will also facilitate a deeper comprehension of the advanced topics covered in this course. Additionally, skills in using engineering software for simulations and analyses will be beneficial for practical applications.

Objectives: The primary objective of this course is to equip students with the necessary knowledge and skills to analyze and design structures with a focus on reliability and safety. By the end of the course, students will be able to apply statistical techniques to assess variability in structural elements, determine appropriate safety formats for failure surfaces, and utilize regression and correlation methods to analyze relationships between variables. Furthermore, students will gain proficiency in reliability-based design principles, including the calculation of partial safety factors and the use of simulation techniques to derive statistics for design variables. Overall, the course aims to prepare students to make informed decisions in structural engineering that prioritize safety, efficiency, and integrity.

Course Outcomes

CO1: Comprehend the concepts and techniques of reliability and probability distributions.
CO2: Define the safety format for failure surfaces for given actions and responses, along with their statistics.
CO3: Learn the statistical regression and correlation of two variables.
CO4: Determine the partial safety factors for a target reliability index.
CO5: Use simulation techniques to derive the statistics of design variables.

Module

Module-1

Concept of Variability

- Applications of statistical principles to deal with randomness in basic variables.
- Statistical parameters and their significance.
- Description of various probability distributions: Binomial, Poisson, Normal, Log-Normal, Beta, and Gamma distributions.

Testing the goodness of fit of distributions to actual data using the Chi-Square method and the Kolmogorov-Smirnov (K.S.) method.

Teaching-Learning Process	**L2, L3, L4**

Module-2

Statistical Regression and Correlation

- Least squares and Chi-Square methods.
- Operations on one random variable, expectation, and multiple random variables.
- Reliability distributions and basic formulations.

Teaching-Learning Process	**L2, L3**

Module-3

Statistical Quality Control in Civil Engineering

- Sampling for quality control: Characteristic strength and characteristic load.
- Probability modeling of strength, geometrical dimensions, material properties, and loading.
- Statistical inference problems: Comparison of various acceptance and rejection testing.

Teaching-Learning Process	**L3, L5**

Module-4

Safety Assessment of Structures • Reliability analysis using I, II, and III order reliability formats. • Mean value method and its applications in structural designs.	
Teaching-Learning Process	**L3, L5**
Module-5	
Reliability of Structural Elements • Simulation techniques: Monte Carlo method and its applications. • Reliability index and reliability formulation in various limit states. • Reliability-based design: Application to the design of reinforced concrete (RC), prestressed concrete (PSC), and steel structural elements under the Load and Resistance Factor Design (LRFD) concept.	
Teaching-Learning Process	**L2, L3**

Question paper pattern:

- The examination will consist of 10 questions, with 2 full questions (each having up to 4 sub-questions) drawn from each of the 5 modules, ensuring comprehensive coverage of all topics. Students are required to answer 5 full questions, selecting one from each module, demonstrating their understanding of the subject matter across all areas of study.

Textbooks:

1. Ang, A.H.S., and Tang, W.H.
   Probability Concepts in Engineering Planning and Design, John Wiley & Sons, New York, Vol. I and II, First Edition (January 1, 1984).
2. Ranganathan, R.
   Reliability Analysis and Design of Structures, Tata McGraw-Hill Publishing Co. Ltd., New Delhi (2008).

Reference Books:

1. Sancheti, D.C., and Kapoor, V.K.
   Statistics: Theory, Methods & Applications (1996).
2. Devaraj, V., and Ravindra, R.
   Reliability-Based Analysis and Design for Civil Engineers, IK International Publishing House Pvt. Ltd. (December 30, 2017).

Web Link: https://archive.nptel.ac.in/courses/105/103/105103140/
https://archive.nptel.ac.in/courses/105/105/105105209/
https://onlinecourses.nptel.ac.in/noc21_ce58/preview

Skill Development Activities Suggested

1. **Workshops on Software Tools:**
   Conduct hands-on workshops using reliability analysis software (e.g., MATLAB, R) to perform simulations and analyses.
2. **Case Studies and Group Projects:**
   Analyze real-life structural failures in groups, focusing on reliability assessments and safety factor calculations.
3. **Guest Lectures and Seminars:**
   Invite industry experts for lectures on reliability-based design and host student seminars to present findings.
4. **Statistical Data Analysis Exercises:**
   Practice statistical methods (e.g., regression, correlation) with civil engineering data sets to enhance data interpretation skills.
5. **Field Visits and Research Projects:**
   Arrange site visits to observe practical applications of reliability analysis and initiate research projects on innovative techniques.

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X	X								
CO2	X	X			X						
CO3	X	X				X					
CO4	X			X			X				
CO5	X	X									X

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

21. Two Unit Tests each of **25 Marks**
22. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

51. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
52. The question paper will have ten full questions carrying equal marks.
53. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
54. Each full question will have a sub-question covering all the topics under a module.
55. The students will have to answer five full questions, selecting one full question from each module

COMPUTATION LABORATORY –II			
Course Code	MCSEL207	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1:2:0	SEE Marks	50
Total Teaching Hours	10 to 12 lab sessions	Total Marks	100
Credits	02	Exam Hours	03

Note: Students are suggested to execute any 8 below mentioned programs.

Sl.NO	Programs	RBT levels
1	Analysis and Design of RCC beam and column elements using MATLAB/Python	L4, L5
2	Analysis and Design of RCC slabs for different end conditions using MATLAB/Python	L4, L5
3	Structural Analysis of 2D beams with different loading and support conditions by using MATLAB/Python	L4, L5
4	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute parameters of rule of mixture and engineering constants.	L4, L5
5	Analysis of STEEL beam and column elements using MATLAB/Python	L4, L5
6	Static and Dynamic analysis and design of Multi-storey Building structures using any FE software	L4, L5
7	Analysis of RC Chimneys/silos/bunkers FE software.	L4, L5
8	Analysis and design of large span roof structure (dome structure) using any FE software.	L4, L5
9	Design of structural drawings for a multi-storied building using FE software	L4, L5
10	Experiments on vibration of multi storey frame models for Natural frequency and modes.	L4, L5

Demonstration Experiments

Sl.NO	Programs	RBT levels
11	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute compliance matrix, stiffness matrix and other related parameters	L4, L5
12	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute A-B-D matrix.	L4, L5
13	Use of Non-destructive testing (NDT) equipment's – Rebound hammer, Ultra sonic pulse velocity meter and Profometer	L4, L5

Course outcomes:

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

1. Carry out structural analysis of RC elements
2. Analysis of beams for different loading and support conditions.

Web links and Video Lectures (e-Resources):
Skill Development Activities Suggested • Conduction of technical seminars on recent research activities • Group Discussion

CO	PO										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	X	X	X	X	X			X	X	X	X
CO2	X	X	X	X	X			X	X	X	X

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Skill and Ability enhancement courses for PG Level Civil Engineering courses			
Course Code	MCSE258	CIE Marks	50
Credits	01	SEE Marks	50

Preamble

The Ability Enhancement and Skill Development Course at the postgraduate level is designed to strengthen students' core competencies and equip them with essential skills for academic and professional advancement. This course focuses on developing critical thinking, academic writing, research methodology, digital literacy, communication, and ethical reasoning to support advanced learning and scholarly engagement. It also emphasizes skill development in areas such as problem-solving, data analysis, entrepreneurship, project management, and the use of discipline-specific tools and technologies. Aligned with the objectives of the National Education Policy (NEP) 2020, the course aims to enhance employability, innovation capacity, and leadership qualities among postgraduate students.

Procedure to take up Skill and Ability enhancement courses for PG Level Civil Engineering courses

Students may opt the subjects from NPTEL (National Programme on Technology Enhanced Learning) online course list and VTU online courses offered during the current semester, subject to the approval of the Department and as per university regulations. The selected course must be relevant to the student's postgraduate program, contribute to academic or professional development, and not duplicate content already covered in the core curriculum. A NPTEL or VTU online course in the semester may be permitted for credit transfer or academic enrichment, provided the course includes assessments such as assignments and proctored examinations. Students must submit their course selection for departmental approval within the first two weeks of the semester. Successful completion of the course, including passing the final certification exam (online) will be required for academic credit or consideration under skill enhancement components.

Some of the Generalized Subjects but not limited for Skill Development Courses (SDC) and Ability Enhancement Courses (AEC)

- Environmental Data Analysis and Simulation Tools
- Disaster Risk Reduction and Management in Infrastructure
- Smart Infrastructure and IoT Applications in Civil Engineering
- Legal Aspects, Contracts, and Arbitration in Construction
- Technical Communication and Scientific Writing for Engineers
- Entrepreneurship and Innovation in Civil Engineering
- Project Formulation and Proposal Writing
- Digital Literacy and Software Tools for Engineering Research
- Intellectual Property Rights and Patent Drafting
- Leadership and Team Management in Engineering Contexts
- Other skill enhancement courses suggested by the respective programs

PROGRAM OUTCOMES

At the end of the program the student will be able to:

PO1	Graduates of the program will be able to demonstrate in-depth knowledge of Structural Engineering discipline and build capability to apply that knowledge to real problems.
PO2	Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO3	Graduates will have the ability to employ technical knowledge and leadership skills to Structural Engineering research and consultancy problems.
PO4	Graduates of the Structural Engineering program will demonstrate the ability to carry out original and useful research in key areas of Structural Engineering.
PO5	Program graduates will be able to identify and analyze the impact of Structural Engineering in development project and find a suitable solution from number of alternatives.
PO6	Graduates of the program will develop skills to communicate technical values of Structural Engineering research with the public, learners, practitioners and other community members of concern.
PO7	Program graduates will develop confidence in Structural analysis and management with high ethical value towards social, environmental and economic issues.
PO8	Graduates will develop enthusiasm and confidence to pursue lifelong learning for professional advancement.
PO9	Program graduates will develop the spirit of working in team for common objectives.
PO10	Graduates of the program will develop interest to pursue higher studies and research.
PO11	Graduates of the program will develop interest to use Modern Engineering and IT tools for further studies and problem solving.