SEMESTER –II			
COMPUTATIONAL STRUCTURAL MECHANICS – FE APPROACH			
Subject Code	**24CCS21**	CIE	50
Number of Lecture Hours/Week	3	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-Study Component: Develop a program for generating the overall stiffness matrix for a truss using any programming language.

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

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

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

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-Study Component**: Develop a program for generating the overall stiffness matrix for beam elements using any programming language.

SEE Question paper pattern

The question paper will have six questions. Each question carries 20 marks. There will be one full question from each module and remaining one from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

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

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

STRUCTURAL DYNAMICS AND EARTHQUAKE RESISTANT DESIGN OF STRUCTURES			
Subject Code	**24CCS22**	CIE Marks	50
TeachingHours/Week(L:P:SDA)	4:0:0	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 work and Hamilton's principle.
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

Engineering Seismology : 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 response. 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 IS1893.Structural behavior, design, and ductile detailing of shearwalls. Overview of linera 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.
(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)

SEE Question paper pattern
The question paper will have six questions. Each question carries 20 marks. There will be one full question from each module and remaining one from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Text 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=PLyVhmjhvTvDbqByamCNEYw2zDBOscOHRbhttps://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

ACTION AND RESPONSE OF STRUCTURES			
Subject Code	**24CCS23**	CIE	50
Number of Lecture Hours/Week	3:0:2	SEE	50
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 03			

Prerequisites: Students should have a foundational understanding of structural analysis, including knowledge of statics, mechanics of materials, and the behavior of structural elements like beams, columns, and slabs. Familiarity with basic concepts of load calculations, wind and seismic loads, and fundamental design codes (such as IS 875, IS 1893) is essential. Prior exposure to software tools for structural modeling and analysis will be beneficial, particularly in handling practical design challenges in complex structures.

Objectives: This course aims to equip students with advanced knowledge of loads and load combinations for buildings and bridges, incorporating standards such as IS 875, IS 1893, and IRC 6. Students will develop the ability to apply analytical and numerical methods to calculate wind, seismic, and vehicular loads. Through self-study projects, they will enhance problem-solving skills, culminating in an understanding of nonlinear structural behavior in tall buildings.

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

CO1	Comprehend the effect of loading on structures in the form of action & response.
CO2	Comprehend the importance of codal provisions for appropriate loading standards.
CO3	Comprehend the provisions of IS 875 part 1,2,4,5 towards dead load and live load combinations
CO4	Apply the provisions of IS 875 part 3 on wind load on buildings
CO5	Comprehend the provisions of IS1893 towards seismic loads on buildings and different types of analysis of tall buildings

Modules	**RBT Level**
Module -1	
Loads and load combination: IS 875 PART 1, 2, 4, 5 Sources, Nature and Magnitude, Probabilistic assessment, Characteristic and Design values. IS 875 PART 1 and 2 code provisions. Load combination rules for design. Load path for gravity loads- Tributary Area and Stiffness based approaches. Estimation of DL and LL on structural elements such as Slabs, Beams and Columns in different types of structural systems, Joint Loads on Trusses, Distributed load on purlins- Numerical examples. *Self-study Component*: students shall prepare a project for calculating the dead loads and live loads acting on various elements of a building and submit the report.	L3, L4, L6
Module -2	
Wind Load - IS 875 PART 3: Buildings - IS 875:2015 revised version Nature and Magnitude, Factors influencing wind loads, Internal and External pressure distribution, Design Wind Speeds and Pressure, Load path for wind loads, Numerical Examples to calculate external and internal pressure for different types of buildings and regions – Flat roofs, Pitched Roofs, Sign boards and Structural glazings. *Self-study Component*: students shall prepare a report for calculating wind loads for a tall building incorporating all the codal provisions.	L3, L4, L6
Module -3	

Seismic Loads: IS: 1893-2016 revised version Nature and Magnitude, Centre of mass and rigidity, Calculation of Design Seismic Force by Static Analysis Method and Dynamic Analysis Method, Location of Centre of Mass, Location of Centre of Stiffness, and Lateral Force Distribution as per codal provisions. - Load path for Lateral loads – Floor diaphragm action. *Self-study Component*: students shall prepare a report for calculating seismic force for various seismic zones incorporating all the codal provisions.	L3, L4, L6
Module -4	
Vehicles Loads as per IRC 6 - 2017 on Road Bridges – Class 70 R, Class AA, Class A, Class B, Tracked Vehicles, Wheeled Vehicles, Load Combinations, Impact, Wind, Water Currents, Longitudinal Forces: acceleration, breaking and frictional resistance, Centrifugal forces, thermal loads, Seismic forces, Snow Loads, Collision Loads. Load Combinations – Simple Numerical Examples. *Self-study Component*: students shall take up a road bridge project and calculate the various load combinations as per IRC provisions.	L3, L4, L6
Module -5	
Structural forms of Tall Buildings: IS:16700; 2017 Different structural forms for Tall Buildings. Linear, Nonlinear behavior, Material nonlinearity, Geometric nonlinearity, Rigid and Elastic Supports, First Order Elastic Analysis, Second Order Elastic Analysis, First order Inelastic Analysis, Second order Inelastic Analysis – Concepts and Brief descriptions *Self-study Component*: students shall study the inelastic behavior of a tall building using any software package.	L2, L4, L6

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

IS Codes

1. IS 875 Parts (1 to 5), IS 1893, IRC 6,
2. SP64: Handbook

Reference Books:

1. An explanatory Handbook on IS 875 (PART 3); Wind Load on Building and Structures, Document No: IITK-GSDMA Wind 07 V1.0 - IITK-GSDMA Project on Building Codes
2. Explanatory Examples on Indian Seismic Code IS 1893 (Part I): Document No.: IITK-
3. GSDMA-EQ21-V2.0 - IITK-GSDMA Project on Building Codes
   Matrix Analysis of Structures, Aslam Kassimali, CengageLearning,2012

Skill Development activities suggested:

1. **Load Calculation Exercises:** Students can calculate dead and live loads for various building elements (beams, slabs, columns) based on IS 875 standards. They can practice using different building types and structural systems, promoting practical understanding of load estimation.
2. **Wind Load Calculation Project:** Students can simulate wind load calculations for a small building using IS 875 Part 3. This can include determining wind pressures, forces on facades, and roof types. Excel or simple software tools can be used to assist in these calculations.
3. **Seismic Load Case Study:** A simple case study can be developed for analyzing seismic loads on a multi-story building. Students can use IS 1893 provisions to compute seismic forces using both static and dynamic analysis methods, reinforcing practical application of seismic codes.
4. **Vehicle Load Modeling:** Students can model vehicle loads on small road bridges using IRC 6 guidelines. They can calculate different vehicle class loads (Class 70R, AA, A, B) and their effects on bridge elements, including impact factors and load combinations.
5. **Software-Based Inelastic Analysis:** As a basic introduction to structural analysis software, students can explore the nonlinear behavior of a simple tall building structure using a free or educational version of structural analysis software (e.g., ETABS or SAP2000). This will develop their competency in modeling and analysis.

Web links: https://archive.nptel.ac.in/courses/105/105/105105166/
https://archive.nptel.ac.in/courses/114/106/114106036/
https://archive.nptel.ac.in/courses/105/107/105107204/

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1: Comprehend the effect of loading on structures in the form of action & response	3	2	2	1	2	2	1	1	2	1	2
CO2: Comprehend the importance of codal provisions for appropriate loading standards	3	2	2	1	2	1	1	2	2	1	2
CO3: Comprehend the provisions of IS 875 part 1,2,4,5 towards dead load and live load combinations	3	2	2	1	2	1	1	1	1	1	2
CO4: Apply the provisions of IS 875 part 3 on wind load on buildings	3	2	2	1	2	2	2	1	2	1	2
CO5: Comprehend the provisions of IS1893 towards seismic loads on buildings and different types of analysis of tall buildings	3	3	2	2	2	2	1	1	2	1	2

Legend:

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

ADVANCED MECHANICS OF MATERIALS			
Subject Code	**24CCS24**	CIE	50
Number of Lecture Hours/Week	3	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Prerequisites: Students should have a foundational understanding of mechanics of materials, including concepts of stress, strain, and basic beam theory. Familiarity with structural analysis and material properties is essential. Previous exposure to topics such as bending moments, shear forces, and basic structural behavior will help in comprehending the complexities of non-symmetrical bending and curved beams.

Objectives: The objectives of this syllabus are to equip students with a comprehensive understanding of various structural mechanics concepts, including non-symmetrical bending in straight beams and shear center analysis for thin-walled sections. Students will learn to apply the method of tension coefficients for three- dimensional structures, analyze curved beams and their stresses, and investigate the behavior of beams on elastic foundations. Additionally, the syllabus aims to provide insight into structures subjected to out-of-plane loading, enhancing problem-solving skills in real-world applications.

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

CO1	Locate the shear center for thin-walled beam cross sections in bending, shear flow in thin- walled beams for singly symmetric and unsymmetrical sections. Learn the non- symmetrical bending of straight beams and determine its deflection
CO2	Learn the method of tension coefficients for the analysis of space frames
CO3	Comprehend the behavior of a curved beam of different types subject to different loadings
CO4	Analyze beams on elastic foundation subject to different loadings with different boundary conditions
CO5	Analyze structures subjected to out of plane loading

Modules	RBT Level
Module -1	
Non-symmetrical Bending of Straight Beams: Symmetrical and non- symmetrical bending, bending stresses in beams subjected to non-symmetrical bending. **Shear Center for Thin-Walled Beam Cross Sections**: Definition of shear center in bending. Approximations employed for shear in thin- walled beam cross sections, Shear flow in thin-walled beam cross sections, Shear center for singly symmetric and unsymmetrical sections. *Self-study component*: Students should observe different structural sections and visualize the position of shear centre in each case and planning to transfer loads through the shear centre. They should go around the campus and observe steel and RC structures to identify situations of non-symmetric bending.	L2, L3, L4, L6
Module -2	
Method of Tension Coefficients for analysis of 3D Structures General principles, Analysis of three-dimensional trusses and frames. *Self-study component*: Students should visualize different constraint possibilities at the supports. Also identify how internal instability is balanced by additional constraints.	L2, L3, L4

Module -3	
Curved Beams: Introduction, Circumferential stress in a curved beam, Radial stresses in curved beams, Correction for circumferential stresses in curved beams having I, T, or similar cross sections, Deflections of curved beams. *Self-study component:* Students should study the analysis of statically indeterminate curved beams such as closed rings or links of chains used in heavy machinery.	L2, L3, L4, L5
Module -4	
Beams on Elastic Foundations: General theory, Infinite beam subjected to concentrated load, Boundary conditions, Infinite beam subjected to a distributed load segment, Semi-infinite beam with different end conditions subjected to concentrated load and moment at its end - short beams. *Self- study component*: Analysis of finite beams on elastic foundation subjected to different loads, Identify beams on elastic foundation in the field.	L2, L3, L4, L5
Module -5	
Structures subjected to out of plane loading: Analysis of simple bents, frames, grids. Beams circular in plan – Cantilever circular beams, semicircular continuous beams with three equally spaced supports, Semicircular fixed beam, ring beams with different number of equally spaced supports. *Self-study component*: Analysis of rectilinear brackets of non-rectangular and circular plan form, Analysis of non-semicircular curved beams.	L2, L3, L4, L5

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Text Books:

1. Arthur P. Boresi and Omar M. Sidebottom: "Advanced Mechanics of Materials", Fourth Edition, John Wiley & Sons,1985
2. JamesM. Gereand S.P. Thimoshenko: "Advanced Mechanics of Materials", Second Edition, CBS Publishers, New Delhi, 2000.

Reference Books:

1. Srinath. L.S., Advanced Mechanics of Solids, TataMcGraw - Hill Publishing Co ltd., New Delhi,2010.
2. Ugural.A.C. and Fenster.S. K "Advanced Strength of material and Applied Elasticity", Arnold Publishers,1981.
3. Junnarkar.S.B., "Mechanics of Structures", Volume - III, Charotar Publications, Anand,2015.
4. R.T. Fenner, Engineering elasticity – R.T. Fenner,1986.

Skill Development Activities Suggested:

- **Bending Analysis Project:** Students can create physical models of beams subjected to non-symmetrical bending and measure deflections to compare with theoretical calculations.

- **Shear Center Visualization:** Organize a workshop where students use CAD software to visualize shear centers in various thin-walled beam cross-sections and analyze their effects on structural integrity.

- **3D Structural Analysis:** Conduct a group activity where students analyze a real-world three- dimensional truss system using the method of tension coefficients, identifying constraints and internal stability.

- **Curved Beam Study:** Students can research and present case studies on the applications of curved beams in engineering structures, including load distribution and stress analysis.

- **Field Analysis of Elastic Foundations:** Organize field visits to observe and analyze structures built on elastic foundations, where students will collect data on real-world loading conditions and perform theoretical analyses.

Web Links https://archive.nptel.ac.in/courses/112/101/112101095/
https://onlinecourses.nptel.ac.in/noc22_ce54/preview
https://archive.nptel.ac.in/courses/105/106/105106049/
https://archive.nptel.ac.in/content/storage2/courses/105106049/lecnotes/main.html

Here's the updated CO-PO mapping table with priority levels indicated for each Course Outcome:

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

Priority Levels:

- **1**: High priority
- **2**: Medium priority
- **3**: Low priority

This indicates that all Course Outcomes are of high priority with respect to the Program Outcomes, while the overall alignment with PO8, PO9, PO10, and PO11 is of medium priority.

ADVANCED DESIGN OF RC STRUCTURES			
Subject Code	**24CCS251**	CIE	50
Number of Lecture Hours/Week	3	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Course Outcomes **At the end of the course the students will be able to**		**Correlating Program Outcome**
CO1	Comprehend the underlying concepts for the design of elements subjected to shear and Torsion	PO1, PO2, PO3
CO2	Comprehend the concept of redistribution of moments in design. Analysis and design of reinforce concrete deep beams subjected to various types loading.	PO1, PO2, PO3, PO4
CO3	Comprehend the analysis and design of reinforce concrete deep beams Subjected to various types loading.	PO1, PO2, PO3
CO4	Comprehend the concept and design of storage structures	PO1, PO2, PO3, PO5
CO5	Comprehend the design of Flat slab systems	PO1, PO2, PO3, PO5

Modules	**Teaching Hours**
Module -1	
Behavior of RC Beams in Shear and Torsion Modes of Cracking, Shear Transfer Mechanisms, Shear Failure Modes, Critical Sections for Shear Design, Influence of Axial Force on Design Shear Strength, ShearResistance of Web Reinforcement, Compression Field Theory, shear in deep beams, Strut-and-Tie Model. Equilibrium Torsion and Compatibility Torsion, Design Strength in Torsion, Design Torsional Strength with Torsional Reinforcement. *Self-study Component*: Using available analysis package compute the shear and torsional forces acting on structural elements.	**13 Hours**
Module -2	
Redistribution of Moments in RC Beams Conditions for Moment Redistribution – Final shape of redistributed bending moment diagram – Moment redistribution for a two-span continuous beam – Advantages and disadvantages of Moment redistribution – Modification of clear distance between bars in beams (for limiting crack width) with redistribution – Moment – curvature Relations of Reinforced Concrete sections. Numerical Example. **Design of Reinforced Concrete Deep Beams** Introduction – Minimum depth -Steps of Designing Deep beams – design by IS 456 - Detailing of Deep beams. *Self-study Component:* Students should gain a vast knowledge on RC beam momentsusing available software packages. Also prepare detailed drawings for RC deep beams using any software package.	**14 Hours**
Module -3	

Design of reinforced walls and grid floors: Behavior of Lateral Load Resisting Systems, design of walls, rectangular and flanged shear walls. **Grid floors**- types of grids, size of beam and topping, design of grid floors. *Self-study Component:* Students should gain knowledge on RC structural wall andshear wall. Also prepare detailed drawings for RC shear using any software package.	**14 Hours**
Module -4	
Analysis and Design of special structures **Bunkers and Silos:** Introduction, Design of rectangular bunkers, circular bunkers, Designof silos. **Chimneys:** Design of Chimneys. *Self-study component:* Students are informed to visit on-going projects and learn tostorage structures	**15 Hours**
Module -5	
Flat Slab Design Component of flat slab construction, Layout of flat slab System, Design of flat slab by direct design method including provision of drop panel and pedestal, slab reinforcement details. punching shear. *Self-study component:* Students should have a complete knowledge on the structural behavior of each element (knowledge related to assessment of tension and compression zone).	**14 Hours**
SEE Question paper pattern The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.	
Text Books: S. Pillai, Devdas Menon- Reinforced Concrete Design 3/ED 3rd Edition, New Delhi, 1990 Varghese. P.C., Advanced Reinforced Concrete Design, prentice, Hall of India, Neevpeth. 2edition (2005)	
Reference Books: Krishna Raju – "Advanced R.C. Design", CBSRD,1986, Park R. and Paulay, T., Reinforced Concrete Structures, John Wiley and Sons, (1 January 1975)Shah and Karve "Reinforced Concrete Design" Standard Publications, (2010) Shah and Karve "Illustrated Design of G+3" Standard Publications, Structures Publications (2010) S. S. Bhavikatti," Advance R. C. C. Design", New Age International PublishersRelevant IS Codes	

ANALYSIS OF PLATES AND SHELLS

Subject Code	**24CCS252**	CIE Marks	50
Number of Lecture Hours/Week	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 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 of shells. 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. All round simply supported plate subjected to uniformly distributed load (UDL) over the entire surface, a central concentrated load, and constant edge moment. All 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.

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

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=PLwdnzlV3ogoXQR59FK4dNDzxb5I65IIuu

https://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.

STRUCTURAL STABILITY ANALYSIS			
Subject Code	**24CS253**	CIE	50
Number of Lecture Hours/Week	3	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Prerequisites:
Bachelor's degree in Civil Engineering or related field, courses in Structural Analysis, Mechanics of Materials, and Mathematics (calculus, statistics), familiarity with design software.

Course Objectives:
Upon completion, students will be able to analyze beam-column structures subjected to various loads, determine critical loads for buckling of frames, beams, and plates, apply finite element approach for stability analysis, evaluate buckling behavior of rectangular plates under combined loads, and develop problem-solving skills using trigonometric series and energy methods.

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

CO1	Derive the differential equations of beam column subject to different types of loads and different end conditions
CO2	Comprehend approximate calculation of critical loads for frames and continuous beams by elastic energy methods
CO3	Apply finite element method to stability analysis of structural elements
CO4	Analyze buckling of rectangular plates with various edge conditions
CO5	Comprehend to analyze buckling of rectangular plates with combined loads

Modules	**RBT Level**
Module -1	
Beam column Differential equation of Beam column subjected to (i) lateral concentrated load,(ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series. Euler's formulation using fourth order differential equation for pinned-pinned, fixed-fixed, fixed-free and fixed-pinned columns. *Self-study*: Students shall develop a programe for differential equation for different loading and end conditions.	**L2, L3, L4**
Module -2	
Buckling of frames and continuous beams: Elastic Energy method . Approximate calculation of critical loads for a cantilever. Exact critical load for hinged-hinged column using energy approach. Buckling of bar inelastic foundation. Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation. Bars with varying cross section. Effect of shear force on critical load. Columns subjected to non-conservative, follower and pulsating forces. *Self-study*: Students shall prepare a report on the concept of buckling of RC structures.	**L3, L4, L5**
Module -3	

Stability analysis by finite element approach Derivation of shape functions for a two noded Bernoulli-Euler beam element (lateral and translational dof) –element stiffness and Element geometric stiffness matrices – Assembled stiffness and geometric stiffness matrices for a discretised column with different boundary conditions – Evaluation of critical loads for a discretised (two elements) column (both ends built-in). Algorithm to generate geometric stiffness matrix for four noded and eight noded isoparametric plate elements. Buckling of pin jointed frames (maximum of two active dof)-symmetrical single bay Portal frame. *Self-study*: Students shall refer the reference material and obtain solution for the column with different boundary conditions	**L4, L5, L6**
Module -4	
Buckling of simply supported rectangular plate Buckling of uniformly compressed rectangular plate simply supported along two opposite edges perpendicular to the direction of compression and having various edge condition along the other two edges- Buckling of a Rectangular Plate Simply Supported along Two opposite sides and uniformly compressed in the Direction Parallel to those sides. *Self-study:* Students shall prepare a report on Buckling of simply supported rectangular plate	**L3, L4, L5**
Module -5	
Buckling of simply supported rectangular plate – Combined effects Buckling of a Simply Supported Rectangular Plate under Combined Bending and Compression – Buckling of Rectangular Plates under the Action of Shearing Stresses – Other Cases of Buckling of Rectangular Plates. *Self-study*: Students shall refer the reference material and obtain solution for the Cases of Buckling of Rectangular Plates	**L5, L6**

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Text Books:

1. Stephen P. Timoshenko, James M. Gere, "Theory of Elastic Stability", 2nd Edition, McGraw-Hill, New Delhi,1998
2. Zeiglar.H," Principles of Structural Stability", Blaisdall Publication, Waltham, Mass.(1968)
3. Robert D Cook et al, "Concepts and Applications of Finite Element Analysis", 3rd Edition, John Wiley and Sons, New York, 4th edition (31 October2001)

Reference Books:

1. Rajashekaran. S, "Computational Structural Mechanics", Prentice-Hall, India, 1 January2001.
2. Ray W Clough and J Penzien, "Dynamics of Structures", 2nd Edition, McGraw-Hill, New Delhi, 2 edition (30 September1993)

Skill Development activities Suggested:

1. Module 1: Beam-Column Analysis
   SDA: Design and analyze a simply supported beam-column structure using Euler's formulation.
2. Module 2: Buckling of Frames and Beams
   SDA: Calculate critical loads for a cantilever beam using the elastic energy method.
3. Module 3: Stability Analysis by Finite Element Approach
   SDA: Develop a finite element model for a pinned-pinned column and evaluate its stability.

4. Module 4: Buckling of Simply Supported Rectangular Plates
   SDA: Analyze the buckling behavior of a rectangular plate under uniform compression.

5. Module 5: Buckling of Simply Supported Rectangular Plates - Combined Effects
   SDA: Investigate the effect of combined loading on the buckling behavior of a rectangular plate.

Web Links: https://archive.nptel.ac.in/courses/105/105/105105217/
https://onlinecourses.nptel.ac.in/noc22_ce91/preview
https://archive.nptel.ac.in/content/syllabus_pdf/105105217.pdf

Here's the CO-PO mapping table with Course Outcomes (COs) as rows and Program Outcomes (POs) as columns:

Course Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1
CO1	1	1		1	1						
CO2	1		1	1	1						
CO3	1	2	2			2					
CO4	1				2		2				
CO5	1	2			2			2			

1: **Low Contribution** – The Course Outcome has a basic or minimal impact on the Program Outcome.
2: **Moderate Contribution** – The Course Outcome contributes to the Program Outcome in a meaningful way but is not central to it.

3: **High Contribution** – The Course Outcome is crucial and significantly supports the Program Outcome.

GEOTECHNICAL EARTHQUAKE ENGINEERING			
Subject Code	**24CCS254**	CIE	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Prerequisites:
Geotechnical Engineering at UG level

Course objectives: This course will enable students to,

- Plan a subsurface exploration
- Evaluate appropriate bearing capacity correction factors to use in design
- Select the appropriate deep foundation type for different soil profiles.

Compute earth pressure and implement the design procedure for earth retaining structures.

Modules

Module -1

INTRODUCTION TO GEOTECHNICAL EARTHQUAKE ENGINEERING: Seismic hazards – Ground Shaking, Structural hazards, Liquefaction, Landslides, Retaining structure failures, Lifeline Hazards, Tsunami and Seiche Hazards; Mitigation of Seismic Hazards, Significant Historical Earthquakes.

DYNAMIC SOIL PROPERTIES: Representation of Stress conditions by Mohr Circle – Principal stresses and stress path; measurement of dynamic soil properties: Field test, lab tests, interpretation of observed ground response.

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

Module -2

LIQUEFACTION: Liquefaction related phenomenon – flow liquefaction, Cyclic Mobility; Evaluation of liquefaction hazards; liquefaction Susceptibility historical criteria. Geologic criteria. Compositional criteria. State criteria: initiation of liquefaction- flow liquefaction surface, Influence of excess pore pressure. Evaluation of Initiation of liquefaction – effects of liquefaction.

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

Module -3

SOIL IMPROVEMENT FOR REMEDIATION OF SEISMIC HAZARDS: densification techniques - Vibro techniques. Dynamic compaction, Blasting. Compaction grouting, Arial extent of Densification- ;Reinforcement techniques – stone columns. Compaction piles. Drilled inclusions; grouting and mixing techniques-drainage techniques. Verification of soil improvement – lab testing techniques.; In-situ testing techniques, Geophysical testing techniques; Other considerations.

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

Module -4

GENERAL PRINCIPLE OF MACHINE FOUNDATION DESIGN: Types of machine and foundation, General requirements of machine foundations; permissible amplitude, Allowable soil pressure. Permissible stresses of concrete and steel. Permissible stresses of timber.

FOUNDATION OF RECIPROCATING MACHINE; Modes of vibration of a rigid foundation block. Methods of analysis, Linear elastic weight less spring method, Elastic half space method. Effect of footing shape on vibratory response, Dynamic response of embedded block foundation. Soil mass participating in vibrations, Design procedure for a block foundation.

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

Module -5

FOUNDATION OF IMPACT TYPE MACHINE: Dynamic analysis. Design procedure for a hammer foundation

FOUNDATION OF ROTARY MACHINES: Special considerations. Design criteria. Loads on a T.G. Foundations, Method of analysis and design, Resonance method. Amplitude method, Combined method

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

Course outcomes(CO):

On completion of this course, students are able to:

Co1: Achieve Knowledge of design and development of problem solving skills. Co2: Understand the principles of engineering seismology

Co3: Design and develop analytical skills.

Co4: Summarize the Seismic evaluation and retrofitting of structures.

Co5: Understand the concepts of earthquake resistance of reinforced concrete buildings.

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Reference Books:

1Dynamics 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. Earthquake Resistant Design of Structures, Duggal, Oxford University Press.

4. Earthquake resistant design of structures - Pankaj Agarwal, Manish Shrikande -PHI India.

5. IS – 1893 (Part I): 2002, IS – 13920: 1993, IS – 4326: 1993, IS-13828: 1993

6. Design of Earthquake Resistant Buildings, Minoru Wakabayashi, McGraw Hill Pub.

7. Seismic Design of Reinforced Concrete and Masonry Buildings, T Paulay and M JN Priestley, John Wiley and Sons.

8. Steven L Kramer – Geotechnical Earthquake Engineering , PHI series

9. Swami Saran – Soil Dynamics and Machine Foundations, Galgotia Publications Pvt. Ltd

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=q-kHDw37XOM&list=PLbMVogVj5nJRNzx4KtSTVj7qr9OxwY3IF

Skill Development Activities Suggested

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

DESIGN OF PRECAST AND COMPOSITE STRUCTURES

Subject Code	**24CCS261**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3	SEE Marks	50
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Prerequisites: Basics of Strength of materials, Structural Analysis

Course objectives:

1. Understand the concepts and techniques of precast construction and Select or design precast elements suitable for project specific requirements
2. Design precast systems to ensure integrity and safety of the structure and toavoid progressive collapse and Design composite floors and beam elements

Modules

Module-1

Concepts, components, Structural Systems and Design of precast concrete floors Need and types of precast construction, Modular coordination, Precast elements- Floor, Beams, Columns and walls. Structural Systems and connections.

Design of precast Concrete Floors: Theoretical and Design Examples of Hollow core slabs. Precast Concrete Planks, floor with composite toppings with and without props.

Teaching Learning Process	**L1,L2**

Module-2

Design of precast reinforced and pre-stressed Concrete Beams Theoretical and Design Examples of ITB – Full section precast, Semi Precast, propped and unpropped conditions.
Design of RC Nibs

Teaching Learning Process	**L3,L4**

Module -3

Design of precast concrete columns and walls Design of braced and unbraced columns withcorbels subjected to pattern and full loading. Design of Corbels Design of RC walls subjected to Vertical, Horizontal loads and moments, Design of vertical ties and horizontal joints.

Teaching Learning Process	**L3,L4**

Module -4

Design of Precast Connections and Structural Integrity Beam bearing, Beam half Joint,Steel Inserts, Socket Connection, Structural integrity, Avoidance of progressive collapse, Design of Structural Ties.

Teaching Learning Process	**L3,L4**

Module -5

Design of Steel Concrete Composite Floors and Beams Composite Floors: Profiled Sheeting with concrete topping, Design method, Bending and Shear Resistance of Composite Slabs, Serviceability Criteria, Design Example.

Composite Beams: Elastic Behaviour, Ultimate Load behavior of Composite beams, Stresses and deflection in service and vibration, Design Example of Simply Supported beams.

Teaching Learning Process	**L3,L4**

Course Outcomes: Co1: Analyse, Design and detail PSC elements

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Reference Books:

1. Hass A.M. – Precast Concrete – Design and applications Applied Science, 1983.
2. David Sheppard – "Plant cast, Precast and Prestressed concrete – McGraw Hill;1989
3. NBC – 2005 (Part I to Part VII) BIS Publications, New Delhi, IS 15916- 2011, IS11447,IS6061 – I and III
4. R.P. Johnson: Composite Structure of Steel and Concrete (Volume 1), BlackwellScientific Publication (Second Edition), U.K., 1994.
5. IS: 11384-1985, Code of Practice for Composite Construction in Structural Steeland Concrete.
6. INSDAG Teaching Resource Chapter 21 to 27: www.steel-insdag.org

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=2qV4osntg6g&t=2558s

https://www.youtube.com/watch?v=fRqxXkxApSY&t=74s

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	

GEOTECHNICAL ASPECTS OF FOUNDATIONS AND EARTH RETAINING STRUCTURES			
Subject Code	**24CCS262**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**3**	SEE Marks	**50**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:
Geotechnical Engineering at UG level

Course objectives: This course will enable students to,

- Plan a subsurface exploration
- Evaluate appropriate bearing capacity correction factors to use in design
- Select the appropriate deep foundation type for different soil profiles.

Compute earth pressure and implement the design procedure for earth retaining structures.

Modules

Module -1

Bearing Capacity of Soils: Generalized Bearing Capacity Equation; Field tests for Bearing Capacity and settlement estimation; Settlement of shallow foundations - Elastic and consolidation settlements; Settlement estimates from penetration tests; Settlement tolerance; Allowable bearing pressure.

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

Module -2

Design Parameters for Substructures: Factors influencing selection of depth of Foundation, Subgrade Reaction, Winkler hypothesis and Beams on Elastic Foundation Approach; Soil Line Method; Foundations on expansive soils. Geotechnical failure of foundations during earthquake – Earthquake Resistant design of Shallow foundation – Liquefaction and Remedial measures.

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

Module -3

Pile Foundations: Classification of pile foundations and general considerations of design; Ultimate load capacity of piles; Pile settlement; Analysis of single pile and pile group; laterally loaded piles and ultimate lateral resistance. Uplift resistance of piles and anchored foundations; under reamed Pile; Pile load tests; Design examples.

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

Module -4

Retaining structures: Earth pressure theories, Fill Walls, Concrete/Gravity walls, Mechanically Stabilized Earth (MSE) walls- Analysis and Design,; Sheet pile walls, internally braced excavations (struts), externally braced excavations (tieback excavations), Soil Nailing.

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

Module -5

Elements of Soil Dynamics and Design of Machine Foundations: IS 2974 Parts I to IV, Machine- Foundation System , Block Foundations, Frame Foundations, Design Criteria, Tuning of Foundation, DOF of a Rigid Block Foundation, Linear Elastic Spring, Elastic Half Space Analog, Parameters influencing Dynamic Soil Parameters, Soil Mass Participation, Effect of Embedment, Soil Damping, Machine Parameters, Vibration Isolation System.

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

Course outcomes(CO):

On completion of this course, students will be able to:

1. Analyze the parameters which decide the bearing pressure various soil
2. Decide upon the type of foundation suitable for different sol types and depths.
3. Design pile foundations in different soil conditions.
4. Compute various parameters required for the design the retaining structures
5. Explain soil dynamics and design machine foundation

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Reference Books:

1. Bowles J.E, Foundation Analysis and Design, McGraw Hill. New York, 1996.
2. Murthy V. N. S., Advanced Foundation Engineering., CBS Publications, New Delhi, 2007.
3. Swami, S., Soil Dynamics and Machine Foundation, Galgotia Publications Pvt Ltd, New Delhi. 1999.
4. N.H. Som, and Das S.C., Theory and Practice of Foundation Design, PHI, Learning Pvt Ltd., New Delhi, 2009
5. Leonards. G.A, Foundation Engineering, McGraw Hill. 1962
6. Tschebotoriff. G.P. Foundations, Retaining and Earth Structures, McGraw Hill, New York, 1973.
7. Srinivasulu. P. and Vaidyanathan, V.. Handbook of Machine Foundations, Tata McGraw-Hill Publishing Company, New Delhi.2000
8. N.H. Som, and Das S.C., Theory and Practice of Foundation Design, PHI, Learning Pvt Ltd., New Delhi, 2009
9. Tomlinson, M.J., Pile Design and Construction Practice, E & FN Spon, London, 1994.

Web links and Video Lectures (e-Resources):
https://www.youtube.com/watch?v=lsYFtwwlHIw&list=PLbRMhDVUMngeiZjKPTPEFl1CByXmYX3Kv https://www.youtube.com/watch?v=LIAAhaeeA8Q

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	
CO2	X	X		X						X	
CO3	X	X		X						X	
CO4	X	X		X						X	
CO5	X	X		X						X	

DESIGN OF STRUCTURAL SYSTEMS FOR BRIDGES AND FLYOVERS			
Subject Code	**24CCS263**	CIE	50
Number of Lecture Hours/Week	3	SEE	50
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

Prerequisites: Students should have a foundational understanding of structural engineering principles, including the mechanics of materials, basic structural analysis techniques, and knowledge of relevant Indian Standards for construction. Familiarity with design concepts for various structural forms and the use of CAD software for analysis is also recommended.

Objectives: The course aims to provide students with a comprehensive understanding of bridge engineering, encompassing the historical context, design principles, and various structural forms of bridges. Students will learn to assess the loads acting on bridges and apply these concepts in the design of elevated bridges, underpasses, and box culverts. Additionally, the course will cover advanced topics such as finite element concepts and soil-structure interaction to prepare students for practical applications in bridge design.

Course Outcomes At the end of the course the students will be able to	
CO1	Comprehend and use the basic concepts in proportioning and design of bridges in terms of aesthetics, geographical location and functionality.
CO2	Develop an intuitive feeling about the sizing of bridge elements and the conceptual design part
CO3	Assess the load flow mechanism and loads on bridges.
CO4	Design of bridge starting from conceptual design, selecting suitable bridge, geometry to sizing of its elements
CO5	Design elevated bridges for given specifications. Conduct finite element analysis of bridge decks

Modules	**RBT Level**
Module -1	
Introduction to bridge engineering Historical background of bridges and types. Bridge aesthetics and proportioning. Bridge geometry. Conceptual design of various structural forms. Foundations with or without piles; abutments, retaining walls and wing walls; columns and cap beams; bearings. *Self-study component:* Prepare a report on Components of bridges- A case study	**L1.L2**
Module -2	
Loads on bridges (IRC6-2010) Class 70 R, Class AA, Class A , Class B , Tracked Vehicle, Wheeled Vehicle, Load Combinations, Impact, Wind, Water Currents, Longitudinal Forces: acceleration, breaking and frictional resistance, Centrifugal forces, temperature, Seismic forces, Snow Load, Collision Loads. Load Combinations *Self-study component:* Prepare a report on types of load referring to IS 873	**L2**
Module -3	
Design of Elevated Bridges and flyovers Solid slab, RCC - T beam and slab, Simple and box girder, PSC Girder systems for bridges and flyovers *Self-study component:* Collect the working drawings of any one from Solid slab, RCC - T beam and slab, box girder, PSC Girder systems for bridges and flyovers and study the same	**L2, L3,L4**
Module -4	

Design of Underpass and Box culverts Analysis and Design of Underpass and Box culverts as per the specifications of relevant Indian Standards *Self-study component:* Collect the working drawings of Box culverts and study the same	**L3,L4**
Module -5	
FE Concepts: Discrete and Continuum models of Bridge Deck – Spine, Grillage, Surface models, Bridge Piers, Support and Loading conditions, Soil-Structure Interaction *Self-study component:* Analyze the structure using CAD software	**L4, L5**

SEE Question paper pattern

The question paper will have six questions. Each question carries 20 marks. There will be one full question from each module and remaining one from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

Text Books:

1. Krishna Raju N "Design of Bridges," Oxford, IBH Publications NewDelhi,2006.
2. Johnson Victor, "Essential of Bridge Engineering," Oxford, IBH Publications, NewDelhi, 2000.
3. Ponnu swamy, S., "Bridge Engineering", Tata McGraw Hill, 2008.

Reference Books

1. Srinath. L.S., Advanced Mechanics of Solids, Tata McGraw -Hill Publishing Co ltd., New Delhi,2010.
2. IRC112 - 2011 Code of Practice for Concrete Road Bridges and Railway Board Codes
3. Jagadeesh. T.R. and Jayaram. M.A., "Design of Bridge Structures", Prentice Hall of India,2004.
4. Raina V.K." Concrete Bridge Practice" Tata McGraw H ill Publishing Company, New Delhi,1991.
5. ITK-RDSO GUIDELINES ON SEISMIC DESIGN OF RAILWAY BRIDGES- Provisions with Commentary and Explanatory Examples ,2010

Skill Development Activities (SDA)

1. **Report Preparation**: Prepare a detailed report on the components of bridges, highlighting the historical background and various structural forms.
2. **Load Types Analysis**: Create a report analyzing different types of loads on bridges as per IS 873, emphasizing load combinations.
3. **Working Drawings Review**: Collect and study working drawings of various bridge types, focusing on understanding their structural components.
4. **Design Application**: Analyze an underpass or box culvert by applying the relevant Indian Standards and preparing design calculations.
5. **CAD Software Analysis**: Use CAD software to model and analyze the structure of a bridge deck, applying finite element concepts and exploring soil-structure interactions.

Web Links: https://archive.nptel.ac.in/courses/105/105/105105216/
https://onlinecourses.nptel.ac.in/noc22_ce63/preview
https://archive.nptel.ac.in/courses/105/105/105105165/
https://archive.nptel.ac.in/courses/124/105/124105015/
https://onlinecourses.nptel.ac.in/noc22_ce73/preview

Here's the CO-PO table for the provided course outcomes (COs) and program outcomes (POs):

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	1	1	1	1	1	1	1	1	1
CO2	2	2	1	1	1	1	1	1	1	1	1
CO3	2	2	1	1	1	1	1	1	1	1	1

CO4	3	3	2	2	2	1	1	1	1	1	1
CO5	3	3	2	2	2	1	1	1	1	1	1

Key:

- **1**: Low correlation
- **2**: Moderate correlation
- **3**: High correlation

RELIABILITY ANALYSIS AND RELIABLE BASED DESIGN OF STRUCTURES			
Subject Code	**24CCS264**	CIE	50
Number of Lecture Hours/Week	3	SEE	50
Total Number of Lecture Hours	40	Exam Hours	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.

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.

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.

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.

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.

SEE Question paper pattern

The question paper will have seven questions. Each question carries 20 marks. There will be one full question from each module and remaining two from any of the modules or with sub questions from any of the modules. Students will have to attempt any five full questions.

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

COMPUTATION LABORATORY –II			
Course Code	**24CCS27**	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 of Simple Multi storey RCC Structure using FEA Package	L4, L5
3	Analysis and Design of RCC slabs for different end conditions using MATLAB/Python	L4, L5
4	Structural Analysis of 2D beams with different loading and support conditions by using MATLAB/Python	L4, L5
5	Analysis of STEEL beam elements using MATLAB/Python	L4, L5
6	Analysis of STEEL column elements using MATLAB/Python	L4, L5
7	Analysis of cold formed STEEL sections for different load conditions using MATLAB/Python	L4, L5
8	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute parameters of rule of mixture and engineering constants.	L4, L5
9	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute compliance matrix, stiffness matrix and other related parameters.	L4, L5
10	Analysis of unidirectional fiber reinforced composite materials by using MATLAB/Python to compute A-B-D matrix.	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